4.9. Present Farm Management and Latent Manpower

4.9.1. Present Farm Management

1) Musaverema (I-2-1)

Type of farming in this project area belongs to "cropping-grazing", in which share of grain production is comparatively high. Holding size mostly ranges 3 to 4 ha covered by family labour with 3 to 4 members. Total labour days per hectare during cropping season from late October to early June are estimated at 72 to 92 days, or 287 days per household. This suggests that only two people seem to cover total holding acreage for most part of cropping period. Mean yield levels are similar to other areas but drought gives damages once in two years. In spite of frequent drought, farm economy relies more on crop production than on livestock.

Expense for agricultural inputs (mainly certified seed and fertilizers for maize) shares 10 to 15 per cent of annual household expenditure. Farmers also fully use manure from abundant heads of cattle. This is attributable to lack of capital, lower response due to frequent drought. Here exists a traditional system of mutual assistance, collective farm practice called "Nymbe-Humwe", through which cattleless farmers, if any, are helped for ploughing or harvesting without payment. Among those who have off-farm side business, farm labour is hired sometimes to cover their family labour shortages. To avoid severe damage from drought, sunflower and other drought resistanct crops are recently increased, which, in turn, serve to ease the peak demand of farm labour, because such crop diversification can disperse planting and harvesting period.

2) Chinyamatumwa (II-1-6)

Farming type in this area falls into the category "cropping", mostly grains. Predominant holding size is estimated in the range between 2.5 and 3 ha covered by 3 people of average family labour. Farm labour requirement during cropping season starting in October, and ending in late May or further early June ranges from 68 to 118 man-days per hectare, except cotton, which needs more than 300 man-days. Total labour to cover a whole holding comes to 253 man-days, for which only one or two persons are good enough to meet it.

Considerably high rate of A.F.C. loan applicants, around 22 per cent of total households and also high percentage of Marketing and Supply Cooperative membership holders (10 per cent) can be described as salient features, which, in turn, is quite consistent with higher rate of agricultural input application. Average annual input cost per household, Z$116, well reflects this situation, but A.F.C. loan users invest Z$210 on an average (Certified Seed and 200 to 250 kg of Chemical fertilizers etc.) for maize groundnuts or cotton, and Z$170 per ha for sunflower. Most of the farmers keep draught animals to cover their own fields, yet Mushandira-Pamwe type mutual help, collective farm practice still remains viable.

3) Mashoko (II-2-1)

Cattle grazing has played an important role to overcome frequent crop failure from drought, and this region is famous for beef cattle production. Therefore, farming type can be expressed as "cropping-grazing", but only two thirds of the total farm households own cattle or draught animal, and a few owners of big size cattle herd are found among them. Some farmers who have no cattle regularly or temporarily go to Triangle or Chiredzi as seasonal farm workers on commercial farms to off-set drought losses.

Three to four family members are available for farm labour to cover 2.4 ha of their holdings on an average. Ordinary labour requirement per ha ranges from 96 to 117 man-days (except cotton) during cropping season starting in October and ending in May or early June. It comes to 278 man-days on farm holding basis, for which only two family members are sufficient to cover. The level of annual input application per household is still low (Z$80), mostly for purchasing certified seed and for applying fertilizers only for maize and cotton. Farmers with side jobs such as seasonal sugar cane workers in Chiredzi sometimes hire neighbours for weeding. They pay Z$1 per 50 sq.metres, or Z$4 per man-day, amounting to Z$200 to 250 per hectare (only limited to cash crops). Traditional mutual help activities are held once or twice a year, by which the plots of cattleless farmers are covered. Trying to mitigate drought damage, the drought resistant crops have been planted in one third of acreage.

4) Munjanganja (IV-4-10)

Type of farming can be described as "cropping", in which share of grains almost reaches four fifths of total acreages. Predominant holding size ranges from 2 to 2.5 ha, reflecting higher population density. Two to four family members actually cover this narrow holding with almost all of their own cattle, since most farmers keep their draught animals. Farm labour is mainly required from October to May. Farm labour required for grains and pulses falls between 181 and 225 man-days per household, and one to two persons of family members can cover for the most part of the season.

Input use by farmers is now increasing. 45 per cent of them purchase fertilizers, 5 per cent of them utilize A.F.C. loan, who spend Z$220 in one season for maize or cotton seed, compound fertilizers and ammonium nitrate, covering around 2 ha. Co-operative membership is still not popular among farmers, although about 2 per cent of the total households registered for marketing and supply co-operative, so far. Such positive farmers' attitude is also reflected in higher rate of marketing through G.M.B., which offers them higher prices than those paid by local dealers, and through the marketing to G.M.B. they can redeem their loan accounts of A.F.C.

5) Magudu (V-3-3)

This area also bears more or less "cropping" type character, but some farmers attach importance to cattle grazing by keeping fairly large herds, as often seen in lowveld areas. Holding size in the proposed area is not considered enough for farmers to sustain household, nor do they have enough grazing space to keep big herds of livestock. Three to four people per household are available to cover 1.5 to 2.0 ha of holding acreage. Farm labour per ha ranges from 94 to 112 man-days for grains and pulses. It exceeds 300 man-days per season for cotton. It follows that only 160 man-days are required to cover small sized holdings and surplus labour force often finds its outlet in seasonal farm labour in Triangle or Chiredzi commercial areas, while a few farmers are engaged in craft work at home, such as weaving bark tissue into mats.

More than half of the households in the area do not have draught cattle, due mainly to drought losses and sales for subsistence. Collective mutual help practices are usually held twice a year, at planting and at harvest. Some farmers having side jobs have to hire farm labour from neighbour to maintain current productivity of their cropland. The hiring charge of cattle for land preparation costs more than Z$40 per hectare due to low availability of cattle at the beginning of the season.

6) Mabvute (VII-1-12)

A typical "cropping" type of agriculture develops around the proposed area where holding size reaches above 3.5 ha. Family labour is also abundant, counting four people who work 84 to 126 man-days per ha during cropping season, except cotton, which required 332 man-days throughout the season. Total farm labour per household per season comes to 378 man-days from late September to early June. Therefore two to three people would be actually required per farm household if cotton crop is not included. The cropping season varies with crops. Therefore, variation of cropping period and crop diversification will help disperse farm labour required at peak period.

Input application except certified seed is not yet popularized. Only 7 per cent of farmers utilize chemical fertilizers, while even costly groundnuts seed is purchased by almost all growers. Nearly 8 per cent of farmers in this ward apply A.F.C. loans, who are mostly cotton growers. Most of the farmers keep their own draught cattle, and some of them keep fairly big scale herd as a type of household asset. Bota region in Zaka, including the proposed area, is known as cotton producing area in the province. The cash crops, such as sunflower and sugarbeans, have become popular, as well as cotton, among farmers.

Table 4-14 shows general features of the present farm management in these project areas.

Table 4－14 Indicators of Farm Management per Household

unit : * person or man-days ** Z$

Site	Musaverema	Chinyamatumwa	Mashoko	Munjanganja	Magudu	Mabvute
Name (Number) of Ward	9	6	2	26	Dowa 6	(24) Dzoro North
Name of Village	Chingore	Nyamhenge	Rusazu	Vidco 3	Magudu	Mabute
Average Holding Size (ha)	3－4	2.5－3	2.4	2－2.5	1.5－2	4
* Average Family Members	7.3	7.5	7.7	5.5	7.3	7.8
* Available Family Labour	3－4	3	3－4	2－4	3－4	4
* Total Man - days for Holding	287	253	278	203	175	420
* Necessary Labour Force	2	1－2	2	1－2	2－3	2－3
** Total Annual Household Expenditure	800	400－850	600－700	600－1,200	900－1,000	1,200
** Of which : Agricultural Inputs	100	116	80	165	45	234
Of which : Labour Hiring Cost	n.a.	n.a.	200－250 / ha	n.a.	n.a.	120－240 / ha
% of Certified Seed Utilization	60	100	90	90	90	100
% of Chemical Fertilizer Application	2	65	45	45	10	7
% of Crop Income on Total Income	60	70	75	35	40－55	65－80
% of Livestock Income	22	5	20	5	15	5－20
% Off - Farm Income	10	25	5	60	30	15
% of A.F.C. Loan Application	2	22	n.a.	5	n.a.	8
Amount (Z$) of A.F.C. Loan / Applicant	n.a.	n.a.	n.a.	220	n.a.	200
% of Co-operative Membership	2	10	n.a.	2	n.a.	n.a.
% of Marketing through G.M.B.	n.a.	70	n.a.	70	n.a.	70
% Draught Animal Kept	n.a.	95－100	67	n.a.	49	95－100
Availability of Collective Practice	3 times	2－3 times	1－2 times	3 times	2 times	0

source : results from interview survey plus information from extension workers.
n. a. : not available. % : per cent

4.9.2. Latent Manpower

Unemployed population is observed throughout rural areas in this province, but the detailed statistics are not available for measuring the extent of latent manpower. Accordingly, an estimation is made under the following assumptions. In this estimation, the wards in which irrigable areas are proposed are considered to be the individual units. The procedure of estimation is as follows.

i) The estimation is made based on the fact that the drought relief food distribution covers only the population of pure farm households who do not have any income source other than agricultural activities on their own holdings.

ii) Economically active population can be estimated at 59.8 per cent of total population in this province, according to the "Report on Demographic, Socio-economic Survey 1983 - 1984" by C.S.O., as the percentage of population other than that of 0 to 14 years old and that of above 60 years old.

iii) In rural areas, most households hold their own arable lands. The farm labour force is required on them during cropping season, but most of family labour power is released from farming during off-season, and returns again to unemployed state. Hence, latent manpower should separately be estimated by seasons.

iv) As far as farm labour is concerned, there is no particular difference between man and woman. But housewives are usually not counted as latent manpower during off-season because they are housekeeping, nursing or Taguta gardening. The households which have not registered as duly receivers of drought relief also have some latent manpower, and this rate is only estimated from farm interview survey results, as "Total family members x 0.598 (economically active) - numbers of outmigrators - housewife, divided by total family members."

v) Irrespective of whether registered, drought relief applicable households or not, farming can absorb latent manpower during cropping season. Required population in terms of farm labour is estimated from the following calculation:

$$P = N \times A \times D$$

where:

P: required from labour (population)

N: number of households in the wards concerned

A: average farm labour per hectare

D: cropping period (day)

At the priod of labour demand peak, at least 1.5 times as much as the required farm labour during the whole cropping season is estimated to be required.

The above-mentioned procedure gives the estimates as shown in Table 4-15. According to this result the latent manpower during off-season ranges from 36 to 46 per cent of total ward population and from 10 to 31 per cent even in cropping season. The result implies that the labour supply would never get tight all the year round.

Table 4－15 Estimated Latent Manpower by Sites

Unit : head or household unless orherwise noted in brackets

	Name of Site	Musaverema	Chinyamatumwa	Mashoko	Munjanganja	Magudu	Mabvute
	Site No.	I－2－1	II－1－6	II－2－1	II－4－10	II－3－3	VII－1－12
	Ward No. (or Name)	9	6	Matsai 2	26	Dowa 6	24
1	Population of the Ward	4,001	7,218	5,875	5,288	4,592	5,855
2	Number of Households of the Ward	487	1,246	1,175	964	615	790
3	of which＝% of Registered Households	62	83	77	80	59	95
4	of which＝% of non-Registered Households	38	17	23	20	41	5
5	% of Economically Active Population	59.8	59,8	59.8	59.8	59.8	59.8
6	% of Latant Manpower in non-Registered Households	24	31	44	33	39	43
7	(1×0.598－2)×3÷100 (Registered)	1,181	2,548	1,530	1,759	1,257	2,576
8	1×4×6÷10000 (non-Registered)	365	380	595	349	734	126
9	7＋8＝ Latent Manpower in Off-Season	1,546	2,928	2,125	2,108	1,991	2,702
10	% of Latent Manpower in Off-Season (9÷1)	39	41	36	40	43	46
11	Average Holdings (ha. per Household)	3.5	3.0	2.4	2.4	2.0	3.6
12	Average Farm Labour / ha. / Season (man-days)	82	95	114	92	98	120
13	Cropping Period / season (days)	180	220	210	190	210	210
14	Required Farm Labour (2×11×12÷13) (persons)	776	1,691	1,531	1,120	574	1,625
15	9－14＝ Latent Monpower in Cropping Season	770	1,237	594	988	1,417	1,077
16	% of Latent Man Power in Cropping Season (15÷1)	19	17	10	19	31	18
17	Farm Labour at the Peak Requirement (14×1.5)	1,165	2,537	2,297	1,680	861	1,616
18	9－17 : Possibility of Tightened Labour Supply	no	no	no	no	no	no

note ＝ % : per cent　　source : estimation by the team

4.10. Farm Economy

1) Musaverema (I-2-1)

Frequent drought spells threaten economic stability in this area. But due to limited grazing area farmers cannot rely on livestock, though share of livestock income reaches 20 per cent. Unstable crop yield has made farmers reluctant to use farm input, yet gross crop income per ha exceeds Z$150. Share of drought resistant crop in total acreage is reaching 20 per cent. Annual household expenditure ranges from Z$600 to Z$800. 38 per cent of total farm households are estimated to have side jobs. Outmigrants contribute to household budget at 18 per cent of total annual income.

Input/Output ratio falls 20 per cent if family labour is not included. Return for overhead family labour for only cropping can be evaluated at 1.5 Z$ per man-day. Well off part-time farmers can afford to hire farm labour and even designing to establish a machinery use system. When drought attacks, many farmers release their cattle for means of livelihood. Even though they sell off or lose all their cattle, mutual help system as hereditary tradition offers them necessary group practice to offset their loss. Current drought damages in this village are so severe that many farmers will have to sell their cattle to maintain present level of living.

2) Chinyamatumwa (II-1-6)

Bikita district is commonly known as cash crop area, but in this area grains are the main crop. Coverage of cash crop is less than 10 per cent of total cropping acreage. Here, dependence to off-farm income reaches a quarter of the total household income. Contribution of cattle sales to household income in drought years surpasses a quarter. Income from this source sharply decreases in ordinary or bumper crop years. Expense for agricultural inputs is 21 per cent as Input/Output ratio, in consistent with its higher loan utilization or cooperative membership.

Economic return for overhead family labour is given as Z$1.8 excluding labour for cattle grazing. Relative dependence of household

sustenance upon off-farm income sources seems to be heavy. About 83 per cent of total households were reportedly registered as legitimate drought relief receivers, implying the remaining 17 per cent of households actually received off-farm income from outmigrators etc. Mutual help field practice by collective ploughing or harvesting operation would serve to support household economy.

3) Moshoko (II-2-1)

Because of closer access to Triangle and Chiredzi, nearly 10 per cent of households send seasonal commercial farm labourers to lowveld sugarcane area. Another 10 per cent of them might be more oriented to cattle herding or home beer brewing for sale, to compensate unstable crop income from narrow holding. These households sometimes hire farm labour offering Z$220/ha to neighbours. Actually, no cash crop is found around the proposed area. Farmers also plant drought resistant crops in 30 per cent of their acreage, to stabilize crop income. The rest 80 per cent are pure peasants.

A low income level is derived from depressed yield levels by frequent drought damages. More than 20 per cent of total annual income of Z$684 stems from cattle sales. Return for overhead family labour remains in low level (Z$1.3). However, a third of total households presently do not keep their own cattle and cannot but cover their acreage through collective, mutual help practice.

4) Munjanganja (IV-4-10)

This area is sometimes affected by drought, but the extent of damage is much less than southern part of the province. Even in drought years farmers manage to keep ordinary or slightly lower yield level than in ordinary years. Even now, in off-seasons, housewives are engaged in vegetable growing at Taguta gardens developed along streams managed by hand watering. Relatively easy access to one of the biggest townships of the Province, Gutu Mupandawana, gives farmers advantage of off-farm labour opportunities, marketing outlets. Such advantages actually offset their narrow holding and dense population, leading to higher level of disposable income and household expenditure.

Input/Output ratio excluding family labour cost lies in between 8 and 15 per cent, and this input cost ratio is consistent with larger amount of loan from A.F.C. This area is situated in cash crop oriented area in Gutu district, but more households are likely to rely rather on outmigratory labour wage than on cash crop income. Economic return for overhead family labour gives Z$1.8 per man-day, and this level reflects a rational cropping on dryland fields.

5) Magudu (V-3-3)

The project area is chronically drought stricken. Drought always aggravates the economic situation of farmers, and their last resort of subsistence is often their cattle sale, or drought relief. Their dependence on off-farm income is quite heavy, and usually one or more family members have experience of off-farm jobs in Renco Mine or in Triangle - Chiredzi commercial areas.

Gross farming income is extremely low, which has probably resulted from narrow holding acreage and lower crop yields. Trying to supplement shortfalls in crop income, many farmers have released their cattle for sale, leading to very low rate of cattle holders to total households (less than 50 per cent).

Input/Output ratio for crop production ranges from 10 to 15 per cent and cattle and goat's manure is applied to their fields to save input expense. Economic return for family labour thus remains as low as Z$1.3 per man-day, reflecting low crop productivity. Also, extremely low ratio of drought-resistant crops in total acreage is one of the factors depressing productivity.

6) Mabvute (VII-1-12)

Fertile soils and dry climate extend over the area where crop yield fluctuates in a wide range. Coverage under drought resistent crops is very low, but mean yield levels are somewhat higher, as compared with surrounding areas, which give higher gross income from crop and lead to less dependency on off-farm income.

Input/Output ratio (where labour cost is not included) indicates above 30 per cent. Farmers are aware of fertilizer response on yield performance. The fact that most farmers own draught animals and favourable cropping conditions seem to cease mutual help collective practices. They also have enough livestock to offer a part for sale, contributing 10 to 15 per cent of total annual household income. Comparatively large holding size in addition to ample family labour input help elevate level of gross crop income, although crop economic return for overhead family labour remains at Z$1.3 per man-day. Master farmers are willing to introduce lucrative crops such as cotton, even at the expense of heavier input cost, while women are devoted themselves in raising vegetables for home consumption in Taguta gardens. All this shows that there is positive propensity to motivate shift from subsistence farming to cash crop farming in this area.

4.11. Socio-Economy

The social situations in the wards related to the six study areas selected for the feasibility study are summarized in Table 4-16. Data and information given in this table were obtained through the interview with the local staff concerned and the details of the survey and results are described in ANNEX.

Table 4-16(1) Social Aspects of Study Wards

Item \ Site	Dam Name (Dam No.)	Musaverema (I-2-1)	Chinyamatumwa (II-1-6)		Mashoko (II-2-1)	Munjanganja (IV-4-10)	Magudu (V-3-3)	Mabvuti (VII-1-12)
	Communal Land	Matibi No. 1	Bikita		Matsai	Gutu	Nyajena	Ndanga
	Ward	No. 9	No. 6	No. 14	No. 2	No. 26	Dowa 6	Dzoro North
1. General	Area (ha)	8 280	7 300	6 390	15 880	12 720	6 150	6 160
	Population	4 001	7 218	6 590	5 875	(5 288) *1	4 592	5 855
	No. of Households	487	1 246	990	1 175	(964)	615	840
	Population Density (Persons sq. Km)	48.3	98.9	103.1	37.0	(57.0)	74.7	95.0
	Household Size (Persons)	8.2	5.8	6.6	5.0	(5.5)	7.4	7.0
2. Health	Name of Hospital/ Clinic	Matibi Mission	Nil	Negavano	Mashoko Mission	Magombedge	Nil	Nil
	Commonest Diseases	• Schistosomiasis • Sexually transmitted diseases • Eye Infections	• Diarrhoea • Eye Infections • Sexually transmitted diseases	• Diarrhoea • Schistosomiasis • Eye Infections	Mukanga • Schistosomiasis • Malaria • Diarrhoea	• Sexually transmitted diseases • Schistosomiasis • Diarrhoea	• Sexually transmitted diseases • Diarrhoea • Schistosomiasis	• Diarrhoea • Schistosomiasis • Sexually transmitted diseases
3. Education	No. of Schools (No. of Pupils)							
	-Primary Sch.	2 (1 348)	3 (1 727)	2 (1 788)	4 (2 566)	6 (2 418)	1(886)	2 (2 158)
	-Secondary Sch.	1 (179)	1 (484)	1 (406)	2 (1 253)	2 (641)	Nil	1 (585)
4. Water Supply	No. of P.W.S (Borehole & Unprotected Well)	9	7	5	19	17	4	11
	P.W.S per sq. Km (units)	0.11	0.10	0.081	0.12	0.13	0.07	0.18
	Population per P.W.S	445	1 031	1 318	309	>400	1 148	532
	Main Water Source *2	Ⓦ Ⓓ	Ⓦ Ⓓ	Ⓦ Ⓓ	Ⓦ Ⓓ	Ⓦ Ⓓ	Ⓦ Ⓓ	Ⓦ Ⓓ
	-Domestic Use	Borehole Riverbed	Borehole	Well Riverbed	Borehole	Unprotected Well	Borehole Riverbed	Protected Riverbed
	-Livestock Use	Dam Dam	Stream Dam	Stream Mujiche River	River Dam	Stream River	Mutilikwe River	Well Stream Spring
5. Social Services	Business Centre	Matibi Mission	Mutikizizi	Mujiche,Negavano	Mashoko Mission Mukanga, Maziva	Mutanbara	Nil	Mabvute, Muzondidya
	Electricity	-do-	Nil	Nil	Nil	Nil	Nil	Nil
	Post	-do-	Nil	Nil	Mashoko Mission	Nil	Nil	Nil
	Telephone	Nil	Mutikizizi	Nil	-do-	Nil	Nil	Nil
6. Agri Facilities	Dip-tank	Musaverema	Mudumu, Guramusana	Mujiche, Negavano	Mukankga, Maziva	Ranga, Munjanganja	Maregere	Musuche, Mungwezi
	Cattle Sale Pens	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	Sub-depot of G.M.B	Nil	Nil	Nil	Mashoko Mission	Nil	Nil	Nil

*1 ( )·····excluded the figures of VIDCO 1 and VIDCO 6

*2 Ⓦ·····wet season Ⓓ·····dry season

Table 4-16(2) Social Aspects of Study Wards

Item \ Site	Dam Name (Dam No.)	Musaverema (I-2-1)	Chinyamatumwa (II-1-6)		Mashoko (II-2-1)	Munjanganja (IV-4-10)	Magudu (V-3-3)	Mabvuti (VII-1-12)
	Communal Land	Matibi No. 1	Bikita		Matsai	Gutu	Nyajena	Ndanga
	Ward	No. 9	No. 6	No. 14	No. 2	no. 26	Dowa 6	Dzoro North
7. Community Activities and Cooperative Movement	Community Groups including planning ones ( )···No. of groups	• Uniform Making (1) • Communal Garden (1) • Poultry Keeping (1) • Hardware (1) • Taguta Garden (1) • Adult Literacy Group	• Dress Making (1) • Community Hall (1) • Pre-school (2) • Saving Club (3) • Taguta Garden (3) • Communal Garden (3)	• Marketing Supply (1) • Pre-school (5) • Community hall (1) • Dress Making (1) • Dam (1) • Taguta Garden (2) • Adult Literacy Group	• Poultry Sales (1) • Community Hall (2) • Taguta garden (1) • Communal Garden (3) • Pre-school (4) • Uniform Making (1) • Saving Club (2) • Cotton Association (1) Others	• Input Supply (1) • Uniform Making (2) • Bakeries (1) • Dam (1) • Taguta/ Communal Garden (2) • Grazing Improvement (1)	Nil	• Uniform Making (2) • Taguta Garden (6) • Poultry Keeping (1) • Saving Club (1) • Marketing Supply (1) • Pre-school (1) • Adult Literacy Group (2) • Cotton Group (2)
8. Rural Development	Existing Development Project ( )···No. of projects	• Gully Reclamation (1) • Brick Moulding (8) • Road Construction (1) All the projects, under Food for Work	• Bridge Construction (2) under Food for Work	• Planned Village Settlement by AGRITEX • Brick Moulding (2) • Gully Reclamation (1) The latter two projects as Food for Work	• Grazing Scheme (1) • Gam Plant (3) • Dam Construction (1) • Brick Moulding (3) • Gully Reclamation (2) • Goat Improvement Management (1)	• Grazing Scheme • GUTAI Programme by West Germany • Gully Reclamation (1) • Brick Moulding (1)	• Dam Construction • Weir Construction • Brick Moulding All of the above projects, under Food for Work	• Gam Plant (6) • Dam Construction (2) • Gully Reclamation (3) • Road Construction (1) • Cash Crop and Introduction of Tractor
9. Local Needs for Development	Priority in Programmes below							
	• Irrigation Facilities	A	A	A	A	B	A	A
	• Water Supply Facilities	A	B	A	A	C	A	C
	• Improvement of Road Network	B	A	C	B	A	C	C
	• Schooling Facilities	C	C	C	-	B	A	B
	• Health Facilities	C	A	C	-	C	A	B
	• Encouragement of Co-operative	B	B	B	B	A	B	B
	• Marketing & Transportation System	A	A	A	A	A	B	A
	• Promotion of Agricultural Input	C	C	B	B	C	C	A
	• Agricultural Advice	B	-	-	-	-	-	-
	• Provision of Credit (A.F.C)	B	B	-	C	A	C	C
	• Technical & Special Training	A	C	A	C	-	B	C

CHAPTER 5. THE PROJECT PLAN

5.1. Objectives and Components of the Project

5.1.1. Objectives

The project areas have a deficit of food production due to the insufficient and erratic rainfall and, especially in drier years, food is imported from the outside areas as drought relief food. Even the water for domestic use and livestock watering is insufficient in dry season.

The main objectives of the proposed Medium Size Dams Projects, which is in line with the Government strategy for development of the communal lands in Masvingo Province, is a water resources development in order to utilize stream flow for irrigation scheme as well as domestic water supply and livestock watering. The distribution of water from the medium size dams should be capable of being utilized by the maximum number of farmers to fall within a scope that the national socio-economic policy would permit. And, at the same time, full technical and financial support from the government agencies concerned should be extended to the farmers who could get the maximum benefit possible.

In more detail, the major objectives are as follows.

1) To increase agricultural production and farm incomes through supplying necessary amount of irrigation water.

2) To improve the present unhygienic and inconvenient conditions of domestic water supply and livestock watering.

3) To strengthen the local supply of fishes through fish farming in the medium size dam reservoirs.

5.1.2. Project Components

The following project components would be incorporated into each of the six projects.

1) To construct medium size dams with storage capacities ranging from one to three MCM.

2) To construct conveyance channels from storage reservoirs to irrigation service area including night storage reservoirs.

3) To develop in field facilities to be supplied with irrigation water.

4) To install water supply systems for domestic use other than drinking water.

5) To encourage the communal farmers to promote fish farming in the reservoirs of medium size dams.

6) To utilize crop residue of by-product of irrigated crops as fodder for cattle fattening.

5.2. Dam Site Hydrology

5.2.1. Runoff at Dam Site

Runoff at dam site is not gauged at all in six dam sites, so that the annual inflow cycle is assumed to follow the pattern of three months inflow at a constant rate, followed by 9 months with no inflow. This assumption is confirmed by the interview from the local inhabitants living near those dam sites, and commonly applied for the yield estimation by MEWRD based on reasonable fitting of Weibull distribution to the variation of the annual inflow from year to year.

Mean annual runoff at dam site is derived from the mean annual rainfall by applying the formula which was reported by T.B. Mitchell, as follows:

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

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

Mean annual rainfall is interpolated on the isohyet map published by the Meteorological Services, and its reliability is proved from comparison with two rainfall stations observing for more than 30 years within 20 km distance from dam sites as mentioned in paragraph 4.2.

5.2.2. Design Flood

Probable flood to be applied in the design of the spillway is estimated from Mitchell's flood formula.

According to the "Assessment of Design Flood Hydrograph" reported by T. C. Kabell, the size of six dams is applied "medium" to three dams except Musaverema (I-2-1), Magudu (V-3-3) and Mabvute (VII-1-12), which are grouped into "Large", and the classification of hazard potential of those dams is estimated "class 2" with the exception of Musaverema, Magudu and Mabvute dams of "class 1".

Following the classification of dams as described above, the following return period is used for design floods:

Class 1 = 2 000 years return period with dry freeboard allowance.
Class 2 = 500 years return period with dry freeboard allowance.

Table 5-1 shows the indices of flood hydrograph of six dams based on the criterion of "Estimation of Design Flood Hydrograph" published by MEWRD in 1984.

Table 5-1 Design Flood Hydrograph

Item \ No. of Project		I-2-1	II-1-6	II-2-1	IV-4-10	V-3-3	VII-1-12
Catchment Area	(km^2)	131.0	16.4	27.2	52.8	41.9	31.1
Length of Catchment	(km)	22.0	5.6	10.0	12.0	11.5	7.5
Drop of River	(m.)	90.	80.	200.	190.	90.	90.
Return Period	(yr.)	2 000	500	500	500	2 000	2 000
Peak Discharge	(m^3/s)	835	163	228	349	415	343
Storm Duration	(hr.)	3.94	1.73	2.06	2.76	3.18	2.24
Base of hydrograph	(hr.)	10.5	4.6	5.5	7.4	8.5	6.0

NOTE:

1) Storm Duration $t(min.) = (2050 \text{ Log } (N.R.) - 3000)/I$

2) Rainfall Intensity $I(mm/hr) = Q/A \cdot K = [2.6x60^2/(0.7x2x10^3)] \cdot QA$
$= 6.87 \cdot Q/A$

3) Time to Peak $Tp(hr) =$ Storm Duration

4) Base of Hydrograph $TB(hr) = 2.67 \cdot Tp$

5.2.3. Sediment

Sediment volume to reservoir is estimated, based on the Report of "Soil and Water Conservation" under National Master Plan for Rural Water Supply and Sanitation Project. For six catchments, the stereoscopic interpretation of aerial photograph is applied to evaluate the state of active soil erosion, in which severe eroded areas of catchments are actually confirmed by the supplemental survey of field trip.

As a result, sediment yield of six catchments varies in the range from 230 to 450 tonnes/sq·km/year, corresponding with the range of erosion index from 1.7 to 2.3. The state of erosion for six catchments is classified on maps with a scale of 1/50 000.

According to the Kabell's classification mentioned in the paper of "Sediment Storage Requirements for Reservoirs", the associated erosion values for MAR = 40, 60, 80 and 100 mm become 200, 300, 400, 500 tonnes/sq•km/year respectively at a mean sediment concentration of 5 000 mg/1.

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 dividing by the bulk density of the deposited sediments (= 1.35 tonnes/cu.m).

The sediment indeces of six catchments are listed below;

No. of Dam	Catchment Area (sq.km)	Erosion Index	Sediment Yield (t/sq.km/yr)	Total Volume of Sediment (1 000 cu.m)
I-2-1	131.0	2.3	450	873
II-1-6	16.4	2.0	340	83
II-2-1	27.2	1.7	230	93
IV-4-10	52.8	1.9	320	251
V-3-3	41.9	1.8	270	168
VI-1-12	31.1	1.7	230	106

5.3. Reservoir Plan

5.3.1. Reservoir Yield

Reservoir yield at both 10 and 20 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, especially at 10 per cent risk level. Among six dams, Munjanganja (IV-4-10) reservoir, which has a storage ratio of 0.44, is worked out based on the latest review of the yield estimation for irrigation dams of low storage ratio, evolved by T.B. Mitchell.

The yield curves of 20 per cent risk level is not available for various types of co-efficient of runoff variation, so that the yield curves are interpolated by using yield curves of 40 per cent risk level listed in the report of "Soil and Water Conservation" (Appendix 31) complied under National Master Plan for Rural Water Supply and Sanitation.

These yields, both 10 and 20 per cent risk levels, should be refined in response to the revision of the stage capacity curves of which maps were prepared by using aerial photographs and have been contoured at intervals of one meter with a scale of 1/5 000 by the field survey.

The yield ratios of three dams, i.e. Musaverema (I-2-1), Magudu (V-3-3) and Mabvute (VII-1-12) are interpolated because of the lack of yield curves in respect of the co-efficient of runoff variations. Following the preparation of yield ratios at 4, 10 and 40 per cent risk levels, the yield of 20 per cent risk is interpolated, as to the five dams except Munjanganja (IV-4-10), of which yield is mentioned in the following paragraph.

10 and 20 per cent risk yields resulted, as follows:

Name of Dam		Yield (Ratio = Q/MAR) 10% Risk		20% Risk		$\left(\frac{\text{20\% Yield}}{\text{10\% Yield}}\right)$
Musaverema	(I-2-1)	757 x 10^3 m^3	(0.17)	1113 x 10^3 m^3	(0.25)	147%
Chinyamatumwa	(II-1-6)	642	(0.38)	811	(0.48)	126
Mashoko	(II-2-1)	313	(0.24)	431	(0.33)	138
Munjanganja	(IV-4-10)	659	(0.16)	861	(0.21)	131
Magudu	(V-3-3)	1012	(0.35)	1272	(0.44)	126
Mabvute	(VII-1-2)	1298	(0.39)	1631	(0.49)	126

In dams of low storage ratio, the estimation method of probable yield has been recently established in the paper No. 257 by T.B. Mitchell, to enhance the estimation accuracy.

Among six project areas, the proposed method is able to be applied to the Munjanganja dam of which storage ratio is as low as 0.44.

The worked procedure of yield is shown as follows:

- Catchment area	= 52.8	sq.km
- Mean annual runoff	= 79	mm
- MAR	= 4171	10^3 cu.m
- Evaporation over 9 dry months	E = 1100	mm
- Full supply capacity	U = 1831	10^3 cu.m
- Full supply surface area	A = 65	ha
- Co-efficient of variation	CV = 110	per cent
- Storage ratio	U/MAR = 0.44	
- Evaporation index	E I = 1.10 x 0.65/1.83 = 0.39	

Using Figure 2 of paper No. 257, the maximum possible annual drawoff from the dam is Q max = 0.78 x 1831 = 1428 x $10^3 m^3$.

The risk level corresponding to this drawoff is estimated from Figure 1 of paper No. 257 : Pmax = 39 per cent.

			CV = 1.0			CV = 1.2		
EI	U/MAR	Qmax/u	10%	20%	30%	10%	20%	30%
0.3	0.4	0.83	0.43	0.58	0.77	0.38	0.48	0.63
	0.5	0.83	0.41	0.52	0.66	0.37	0.44	0.55
0.5	0.4	0.72	0.34	0.48	0.66	0.29	0.39	0.53
	0.5	0.72	0.31	0.42	0.56	0.28	0.35	0.46
Interpolating for EI = 0.39. U/MAR = 0.44								
0.39	0.44	0.78	0.38	0.52	0.68	0.34	0.42	0.56

Interpolating for CV = 1.1

10%	20%	30%
0.36	0.47	0.62

Therefore yield is:

10 per cent risk level	0.36 x 1831 = 659	10^3cu.m/year
20 per cent risk level	0.47 x 1831 = 861	
30 per cent risk level	0.62 x 1831 = 1135	

Table 5-2 Reservoir Yield at 10% and 20% Risk Level

Item \ Area	Musaverema (I-2-1)	Chinyamatumwa (II-1-6)	Mashoko (II-2-1)	Munjanganja (IV-4-10)	Magudu (V-3-3)	Mabvute (VII-1-12)
Mean Annual Inflow						
Rainfall (mm)	580	800	640	740	710	810
Runoff (mm)	34	103	48	79	69	107
Evaporation (mm)	1700	1900	1800	1900	1700	1700
Nett Evap. (m)	1.38	1.46	1.45	1.49	1.31	1.25
Resevoir						
Catchment (km^2)	131.0	16.4	27.2	52.8	41.9	31.1
Gross C. (10^3m^3)	7526	2338	1546	2082	5840	3238
Sediment						
$ton/km^2/yr.$	450	340	230	320	270	230
$10^3m^3/20yr.s$	873	83	93	251	168	106
Full Supply						
Capacity (10^3m^3)	6653	2255	1453	1831	5672	3132
Area (10^3m^2)	2505	471	356	644	1299	711
Storage Ratio	1.5	1.3	1.1	0.4	2.0	0.9
E. Factor	1.91	0.13	0.13	0.54	0.31	0.15
MAR/EF	2300	13000	10000	7700	9300	23000
CV	120	100	140	110	120	85
MAR (10^3m^3)	4454	1689	1306	4171	2891	3349
10% Risk Level						
Yield Ratio (Q/MAR)	0.17	0.38	0.24	0.16	0.35	0.39
Yield (10^3m^3)	757	642	313	659	1012	1298
20% Risk Level						
Yield Ratio (Q/MAR)	0.25	0.48	0.33	0.21	0.44	0.46
Yield (10^3m^3)	1113	811	431	861	1272	1631

Note; E. Factor··· Evaporation Factor , MAR··· Mean Annual Runoff
Net Evap. = Evaporation - 0.55 x Rainfall
Cross C. = Gross Capacity

5.3.2. Optimum Scale of Reservoir

A spillway is one of the major structure in a dam. When a length of spillway sill becomes long, volume of sill structure and foundation excavation will increase. When a length of sill becomes short, it will increase overflow depth and then induce an increment of dam embankment volume. To make dam planning economical relationship of cost between scales of dam and spillway is studied under the following conditions.

- o The freeboard for dam is calculated on the guide line formula in Zimbabwe.
- o The dam embankment volume is roughly estimated in taking 0.5 m stripping of surface soil into considration.
- o The overflow depth at sill is calculated with overflow coefficient of 1.8.
- o Concrete volume of sill body and excavation including spillway apron is considered for cost estimation.

The calculations of the work volume and cost estimations are summarized in Table 5-3. Based on the above cost estimation, individual dam site, suitable sill scale and dam crest elevation at the optimum condition are summarized as follows in due consideration of particularity of each dam site.

Name of Dam	Dam No.	Overflow Head hc (m)	El. of Dam Crest (m)
Musaverema	I-2-1	* 2.5	683.7
Chinyamatumwa	II-1-6	1.5	753.7
Mashoko	II-2-1	1.5	666.7
Munjanganja	VI-4-10	1.0	1151.1
Magudu	V-3-3	3.0	533.2
Mabvute	VI-1-12	3.0	648.2

* The most economical case of hc is 2.0 m.
With sill crest length of 174 m. However it is very difficult to install such long spillway from the topographical condition.

5.4. Irrigation Plan

5.4.1. Irrigation Water Requirements

1) Reference Crop Evapotranspiration

The reference crop evapotranspiration (ETo), which is generally recognized as fairly reliable index for calculating consumptive use, can be determined by a number of methods, such as the evaporation measurement with evaporation pan and the application of empirical formula based on the climatological data. In the Project, evapotranspiration was estimated on the monthly basis, 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 as 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	1811

Note: Details are given in ANNEX.

2) Net Irrigation Water Requirement

The net irrigation water requirements for the proposed cropping programme was estimated and is shown in Table 5-4.

Table 5-3 Net Irrigation Water Requirements Weighted for Acreage (mm/year)

Name of Project	Crop	1) IWR (mm/year)	2) CP (%)	3) NIWR (mm/year)
Musaverema (I-2-1)	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 (II-1-6)	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 (II-2-1)	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 (IV-4-10)	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 (V-3-3)	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 (VII-1-12)	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

3) Gross Irrigation Water Requirements

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

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

The gross irrigation water requirement determined from the net irrigation requirements and the overall project efficiency are as follows.

Gross Irrigation Water Requirement (mm/year)

Musavereme (I-2-1)	2 090	Munjanganja (IV-4-10)	1 980
Chinyamatumwa (II-1-6)	1 850	Magudu (V-3-3)	1 980
Mashoko (II-2-1)	2 060	Mabvute (VII-1-12)	1 840

4) 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 are 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.

5.2.2. Irrigation Schedule

Under the proposed cropping programme the irrigation interval is determined. For design purposes the worst conditions occur in November, when the maize crop is nearing peak demand and evapotranspiration is at its highest. In this stituation the irrigation interval of maize is 9-day cycle. (Detail estimates are given in ANNEX)

In order to simplify the rotational irrigation, 7-day cycle will be adopted, so that farmers will be accustomed to receiving a water on the same day every week. During peak demand for vegetable and other summer crops with shallow rooting depth, more frequent irrigations are necessary, though the depth of water applied is reduced accordingly.

The basic intake rate observed in the field ranged from 5.0 mm/hr to 20.0 mm/hr. Taking the above into consideration, the method of applying irrigation water in the field is by furrows supplied with water from field canals through portable siphons. Duration of supply to the field is 12 hours per day in peak season.

5.4.3. Design Discharge

The design discharge for irrigation facilities such as water conveyance canal, pump, pipeline and night storage reservoir can be decided from irrigation plan. Design discharges are summarized in Table 5-5.

Table 5-4 Design Discharge

Item	Musaverema (I-2-1)	Chinyamatumwa (II-1-6)	Mashoko (II-2-1)	Munjanganja (IV-4-10)	Magudu (V-3-3)	Mabvute (VII-1-12)
Net Irrigable Area (ha)	36.2	34.7	15.2	33.3	51.1	70.5
Design Discharge						
Conveyace Canal[1] (ℓ/sec)	54.0	-	23.0	49.0	76.0	-
Pump Facilities[2] (ℓ/sec)	-	74.0	-	-	-	151.0
Night Storage[3] (m^3)	4630	4270	1950	4260	6540	8670

Notes

1) Discharge (ℓ/sec)=Peak crop evapotranspiration(mm/day)× $\frac{1}{\text{overall efficiency}}$
× irrigable area(ha)× $\frac{100}{864}$

where: peak crop evapotranspiration 6.4mm/day
overall efficiency 0.50

2) Discharge (ℓ/sec)=Peak crop evapotranspiration(mm/day)× $\frac{1}{\text{overall efficiency}}$
× irrigable area(ha)× $\frac{100}{864}$ × $\frac{24}{\text{Pump operating hours}}$

where: peak crop evapotranspiration 6.4mm/day
overall efficiency 0.52
pump operating hours 16 hours

3) Capacity (m3)=Peak crop evapotranspiration(mm/day)× $\frac{1}{\text{overall efficiency}}$
× irrigable areas(ha)× $\frac{360}{864}$ × storage hours(hr)

where: peak crop evapotranspiration 6.4mm/day
overall efficiency 0.50 , 0.52
storage hours 24 hours

5.5. Proposed Land Use

5.5.1. Setting Up of the Irrigation Area

In each project area, most of the land is composed of farm lands. The areas to be cleared by new reclamation are so little that the change on land category by the project may be negligible. However existing farm lands in each project area generally consist of many irregular farm plots, which are not so flat in surface, partly lay a lot of stones on, and partly bear the marks of waterlogging in rainy season.

Because of the farm conditions, it is necessary to enforce appropriately the land improvements so as to apply furrow irrigation effectively. In addition, in sloping and undulating areas, protection against the soil erosion will be planned by application of land improvement on the basis of contour cultivation.

Setting up of the irrigation area in each project area should undergo as follows respectively.

1) Musaverema (I-2-1)

The topography of this area is so flat that it is easy to prepare and allot its irrigation area. However, as the area which can be irrigated under gravity is limited around here, it is unavoidable to include the areas whose soils tend a little shallow and gravelly, in order to keep irrigated area as much as possible for effective water use. Therefore it may be required to remove gravells or to improve subsoil in some parts of the area.

2) Chinyamatumwa (II-1-6)

As irrigation water is to be supplied by pumping up in this area, it is not so tight to set up the irrigated area. But irrigated area should set up on the southern clayey or moderately clayey zone excluding northern excessive sandy zone as far as possible, and it has always to be taken into account to prevent soil erosion through the land consolidation planning, irrigation planning and land cultivation because of considerable slope and undulation in this southern zone.

3) Mashoko (II-2-1)

Excepting western sandy area with slightly high altitude, very flat dry land which has moderately clayey and deep soils stretches along the river. So it is no problem to set up the irrigation area, though there are partly some areas with low permeability which should be improved.

4) Munjanganja (IV-4-10)

Most of the project area is less undulated dry land which slopes slightly towards the river and is composed of moderately clayey soils. Accordingly to establish the irrigation area is easy if southwestern sandy zone is excluded.

5) Magudu (V-3-3)

The project area is generally composed of flat and moderately clayey dry land, but some northern parts of sligthly high altitude, near Magudu school, include highly sands and gravels, while southern boundary parts undulate complicatedly. Therefore it is to be desired to exclude these areas as far as possible for irrigation field.

6) Mabvute (VII-1-12)

This area has very intricated topography and also considerable slope so as to be inevitablly divided to some irrigation blocks. It is required to conduct land consolidation planning irrigation planning and cultivation with sufficient consideration for preventing land erosion, and it is adequate to found irrigation blocks without including southern sandy slope by the Chipfunde school where the cultivation had been given up.

5.5.2. Proposed Land Allotment

At present, farmers in the project area have 2 to 4 ha of cultivation land under dry farming. The irrigable plots in the project area should be equitably shared by as many farmers as possible. Consequently existing land use in the project areas should be reformed by a new principle for irrigation. In communal lands, farmers do not have any land ownership, but can only use their farm plots which are alloted by WADCO and VIDCO concerned. Therefore these committees can allot the irrigable area smoothly with the redistribution of dry farm lands around there.

Though an allotment size of the irrigated area may vary depending on the situation of each project area, it is assumed that 0.2 ha in an allotment size is reasonable considering both benefit to more farmers and impact to individual farmer.

If allotted size of irrigated farm would be about 0.2 ha per household, a farmer who has 2.5 ha of farmland can cultivate 0.2 ha. of irrigable plots and 2.3 ha of dry plots.

5.6. Crop Production Plan

5.6.1. Proposed cropping pattern

The expected individual allotment size of the irrigation farm may be only 0.2 ha, and most of existing farms will keep their dry land plots. So the existing cropping pattern will hardly be reflected by that of irrigated cropping.

In the interim report in which 4 cropping patterns (A, B, C and D) were proposed, pattern A was applied for project areas of Chinyamatumwa, Munjanganja, Magudu and Mabvute, and pattern C for project areas of Musaverema and Mashoko. However, detailed survey revealed that pattern C should be applied for Magudu rather than A. These cropping patterns were proposed mainly to supplement harvest shortfall on dry land.

In general, in existing irrigation schemes, the growings of maize are predominant. While, in Makonese irrigation scheme, Chivi District, which is highly valued as an excellent one, its cropping is thoroughly composed of cash crops such as vegetables owing to the favourable location and the good markets.

It must be very difficult to apply immediately the cropping pattern as that of Makonese, because of their present conditions of location. Cropping pattern in which maize occupies too much proportion is unfavourable for keeping soil fertility or controlling crop disease and insect pest.

In consideration of the above, two cropping patterns, Type A for Natural Region III and IV and Type B for Natural Region V, are proposed tentatively instead of those in interim report. These cropping patterns are shown in Figure 5-1, and they are based on the following principles.

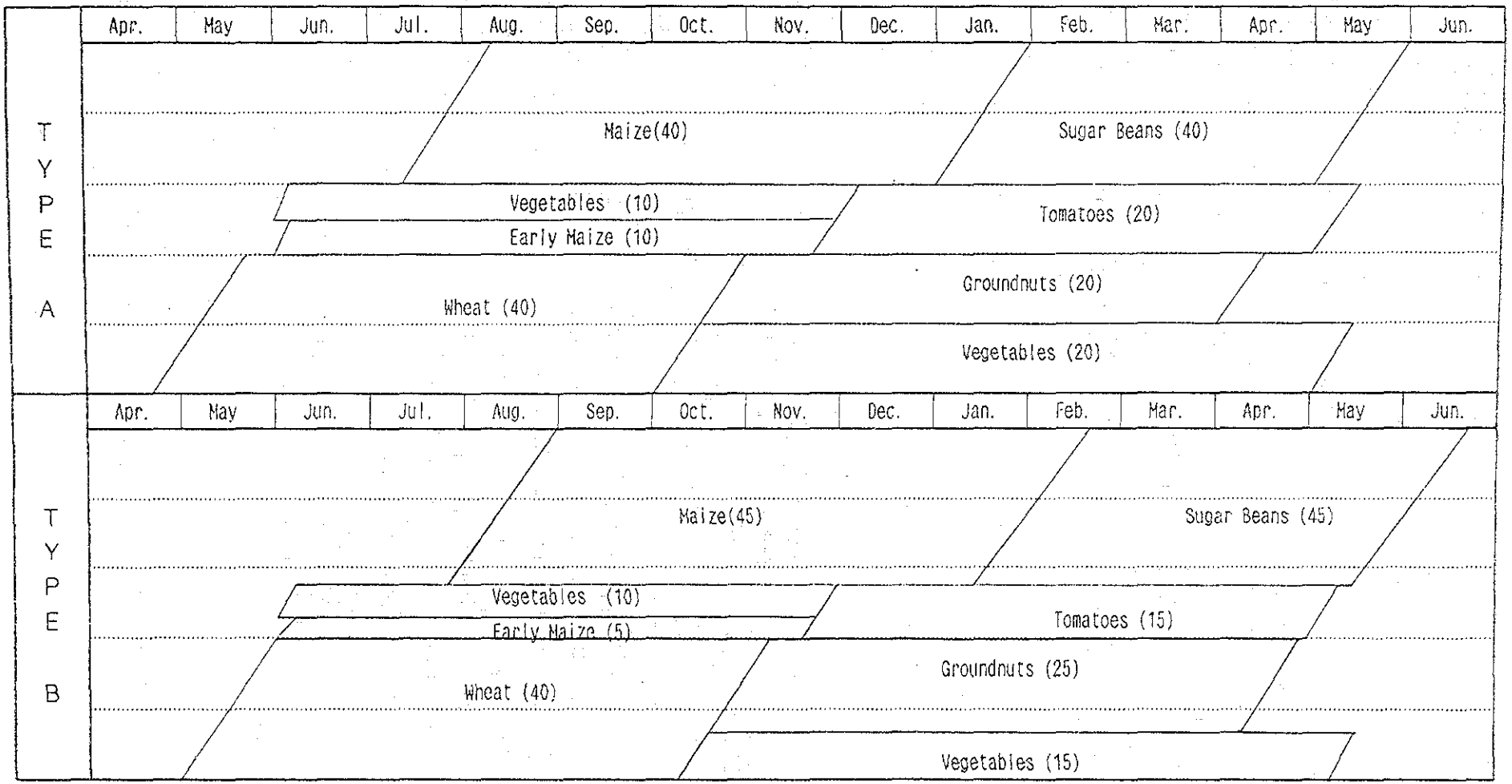
(1) Grain crops are given first priority to supplement harvest shortfall on dry land. Especially, the proportions of them are raised up in Type B which is applied to the dry areas.

(2) To avoid consecutive planting of the same crop, the cropping proportion is limited to 2/3 of the total cropping area. Especially, ground nuts are limited to 1/4 of the total, and cereal crops cannot be followed by any kind of cereal crops.

(3) Sugarbeans and groundnuts which can be sold to the G.M.B, are introduced to the cropping pattern in high proportions. They work well among the crop rotation and contribute to the improvement in nutritional level of the farmers.

(4) In order to increase the nutritional level of the farmer and to increase farmer's income, tomatoes and leaf vegetables should be grown to the extent that they do not bring about over-production. The proportion of vegetables is a little higher in TYPE A than in TYPE B which is applied to the areas with more severe conditions of location.

Figure 5-1 Proposed Cropping Pattern ( ) : %



5.6.2. Yield per Hectare with Project

The productivity of the dryland in communal lands generally has stagnated though upward tendency is observed only a little for maize. So the future yield per hectare of maize in dryland which is cultivated by farmers concerned is assumed that it will not be well over about 1 tonne. And it is also assumed that yield level of other crops will keep the existing level. While to estimate the yields of main crops in the project irrigation areas it is suitable to be based on the result of exiting irrigation schemes.

The yield per hectare of irrigated crops in existing irrigation farm is as follows.

1) Maize

In Mupunzure, one of the existing irrigation schemes in Masvingo communal land, the results in the last 5 years were as below.

Year	1981/82	1982/83	1983/84	1984/85	1985/86	
Yield	6.4	2.3*	7.3	9.6	5.9	t/ha

* Streak virus disease

Average yield in which that of 1982/83 was excluded is 7.3 tonnes per hectare. And "Grain Handbook" says that the average yield of maize under irrigation ranges from 6.5 to 10 tonnes per hectare variable with the planting season.

2) Wheat

The results in ARDA irrigation farm in the last 4 years are shown; below.

Year	1980	1981	1982	1983	Average
Yield	3.351	4.204	3.681	4.294	3.883 t/ha

While according to an interview in Mushundike, one of the existing resettlement irrigation schemes in Chivi communal land, the yield per hectare of wheat was 5.5 tonnes in 1986. And based on "Grain Handbook", trials for wheat varieties in middle to low veld achieved 4.3 - 7.3 tonnes in yield per hectare from 1977 to 1980.

3) Groundnuts

The results of irrigation for groundnuts in above mentioned ARDA were as follows.

Year	1980	1981	1982	1983
Yield	1.680	1.913	3.203	4.418 t/ha

While depending on AGRITEX data for extension workers, the target yield per hectare of unshelled groundnuts under irrigation is set up to 4.2 - 4.4 tonnes for long season varieties and 1.6 - 1.8 tonnes for short season varieties.

4) Sugar Beans

There are insufficient data useful for yield estimation of sugar bean under irrigation. But in Chiredzi research station from 1979 to 1981, average yield of sugar bean ranged from 3.0 to 3.2 tonnes per hectare.

5) Tomatoes

The results for tomatoes production in said Mupunzure in last 5 years are given as below.

Year	1981/82	1982/83	1983/84	1984/85	1985/86
Yield	10	20	10*	30	15 t/ha

* red spider mite was very severe

The target yield of irrigated tomato for extension in AGRITEX is 30 tonnes per hectare.

6) Green Vegetables

The yield of green vegetables like cabbage, onion or rape, varies due to variety, cropping season and harvesting method and yield range is from 10 to 45 tonnes per hectare under irrigation (green onions are classified as vegetables for convenience).

7) Early maize (Green maize)

Though the yield primarily depends on the planting population, generally it is estimated to be 40,000 - 50,000 cobs per hectare (250 g for a cob) on irrigation farm.

As referred to above, the crop yield in irrigated farm is remarkably higher than that of dryland, and it tells us how the irrigation water controls decisively the crop yield. So it is well possible to achieve these yield level in each project area, and on account of this the each crop yield per hectare with project was estimated as below based on above data and an assumption with increase of yield in future.

Maize	8 tonnes/ha
Wheat	3.5
Groundnuts	3
Sugar beans	2.5
Tomatoes	20
Vegetables	20
Early maize	10

Under above estimation, though compared with dry land, the irrigated farm is very small in individual farm, it is appraised for maize that the produce in 0.2 ha of irrigated farm equals that in 1.6 ha of dry farm, provided that the yield per hectare of maize would be 8 tonnes in irrigated farm, while 1 tonne in dry farm. In addition, the cropping in dry season enhances the produce in the irrigable area. On the other hand, the substantial productivity in dry farm will not change too much in future, but it will be possible to shift the present crops to more drought-resistant crops.

5.6.3. Crop Production in Each Project Area

Conforming to the proposed cropping patterns and estimated yield per hectare with project mentioned formerly, crop production in each project area is estimated as Table 5-6.

5.6.4. Plan of Crop Rotation

Meanwhile, it will be difficult to develop the effective crop production if the individual farmer cultivates his farm as he likes, in different ways, in the small allotted area of the entire area of allotted farms.

The kind of crops will be limited to some extent in order that some irrigation blocks are formed by a group of farms. Moreover, the cropping pattern should be arranged by setting up some rotation blocks to produce each crop according to the scheduled crop rotation programme.

The rotation system with three blocks is successfully introduced in the existing Makonese irrigation scheme, and it is possible to introduce the same system to each project area. Based on the proposed cropping pattern, 4 years crop rotation system may be planned, and such 4 rotation blocks should be set up for this system. If individual farmer divides his allotted farm into 4 small blocks, he can produce exactly his crops according to the above-mentioned crop rotation programme.

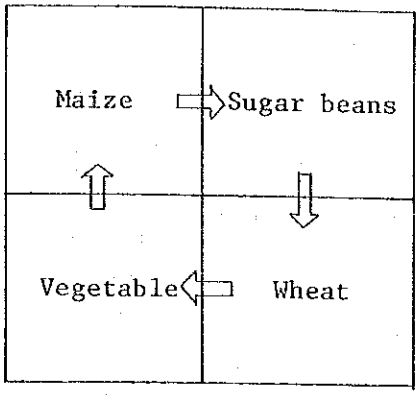
Table 5-5 Estimated Crop Production in Each Project Area

Unit Cropping Area : hectare
Production : tonne

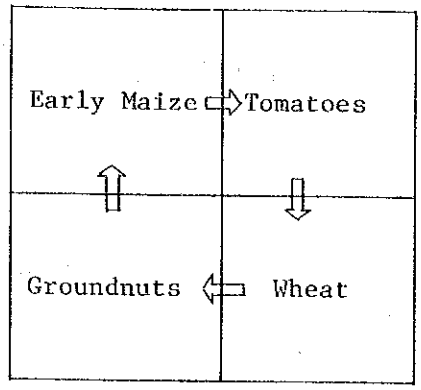
Area / Crop	Musaverema (I-2-1)		Chinyamatumwa (II-1-6)		Mashoko (II-2-1)		Munjanganja (IV-4-10)		Magudu (V-3-3)		Mabvute (VII-1-12)	
	Cropping Area	Production	Cropping Area	Production	Cropping Area	Production	Cropping Area	Production	Cropping Area	Production	Cropping Area	Production
Maize	16.3	130.4	13.9	111.2	6.8	54.4	13.3	106.4	23.0	184.0	28.2	225.6
Wheat	14.5	50.8	13.9	48.7	6.1	21.4	13.3	46.6	20.4	71.4	28.2	98.7
Groundnuts	9.1	27.3	6.9	20.7	3.8	11.4	6.7	20.1	12.8	38.4	14.1	42.3
Sugar beans	16.3	40.8	13.9	34.8	6.8	17.0	13.3	33.3	23.0	57.5	28.2	70.5
Tomatoes	5.4	108.0	6.9	138.0	2.3	46.0	6.7	134.0	7.7	154.0	14.1	282.0
Vegetables	9.0	180.0	10.4	208.0	3.8	76.0	10.0	200.0	12.8	256.0	21.2	424.0
Early Maize	1.8	18.0	3.5	35.0	0.8	8.0	3.3	33.0	2.5	25.0	7.0	70.0
Total	72.4		69.4		30.4		66.6		102.2		141.0	
Net Acreage	36.2		34.7		15.2		33.3		51.1		70.5	

Some examples of 4 year rotation type are shown as below.

(1) Example 1



(2) Example 2



Introducing this rotation system, it will become possible to use tractors co-operatively for land preparation (it is effective for deep ploughing and planting in exact season), to use irrigation water effectively, and to carry out timely pest controls, which may be difficult to do individually, and this management will contribute towards higher productivity in the project area.

5.7. Stockbreeding Plan

It is considered to be very hard from the economical point of view to irrigate the grazing land or to plant forage crops in the irrigated farm.

It will, of course, become more easy to feed livestock with water after materialization of the project. The project will play an important roll in improvement of health and sanitary conditions of livestock. The residual stovers produced in irrigated farm are also quite valuable as forage.

The yield of maize stover is same as that of its grain, its feeding value will be estimated as follows.

Dry Matter (DM)	Total Digestible Nutrients (TDN)	Digestible Protein (DP)	Metabolisable Energy (ME)
90%	45%	1%	1.6 Mcal/kg

TDN kg/ha = 8 000 kg x 0.9 x 0.45 = 3 240 kg/ha
DP kg/ha = 8 000 x 0.9 x 0.01 = 72 kg/ha
ME Mcal/ha = 8 000 x 1.6 Mcal = 12 800 Mcal/ha

Comparing with the energy requirement of a steer, which is estimated at 25 ME per day, above evaluation for maize stover cannot be underestimated at all. To add to this other crop residuals such as wheat straw will be available for supplementary feed.

However, Stock breeding in this province generally tends to make livestocks of precious savings or draught powers. And while the productivity of grazing land is hard to grasp quantitatively. Therefore, it is very difficult to estimate the feeding value of above byproducts as the benefits of the irrigation.

5.8. Fish Farming Plan

The reservoirs which are constructed in the project can be utilized for fish farming though some limitation on water use for irrigation or dam conservation may be involved. The reservoir with the depth over 5 meters is good for applying fish preserve method with net while the shallow reservoir is suitable for fish farming in partitioned water body.

Breams which belong to Tilapia genus are generally best to farm because of easiness to breed, strong viability, good conversion rate, parasites-free and tasty. The farming of these fishes in small ponds has already been promoted by AGRITEX and the catch will increase remarkably by making good use of concerned reservoirs.

But it is difficult to evaluate quantitatively such benefits and it is necessary to take notice not to pollute irrigation water and block flood water by facilities of fish farming.

5.9. Farm Management Plan

5.9.1. Management Strategy and Policy

Either of two types of management is proposed, as mentioned below, for each of proposed projects. The first type, viz. supplementary schemes in order to stabilize basic food supply. The schemes at Musaverema, Mashoko and Magudu are included in this category. Allotted plots under irrigation serve as supplementary means to self-sustenant, traditional dry land cropping in these projects. The second type, viz. more cash-crop-oriented management, is to be applied to Chinyamatumwa, Munjanganja and Mabvute. Seeking for a higher level of profit through marketing cash crops, this category of projects makes full use of favourable market access for the management.

In either type of management, a policy orientation to organize plot holders as a farming group plays a key role in leading the project to a success. Since group practice known as Nimbe-humwe or Mushandira-pamwe is a typical tradition among farmers, it will never fail to suit for irrigation projects in communal areas.

This system can be materialized by adopting a large sized block rotation, even if the individual allotment is small in which a single crop or variety is cropped in the same phase of rotation adopted. Under this group farming, collective practices for tractor hiring, sowing or planting, chemical spraying, watering, etc. are simultaneously performed according to the pre-determined schedule. It gives plot holders various advantages. This system enables farmers to realize efficient water use, effective pest and disease control, economical transportation with larger lots of marketable produce, and economical deep ploughing.

5.9.2. Key to Successful Management

Taking into account the present situation in the existing schemes, it is recommended that the following main points should be well reflected upon the implementation of the proposed projects.

(1) Land Cultivation

Pertinent Land Preparation before Every Planting

The work includes deep ploughing and manuring for higher water holding capacity, supply of deficient micronutrients such as sulpher and boron, and long lasting effect of fertilizers. If tractor ploughing is available, it helps to form a subsoil pan layer which reduces water loss from percolation.

Gradient Furrow from Irrigation Canal to the Tail

The work is useful to facilitate smooth and uniform watering to all the plants in a plot. The slope gradient of furrows should be appropriate with soil physical properties, especially infiltration rates.

(2) Cropping

Avoidance of Continuous Cropping Hazards.

The continuous planting of monocotyledon crops which accelerates the prevalence of virus diseases. Legumineae-Gramineae, Solanaceae, Brassica or Chrysanthemum combination is recommended to be cultivated in such rotation system.

Use of Certified Seed, Enough Basal and Top Dressing

It is useful to meet quicker response of crop to inputs in irrigated farming, especially for cash crops. The simultaneous manure application will make uptake of nutrients by crop more effective. Split application of fertilizers with the interval of every two or four weeks according to crops is also important for the prevention of leaching out during watering.

Elimination of Host Plants for Pests in or around the Farm

It is required to eradicate hoppers or other insects as virus carriers relying on host plants during fallow or rotation period without including host crop.

Differential Sowing/Transplanting of Vegetables

It is essential to deliberately disperse the harvesting period, thus avoiding risk of overproduction and price slump induced by a flood or supply in markets.

Utilization of Residues for Higher Supply of Manure

Collecting and feeding as much crop residues, stovers and straws as possible in Mashanga over kraal will promote manure production.

(3) Labour Use

Optimum Labour Allocation between Irrigated and Dry Land

To mitigate labour competition within household covering both irrigated crops and dryland ones, proper planning is needed so that sowing, planting or harvesting on irrigated hand may not be coincided with these periods.

Providing Labour for Marketing Farm Produce

Plot holders who share duty to grade, pack, store, transport and sell farm produce, especially for cash crops, provide labour for marketing

Removal to Living Quarters Adjacent to the Farm

For those plot holders who live far from plots allotted to them remove living quarters totally or partly to concentrate on irrigated crop management.

(4) Farm Management

Efficient Use of Co-operatives or A.F.C.

Co-operatives or A.F.C. will ensure access to high quality inputs that are sometimes subject to tight supply and also save transport costs or unit costs through bulk purchases in accordance with annual farm schedule.

Diversification of Management Sectors

In order to maximize available resources, it is recommendable to be made by re-investing plot holders' earning to orchard, fish ponds, livestock enterprise etc.

Long Term Transport Contracts

It is made with a reliable transport firm to secure the means of marketing.

The above cited points are recommended to be debated in the meetings of the Irrigation Management Committee.

5.10. Marketing Plan

5.10.1. Necessity of Improving Marketing Facilities

It is proposed to improve marketing facilities for all proposed projects because they are located quite far from existing markets or G.M.B. depots. After an irrigated farm is established, the quantities of annual produce are expected to increase. Also, marketing of perishable cash crops becomes essential, especially in a type of more cash-crop-oriented management. Failure of market access often results in a great loss of income as is occasionally the matter in the existing schemes.

Hired lorries, buyers' vehicles which occasionally visit the farm, are only available means of transportation to plot holders. However, they are not necessarily available all the time for a farm to meet its transportational requirements. Also, road conditions during rainy seasons often hinder the access of any vehicles with heavy loading to the farm.

5.10.2. Facilities to be Improved

It is therefore desirable that all the proposed projects be installed with the facilities listed in the following Table. Timely marketing to maximize crop income always requires up-dated and broadly collected information of market price fluctuations, availability of commodities in markets and change in demand, etc. It is therefore desirable for each proposed project to introduce a battery driven short wave radio apparatus for the time being. In future, it will permanently be switched into a telephone line, as a reliable communication medium.

As regards transportation facilities, it will be relevant to establish a temporary collection point in a nearby business centre to facilitate delivery of statutory crops to G.M.B. The proposed project will promise constant supply of bulk grains and pulses. Either a regularly hired lorry under a long term contract basis with a transporting company or an owned vehicle will greatly facilitate and secure marketing of its produce. In case of an owned lorry, the farm could entrust its maintenance and repair to the workshop of District Development Fund. It is especially true for the projects heavily dependent on cash crops. Plot holders should contribute to work for road maintenance for an access road between the farm entrance and the main trunk road, and the owned lorry will also do much for the road maintenance.

Table 5-6 Facilities to be Improved

Place to be Installed	Facilities	Function
Farm Office	Store-house for Inputs	Storing Seed, fertilizers tools, implements, machinery
ditto	Stock Yard for Farm Produce	Grading, bundling, packing, washing farm product
ditto	Radio Apparatus (Telephone Line)	Contacting with Agritex Headquarter etc.
ditto	Motor Bicycle	Collecting information on marketing, contacting with transporters, etc.
Large Townships	Sales Stands	For retail perishable produce remaining after bulk marketing
District Development Fund	Lorry or Pick-up	Purchasing inputs marketing produce or access road maintenance
Nearby Township	Temporary Collection Point	Delivering bags to G.M.B.

5.11. Farmer's Organization Plan

5.11.1. General

In view of an organizational aspect in the project, setting up the supporting organization at local government level like district, ward and village would be indispensable as well a liaison and cooperation between MEWRD and AGRITEX for the success of the project. It is desirable that the proper organizations would be established in order to maximize the benefit accruing from the project and to enable beneficial farmers to enjoy its benefit equitably. In other wards, the establishment of the proper organizations is prerequisite for realizing the national slogan, 'Growth with Equity' in the project.

Two types of farmer's organization plan is proposed in accordance with the project stage, namely, the construction stage and the project running stage after the completion of the construction.

5.11.2. Medium Size Dam Project Promotion Committee

Prior to the implementation of the project, it is proposed that 'Medium Size Dam Project Promotion Committee (hereinafter referred to as Project Promotion Committee) should be established for smooth implementation of the project.

The project promotion committee would play a crucial role for liaison and coordination between grass-roots level which implies local farmers and the relevant ministries and departments at district and provincial level during the construction period, and would be dissolved after the completion of preparation for the irrigation scheme.

This committee is chaired by District Administrator who is in charge of the project area and is composed of the following three subcommittees.

1) Manpower Management Subcommittee

The construction of facilities under the project can create employment opportunities in rural areas. This subcommittee would have a function to arrange rural manpower so that the farmers registered as the beneficiaries of drought relief service, can be given jobs as construction labour preferably. This system is similar to that of the ongoing food for work projects. Furthermore, the subcommittee would encourage the farmers to save the wage to be earned as casual labourer in order to purchase agricultural input materials for irrigated farming in the project.

The chairman of this subcommittee is District Social Welfare Officer and he coordinates between the local staff, councillors and traditional chiefs and the project executing agencies, MEWRD and AGRITEX.

2) Subcommittee for Land Allocation and Selection of Beneficiaries

This subcommittee has two functions. One is re-allocation of dry land for the farmers who are now cultivating the land in the proposed irrigation field or reservoir area. The other is selection of beneficiaries and decision of the size of one allotment under irrigation.

The subcommittee chaired by Local Government Promotion officer (L.G.P.O) is composed of councillors, traditional chiefs and the representatives of the ministries and departments concerned. Technical advice would be given to selection of beneficiaries and desicion of one plot size of irrigation field by the AGRITEX extension worker who is covering the project area inclusively as well as Irrigation Officer and Irrigation Manager.

3) Irrigation Management Training Subcommittee

This subcommittee has responsibility for pre-training of new forming techniques associated with irrigation in order that new irrigators can manage irrigated farming smoothly as soon as possible after the irrigation water is available. This subcommittee is expected to function as a preparatory committee of Irrigation Management Committee mentioned later. Various programme such as lecture on irrigation and the excursion to the existing irrigation schemes would be planned and carried out in collaboration with AGRITEX. The subcommittee, in addition, would educate local farmers about the health and sanitary matters such as water utilization and prevention of sluggish water in irrigation facilities in the project, keeping mutual cooperation with the Ministry of Health.

The subcommittee is chaired by Irrigation Officer on Irrigation Manager and comprises AGRITEX extension worker, health workers and the representatives of promising irrigators.

Figure 5-2 illustrates the proposed organization structure of Project Promotion Committee.

5.11.3. Irrigation Management Committee

As already organized in existing schemes, "Irrigation Management Committee" (hereinafter referred to as I.M.C.) should be set up in the Project. It is recommended that I.M.C should succeed to Irrigation Management Training Subcommittee of Project Promotion Committee and be re-organized by committee members democratically elected among new beneficiaries. As a result, new beneficiaries can engage in irrigated farming smoothly in the first cropping year in irrigation schemes. I.M.C is managed by the beneficiaries and its functions are as follows.

a) Maintain discipline among the plot holders,
b) Control water distribution throughout the scheme,
c) Recommend the eviction of unobservant plot holders,
d) Recommend the selection of new plot holders
e) Collect maintenance fees and other service charges,
f) Maintain all structures at community schemes,
g) Set up local rules applicable to that particular scheme,
h) Determine local requirements and standards for the plot holders.

It is also advised to set up various subcommittees chaired by a committee member, excluding the chairman, the secretary and the treasurer of the I.M.C.

These subcommittees may include Sales Promotion, Saving and Loan Application, Reinvestment and Multiple Management, Agrotechniques Renovation, etc. As autonomous body, an I.M.S. can represent the irrigation project at district council level in all matters that affect the project.

The I.M.C. also has the functions as a channel to all the governmental, statutory and private organizations.

5.11.4. Cooperatives

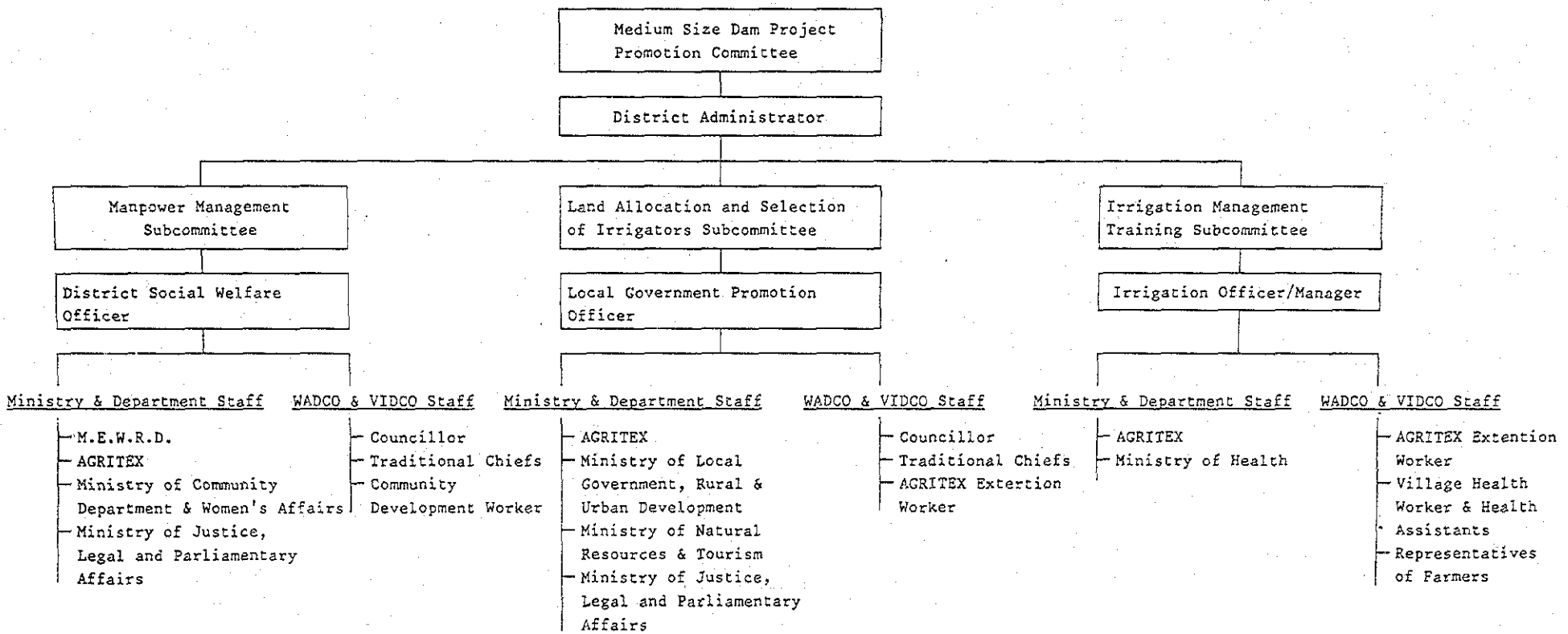
It is proposed that cooperatives for purchase of bulk agricultural inputs, and consumers goods, sales of agricultural produce, fish farming, etc. would be established. A cooperative for purchase of bulk agricultural inputs and consumers goods would contribute to purchasing commodities such as fertilizers, pestisides, and herbicides cheap and stably as well as to reducing transportation cost. The objectives of a cooperative for sales of agricultural produce are to reduce transport cost and to secure markets for the sales of products. A cooperative for fish farming should be established in order to buy fish fly jointly and to manage cooperative works when fish farming is introduced by means of a reservoir under the project.

5.12. Social Environment Improvement Plan

Republic of Zimbabwe emphasizes improvement of living environment of rural areas under the Five Year Plan (1986 - 1990). This project is identified in line with this national policy, contributing towards increase in agricultural productivity and farm income coupled with improving in living standards in communal lands.

Furthermore, the areas brought under irrigation have potentiality to activate secondary and tertiary industries through introduction of service and processing industries by using agricultural produce derived from irrigated agriculture and to promote the business of transportation and sales of consumers goods resulting from increase in purchasing power of rural farmers. Such economic development requires improvement of social infrastructure like road network. On the other hand, improvement of social welfare facilities are desired in response to increase in farm economy so as to better rural life. It is expected that the rural development plan which can harmonize rural economy and social environment of rural areas would be formulated. In case that the development plan lacks its harmony, the disparity in living standards between rural and urban areas would not be alleviated. As a result, exodus of rural population would be accelerated, causing population increase in urban areas, which is, at present, recognized as one of the major social problems of the Country.

Figure 5-2 Proposed Organization Structure of Medium Size Dam Project Promotion Committee



The rural development plan to be balanced between physical and socio-economic elements should be designed from the broader perspective. In this study, however, the social environment improvement projects are envisaged mainly focusing upon short-term plan which can be undertaken for short period. If the social environment improvement projects described later are implemented around the irrigation areas, the irrigation areas would be identified as a model area of development in communal lands.

The lack of capital is one of the main problems for the implementation of the development projects, in communal lands. For undertaking the various projects the application of development system based on self help and self reliance among rural people should be taken into account in order to limit public investment as little as possible. It is desirable that the farmers would serve the civil works as labour force in the implementation of the project and, furthermore, part of capital costs of projects would be supplied by farmers, themselves. A surplus of farmers economy is expected to be utilized as rural development investment. The proposed plan in relation to the medium size dams are as follows.

- o Improvement of road networks including construction of bridges to improve access to important centres in rural areas.
- o Implementation of proper land management under land use plan, taking into account population increase and conservation of natural resources.
- o Promotion of farmer's resettlement plan to solve the population increase problem
- o Provision of piped water supply system by means of communal taps
- o Development of rural industries in order to create employment opportunities in rural areas.

CHAPTER 6. PROPOSED PROJECT FACILITIES

6.1. Dam and Appurtenant Structure

6.1.1. Type of Dam

It is apparently recognized that 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. Therefore a concrete type dam might have 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, accordingly, is not recommendable and earth fill type is selected for each dam site.

Embankment work of dam will 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 is small. Considering above condition and dam scale zoned fill dam with center core is finally adopted for each site.

6.1.2. Embankment Details

(1) Crest Width

The crest width of dam is determined as given below in due consideration of available materials, height of dam, possible roadway requirement for maintenance and practicability of construction works. Empirical formula derived from the above concepts will be applied for the decision of crest width.

$$B_1 = 3.6H^{1/3} - 3.0$$

$$B_2 = 0.6 + 1.1\sqrt{H}$$

where, B_1, B_2: Crest width (m)
H : Dam height (m)

The crest widths estimated by the above formula are averaged and rounded up as follows.

Name of Dam	Dam No.	H (m)	B_1 (m)	B_2 (m)
Musaverema	I-2-1	12.7	5.4	4.6
Chinyamatumwa	II-1-6	18.8	6.6	5.4
Mashoko	II-2-1	18.4	6.5	5.4
Munjanganja	IV-4-10	18.7	6.6	5.4
Magudu	V-3-3	18.8	6.6	5.4
Mabvute	VII-1-12	19.3	6.7	5.5

Accordingly the crest width of each dam is determined to be 6 m.

(2) 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 in the guide line of Zimbabwe.

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

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

Name of Dam	Dam No.	F (km)	h (m)	h x 1.5 (m)
Musaverema	I-2-1	2.0	0.77	1.2
Chingymatumwa	II-1-6	1.5	0.75	1.2
Mashoko	II-2-1	2.0	0.77	1.2
Munjanganja	IV-4-10	0.9	0.72	1.1
Magudu	V-3-3	2.1	0.78	1.2
Mabvute	VII-1-12	2.5	0.80	1.2

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.

Wet freeboard is defined as a vertical height above full supply level of reservoir at flood. This is calculated as an overflow head on the sill of spillway at the design flood condition. It is shown as below.

Name of Dam	Dam No.	Wet freeboard (m)	Dry freeboard (m)	Total freeboard (m)
Musaverema	I-2-1	2.5	1.2	3.7
Chinyamatumwa	II-1-6	1.5	1.2	2.7
Mashoko	II-2-1	1.5	1.2	2.7
Munjanganja	IV-4-10	1.0	1.1	2.1
Magudu	V-3-3	3.0	1.2	4.2
Mabvute	VII-1-12	3.0	1.2	4.2

* Total freeboard is defined here as a vertical distance between the dam crest and F.S.L.

(3) 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.

In considering 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 wind and rainfall erosion usual types of surface protection for the upstream are rock riprap either dry-dumped or hand-placed. In due consideration of quality of rock materials and construction cost the hand-placed riprap is selected for each dam. The protection of hand-placed 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	D50	Max. Size	Filter Thickness
45 cm	30 cm	45 cm	15 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 remaining.

Core trench must pass through soil, sand and gravel layers and reach foundation rock. The bottom width of core trench is planned about 6 m. This is enough width to operate excavation work by heavey 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 pervions foundation of more than five lugion.

6.1.3. Spillway Design

(1) Site and Alignment of Spillway

Spillway is one of most important appurtenant structure 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 condition.

(a) Musaverema (I-2-1)

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 shellow 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.

(b) Chinyamatumwa (II-1-6)

Spillway will be set on the abutment. There is not a great difference about shape of slope and thickness of soil and weathered rock between the both abutment. 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.

(c) Mashoko (II-2-1)

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 repidly 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 in the soil layers. It will be protected with dry or wet stone masonry.

(d) Munjanganja (VI-4-10)

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 difference 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. There, 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.

(e) Magudu (V-3-3)

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.

(f) Mabvute (VII-1-12)

Both the abutment 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 nongated spillway is selected on the left abutment where alignment of chute channel is shorter than on the right abutment.

(2) Dimension of Spillway Sill

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

Name of Dam	Dam No.	Overflow Head (m)	Length (m)	Design Flood
Musaverema	I-2-1	2.5	125	835 m^3/sec
Chinyamatumwa	II-1-6	1.5	53	163
Mashoko	II-2-1	1.5	73	228
Munjanganja	IV-4-10	1.0	206	349
Magudu	V-3-3	3.0	47	415
Mabvute	VII-1-12	3.0	39	343

6.1.4. Design of outlet Works

(1) Site and Alignment

A location site of outlet works will be same abutment side with irrigation farm. The alignment of outlet works will be selected on the middle of abutment to place it in shortest length of conduit pipe. Considering the geology of abutment and the dead water level (D.W.L.) of reservoir, a location for each dam is selected as summarized below

Name of Dam	Dam No.	Site	Crossing Dam Axis No.
Musaverema	I-2-1	Right Abutment	D30 +20 m
Chiyamatumwa	II-1-6	- do -	D10 +0 m
Mashoko	II-2-1	Left Abutment	D10 +0 m
Munjanganja	IV-4-10	- do -	A11 +35 m
Magudu	V-3-3	- do -	D4 +18 m
Mabvute	VII-1-12	Right Abutment	D1 +0 m

(2) Details of Structure

The intake will be provided with screen and emergency gate. The conduit asbestos pipe will be protected with concrete and be set in the foundation rock (more than Cl class). But if the rock is massive and hard, conduit will be placed on the foundation.

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

(3) Hydraulic Calculation

(a) Diameter of Pipe

A diameter of conduit pipe is calculated by following formula.

$$D = \sqrt{\frac{4Q}{\pi V}}$$

where D: Diameter of pipe
Q: Design discharge
V: Design velocity

Pipe line standard design velocity for the small pipe is proposed as follows.

Diameter (mm)	Design Velocity (m/sec)
75 to 150	0.7 to 1.0
200 to 400	0.9 to 1.6
450 to 800	1.2 to 1.8

The diameter of conduit pipe for each dam is summarized as follows.

Name of Dam	Dam No.	Diameter of Pipe (mm)	Velocity (m/sec)	Design Discharge (sm/s)
Musaverema	I-2-1	220 ≒ 250	1.5	0.054
Chinyamatumwa	II-1-6	260 ≒ 300	- do -	0.074
Mashoko	II-2-1	140 ≒ 200	- do -	0.023
Munjanganja	IV-4-10	210 ≒ 250	- do -	0.049
Maguda	V-3-3	260 ≒ 300	- do -	0.076
Mabvute	VII-1-12	360 ≒ 400	- do -	0.151

(b) Elevation of Pipe

A conduit will be set in the foundation. The elevation of pipe center will be about 2 m below D.W.L. to utilize the reservoir water fully.

(3) Diameter of Main Valve

A diameter of valve can be made smaller than the conduit pipe. To determine its diameter pipe flow calculation was made based on the following formula.

$$Q = k \cdot \sqrt{2gh}$$

$$k = \frac{1}{\sqrt{S(fi/Ai)^2}}$$

where Q: Discharge (m^3/sec)
g: Acceleration of gravity (9.8 m/sec)
H: Water head (m)
fi: Coefficient of loss
Ai: Area (sm)
i: 1 to 5 here, for screen loss, entrance loss, friction loss, sub-valve loss, main valve loss

On the condition that upstream water head is D.W.L. and downstream water head is 0.1 m above the wall top of dissipating box, discharges are calculated for each dam. Results of selected valve show that the possible discharge satisfies the design as summarized below.

Name of Dam	Dam No.	Diameter of M. Valve	Formula	Design Discharge	Possible Discharge
Musaverema	I-2-1	150 mm	$Q=0.0140\sqrt{2.g.H}$	0.054	0.071 m^3/s
Chiayamatumwa	II-1-6	200	$Q=0.0213\sqrt{2.g.H}$	0.074	0.108
Mashoko	II-2-1	100	$Q=0.0068\sqrt{2.g.H}$	0.023	0.034
Munjanganja	VI-4-10	150	$Q=0.0151\sqrt{2.g.H}$	0.049	0.076
Magudu	V-3-3	200	$Q=0.0206\sqrt{2.g.H}$	0.076	0.104
Mabvute	VII-1-12	250	$Q=0.0394\sqrt{2.g.H}$	0.151	0.199

6.2. Conveyance Facilities

6.2.1. Water Conveyance Canal

The water conveyance canal between dam and night storage reservoir are 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.

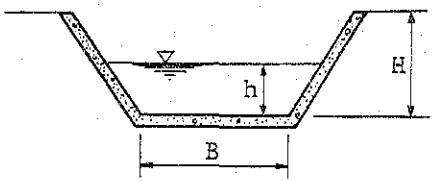
Layout of the canal was aligned on a topographical map scaled 1:5 000. Particular attention was given to minimize length of canal. Since the most of the canal alignment pass through sandy pervious soil, protection against leakage is necessary and concrete lining will be planned from the economic viewpoint 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.

The siphon is 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 structure. The canal and the related structure are required to be entirely enclosed with stable fences. The maintenance road with 4 m is effective width is planned along the canal.

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.

Table 6-1 Main Features of Water Conveyance Canal

Items	Musaverema (I-2-1)	Mashoko (II-2-1)	Munjanganja (IV-4-10)	Magudu (V-3-3)
1. Design Discharge (l/sec)	54	23	49	76
2. Manning's Roughness Coefficient	0.016	0.016	0.016	0.016
3. Canal Slope	1/1 000	1/300	1/400	1/400
4. Canal Section				
1) B (m)	0.30	0.25	0.25	0.30
2) H (m)	0.35	0.25	0.30	0.35
3) h (m)	0.25	0.11	0.20	0.23
5. Design Velocity (m/s)	0.50	0.64	0.69	0.77
6. Length (m)	5 600	800	4 720	7 940
7. Related Structures				
1) River Crossing (No.)	1	-	1	1
2) Road Crossing (No.)	1	-	-	2
3) Drop Structure (No.)	-	9	15	1
4) Domestic Water Supply (No.)	7	-	6	9



6.2.2. Pumps and Pipeline

The water should be pressurized and conveyed from dam to highly located night storage reservoir in case 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 and one standby pump are to be installed to avoid the risk of unexpected trouble or accident.

As 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 following factors.

a) The water is to be pressurized by pump.
b) Total head is rather high (40 m and 55 m).
c) Water hammer and negative pressure are predicted by sudden stopping of pump.
d) Steel pipe is strong enough to tolerate unexpected force such as concentrated force caused by striking.
e) Steel pipe can be easily repaired by welding when leakage is found.

Table 6-2 Main Features of Pumps and Pipeline

Items	Chinyamutumwa (II-1-6)	Mabvute (VII-1-12)
1. Pump		
1) Design discharge (l/sec)	74	151
2) Actual head (m)	29.0	43.5
3) Pump - 3sets		
Type	Double suction volute type	Double suction volute type
Dicharge (cu.m/min)	2.22	4.53
Total head (m)	40.0	55.0
Diameter (mm)	150×100	200×100
Output of motor (kw)	30	75
4) Diesel generator-3sets (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

6.2.3. Night Storage Reservoir

The consumption of water varies widely as a matter of course 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.

Main Features of Night Storage Reservoir

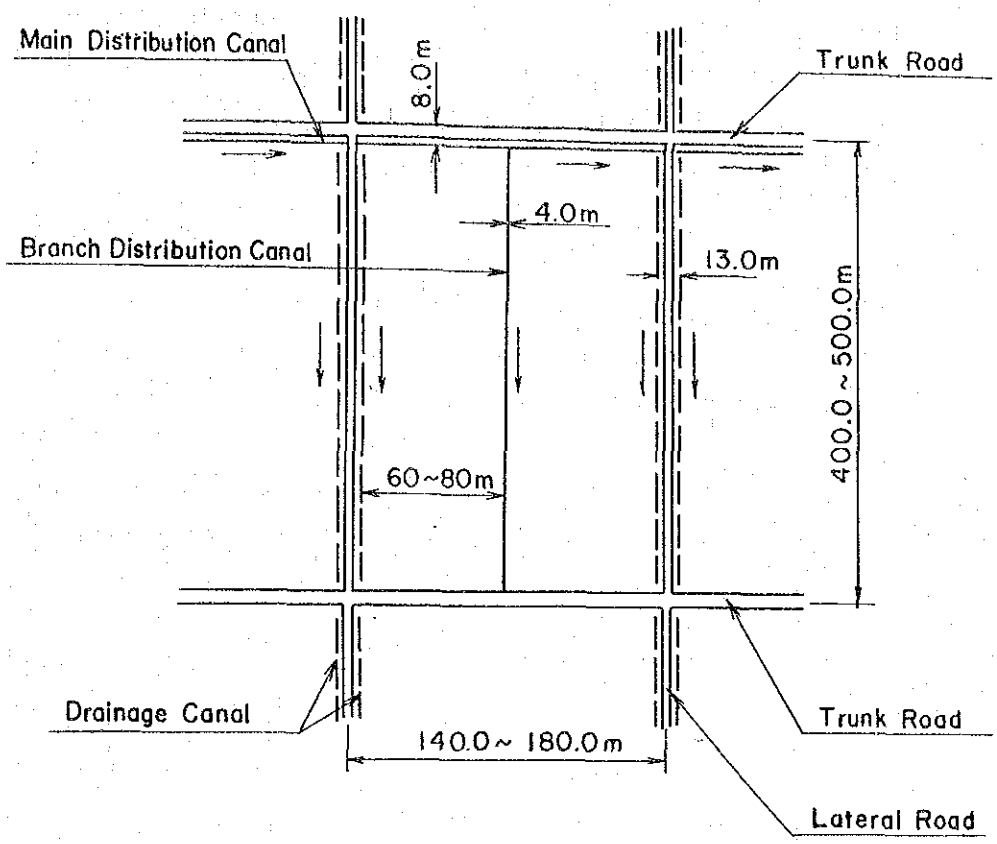
Name of Project	Design Capacity	Size	Effective Depth
	(cu.m)	(m)	(m)
Musaverema (I-2-1)	4 600	57 x 57	2
Chinyamatumwa (II-1-6)	4 300	55 x 55	2
Mashoko (II-2-1)	1 900	40 x 40	2
Munjanganja (IV-4-10)	4 300	55 x 55	2
Magudu (V-3-3)	6 500	66 x 66	2
Mabvute (VII-1-12)	8 700	75 x 75	2

6.3. In-field Facilities

6.3.1. 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.

Figure 6-1 Farmland Block Plan



6.3.2. 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 receiving 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.

6.3.3. 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 associated facilities and public facilities.

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

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

6.3.4. Drainage Canal

The large scale drainage sytstem 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 so 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.

Table 6-3 Main Features of In-field Facilities

Items	Musaverema (I-2-1)	Chinyamatumwa (II-1-6)	Mashoko (II-2-1)	Munjanganja (IV-4-10)	Magudu (V-3-3)	Mabvute (VII-1-12)
1. Farm area (ha)	44.0	50.0	21.0	51.0	70.0	100.0
2. Net irrigable area (ha)	36.2	34.7	15.2	33.3	51.1	70.5
3. Distribution canal (km)	5.8	5.4	2.0	4.9	8.5	11.2
4. Drainage canal (km)	7.7	6.2	3.5	6.4	9.6	14.5
5. Farm road (km)	6.6	9.0	3.3	7.1	10.2	15.7

Other farming facilities : Farm store, Office, Multi-purpose room, Living quarter, Blair latrine and Fence

6.4. Construction Plan

6.4.1. General

1) Temporary and Preparatory Works

The following temporary works are to be planned and carried out by the contractor.

- o Site office and workers' camp
- o Material stockyard and machinery pool
- o Development of borrow pit
- o Access road, temporary road, temporary bridge, crossings
- o Water supply works
- o Drainage and watering works
- o Safety and protection works

2) Working Time

The actual working time is 6.5 hours a day and 25 days per month in dry season. However, the working days of dam embankment work in rainy period (Nov. - Feb.) is 15 days per month for impervious fill and 20 days per month for other embankment. Night work is not basically adopted except for grouting works. The grouting work is carried out day and night by two shifts with many sets of machines and crews to avoid an obstacle to the progress of embankment works.

No influence of the rainy season is considered upon the reduction of working days per month for concrete works, building works and stone works, etc.

3) Construction Schedule

The construction schedule of each project is as shown in ANNEX.

4) Quantities of the Construction Works

The quantities of each project is as shown in ANNEX.

6.4.2. Dam Work

1) Embankment Materials

The whole dams at 6 projects are centre core type earth dams. The embankment materials are collected from the proposed borrow pits in the vicinity of dam construction sites. The excavated materials from spillway and cut-off trench of dam are planned to be used for embankment materials as much as possible in order to construct these dams economically.

The dam body is composed of the impervious zone, semi-pervious zone, pervious and drain zone. The respective materials are to be collected from the following proposed borrow pits.

Table 6—4 Proposed Borrow Pits of Embankment Materials

Material	Borrow pit	Distance	Remarks
MUSAVEREMA (I-2-1)			
Impervious	upstream right bank	0.8km	
Semi-pervious	upstream left bank	0.8km	
Pervious	〃 〃	0.9km	
Drain	〃 〃 river bed	0.5km	
CHINYAMATUMWA (II-1-6)			
Impervious	right bank upstream	0.5km	
Semi-pervious	right bank upstream	0.5km	
Pervious	left bank	0.2km	
Drain	out of project site	5.0km	MUJICHE R.
MASHOKO (II-2-1)			
Impervious	upstream right bank	1.0km	
Semi-pervious	upstream left bank	0.5km	
Pervious	upstream right bank	0.7km	
Drain	upstream small dam	4.0km	

Material	Borrow pit	Distance	Remarks
MUNJANGANJA (IV-4-10)			
Impervious	down stream right bank	0.5km	
Semi-pervious	upstream left bank	0.5km	
Pervious	upstream both banks	0.3km	
Drain	out of project site	15.0km	DEVURE R.
MAGUDU (V-3-3)			
Impervious	upstream left bank	0.5km	
Semi-pervious	upstream right bank	0.2km	
Pervious	upstream left bank	0.8km	
Drain	down stream both banks	5.0km	
MBVUTE (VII-1-12)			
Impervious	upstream both banks	0.5km	
Semi-pervious	upstream left bank	0.5km	
Pervious	left bank	1.0km	
Drain	down stream small dam	7.0km	

The excavated rocks and hard stones from spillway are used for the materials of rip-rap, stone pitching and masonry. The shortage is covered with the rocks and stones collected and brought from quarry.

The river sand is washed and used for the fine aggregates of concrete, the coarse aggregates are to be purchased from the existing supplier.

2) Embankment

The embankment work of dam is commenced following the completion of stripping and trench excavation. The embankment work is commenced in the dry season in order to carry out the work economically without water diversion works.

The steel pipe encased with concrete is embedded at the bottom of dam prior to the commencement of embankment works in order to make the river water flow down during the construction.

This pipe is finally used as the conduit pipe of intake facilities.

The grouting work must precede the embankment work.

The following standard is adopted to obtain the suitable and stable compaction in embankment works. However, the embankment test must be conducted prior to the actual work to confirm the following standard.

Zone	Spread Thickness	Rolling Times	Machinery	
Core	20 cm	8 times	Tamping roller	8 - 10 tons
Filter	30 cm	6 times	Vibratory roller	3 - 5 tons
Shell	30 cm	6 times	Vibratory roller	3 - 5 tons

The moisture contents of the embankment materials should be so adjusted as to give the compacted density more than 95 percent of the maximum dry density in the Standard Proctor Compaction Test.

6.4.3. Water Conveyance Facilities

1) Gravity System by Open Canal

It is not difficult to complete these facilities within the construction period of dam construction taking into account the construction techniques and quantities.

However, the main point of the construction is to continue the systematic concrete lining work following the progress of earth work on the canal alignment.

2) Pump and Pipeline System

The building work of pump house and installation of pumps, generators and automatic control system must be completed within the period of dam construction.

For the above, the precise work programmes are to be drawn up for importation, installation and adjustment of the equipment.

The specialist is dispatched from the manufacturer when the equipment is installed.

3) Night Storage Reservoir

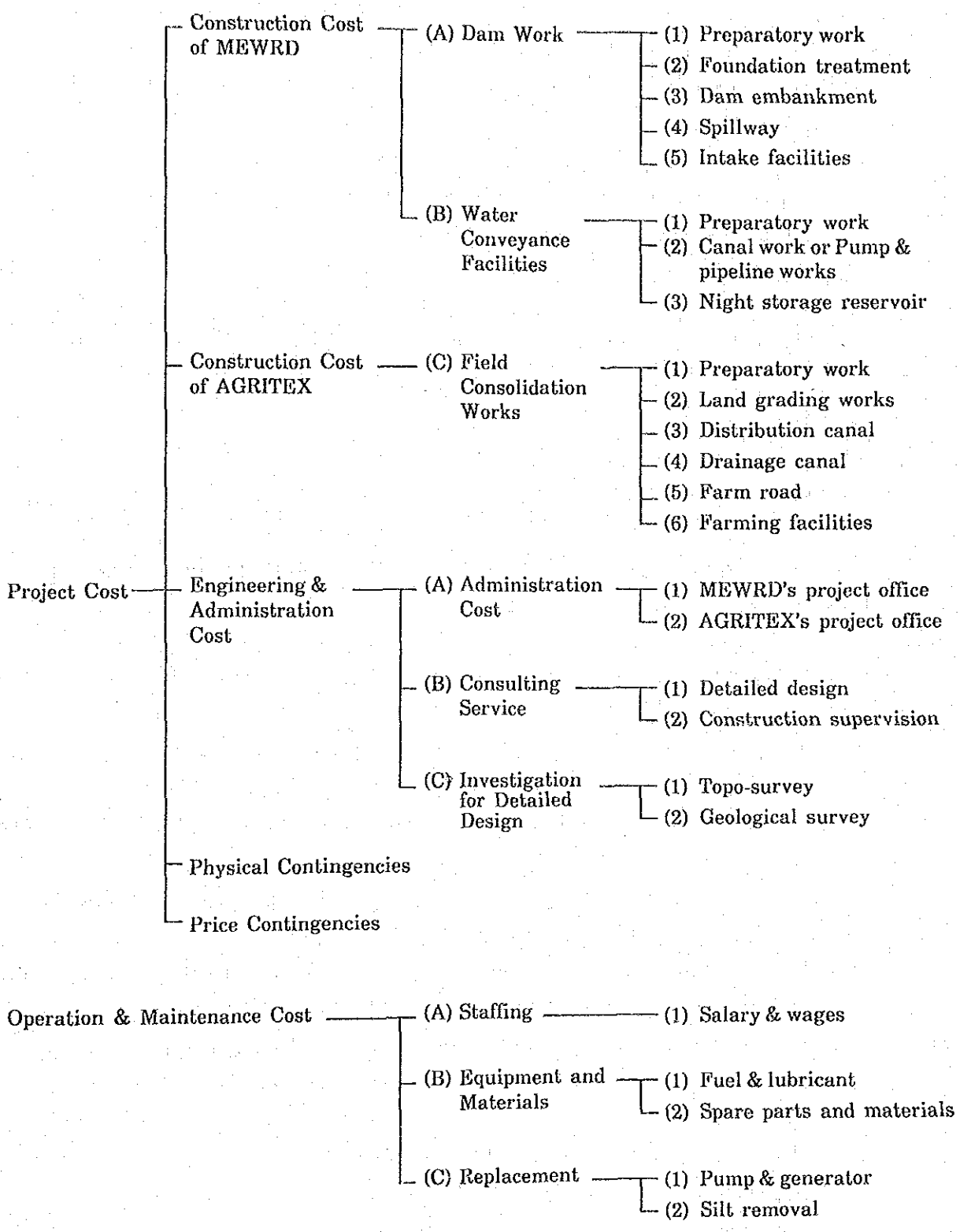
The timely supply of concrete and steel materials even though the excavation and embankment are the chief works.

6.4.4 Field Consolidation Work

The work consists of the following three major items.

i) Land grading and levelling works
ii) Distribution canals, Roads and Drainage canals
iii) Building works

Figure 6-2 PROJECT COST COMPONENT



In order to complete this work at the same time of completion of dam and water conveyance facilities, the following matters are considered.

(i) The precise labour control and progress control are required to complete the work in the construction period because the work requires much labour.

(ii) The work output is always checked to meet the scheduled work because most of works are carried out by man power.

(iii) The fabrication system of precast concrete flume must be promptly established after commencement of the works.

6.5. Cost Estimates

6.5.1. Condition of Cost Estimation

1) The project cost is classified roughly into three (3) items as follows.

- Expenses of Detailed Design and Preparation of Tender Documents
- Expenses of Construction and its Supervision
- Expenses of Operation and Maintenance throughout the project life.

2) The project cost is estimated under the following conditions.

a) The construction of dam and water conveyance system including night storage reservoir is to be implemented by the MEWRD.
The construction cost is estimated on the contract basis through international tender followed by the introduction of foreign fund.

While, the farmland consolidation work is carried out by the AGRITEX as a rule.
The cost is however estimated based on the contract basis in accordance with AGRITEX's request to complete the work on schedule.

b) The project cost is estimated as of August, 1987 and the following exchange rate is applied for.

US$ 1 = 1.515 Z$ (Zimbabwe Dollar)
US$ 1 = 144.0 YEN

c) Two components are considered as contingent expenses.

- o Physical contingency: to cope with the difference of costs designed and actually constructed, extra cost unforeseeable when designed, increase in cost due to site and geological conditions.

- o Price contingency: to cope with the price escalation.

The physical contingency related to the construction and associated cost is set at 15% of the direct cost.

The price contingency is predicted at 12.7% per annum for local currency based on a positive deflator of 1.0% per month. No contingency is, however, provided for foreign currency because the exchange rate is stable and will not sharply be fluctuated.

d) The expenses of operation and maintenance of the project after completion of the construction is estimated throughout the project life.

e) For the estimation of amount of foreign fund to be introduced, each component of project cost is summmed up separating into the foreign and local currency portions.

6.5.2. Construction Cost

1) Basic Rate

The basic rate of labour, material and construction machinery is estimated considering the prevailing rate in Zimbabwe.

Detailed basic rate is shown in ANNEX together with the below-mentioned construction cost.

2) Unit Construciton Cost

For the estimation of construction cost, the present unit prices of construction works, current market prices of materials and price indices are well examined in order to decide the appropriate unit rates of respective work items.

The construction cost is worked out taking into account the designed work quantities and the construction plans.

3) Construction Cost

The construction cost is divided into foreign and local currency portions.

The local currency portion is estimated on the basis of the current prices in Harare (some items are in Masvingo) in 1987, and the foreign currency portion is estimated on the CIF prices in Harare. The construction cost is estimated based on unit cost for each work item.

6.5.3. Associated Cost

In connection with the respective construction works executed by MEWRD and AGRITEX, the associated cost is composed of the engineering cost including the consulting services, administration cost and O&M cost etc.

The expense for land acquisition and the related compensation is not required to be considered in accordance with the national policy.

6.5.4. Project Cost

The total sum, foreign and local portions of project cost in six (6) projects are summed up as follows. The details are shown in Table 6-5.

PROJECT COST

(Unit: 1 000Z#)

Dam No	Name of Sub. project	Project Cost		
		Total Sum	F/C	L/C
I-2-1	MUSAVEREMA	5245	2265	2980
II-1-6	CHINYAMATUMWA	5164	2687	2517
II-2-1	MASHOKO	3822	1647	2175
IV-4-10	MUNJANGANJA	4646	1962	2684
V-3-3	MAGUDU	5116	2137	2979
VII-1-12	MABVUTE	6994	3593	3401

NOTE: F/C ..... Foreign Currency Portion
L/C ..... Local Currency Portion

Table 6-5

PROJECT COST

(unit : 1,000 z$)

Description	MUSAVEREMA (I-2-1)			CHINYAMATUMWA (II-1-6)			MASHOKO (II-2-1)			MUNJANGANJA (IV-4-10)			MAGUDU (V-3-3)			MABVUTE (VII-1-12)		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
1. Construction Cost																		
(A) MEWRD																		
Dam works	1 179	964	2 143	984	765	1 749	1 076	911	1 987	1 093	925	2 018	983	828	1 811	1 128	839	1 967
Water conveyance works	242	204	446	842	152	994	46	41	87	210	177	387	389	315	704	1 162	189	1 351
(Sub - Total)	1 421	1 168	2 589	1 826	917	2 743	1 122	952	2 074	1 303	1 102	2 405	1 372	1 143	2 515	2 290	1 028	3 318
(B) AGRITEX																		
Field Consolidation works	388	383	771	316	337	653	147	159	306	279	303	582	401	425	826	628	668	1 296
Total (A + B)	1 809	1 551	3 360	2 142	1 254	3 396	1 269	1 111	2 380	1 582	1 405	2 987	1 773	1 568	3 341	2 918	1 696	4 614
2. Engineering and Administration cost	231	313	544	208	300	508	210	254	464	206	285	491	203	308	511	216	375	591
3. Total (1 + 2)	2 040	1 864	3 904	2 350	1 554	3 904	1 479	1 365	2 844	1 788	1 690	3 478	1 976	1 876	3 852	3 134	2 071	5 205
4. Phisical Contingency (10%)	204	186	390	235	155	390	148	137	285	179	169	348	198	187	385	313	207	520
5. Total (3 + 4)	2 244	2 050	4 294	2 585	1 709	4 294	1 627	1 502	3 129	1 967	1 859	3 826	2 174	2 063	4 237	3 447	2 278	5 725
6. Price Contingency (43% of L/C for 3yrs.)	—	881	881	—	735	735	—	646	646	—	799	799	—	887	887	—	979	979
7. Grand Total	2 244	2931	5175	2 585	2444	5029	1 627	2148	3775	1 967	2658	4625	2 174	2950	5124	3 447	3257	6704

CHAPTER 7. PROJECT ORGANIZATION AND IMPLEMENTATION

7.1. Project Implementation Agencies

7.1.1. Executing Agency of the Project

This project is carried out by two agencies under the following jurisdictions from the detailed design stage to the actual operation and maintenance stage followed by the completion of constuction.

- o Ministry of Energy, Water Resources and Development (MEWRD) executes;
  Dam and Water Intake Facilities, Conveyance Facilities and Night Storage Reservoir.

- o Agricultural Technical and Extension Service (AGRITEX), Ministry of Agriculture executes;
  Farm consolidation, In-field Facilities following the outlet of Night Storage Reservoir, and all the Related Farming Structures.

Since the above-mentioned agencies and their jurisdictions of works have been established in the existing similar project in Zimbabwe, the Provincial Office of Water Development, Masvingo - MEWRD and the Provincial Agritex Office, Masvingo - Ministry of Agriculture are respectively to fill the role of the implementation of this project within their jurisdictions.

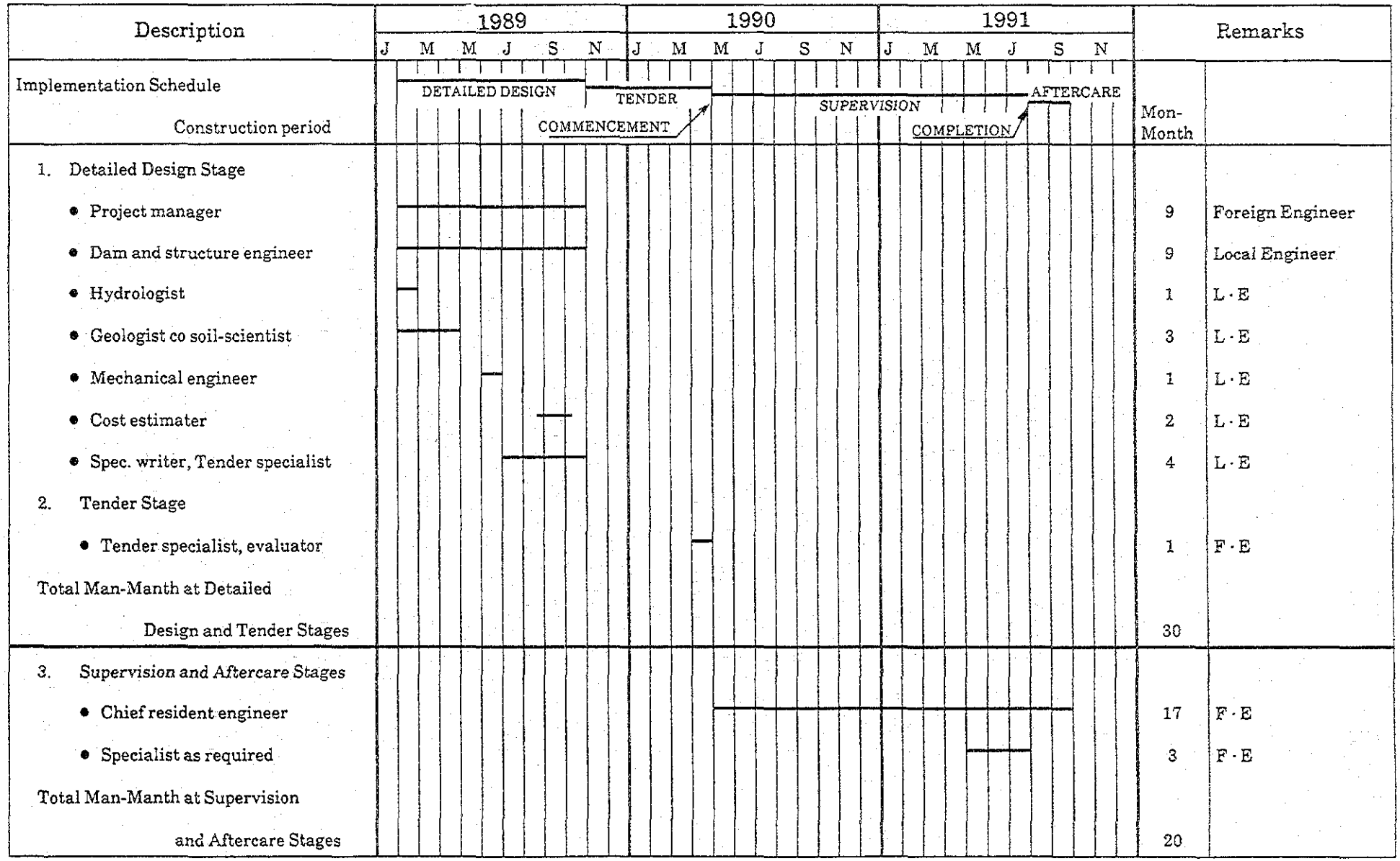
7.1.2. Financing and Funding Agencies

The foreign currency portion of the project will be financed by the international financing institute while the local currency portion will be provided by the government of Zimbabwe.

7.2. Consulting Services

For the engineering service attended with the similar construction projects, the basic study and detailed design works are so far entrusted to a consultant firm by both the executing agencies. Except for some large

Figure 7-1 Schedule of Consultant Service
as per 1 project



Description	Mon-Month	Remarks
Implementation Schedule		
Construction period		
1. Detailed Design Stage		
• Project manager	9	Foreign Engineer
• Dam and structure engineer	9	Local Engineer
• Hydrologist	1	L·E
• Geologist co soil-scientist	3	L·E
• Mechanical engineer	1	L·E
• Cost estimater	2	L·E
• Spec. writer, Tender specialist	4	L·E
2. Tender Stage		
• Tender specialist, evaluator	1	F·E
Total Man-Manth at Detailed Design and Tender Stages	30	
3. *Supervision and Aftercare Stages*		
• Chief resident engineer	17	F·E
• Specialist as required	3	F·E
Total Man-Manth at Supervision and Aftercare Stages	20	

projects, the supervision of construction work is usually carried out by both the executing agencies themselves whatever the construction work is implemented by contract or force account. As a matter of fact, the construction works are presently supervised by their own engineering staff and the foreign engineers despatched to these two executing agencies.

In such circumstances, the MEWRD expresses the intention to entrust the supervision of construction work of this project to the consultant firm who undertakes the basic study and detailed design works taking into account the intention and conditions of the funding agency. Because it becomes quite difficult for the MEWRD to carry out all the supervision of further projects coping with increase in number in the similar project. The plan of engineering service is drawn for this project in line with the above-mentioned policy of the MEWRD.

The consultant firm to be entrusted the detailed design works and supervision of construction is selected at a fair valuation along the intentions and conditions of the funding and/or the executing agencies. The total man-months of consulting staff to be engaged in the detailed design and construction supervision are 30 man-months and 20 man-months for each project respectively.

7.3. Project Implementation Plan

7.3.1. Present Condition of Implementation Method

The construction of the similar projects is implemented by two agencies in accordance with the following methods (construction mode) respectively. MEWRD carried out the similar scale of construction works to this project on the force account (direct work) or on the contract basis. In case that he gives out a contract, the unit price contract is made. While, AGRITEX executes all the construction works on the force account.

In order to carry out the works on force account, both the agencies (MEWRD and AGRITEX) always employ and insure in each provincial office the civil engineers, supervisors, mechanicians, electricians, foremen, store keepers and so on, as well as the facilities, equipment and tools for the construction works.

However, both the agencies do not possess the large construction machinery as their own, they hire the machinery with operators whenever required from private construction companies and/or the Central Machinery and Equipment Department, the Ministry of National Supplies in accordance with the hiring method (so called Plant Hire) superintended by the Ministry of Transport.

7.3.2. Implementation Method

In this project, the construction work of the facilities falling under jurisdiction of the MEWRD is to be undertaken by the contractor fairly decided with the international tendering, under the supervision of the consultant.

7.3.3. Land Acquisition

The land aquisition for the construction of dams, conveyance canals, night storage reservoirs and field facilities are to be carried out by two agencies (MEWRD and AGRITEX) prior to the commencement of construction works. No expense for land expropriation is required in accordance with the national policy of Zimbabwe.

7.3.4. Implementation Schedule of the Project

The construction to be implemented by the MEWRD will be commenced at about two years after the completion of this feasibility study taking into account the periods required for the funding procedures, the consultant recruitment, the detailed design, tendering and contracting of the construction works. The construction works will be completed within one and half years.

The field consolidation works to be carried out by the AGRITEX are very necessary to be completed at the same time as the completion of the MEWRD's works so that water may be conveyed and supplied to the new field to start the earliest farming.

In order to materialize the above, both the executing agencies are expected to tie up closely with each other to carry forward the project.

The implementation schedule is shown in Figure 7-1. The detailed construction schedule is shown in ANNEX.

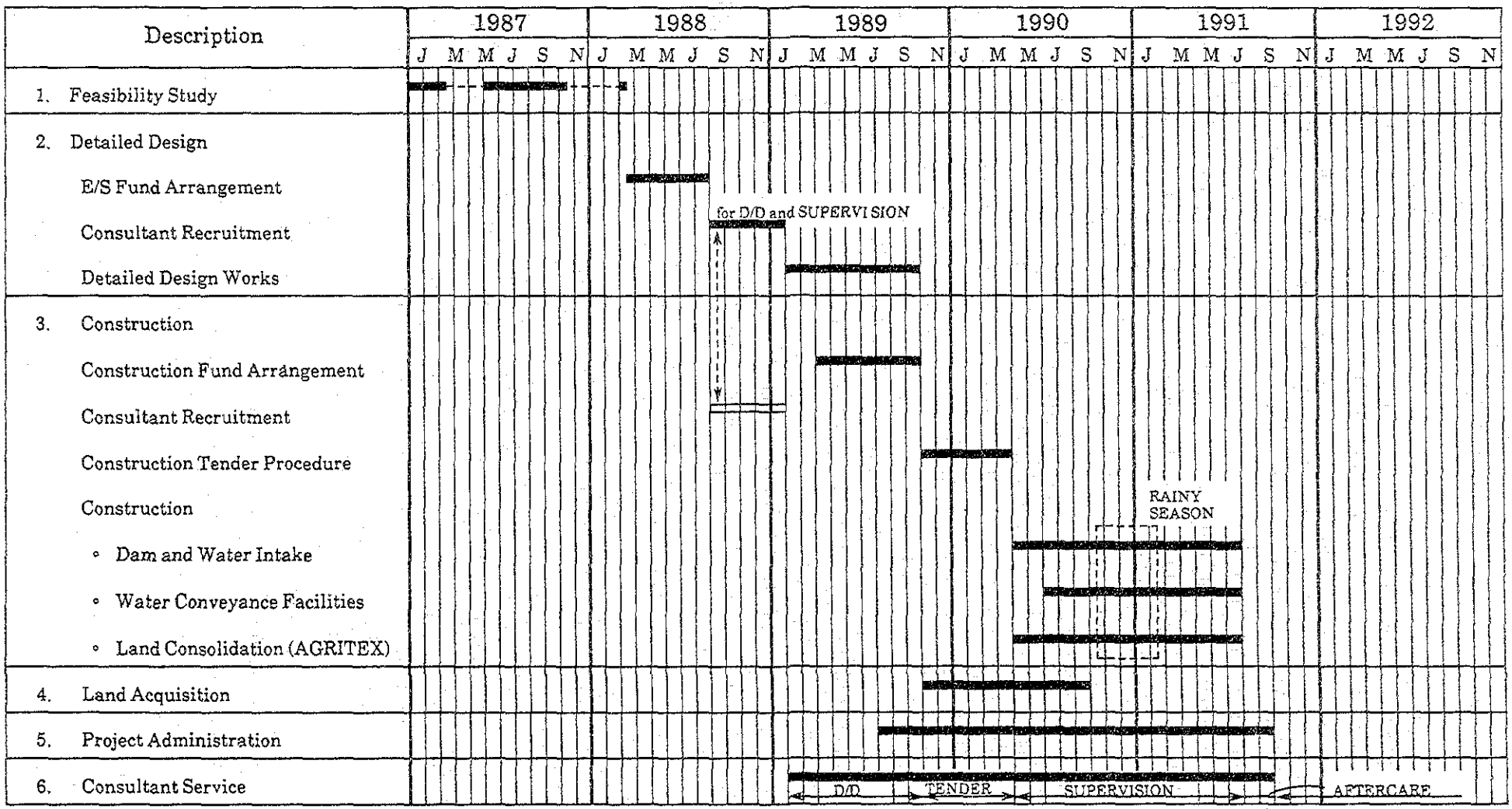
7.4. Operation and Maintenance

7.4.1. Operational System of the Projects

Dams, pumps, canals, night storage reservoirs and other facilities or structures attached to the main system are presently operated and maintained by MEWRD. On the other hand, AGRITEX of Ministry of Agriculture is responsible for the operation and maintenance of all the facilities within irrigated farm areas.

The same system of operation and maintenance as currently adopted by the existing irrigation schemes is applicable to the proposed projects, where the major frameworks are given as follows:

Figure 7-2 Project Implementation Schedule



[MEWRD] Officer in charge of the district in Provincial Office —(Field Station) — Foreman — Handyman — Bailiff

[AGRITEX] Irrigation Officer in Provincial Agritex — Regional Agricultural Extension Officer — Extension Worker

Operation and maintenance costs as a part of the project cost comprise the replacement costs of equipment and materials, running costs such as fuel cost, wages required for the operational works including staffing of official employees and transportation.

7.4.2. Works of Operation and Maintenance

Major operational and maintaining works for the proposed projects as breakdown into major facilities and administrative sectors are illustrated in the following:

General Maintenance of Facilities

Dam [under MEWRD]	Refilling and Protecting works on eroded and scoured slopes of dykes, etc.
Pump Station [- do -]	Daily operation, maintenance and replacement (in the eleventh year)
Main Canal [- do -]	Removal of fallen stones and sediment, weeding, cleaning in drops and culverts, etc.
Night Storage Reservoir [- do -]	Weeding water weed, refilling slopes
Canal and Drainage [under AGRITEX]	Replacing broken flumes, Repairing gates, boxes, etc.

In-field Management [- do -]	Replacing broken fences, repairing latrines, etc.
Farm Buildings [- do -] Go-downs	Repainting, regular cleaning, disinfectioning

7.4.3. Operation and Maintenance Costs

Operation and maintenance costs of the projects are shown in ANNEX, inclusive of transportation in each item except staffing and casual labours.

CHAPTER 8. PROJECT EVALUATION

8.1. Project Justification

8.1.1. Concept of Project

The proposed project areas on the whole acutely suffer from water shortage both for agricultural and domestic use. The following benefits are expected from the proposed projects, which will support rural development policies as a component of the first five year national development plan.

i) to assure food security and to improve nutritional situation from diversified food production.

ii) to stabilize and to improve farm economy through increased farm production.

iii) to mitigate cattle loss and other serious drought damages by the provision of new water sources.

iv) to substitute imports (of grains and pulses) through increased and diversified production, thus saving foreign currency for food imports.

v) to secure domestic water, to save household labour, as well as to create an additional labour opportunity in crop fields.

Although these types of effects are not always tangible, the role of water source development is far more important than any other tangible, alternatives, because all of tangible benefits stem from the creation of permanent water sources.

8.1.2. Components of Project Effects

The proposed project areas chronically suffer drought-induced food shortages, which should be supplemented through government drought relief. The expected production, increase from the proposed projects, amounting to 1 400 tons per annum, will be able to meet apart of these food relief requirements. This will not only solve the food deficit problems suffered by 26 thousand inhabitants within the project areas, but further to meet the food requirement for more than 500 people around the areas.

At the same time, 40 thousand km. of food transport mileage per annum for government food relief would also be saved through this project.

8.1.3. Contribution to Farm Income

The expected benefit from the aspect of farm economy is quite remarkable. Namely, annual farm income per household will increase from the current level of Z$ 190 - 520 per household to the project range, Z$ 420 - 780, provided that 0.1 ha. of irrigable plot is allotted to each farm. If each plot holder in such remote areas as Musaverema, Mashoko or Magudu receives 0.2 ha., this range will further be expanded to Z$600 - 830.

The income range expected from the allocation of even 0.1 ha. will almost meet annual household budgetary requirement in the proposed areas. Moreover, the levels derived from the allocation with 0.2 ha. only in the handicapped areas will guarantee at least 0.63 kg of grains and pulses or more than half a loaf of bread to every family members as daily food supply.

8.1.4. Prevention of Drought Loss and Water Security

Four of the project areas are subject to incur a heavy toll of cattle loss whenever drought attacks. Such loss would be greatly alleviated by the proposed projects, either through the creation of permanent watering facility or through the feeding of increased stovers and other crop residues supplied from irrigation farms. The estimated increase of cattle survival will reach 910 LSU per annum particularly in Musaverema, Mashoko, Munjanganja and Magudu.

In addition to the prevention of cattle sacrifice from drought damages, the creation of new water source will improve the water supply to villagers in the project areas. Domestic water supply to the communal population in the six proposed areas (13 260 persons) is estimated at 201 thousand tonnes per annum, including supply to cattle (11 520 LSU). Some 120 boreholes would be necessary to rely this volume on groundwater, though probably not avilable in the project areas.

8.1.5. Import Substitution and Support of State Policies

The proposed projects include wheat and sugarbean production, which can save a small part of import requirement (0.3% of 231 thousand tonnes of annual average imports). Groundnut production will also contribute the policy oriented to oil crops recently launched.

The amount of saving is evaluated at US$136 thousand from import side and that of earning from groundnut exports comes to US$ 56 thousand. It follows that the total contributions to foreign currency gains will exceed US$ 190 thousand for the whole projects.

8.1.6. Creation of Labour Opportunities

The proposed project will create additional labour opportunities in the irrigated farm, as cropping intensity is doubled and labour peak is more accentuated. The estimated increase in labour days for irrigated farm acitivites comes to 11 - 24 man-days per household or 28 400 man-days for the whole projects, equivalent to 150 persons including instructors.

8.2. Project Evaluation

8.2.1 Concept

The proposed projects are only evaluated by completely tangible benefits, even if there were various socio-economic benefits and impacts as stated in 8.1.

Crop production values for "with project" are derived from the proposed cropping patterns, projected yield levels under irrigation and economic prices based on so-called "border prices" and conversion from local market prices.

Those for "without project" are similarly obtained from the performance of current dryland cropping. Benefits of each project are separately measured for the total irrigable area in the respective projects.

8.2.2. Method and Procedure of Evaluation

Benefit evaluation follows the conventional method and the procedure of calculating economic internal rate of returns (EIRR) computed by discounting economic benefits and costs along through the balance stream flows over the project life.

The basis adopted for the economic evaluation is as follows:

Prices; Economic prices as border prices or those converted from current 1986/87 local market prices with conversion factors.

Project life; 40 years, but pumps are replaced in the twenty-first year and silt is removed from reservoirs in the same year.

Costs; Construction costs (dams, water-conveyance facilities and in-field works + consultant costs + physical contingencies + costs for operation, maintenance and replacement + administration costs.

Benefits; Crop benefits from the third year (1/2 of target yields), the fourth year (3/4 of these) and the fifth year and later (up to 40th year).
For those from vegetables, only a half of target yields (where marketability rate is set at 1/3), are economically counted into evaluation, while for green millies 3/4 of the harvest is evaluated (where marketablility rate is set at 1/2), including home consumption etc.

Construction period; 2 years, during which 30 per cent of the construction costs is disbursed in the first year and the rest is met for the expenditures in the second year.

Conversion factors; As per attached table in Annex.

Replacement; Pumps and generators are replaced in the 21st year of the project period. And sedimented silt in all the dams are removed in the same year.

Sensitivity analyses are also checked to estimate the extent of influences from the fluctuations of construction costs (minus ten per cent only) and benefits (plus ten per cent only), as shown in Table 8-1.

8.2.3. Results of Project Evaluation

On the basis of benefits and costs as mentioned above, the proposed projects were evaluated through benefit and cost streams for individual projects. The results as listed in Table 8-1 show that five projects are economically feasible. The rest, with the narrowest irrigable area, fail to show positive value of EIRR, though its benefit is larger than the projects cost (without price escalation, excluding operation and maintenance cost. Nevertheless, the latter is also considered to be fully feasible from the fact that it is a centre of beef production area, with heavy economic dependence on livestock to which a number of intangible benefits are expected other than those from crop production.

8.2.4 Alternative Evaluation

With a view to evaluating the proposed projects on the basis of reservoir yield at 20 per cent risk, instead of ten percent risk basis, increased benefits and costs from larger irrigable areas, corresponding to larger yield as given in 5.3.1 are estimated. The same method of evaluation was applied to these estimated results, giving the figures in Table 8-2 (also refer to Annex H).

Table 8-1 E.I.R.R.the Six Projects

unit : thousand z$, unless otherwise specified

Site No.	I -2-1	II -1-6	II -2-1	IV -4-10	V -3-3	VII -1-12
Net irrigable Area(ha.)	36.2	34.7	15.2	33.3	51.1	70.5
Economic Benefit/ha.	3.5	4.0	3.8	4.1	3.8	4.1
Annual Benefit	126	139	57	137	195	292
Total Benefit through Project Life	4,694	5,179	2,124	5,104	7,264	10,877
Total Economic Construction Cost	2,752	3,097	2,074	2,465	2,728	4,118
O.M.costs in the Project Period	741	953	152	274	219	1,995
of which; staffing*	55	119	55	55	55	119
fuel, material etc.	43	393	30	38	43	1,215
replacement	643	441	67	181	121	661
Total Economic Cost(as of 1987)**	3,493	4,050	2,226	2,739	2,947	6,113
Calculated E.I.R.R.(%)	1.9	1.6	negative	3.7	5.6	4.4
Indicaters for Reference						
Total Final Costs/ha.*	163.3	149.1	219.4	126.2	88.8	121.5
Corresponding Economic Costs/hs.	96.5	116.8	146.4	82.2	57.7	86.7
Benefit-Cost Ratio at i = 0	1.3	1.3	0.9	1.9	2.5	1.8

* including staffing cost for pump operator (38 years), a foreman and E.W.(both 5 years)

** no price escalation was included either in financial or in economic costs

Table 8-2 Expected Benefits and Costs on the Basis of Yield at Two Levels of Risk
(20 instead of 10 per cent risk on reservoir yield)

unit: * Z$, ** ThousandZ$

	Site No.	I-2-1	II-1-6	II-2-1	IV-4-10	V-3-3	VII-1-12
Area and Yield	Reservoir Yiels at 10 per cent Risk(10^3m^3.)	757	642	313	659	1 012	1 298
	at 20 per cent Risk(10^3m^3.)	1 113	811	431	861	1 272	1 631
	Yield Ratio	1.47	1.26	1.38	1.30	1.26	1.26
	Irrigable Area at 10 per cent Risk (S_0ha.)	36.2	34.7	15.2	33.3	51.1	70.5
	at 20 per cent Risk (S_1)	53.2	43.7	21.0	43.3	64.4	88.8
	Increased Acreage ($S=S_1-S_0$ ha.)	17.0	9.0	5.8	10.0	13.3	18.3
Benefit	Benefit per ha. without any Shortfall (A)*	3 872	4 461	4 179	4 581	4 242	4 609
	Benefit per ha. at 10% Risk ($\frac{100-10}{100}$ =Y0)*	3 485	4 015	3 761	4 123	3 818	4 148
	at 20% Risk ($\frac{100-20}{100}$=Y)*	3 098	3 569	3 343	3 665	3 394	3 687
	Annual Benefit at 10% Risk $B_0=S_0Y_0$ *	126 157	139 321	57 167	137 296	195 100	292 434
	Benefit Increment from increased Risk B=SY*	52 666	32 121	19 389	36 650	45 140	67 472
	Annual Benefit at 20% Risk $B=S_0Y_0+SY$*	178 823	171 422	76 556	173 946	240 240	359 906
	Total Project Benefit during the Project Period**	6 661	6 386	2 852	6 479	8 949	13 406
Proj.cost	Economic Cost at 10 per cent Risk **	3 486	4 088	2 233	2 709	2 864	6 202
	Expected Economic Cost Increment note 1) **	286	330	86	136	177	733
	Economic Cost expected at 20 per cent Risk**	3 772	4 418	2 319	2 845	3 041	6 935
	Benefit/Cost Ratio at 20 per cent Risk	1.77	1.45	1.23	2.28	2.94	1.93
	E.I.R.R. expected at 20 per cent Risk	3.9	3.4	+1.1	5.1	6.9	5.6

Note: 1) Construction cost for dam and conveyance are not increased, but those for in-field facilities and O.M. are raised by the rate of Yield ratio.

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