3.2. Dam and Reservoir

3.2.1. Field Investigation

The field investigation for dam sites has been performed from September to November in 1986. Number of dam sites investigated by dam group is as follows.

Batanai:	5 sites out of 8 potential dam sites	
Bikita:	12 sites out of 14	- do -
Gaza:	14 sites out of 18	- do -
Gutu:	17 sites out of 18	- do -
Masvingo:	12 sites out of 13	- do -
Chivi:	10 sites out of 10	- do -
Zaka:	12 sites out of 13	- do -

Total 82 sites have been investigated by dam group. 12 dam sites were not visited because of hard accessibility within a short survey period.

Engineering comments on the potential dam sites of each district are briefed as follows:

(1) Batanai District

Every dam site can be placed on the bedrock of hard and massive gneiss. Most of bed rock in this district might have water tightness against leakage from reservoir except Zvirikre (I-2-2) and Mushava (I-2-4) sites. The above two dam sites with formation of lineament in some cracky or fault zones will require some treatment against leakage especially for Zivikre site.

Dam sites in this district have mostly moderate and low abutment. The dam height will be less than 12 m except for Zivirikure (I-2-2). Along the river, development of erosion or gully and sand deposit are frequently observed. Fairly large amount of sediment load will be anticipated.

Embankment materials for earth dams will be obtained on the hill slope close to dam sites. The materials are of residual soils and deposit soils. They are mostly sand or silty soils. Clayey soils are not abundant. Sand materials for filter and concrete can be obtained from river bed easily. Rock materials for masonry and rip rap are also obtained from riverbed or foot of domed hill, which will, however, require crushing or blasting.

(2) Bikita District

A bed rock in this district is basically granite. Granite in the northern area of Bikita C.L. is generally hard and massive. But it has soft weathered zone or patched zone around faults or intruded dykes of dolerite. This will require treatment to avoid leakage from reservior. Granite in the southern area is porphyritic granite with more than 10 m of thick weathered layer which may have high permeability. But the bed rock of Chigumisirwa (II-1-10) dam site has thin weathered layer and good foundation for dam. In the Matsai C.L., a bed rock consists of granite with intrusion of dolerite, which makes a weak and pervious zone in granite. Most of dam sites would require a foundation treatment to avoid hazardous leakage from reservoir.

Embankment materials can be obtained on the hill slopes. They are sandy to clayey residual soils. Sand and rock materials can be obtained in the vicinity of every dam site.

An unconsolidated deposit along river is abundant. Its thickness sometimes develops more than five meters. This indicates sediment load retained by dam would be large.

(3) Gaza Komanini District

A bed rock in Matibi No. II and Sengwe C.L. mainly consists of basalt. Partly conglomerate intersects. Basalt in this area is highly weathered. It becomes wholly soft and pervious foundation rock. On the other hand, conglomerate, which is observed at the dam site of Thinana (III-3-8), is hard and massive with scarce joints. A bed rock in Sangwe C.L. area is basalt with intrusive diorite or sandstone with intrusive dolerite. These rocks form boulder-like zone or patched zone by weathering. They seem to have high permeability. Most dam sites would require careful treatment against leakage. Rivers in this district eat their ways through gentle or flat land with shallow depth. Therefore abutment of dam sites are low. Most of the dams could not be higher than 10 m. Sediment load retained in dam is undoubtedly a serious problem.

Embankment materials nearby dam sites are residual soils of bed rock and deluvial or alluvial unconsolidated soil. Those materials contain much amount of silty soil which is weak against erosion and piping in low density condition. Sand material can be obtained from river bed, but it must be washed to clean. Most of the dam sites in this district have low or less potentiality for medium scale dam from geological and topographical viewpoint.

(4) Gutu District

A bed rock in this district is granite. It is usually massive and hard rock with thickness of less than two meters of weathered surface rock. Mostly it is suitable for dam foundation. But granite in the eastern area where it has three dam sites (Musangwe; IV-4-6, Chingai; IV-4-7 and Mutanda: IV-4-8) is highly weathered granite. This granite forms thick, soft and extremely pervious layer.

Most of the abutments are covered with unconsolidated soil. The thickness is considered to be less than three meters.

Sediment load retained by dam might be not serious, except eastern area of this district.

Embankment materials can be obtained on the hill slopes in the vicinity of dam site. They are sandy to clayey soils, which originate from granite. Sand materials are available from river bed, but not abundant. Rock materials are boulder or massive rock from river bed or hilly quarry site around dam site.

(5) Masvingo District

A bed rock in this district is mainly granite or granitic gneiss. Most of granite is hard and massive. But some of granite have open crack in the surface layer. Granitic gneiss in this distinct is more weathered than granite and the cracky zone is well developed. Dolerite and granite with diorite intrusion were distributed in Munongo (V-1-1) and Fusira (V-3-2), respectively. Those rocks are very hard but abundant in open cracks into deep foundation, which might cause hazardous leakage. The majority of dam sites have unconsolidated soils layer on the abutment. Its thickness is ranging about two to five meters. Sediment load is anticipated to be fairly large.

Embankment materials for dam can be obtained on the hill sloped nearby dam site. They are sandy to clayey, and originate from granitic rocks. Sand material is not abundant near the dam site, except Maramwidze (V-3-1) and Magudu (V-3-3).

(6) Chivi District

A bed rock in this district is granitic rock basically. In Mashaba and the northern area of Chivi C.L. it is granite or porphyritic granite. This has shearing or foliated zone and accordingly has soft and pervious zone partly to mostly. A granite in Chasiya (VI-1-8), however, is wholly hard and massive rock with partial open cracks in the surface layer. A bed rock of the middle and southern area of Chivi C.L. is gneiss. Gneiss is mostly hard and massive. But sheared zone is soft or excessively cracky rock which can be observed in Musuvovi (VI-1-4) Zifunzi No. 2 (VI-1-6) sites.
Sand and silt deposits are frequently observed on and along the river bed. This will insinuate that sediment load retained by dam is fairly large.

Every embankment and construction material can be obtained in the vicinity of the dam site. More than half the number of potential dams could not be 10 m in height because of topographical condition.

(7) Zaka District

A bed rock in this district is granitic rock, basically. It is granite or porphyritic granite or granitic gneiss. It is generally hard and massive rock. Most of dam sites have weathered rock which changed into soft or boulder-like and semi-pervious or pervious zone in the abutment or both of abutment and riverbed. Thickness of this zone may not mostly exceed five meters in abutments. Intrusion of dolerite was partly existing in the district. It is fine and hard rock, but excessively cracky and very pervious near the surface. This dolerite is observed in Mubvuti (VII-1-12) sites, where cracky dolerite may develop more than 10 meters deep from river bed.
An unconsolidated soil deposit is rather thin. This may be less than two meters in most of dam site.

Every embankment material and construction material for dam can be obtained in the vicinity of dam site. Soil material is from the hilly slope. Sand material is from riverbed. Rock material is from river bed or quarry site, but reasonable size of gravel or stone is scarce. This may need the process of crushing or blasting.
Soil materials in this district as well as other districts are usually dry condition. To excavate them efficiently and to use for impervious embankmet, control of water content must be taken, such as wet season construction and stock-piling.
To ensure safety and good quality of imperivous embankment soil properties of coefficient o premiability must be tested, as most soils contained much sand or silt.

3.2.2. List of Dam site and Scale of Reservoir

Through the field investigation dam axes of most sites have been selected in taking into account topographical and geological condition and an alignment of appurtenant dam structures. For those dam sites where field investigation was not conducted, selections of dam axes are based on studies on 1:10,000 maps which were made by 1/25,000 aerophotograph.

Table II-3-2 shows the name and number of each damsite with location (coordinates with dam axis and river), elevation of riverbed, catchment area, possible capacity of reservoir, etc. For the estimation of possible capacity of reservoir following conditions are taken into consideration.

1) No definition or regulation on medium size dam are spread in Zimbabwe. But a guideline described below is commonly used in MEWRD.

Dam size	Capacity of Reservoir (M.C.M.)	Dam height (m)
Small	Below 1	Below 8
Medium	1 - 3	8 - 15
Large	3 - 20	15 - 30
Major	Above 20	Above 30

The above guideline shows the maximum dam height of medium scale is 15 m. If the project follows above guideline on dam height, many potential damsites cannot exceed the reservoir capacity of one MCM. This is not considered to be enought capacity for the planning of medium scale irrigation project. Scale of dam height is considered to be only one factor and not to have severe restriction for the project scale. At this stage of the Study, limit of maximum dam height of 18 m is adopted, that is 20 percents increase to that of the above guideline for medium size.

For the estimation of capacity of reservoir, full water level of reservoir is set to be two meters below dam crest. This includes wet and dry freeboard.

2) In case there is suitable dam height for spillway setting, full water level can be placed below the maximum limit mentioned in the above condition. Because construction of spillway will affect the dam cost heavily, especially on the weak spillway foundation.

3) Excessively long dam would require much construction cost and might induce evil social impact. To avoid them and for the convenience of dam planning, length of dam crest is limited to less than 1 km.

The possible capacity of each reservoir shown in the Table 4-9 is derived from the above conditions without any consideration on the hydrological condition.
The number of dam sites with storage capacity of more than 1 MCM is shown as follows. Both districts of Gaza Komanani and Chivi show lower potentiality for medium scale dam than the rest.

	District	Number of damsites with storage capacity more than 1 MCM
I.	Batanai	6/8
II.	Bikita	6/14
III.	Gaza komanani	10/18
IV.	Gutu	14/18
V.	Masvingo	11/13
VI.	Chivi	3/10
VII.	Zaka	11/13

3.2.3. Dam Type and Preliminary Design

Damsites in this scheme mostly have low but long abutment. Concrete type dams are apparently less economic than fill type dams. Some damsites have narrow valley with solid rock foundation which can bear the stress of any concrete type of dams. However, it will be costly to quarry and produce concrete aggregates for a dam. Accordingly fill type is best to be adapted basically for all the dams in this scheme.

A fill type dam can be roughly classified into two groups, i.e. earthfill dam and rockfill dams. Earth materials are available in the vicinity of every dam site. The embankment materials do not require so high strength as rocks because of the low dam height. In taking into account the cost of both earth and rock material, earthfill dam is suitable to every dam site in the Project.

Earth materials in the most damsites are in rather dry condition for embankment. This will require careful control of water contents. Most of earth materials contain much sand and silt particles with less consistency.

They will not be able to get sufficient imperviousness without proper control of water contents and compactions. Considering above characteristic of earth material, zoned type (center core) earth fill dam is judged to be suitable for this medium scale dams. However, a homogeneous earth dam can also be adapted if dam is low.

To proceed the preliminary design of dam, followings will be taken into consideration.

1) Top Width of Dam (B)

The top width of dam is decided at 6 m in adapting the current guideline in Zimbabwe.

Small	4 m
Medium	6 m
Large (Major)	8 m

2) Dry Freeboard

Dry freeboard above high water level (at design flood discharge) will be derived the formula belows:

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

where h: Design wave height

V: Wind velocity in km/hour

V = 55 km/hour is adapted.

F: Fetch in km.

For the design of freeboard modification factor of 1.5 is applied to include the uprush on the dam slope.

3) Slope of Dam

Upstream and downstream slopes of dam will be designed through the circular slip calculation. Shear strength of embankment will be estimated on the physical properties of materials. For the stability calculation, no effect of earthquake will be taken into account.

4) Protection of slopes

To protect slopes of dam against erosion by wave, rainfall runoff, wind, etc, the upstream slope will be covered with rip-rap or pitching of rocks. Downstream slope will have grass cover. A surrounding of embankment will also be protected with a fence of barbed wire against inroad by cattle.

5) Spillway

A foundation of spillway weir should be placed on hard rock. A weir will be made of concrete or stone masonry. Chute and channel of spillway will generally be made without concrete lining by trimming hard rocks. For the dam site with deep soil or weathered rock foundation, concrete flume type chute and channel will be constructed on the firm foundation.

6) Outlet

Outlet facilities are installed on the consolidal dam foundation to release reservoir water smoothly to downstream of dams. Discharge of water will be controlled by the valve or gate at existside of conduit.

7) Diversion of River

Embankment works will be conducted during dry season. Accordingly no special diversion structure for large discharge will be required.

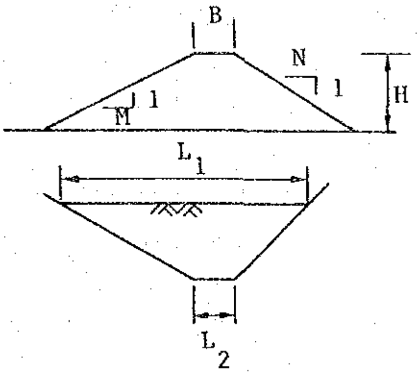
3.2.4. Estimation of Construction Quantity

A stage capacity curve of reservoir has been made for every potential dam sites. A hydrological analysis based on the data and the above stage capacity curve gives the storage capacity and normal full water level of reservoir. A major feature of dam and relevant facilities are estimated and shown in the Table II-3-3. Estimation of work quantities are obtained by the formula described below.

1) Embankment Volume

Embankment volume of dam is calculated by following formula.

$$Vb = \frac{1}{2} B\cdot H(L1 + L2) + \frac{1}{6} (M + N)\cdot H^2\cdot(L1 + 2L2)$$



where Vb: Volume (cu.m)

H: Height of dam (m)

L1: Length of dam crest (m)

L2: Width of river bed (m)

M.N: Slope ratio of dam (m)

(M = 2.25, N = 2.0)

B: Width of dam crest (6 m)

2) Excavation Volume

Excavation volume of dam foundation will roughly be calculated by the following formula.

$$Ve = [B + (M+N)\cdot H/2]\cdot L2\cdot D$$
$$+ [B + (M+N)\cdot H/4]\cdot(L1 - L2)\cdot D$$

where Ve: Excavation volume (cu.m)

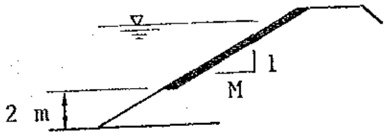
D: Depth of excavation (1 m)

3) Protection of Upstream Slope

Area of rock pitching as protection of slope are roughly calculated by following formula.

$$A = \sqrt{1 + M^2}\cdot(H-2)\{L2 + \frac{1}{2}(L1 - L2)\}$$

where A: Area of protection (sq.m)



4) Grouting

A grouting with cement milk will be applied to the pervious foundation with open cracks. Rows of grouting are two with 2 m width and intervals of grout holes in the same row are also 2 m. Depth of grouting is planned to be half of dam height or 5 m in minimum.

5) Spillway Chute and Channel

Dam sites where hard rock foundation is not expected will have concrete flume chute or channel. Typical cross section of chute or channel are briefed below.

a) Type and Dimension according to Discharge

The types and dimensions of the spillways are roughly classified into following three groups according to the design flood discharge.

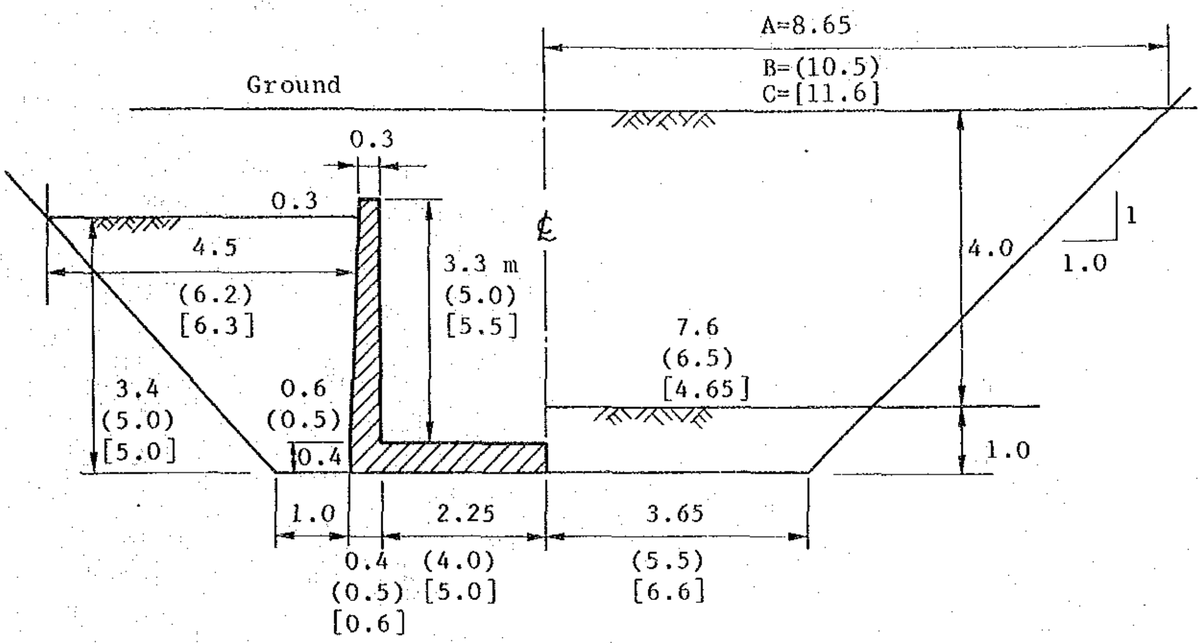
Discharge (cu.m/sec)	Scale
less than 100	Small (Type A)
100 - 300	Medium (Type B)
more than 300	Large (Type C)

b) Section of channel can be designed by the calculation of following hydraulic formula which is useful at critical flow. Cross section will be rectangular where width is as double as critical flow depth.

$$dc = 0.467 \ (Qd/B)^{2/3}$$

where dc: Critical flow depth (m)
Qd: Design discharge (cu.m/sec)
B: Width (m)

For the estimation of the dimension of the flume, the design discharges of 50, 200 and 300 cu.m/sec are adopted for type A, B, and C, respectively.



No parenthesis	Type A
( )	Type B
[ ]	Type C

Table II-3-2 Number of Dam Sites in District and Communal Land

District	Total No. of Dam Sites	Communal Land	No. of Dam Sites
I . BATANAI	8	1. Maranda	3
		2. Matibi No.1	5
II . BIKITA	14	1. Bikita	11
		2. Matsai	3
III . GAZA KOMANANI	18	1. Matibi No.2	5
		2. Sangwe	5
		3. Sengwe	8
IV . GUTU	18	1. Chikuwanda	4
		2. Denhere	1
		3. Serima	2
		4. Gutu	11
V . MASVINGO	13	1. Masvingo	3
		2. Mtilikwe	4
		3. Nyajena	3
		4. Zimutu	3
VI . CHIVT	10	1. Chivi	8
		2. Mashaba	2
VII . ZAKA	13	1. Ndanga	13
Total	94		94

Table II-3-3 (1) Major Features of Proposed Dam Sites

Name		Dam No.	Map Ref.	Coordinate of Damsite	Catch-ment A. (Km^2)	El. of Site (m)	El. of F.W.(M) (m)	App. Vol. of Res. (MCM)
BATANAI	Cheshauga	I-1- 1	2130 A1	TM 098583	14.9	662	674	0.70
	Sipala	1- 2	2130 A2	TM 213688	22.5	616	627	1.80
	Dengenya	1- 3	〃	TM 291604	21.3	594	602	0.50
	Musaverema	2- 1	2030 D3	TN 397011	131.0	672	680	4.78
	Zvirikure	2- 2	〃	TM 500868	25.0	620	636	3.00
	Cingami	2- 3	〃	TM 528822	36.2	592	602	1.30
	Mushava	2- 4	2130 B1	TM 479671	9.9	597	607	2.00
	Boyi	2- 5	〃	TM 459669	23.8	583	590	1.99
BIKITA	Muruwira	II-1- 1	1931 D3	UP 591022	20.6	910	925	0.74
	Musukutwa	1- 2	1931 D4	UP 772038	9.2	833	845	0.59
	Mutsinzwa	1- 3	〃	UN 872960	23.2	759	770	0.88
	Maranganyika	1- 4	〃	UN 907926	15.9	793	808	0.59
	Mundzami	1- 5	2031 B1	UN 628769	11.6	802	818	0.42
	Chinyamatumwa	1- 6	〃	UN 654702	16.4	736	754	3.60
	Chanyau	1- 7	〃	UN 618871	10.0	993	1009	1.30
	Beta	1- 8	2031 B2	UN 747784	30.8	786	802	0.65
	Chikuku	1- 9	〃	UN 807871	27.0	810	826	1.13
	Chigumisirwa	1-10	〃	UN 791799	16.3	778	791	1.50
	Boora	1-11	〃	UN 825814	16.1	750	766	1.20
	Mashoko	2- 1	2031 B4	UN 709346	27.2	644	656	0.95
	Zindove	2- 2	〃	UN 740375	10.6	627	640	0.93
	Mafaune	2- 3	〃	UN 855398	34.6	555	562	0.40
GAZA KOMANANI	Majijimbe	III-1- 1	2131 A4	UM 433376	84.3	395	398	0.99
	Chanyenga'	1- 2	2131 C2	UM 241122	40.7	437	442	0.30
	Mpagati	1- 3	〃	UM 306103	41.6	423	432	2.40
	Malisanga	1- 4	2131 B3	UM 490413	55.0	380	383	0.60
	Chingelelani	1- 5	〃	UM 617308	282.0	386	391	0.70
	Chisakwasi	2- 1	2032 C1	VN 159097	115.5	408	415	1.13
	Chegwama	2- 2	2032 C3	VN 115005	9.7	430	440	1.19
	Chompimbi	2- 3	〃	VM 050892	13.5	408	415	0.61
	Chitsa	2- 4	2132 A1	VM 092649	3.8	380	385	0.89
	Chitsazani	2- 5	〃	VM 122640	60.4	370	375	0.48
	Dunezo	3- 1	2131 C3	UL 132736	13.8	472	483	1.48

Table II-3-3 (2) Major Features of Proposed Dam Sites

Name		Dam No.	Map Ref.	Coordinate of Damsite	Catch-ment A. (Km^2)	El. of Site (m)	El. of F.W.(M) (m)	App. Vol. of Res. (MCM)
GAZA KOMANANI	Shavani	Ⅲ-3- 2	2131 C3	UL 099707	30.0	474	485	1.80
	Malibangwe	3- 3	2231 A1	UL 050614	38.5	398	410	2.55
	Gezani	3- 4	〃	UL 092573	21.8	360	375	3.75
	Chomnanga	3- 5	〃	UL 162540	25.0	304	320	3.01
	Mangezi	3- 6	2231 A2	UL 286392	20.6	231	242	1.80
	Grootvlei	3- 7	2231 A3	UL 086321	39.5	217	220	0.23
	Thinana	3- 8	2131 A1	UL 023528	25.0	404	413	1.00
GUTU	Mutema	IV 1- 1	1930 D4	TP 887008	28.3	1156	1168	1.10
	Gabriel	1- 2	1931 C3	TN 948971	22.7	1153	1163	2.20
	Chimedza	1- 3	〃	UP 008031	11.8	1215	1230	4.95
	Mukaro	1- 4	〃	UP 108108	7.2	1302	1313	2.00
	Chimombe	2- 1	1931 A3	UP 127694	7.0	1221	1237	1.65
	Gondongwe	3- 1	1930 B4	TP 836453	16.4	1406	1422	1.15
	Vushe	3- 2	1930 D2	TP 785355	23.9	1384	1400	2.66
	Chinyika	4- 1	1931 C2	UP 374420	33.4	1103	1110	0.49
	Chatikobo	4- 2	〃	UP 277385	17.5	1149	1160	1.68
	Muruta	4- 3	〃	UP 322333	13.0	1093	1107	1.85
	Mutero	4- 4	〃	UP 362272	17.5	1068	1080	2.47
	Sinbanegavi	4- 5	〃	UP 208185	32.8	1200	1211	1.25
	Mushangwe	4- 6	1931 D1	UP 624271	18.5	970	977	0.28
	Chingai	4- 7	1931 D2	UP 735184	9.9	899	905	0.57
	Mutanda	4- 8	1931 D4	UP 726091	10.4	842	858	2.30
	Mukuro	4- 9	1931 C2	UP 263228	219.0	1121	1130	1.17
	Munjanganja	4-10	1931 C4	UP 278155	52.8	1134	1150	1.24
	Masunda	4-11	1931 C2	UP 355375	3.1	1097	1110	1.68
MASVINGO	Munongo	V 1- 1	2030 B4	TN 680540	15.3	898	907	0.30
	Musingarabwe	1- 2	〃	TN 694443	9.5	863	878	1.40
	Matsikidzi	1- 3	2031 A3	TN 969386	48.7	744	760	4.27
	Makwawa	2- 1	〃	UN 019546	16.0	862	878	0.70
	Vzeze	2- 2	〃	TN 945503	11.0	861	877	1.90
	Majiri	2- 3	〃	UN 004438	20.7	699	715	1.35
	Chatikubo	2- 4	〃	UN 065396	20.5	675	691	1.75
	Maramwidze	3- 1	2031 C1	TN 981181	15.0	733	749	1.40

Table II-3-3 (3) Major Features of Proposed Dam Sites

Name		Dam No.	Map Ref.	Coordinate of Damsite	Catch-ment A. (㎢)	El. of Site (m)	El. of F.W.(M) (m)	App. Vol. of Res. (MCM)
MASVINGO	Fusira	V-3- 2	2031 C1	UN 041091	30.8	556	572	3.00
	Magudu	3- 3	2031 C3	UN 078021	41.9	514	530	6.42
	Marongera	4- 1	1930 D2	TP 776174	11.4	1255	1270	4.20
	Macheka	4- 2	1930 D4	TP 850143	29.2	1217	1225	1.21
	Mahoto	4- 3	〃	TN 768959	23.4	1139	1148	1.20
CHIVI	Chirongwe	Ⅵ 1- 1	2030 D1	TN 473312	13.8	808	824	2.00
	Nemavuzhe	1- 2	〃	TN 558195	19.2	735	740	0.45
	Madzivire	1- 3	2030 D4	TM 682955	21.3	603	611	0.07
	Musuvovi	1- 4	2030 D1	TN 477081	5.9	670	680	1.06
	Magwari	1- 5	〃	TN 619121	15.0	675	683	0.45
	Zifunzi No.2	1- 6	2030 D2	TN 724116	6.4	670	677	0.33
	Takavarasha	1- 7	2030 A4	TN 171525	30.4	811	818	0.50
	Nyamakwe	1- 8	2030 B3	TN 552488	22.1	819	830	0.63
	Mukovoriri	2- 1	2030 A1	TN 065775	9.8	922	930	0.69
	Nadangombe	2- 2	2030 A2	TN 209819	4.4	986	1000	0.89
ZAKA	Zishiri	Ⅶ 1- 1	2031 A2	UN 201648	14.0	1027	1045	2.41
	Chida	1- 2	〃	UN 317732	20.0	969	985	0.44
	Veza	1- 3	2031 A4	UN 254470	18.3	749	765	1.50
	Zinguo	1- 4	〃	UN 285370	9.3	669	685	0.83
	Nemakau	1- 5	〃	UN 303557	10.6	797	810	1.15
	Siyawarewa	1- 6	〃	UN 423388	16.2	687	698	1.10
	Manjeru	1- 7	〃	UN 291471	8.5	727	740	1.04
	Chenya	1- 8	〃	UN 197404	25.1	671	687	4.50
	Maraire	1- 9	2031 B3	UN 520545	8.7	712	728	1.70
	Chivamba	1-10	〃	UN 515488	18.5	701	713	1.78
	Fuve	1-11	〃	UN 552490	48.1	675	688	2.54
	Mabvute	1-12	2031 C2	UN 388234	31.1	630	645	2.93
	Mujena	1-13	〃	UN 306265	35.9	605	621	1.70

3.3. Reservoir Yield

3.3.1. Maximum Storage of Reservoir

Maximum storage capacity at proposed dam site is determined through the field investigation on the topographical viewpoint, by using the stage capacity curve derived from the map (scale of 1/10 000).

The value of storage ratio, determined to get the maximum storage on the physical viewpoint, is seen in the wide range form 0.06 to 18.06, although the applied ratio for the design criteria of medium size dam in Zimbabwe is limited in the range of 0.1 - 2.0 practically. With regard to the ninety four dam sites listed in the inventory, the five sites, of which ratio is less than 0.1, are recognized as unsuitable due to loss of entire capacity by the siltation within a project life.

On the other hand, the maximum reservoir capacity of twenty six dam sites, of which ratio exceeds the practical upper limit of 2.0, are confined to two times of MAR in order to save the loss of evaporation.

3.3.2. Potential Yield

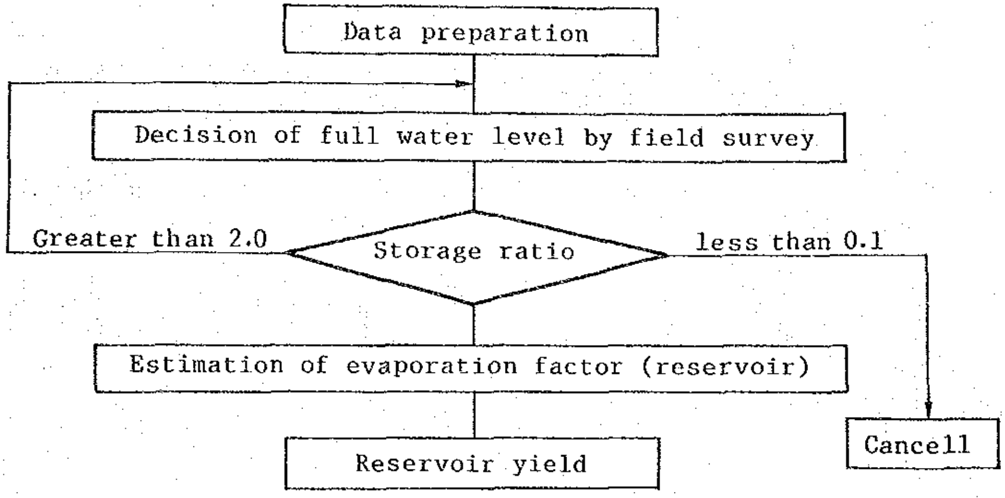
The risk factor of the agriculture project has been accepted to employ 10 per cent by MEWRD, although that is recently discussed to adopt 20 per cent risk factor which is widely used by commercial farmers in order to utilize the limited water resources as favourably as possible from the economic viewpoint.

However, the applied risk factor for the Project is confirmed to use 10 per cent , because of the low intensity of farm management in communal lands when compared with that of the commercial farms.

Accordingly, to work out the reservoir yield of 10 per cent risk level, the "Transition Probability Matrix" method commonly applied by MEWRD for the water resource estimation of domestic project is adopted by using the hydrological and topographical data according to the order shown below;

Hydrological data ------------- mean annual rainfall, runoff,
evaporation 10, year's probable
rainfall, coefficient of variation

Topographical data ------------ stage capacity curve, catchment area
sediment yield (for 20 years period)



Calculation of Reservoir Yield

Hydrological features and reservoir yield of 94 dam sites are as listed in the Table II-3-4.

As a consequence of estimation, there is no dam site yielding more than 100 000 cu.m in the southern region of the Province (21°S in latitude) where the Chiredzi and Mwenezi districts known as the severe dry zone are located, which is the reason why no medium size dam has been developed in this region. On the other hand, the relatively high yields are seen in the northern region of the Province where 4 districts (i.e. Gutu, Bikita, Zaka and Masvingo) are located. Dam sites classified by the yield in each district are summarized as follows;

Table II-3-4 (1) Reservoir Yield

No. of	Mean Annual Inflow			Reservoir				Siltation			Evaporation Factor				10% Risk		
Dam Site	Rainfall	Runoff	Evap.	C.Area	R.Vol.	S.Ratio	S.Area	ton/yr.	m^3/20yr.s	E.vol.	Evap.F.	MAR/EF	CV	Q/MAR	Yield	W.Right	Remarks
	(mm)	(mm)	(mm)		×10^3		×10^3		×10^3	×10^3		×10^3			×10^3	×10^3	
I-1-1	540	26	1800	14.9	700	1.81	190	270	60	640	0.12	3300	130	0.19	74		
I-1-2	580	34	1800	22.5	1530	2.0	525	270	90	1440	0.46	1700	130	0.11	84		
I-1-3	560	29	1800	21.3	640	1.04	263	270	90	550	0.41	1500	130	0.09	56		
I-2-1	580	34	1700	131.0	4780	1.07	1586	270	520	4260	1.18	3800	120	0.18	801		
I-2-2	650	51	1700	25.0	2550	2.0	538	270	100	2450	0.13	10000	120	0.35	447		
I-2-3	650	51	1700	36.2	1300	0.70	421	270	140	1160	0.27	6700	120	0.15	277		
I-2-4	600	38	1800	9.9	750	2.0	322	270	40	710	0.43	900	130	0.08	30		
I-2-5	600	38	1800	23.8	1810	2.0	687	270	100	1710	0.72	1300	130	0.09	81		
II-1-1	700	66	2000	20.6	740	0.54	162	310	90	650	0.09	16000	110	0.20	272		
II-1-2	800	103	2000	9.2	550	0.58	140	310	40	510	0.08	12000	110	0.22	208		
II-1-3	750	83	2000	23.2	770	0.40	165	310	110	660	0.08	23000	110	0.18	347		
II-1-4	710	69	2000	15.9	590	0.54	147	310	70	520	0.10	11000	110	0.19	208		
II-1-5	980	194	1900	11.6	430	0.19	78	310	50	380	0.02	131000	100	0.13	293	32	
II-1-6	800	103	1900	16.4	2450	1.45	491	310	80	2370	0.13	13000	100	0.39	659		
II-1-7	880	140	2000	10.0	1340	0.96	298	310	50	1290	0.11	12000	110	0.29	406		
II-1-8	880	112	2000	30.8	660	0.19	138	310	140	520	0.07	50000	100	0.10	345		
II-1-9	820	112	2000	27.0	1160	0.38	209	310	120	1040	0.06	47000	150	0.12	363		
II-1-10	800	103	2000	16.3	1500	0.89	364	310	70	1430	0.18	9200	150	0.19	319		
II-1-11	780	95	2000	16.1	1200	0.78	240	310	70	1130	0.09	18000	150	0.18	275		
II-2-1	640	48	1800	27.2	1020	0.78	288	320	130	890	0.19	7000	140	0.19	248		
II-2-2	630	45	1900	10.6	930	1.95	240	320	50	880	0.14	3500	100	0.29	138		
II-2-3	590	36	1900	34.6	500	0.40	235	320	160	340	0.90	1400	100	0.09	112		

Note: Evap.=Evaporation, C.Area=Catchment Area(km^2), R.Vol=Reservoir volume(×10^3 m^3), S.Ratio=Storage Ratio, S.Area=Reservoir Surface Area(×10^3 m^2), E.vol.=Effective volume(×10^3 m^3), Evap.F.=Evaporation Factor, MAR=Mean Annual Runoff, CV=Coefficient of variation, W.Right=Water Right(m^3)

Table II-3-4 (2) Reservoir Yield

No. of	Mean Annual Inflow			Reservoir				Siltation			Evaporation Factor				10% Risk		
Dam Site	Rainfall	Runoff	Evap.	C.Area	R.Vol.	S.Ratio	S.Area	ton/yr.	m^3/20yr.s	E.vol.	Evap.F.	MAR/EF	CV	Q/MAR	Yield	W.Right	Remarks
	(mm)	(mm)	(mm)		$\times 10^3$		$\times 10^3$		$\times 10^3$	$\times 10^3$		$\times 10^3$			$\times 10^3$	$\times 10^3$	
III-1-1	500	19	2000	84.3	990	0.62	772	45	60	930	5.5	300	150	0.01	16		
III-1-2	450	13	2100	40.7	290	0.55	146	45	30	260	0.60	900	160	0.02	11		
III-1-3	460	14	2100	41,6	1160	2.0	499	45	30	1130	1.2	500	160	0.02	12		
III-1-4	520	22	2000	55.0	600	0.50	603	45	40	540	7.7	200	150	0.01	12		
III-1-5	530	24	2100	282.0	700	0.10	538	45	190	510	7.2	900	150	0.01	67		S.Ratio=0.1
III-2-1	530	24	2000	115.5	1650	0.60	533	45	80	1570	0.62	4400	150	0.10	277		
III-2-2	570	31	2000	9.7	600	2.0	201	45	10	590	0.23	1300	150	0.07	21		
III-2-3	580	33	2000	13.5	420	0.94	153	45	10	410	0.20	2200	140	0.10	45		
III-2-4	570	31	2100	3.8	240	2.0	158	45	10	230	0.87	140	140	0.01	1		
III-2-5	570	31	2100	60.4	480	0.26	250	45	40	440	0.94	2000	140	0.04	75		
III-3-1	470	15	2100	13.8	410	2.0	191	45	10	400	0.56	400	160	0.01	2		
III-3-2	470	15	2100	30.0	900	2.0	270	45	20	880	0.32	1400	160	0.05	22		
III-3-3	430	11	2100	38.5	850	2.0	312	45	30	820	0.59	700	160	0.02	8		
III-3-4	400	8	2200	21.8	350	2.0	149	45	20	330	0.48	400	160	0.01	2		
III-3-5	390	7	2200	25.0	350	2.0	143	45	20	330	0.43	400	160	0.01	2		
III-3-6	360	5	2200	20.6	210	2.0	113	45	10	200	0.58	200	160	0.01	1		
III-3-7	350	5	2200	39.5	230	1.16	176	45	30	200	2.2	100	160	0.01	2		
III-3-8	400	8	2200	25.0	400	2.0	159	45	20	380	0.44	500	200	0.01	2		
IV-1-1	700	65	1800	28.3	1050	0.57	297	60	30	1020	0.15	12700	95	0.23	423		
IV-1-2	710	69	1800	22.7	2200	1.4	642	60	20	2180	0.32	4900	100	0.30	469		
IV-1-3	730	75	1900	11.8	1770	2.0	399	60	10	1760	0.15	6000	100	0.34	301		
IV-1-4	760	87	1900	7.2	1250	2.0	439	60	10	1240	0.37	1700	100	0.20	125		
IV-2-1	800	102	1900	7.0	1430	2.0	280	330	30	1400	0.07	10000	100	0.41	293		

Table II-3-4 (3) Reservoir Yield

No. of	Mean Annual Inflow				Reservoir			Siltation			Evaporation Factor				10% Risk		
Dam Site	Rainfall	Runoff	Evap.	C.Area	R.Vol.	S.Ratio	S.Area	ton/yr.	m^3/20yr.s	E.vol.	Evap.F.	MAR/EF	CV	Q/MAR	Yield	W.Right	Remarks
	(mm)	(mm)	(mm)		×10^3		×10^3		×10^3	×10^3		×10^3			×10^3	×10^3	
IV-3-1	780	95	1900	16.4	1180	0.76	241	60	20	1160	0.07	23000	95	0.28	436		
IV-3-2	780	95	1900	23.9	2660	1.17	495	60	20	2640	0.11	20100	95	0.34	772		
IV-4-1	720	72	1900	33.4	400	0.17	189	320	160	240	0.81	3000	110	0.06	144		
IV-4-2	720	91	1900	17.5	1390	0.87	397	320	80	1310	0.24	6600	110	0.22	350		
IV-4-3	730	76	1900	13.0	1690	1.71	490	320	60	1630	0.30	3300	110	0.20	198		
IV-4-4	710	69	1900	17.5	2420	2.0	552	320	80	2340	0.22	6000	110	0.32	386		
IV-4-5	770	91	1900	32.8	1250	0.42	374	320	160	1090	0.29	10000	110	0.16	477		
IV-4-6	600	38	2000	18.5	350	0.50	155	320	90	260	0.53	1300	100	0.10	70		
IV-4-7	600	38	2000	9.9	580	1.54	217	320	50	530	0.35	1100	100	0.15	56		
IV-4-8	700	66	2000	10.4	1370	2.0	293	320	50	1320	0.12	5500	110	0.32	220		
IV-4-9	760	87	1900	219.0	1170	0.06	330	320	1040	130	14.2	1300	110	0.01	190		S.Ratio<0.1
IV-4-10	740	79	1900	52.8	1240	0.30	365	320	250	990	0.34	12400	110	0.14	584		
IV-4-11	720	72	1900	3.1	450	2.0	162	320	10	440	0.15	1500	110	0.16	36		
V-1-1	740	79	1600	15.3	300	0.02	99	530	120	180	0.10	12000	120	0.01	12		S.Ratio<0.1
V-1-2	780	95	1600	9.5	760	0.84	171	530	70	690	0.03	26000	100	0.30	270	24	
V-1-3	760	87	1600	48.7	4270	1.01	711	230	170	4100	0.07	5900	90	0.31	1313		
V-2-1	890	145	1600	16.0	700	0.30	101	230	50	650	0.007	341000	90	0.23	534		
V-2-2	900	150	1600	11.0	1900	1.15	314	230	40	1860	0.025	67000	90	0.47	776		
V-2-3	900	150	1600	20.7	1350	0.44	296	230	70	1280	0.04	71200	90	0.24	745		
V-2-4	800	102	1600	20.5	1750	0.84	388	230	70	1680	0.07	32000	90	0.35	732		
V-3-1	830	103	1600	15.0	1400	0.91	311	230	50	1350	0.05	31000	90	0.36	556		
V-3-2	790	99	1600	30.8	3000	0.98	618	230	110	2890	0.09	33000	90	0.37	1128		
V-3-3	710	69	1700	41.9	5780	2.0	1295	230	150	5630	0.31	9200	120	0.33	954		

Table II-3-4 (4) Reservoir Yield

No. of	Mean Annual Inflow				Reservoir			Siltation			Evaporation Factor				10% Risk		
Dam Site	Rainfall	Runoff	Evap.	C.Area	R.Vol.	S.Ratio	S.Area	ton/yr.	m^3/20yr.s	E.vol.	Evap.F.	MAR/EF	CV	Q/MAR	Yield	W.Right	Remarks
	(mm)	(mm)	(mm)		$\times10^3$		$\times10^3$		$\times10^3$	$\times10^3$		$\times10^3$			$\times10^3$	$\times10^3$	
V-4-1	690	62	1900	11.4	1410	2.0	428	60	10	1400	0.29	2500	95	0.24	170		
V-4-2	690	62	1900	29.2	1210	0.67	437	60	30	1180	0.43	4200	95	0.18	326		
V-4-3	670	56	1800	23.4	1280	0.98	423	60	20	1260	0.28	4600	95	0.21	275		
VI-1-1	560	29	1600	13.8	800	2.0	208	70	10	790	0.06	6300	130	0.27	108	45	
VI-1-2	570	31	1600	19.2	350	0.59	186	70	20	330	0.25	2300	120	0.10	60		
VI-1-3	690	62	1700	21.3	70	0.05	27	70	20	50	0.04	37000	120	0.01	13		S.Ratio<0.1
VI-1-4	570	31	1600	5.9	370	2.0	154	70	10	360	0.12	1500	120	0.12	22		
VI-1-5	600	38	1600	15.0	520	0.91	244	70	20	500	0.24	2300	120	0.11	63		
VI-1-6	650	51	1600	6.4	330	1.01	141	70	10	320	0.11	3100	100	0.19	62		
VI-1-7	590	36	1700	30.4	500	0.46	228	70	30	470	0.29	3800	130	0.10	109		
VI-1-8	590	36	1600	22.1	630	0.79	188	70	30	600	0.08	10100	120	0.23	183	24	
VI-2-1	620	43	1800	9.8	690	1.64	252	700	100	590	0.29	1400	120	0.12	51		
VI-2-2	620	43	1800	4.4	380	2.0	121	440	30	350	0.09	2100	120	0.12	23		
VII-1-1	1000	206	1700	14.0	1670	0.58	330	320	70	1600	0.04	66000	85	0.34	981		
VII-1-2	1070	250	1800	20.0	440	0.09	64	320	90	350	0.008	640000	85	0.10	500		S.Ratio<0.1
VII-1-3	850	125	1600	18.3	1500	0.66	258	230	60	1440	0.02	94000	120	0.24	549		
VII-1-4	820	112	1600	9.3	970	0.93	182	270	40	930	0.02	48000	120	0.29	302		
VII-1-5	820	112	1700	10.6	1150	0.97	256	320	50	1100	0.06	22000	85	0.40	475	5	
VII-1-6	750	83	1700	16.2	1100	0.82	317	320	70	1030	0.13	10000	85	0.32	430		
VII-1-7	800	103	1700	8.5	1040	1.19	259	270	30	1010	0.07	13000	120	0.30	263		
VII-1-8	850	125	1600	25.1	4500	1.43	859	230	90	4410	0.10	32000	90	0.46	1443		
VII-1-9	740	79	1800	8.7	980	1.43	237	320	40	940	0.08	8300	100	0.34	234		
VII-1-10	720	72	1700	18.5	1950	1.46	450	320	90	1860	0.12	11200	100	0.38	506		
VII-1-11	710	69	1800	48.1	2790	0.84	678	320	230	2560	0.27	12200	100	0.30	996		
VII-1-12	810	107	1700	31.1	2930	0.88	601	320	150	2780	0.11	29000	85	0.38	1265		
VII-1-13	820	112	1600	35.9	1700	0.42	276	270	140	1560	0.03	150000	120	0.21	844		

Table II-3-5 Dam Sites Number Classified by Reservoir Yield

District	Average Yield (10^3m^3)	Above $1000x10^3m^3$ (Sites)	1000 - $500x10^3m^3$ (Sites)	500 - $200x10^3m^3$ (Sites)	Below $200x10^3m^3$ (Sites)	Total Dam Sites (Sites)
Gutu	307	0	2	9	7	18
Bikita	300	0	1	11	1	14
Zaka	676	2	6	5	0	13
Masvingo	599	2	6	3	2	13

3.4. Irrigation Water Requirements

3.4.1. Net Irrigation Water Requirement

The net irrigation water requirements for the proposed cropping programme are given in Table II-3-6. The monthly irrigation requirements have been calculated on the basis of applying Pan Evaporation Method.

According to Agritex Irrigation Handbook, Masvingo Province is divided into two areas of similar irrigation requirement; namely Area 4 and Area 5. The total annual net irrigation requirements for the two types of proposed cropping pattern are 815 mm and 790 mm in Area 4, and 983 mm and 987 mm in Area 5, respectively.

3.4.2. Gross Irrigation Water Requirements

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

Conveyance Efficiency (concrete lining)	0.9
Field Canal Efficiency (concrete lining)	0.9
Field Application Efficiency (flood irrigation)	0.6
Overall Efficiency	0.49
Say	0.5

The gross irrigaiton water requirement determined from the net irrigation requirements and the overall project efficiency, are 1,630 mm and 1,580 mm in Area 4, and 1,966 mm and 1,974 mm in Area 5, respectively. However in order to provide a degree of flexibility to allow changes in the cropping pattern, a water allocation equivalent to an annual depths of 1,700 mm in Area 4 and 2,000 mm in Area 5, respectively are adopted.

3.4.3. Peak Daily Water Requirements

The theoretical peak daily water requirement is based on a fully-matured crop (Et/Eo = 1), growing on the entire acreage during October when the daily pan evaporation at Makaholi Experimental Station in Area 4 and Chisumbanje Experimental Station in Area 5 are 7.42 mm and 8.03 mm, respectively. In assuming an overall efficiency of 50 per cent, the gross daily water requirements are 1.718 l/sec/ha for Area 4 and 1,859 l/sec/ha for Area 5 which will be used for planning of irrigation facilities.

3.4.4. Irrigation Plan

The method of applying irrigation water in the field is by furrows supplied with water from field canals through portable syphons. 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. Duration of supply to the field is 12 hours per day.

Design discharges for irrigation facilities are summarized in Table II-3-7.

Table II-3-6 Net Irrigation Water Requirements

Unit; mm/year

Crop	Net Irrigation Water Requirements			
	Area 4 1)		Area 5 1)	
	A 2)	B 2)	C 2)	D 2)
(Summar)				
Maize	325	271	413	379
Groundnuts	71	143	143	191
Vegetable	86	43	48	24
(Winter)				
Wheat	199	199	257	283
Sugar bean	90	90	98	98
Vegetable	44	44	24	12
Total	815	790	983	987

Notes

1) Area of Similar Irrigation Requirement (Agritex Irrigation Handbook).

Area 4 - Bikita, Gutu, Masvingo, Chivi and Zaka districts

Area 5 - Batanai and Gaza Komanani districts

2) A, B, C and D - Type of cropping pattern

3) Detailed estimates of Net Irrigation Water Requirements are given in Annex D-1

Table II-3-7 Design Discharge

Item	Unit Amount	
	Area 4	Area 5
Gross Irrigation Water Requirements	1,700 mm/year	2,000 mm/year
Design Discharge		
Conveyance Canal 1)	1,718 ℓ/sec/ha	1,859 ℓ/sec/ha
Pump Facilities 2)	2,577 ℓ/sec/ha	2,789 ℓ/sec/ha
Night Storage 3)	148 cu.m/ha	161 cu.m/ha

Notes

1) Peak crop evapotranspiration(mm/day) $\times \frac{1}{\text{overall efficiency}} \times$ conversion factor

$$7.42 \times \frac{1}{0.5} \times \frac{100}{864} = 1{,}718 \ (\ell/\text{sec/ha}) \text{ --- Area 4}$$

$$8.03 \times \frac{1}{0.5} \times \frac{100}{864} = 1{,}859 \ (\ell/\text{sec/ha}) \text{ --- Area 5}$$

2) Peak daily water requirement(ℓ/sec/ha) $\times \frac{24}{\text{pump operating hours}}$

$$1{,}718 \times \frac{24}{16} = 2{,}577 \ (\ell/\text{sec/ha}) \text{ ------- Area 4}$$

$$1{,}859 \times \frac{24}{16} = 2{,}789 \ (\ell/\text{sec/ha}) \text{ ------- Area 5}$$

3) Delivery (cu.m/hr/ha) × maximum period when no irrigation is taking place

$$1{,}718 \times \frac{3{,}600}{1{,}000} \times 24 \fallingdotseq 148 \ (\text{cu.m/ha}) \text{ ---- Area 4}$$

$$1{,}859 \times \frac{3{,}600}{1{,}000} \times 24 \fallingdotseq 161 \ (\text{cu.m/ha}) \text{ ---- Area 5}$$

3.5. Water Demand for Rural Water Supply

3.5.1. General

The project is expected to improve rural water supply as well as to introduce irrigated agriculture in communal lands. Rural water supply are largely divided into three categories, namely, domestic use, livestock watering and garden watering. In the projected rural water supply, potable water supply is, in principle, excluded for the following reasons.

1) 'National Master Plan for Rural Water Supply and Sanitation' proposes that a number of boreholes and protected well should be implemented throughout the communal lands in the Province.

2) Potable water supply by utilizing medium size dams requires water treatment systems inclusive of purification facilities. In view of the cost and operation and maintenance, groundwater is suitable as the source for drinking water in communal areas owing to the low costs, hygiene, proximity and easier maintenance of provided facilities.

Therefore, rural water supply plan in the project are formulated for 1) domestic use excluding potable water, 2) livestock use, and 3) gardening. As for garden watering, the water demand was neglected in this study because it is very hard to set out the number of beneficial farms and the water demand is expected to be much less than that for domestic and livestock use.

3.5.2. Water Demand for Domestic Use

The water demand on each potential dam is estimated on the basis of following premise.

1) Per capita daily water demand

The Ministry of Health suggests that clean water of thirty to fifty litres is necessary as per capita daily demand for communal people. Twenty litres equivalent to a half of such demand is herein applied as per capita daily water demand for domestic use other than drinking.

2) Number of beneficiaries

The population density of the ward which includes the dam site or irrigable area is applied to each project. Data of population density at the ward level were given from the rural (Ward) questionnaire survey which had been filled by regional AGRITEX staff.
With respect to the beneficial area, three alternative cases were set up as follows:

Case-D1	10 sq.km
Case-D2	30 sq.km
Case-D3	50 sq.km

The number of beneficiaries of each possible dam was calculated by multiplying the population density (person per sq.km) by the respective areas.

The population growth rate is not taken into account because the growth rate at ward level is not available and it is anticipated that numerous communal people would migrate to resettlement areas so as to solve the present high population density in communal lands.

On the basis of such assumption, the water demands of three cases were estimated respectively and the result is given in ANNEX-F. Among the water demands worked out by three cases, one is applied as the projected water demand.
Case-D1, Case-D2 and Case-D3 correspond to 'good', 'fair', and 'bad' in the present domestic water situation in order. The present domestic water situation around each possible dam is judged from rural (Ward) survey and information obtained by local authorities.

3.5.3. Livestock

1) Daily Water Demand per LSU (Livestock Unit)

Daily livestock water demand per Livestock Unit (LSU) is determined to be 45 litres based on information from AGRITEX and the discussion with the local staff concerned.

2) Number of LSUs

The number of LSUs per sq.km is given from the rural (Ward) survey as well as the population density. The following conversion factors of livestock are employed in order to compute the number of LSUs.

Cattle --------	0.65 LSU
Donkey --------	0.4
Goat --------	0.1

The above figure of cattle is determined, taking into account the rate of composition of cow, heier, calf, ox and bull among cattle. The present number of LSUs for grazing areas in the communal lands other than Sengwe C.L. shows overpopulation against the desired potential stocking rate recommended by AGRITEX. Hence, it is assumed that the present number of LSUs will remain static by the implementation of grazing schemes, livestock management schemes and land use schemes in the communal lands.

Consequently, as for the projected number of LSUs of each dam site, the present number is applied. The ratio of the grazing area to one LSU around every possible dam located in Sengwe C.L is less than 10 ha. In recent years, the animal rehabilitation project is proposed in Sengwe C.L and the number of cattle would increase. Accordingly, for every possible dam site in Sengwe C.L, the projected number of LSUs was determined by the ratio to grazing area as one to ten (1:10).

Three alternative cases in terms of the beneficial area were set forth as follows:

Case-L1 --------	20 sq.km
Case-L2 --------	50 sq.km
Case-L3 --------	100 sq.km

The annual water demand worked out by the respective cases are shown in ANNEX-F. The projected water demand was determined, taking into account the present water supply situation, that is, case-L1 to 'good', case-L2 to 'fair' and case-L3 to 'poor'.

Table II-3-8 shows the result of the preliminarily projected water demand for rural water supply.
The annual water demands are calculated on the assumption that water from the medium size dams is utilized among communal people throughout the year.

Table II-3-8 (1) Water Demand for Rural Water Supply (1/2)

(unit: thousand cu.m)

Dam. No.	Domestic Use		Livestock		Total
	Applied Case	Annual Demand	Applied Case	Annual Demand	Annual Demand
I. MWENEZI					
1. Maranda C.L					
I-1-1	D2	9.7	L3	11.3	21.0
I-1-2	D2	9.9	L3	48.1	58.0
I-1-3	D2	4.5	L3	9.2	13.7
2. Matibi No.1 C.L					
I-2-1	D2	9.8	L2	13.9	23.7
I-2-2	D2	11.7	L2	7.9	19.6
I-2-3	D2	9.4	L2	9.4	18.8
I-2-4	D2	10.9	L2	12.6	23.5
I-2-5	D2	10.9	L2	12.6	23.5
II. BIKITA					
1. Bikita C.L					
II-1-1	D1	10.4	L2	41.2	51.6
II-1-2	D2	29.4	L1	27.8	57.2
II-1-3	D1	12.1	L1	20.6	32.7
II-1-4	D2	29.4	L1	27.8	57.2
II-1-5	D1	5.9	L2	88.8	94.7
II-1-6	D1	5.9	L2	88.8	94.7
II-1-7	D1	10.7	L1	54.0	64.7
II-1-8	D2	8.1	L2	41.3	49.4
II-1-9	D1	13.9	L1	28.6	42.5
II-1-10	D2	8.1	L2	41.3	49.4
II-1-11	D1	13.9	L1	28.6	42.5
2. Matsai C.L					
II-2-1	D2	8.4	L2	21.3	29.7
II-2-2	D2	8.4	L2	21.3	29.7
II-2-3	D1	2.8	L3	63.8	66.6
III. CHIREDZI					
1. Matibi No.2 C.L					
III-1-1	D3	10.2	L2	8.5	18.7
III-1-2	D3	14.5	L2	9.4	23.9
III-1-3	D3	12.5	L2	9.0	21.5
III-1-4	D3	10.2	L2	8.5	18.7
III-1-5	D2	5.1	L2	7.4	12.5
2. Sangwe C.L					
III-2-1	D2	11.3	L2	16.1	27.4
III-2-2	D2	11.3	L2	16.1	27.4
III-2-3	D2	8.3	L2	16.1	24.4
III-2-4	D2	32.3	L2	16.1	48.4
III-2-5	D2	13.8	L2	16.1	29.9
3. Sengwe C.L					
III-3-1	D3	2.9	L3	14.9	17.8
III-3-2	D3	2.9	L3	14.9	17.8
III-3-3	D3	2.5	L3	14.8	17.3
III-3-4	D3	2.9	L3	14.9	17.8
III-3-5	D3	5.9	L3	15.8	21.7
III-3-6	D3	6.4	L3	15.6	22.0
III-3-7	D3	2.5	L3	14.8	17.3
III-3-8	D3	2.5	L3	14.8	17.3
IV. GUTU					
1. Chikuwanda C.L					
IV-1-1	D2	17.1	L1	7.5	24.6
IV-1-2	D2	17.1	L1	7.5	24.6
IV-1-3	D2	11.0	L1	13.1	24.1
IV-1-4	D2	8.4	L2	16.8	25.2
2. Denhere C.L					
IV-2-1	D2	16.4	L1	13.9	30.3

Table II-3-8 (2) Water Demand for Rural Water Supply (2/2)

(unit: thousand cu.m)

Dam. No.	Domestic Use Applied Case	Domestic Use Annual Demand	Livestock Applied Case	Livestock Annual Demand	Total Annual Demand
3. Serima C.L					
IV-3-1	D2	25.9	L2	25.2	51.1
IV-3-2	D2	26.4	L2	30.8	57.2
4. Gutu C.L					
IV-4-1	D1	6.0	L2	41.9	47.9
IV-4-2	D2	19.0	L1	10.4	29.4
IV-4-3	D2	32.3	L1	11.4	43.7
IV-4-4	D2	16.7	L2	29.9	46.6
IV-4-5	D2	11.0	L1	7.4	18.4
IV-4-6	D2	12.6	L2	13.1	25.7
IV-4-7	D2	15.1	L2	17.1	32.2
IV-4-8	D2	20.3	L2	19.8	40.1
IV-4-9	D2	11.5	L1	12.1	23.6
IV-4-10	D2	11.0	L1	7.4	18.4
IV-4-11	D2	18.5	L2	41.6	60.1
V. MASVINGO					
1. Masvingo C.L					
V-1-1	D2	29.7	L2	42.0	71.7
V-1-2	D2	6.5	L2	9.0	15.5
V-1-3	D1	4.7	L2	22.2	26.9
2. Mtilikwe C.L					
V-2-1	D1	3.8	L1	20.2	24.0
V-2-2	D2	11.0	L1	11.6	22.6
V-2-3	D2	12.1	L1	15.0	27.1
V-2-4	D2	17.1	L1	15.8	32.9
3. Nyajena C.L					
V-3-1	D2	11.6	L3	53.9	65.5
V-3-2	D2	18.2	L3	39.9	58.1
V-3-3	D3	27.3	L3	53.2	80.5
4. Zimutu C.L					
V-4-1	D2	14.0	L2	20.9	34.9
V-4-2	D2	13.5	L2	32.1	45.6
V-4-3	D2	21.7	L2	21.5	43.2
VI. CHIVI					
1. Chivi C.L					
VI-1-1	D3	14.9	L3	29.7	44.6
VI-1-2	D3	16.2	L3	37.1	53.3
VI-1-3	D3	16.5	L2	13.3	29.8
VI-1-4	D2	6.7	L2	9.4	16.1
VI-1-5	D3	16.2	L3	37.1	53.3
VI-1-6	D2	10.1	L2	20.7	30.8
VI-1-7	D3	23.4	L3	18.4	41.8
VI-1-8	D3	19.4	L2	15.2	34.6
2. Mashava C.L					
VI-2-1	D2	16.4	L2	19.8	36.2
VI-2-2	D3	30.1	L2	14.1	44.2
VII. ZAKA					
1. Nadanga C.L					
VII-1-1	D2	30.6	L2	20.1	50.7
VII-1-2	D2	14.1	L2	16.8	30.9
VII-1-3	D2	19.9	L3	46.5	66.4
VII-1-4	D2	12.8	L2	34.7	47.5
VII-1-5	D2	28.2	L2	24.3	52.5
VII-1-6	D2	25.2	L2	8.9	34.1
VII-1-7	D2	14.8	L2	19.2	34.0
VII-1-8	D2	20.2	L2	30.0	50.2
VII-1-9	D2	14.0	L2	36.1	50.1
VII-1-10	D2	14.0	L2	36.1	50.1
VII-1-11	D2	14.0	L2	36.1	50.1
VII-1-12	D2	44.0	L2	61.5	105.5
VII-1-13	D2	20.4	L2	26.9	47.3

3.6. Irrigation and Other Facilities

3.6.1. Preference of Site from Viewpoint of Irrigation Plan

In respect of the preliminarily selected possible dam sites (94 sites), the comparative study on the water conveyance method and the required facilities from dam to the proposed irrigable area has been made from the topographical, technical and economical points of view through the site investigation and the ensuing home work.

The detailed features in respective sites have been worked out in order to offer the factors for economic comparison which would be one of the strong indices to rank ninety-four (94) sites in the comprehensive priority.

The technical heed and conception of layout of facilities are as described in the following clauses 3.6.2. to 3.6.7.

The result is summarized on Table II-3-9 "Mahor Features of Water Resources and Conveyance Facilities" for easy comparison among respective sites.

3.6.2. Alignment of Water Conveyance Facilities for Irrigation

Relating to the water conveyance facilities from water source to proposed irrigable area, the possible dam sites (94 sites) are classified into three (3) groups by the method as follows:

Gravity method	:	48 sites
Pumping method	:	34 sites
Conveyance not required	:	12 sites

The layout of the facilities in these ninety-four (94) sites has been made impartially on the same level based on the information and topographical maps (1/50 000 scaled).

The result is shown on Table II-3-9 "Major Features of Water Resources and Conveyance Facilities" in this report and the summary table and general plan compiled in the other volume "DAM SITE INVENTORY".

3.6.3. Regulating Fscilities

The consumption of water varies widely as a matter of course in accordance with the cropping patterns, farming program planned and seasons in each area to be irrigated. However, the plan of facilities becomes excessive and the water conveyance operation becomes quite complicated if the quantity of conveyed water is fluctuated in wide range or sent much in short spell.

In order to avoid such an irrationality, the night storage reservoir (regulating pond) is to be planned at the most suitable place near the field edge of irrigable area taking the gravity irrigation system into consideration.

The reservoir is planned to be the pond enclosed with earth dikes, which is equipped with inlet, outlet, drain, staff gauge, bypass, spillway, etc. The required capacity is decided in accordance with the method standardized in the Agritex Irrigation Handbook taking into account the irrigation plan described in 3.4 "Irrigation Water Requirement".

The required reservoir capacity is planned to be equal to the quantity conveyed from dam for twenty-four (24) hours.

The inner face of night storage reservoir is planned to have vertical walls made of concrete or stone masonry in the required portions to suppress the inhabitability of hosts (snails) of Bilharzia parasites. The storage reservoir will be fenced against intrusion of cattle and to prevent inhabitants from danger.

3.6.4 Facilities to Convey the Irrigation Water by Gravity

1) Water Conveyance Canal

The water conveyance facilities between dam and night storage reservoir are planned to have a carrying capacity enough to convey the required quantity per day (including all losses), as mentioned in 3.4 "Irrigation Water Requirement", 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 (L.W.L.) in dam and full water level in night storage reservoir (i.e.; the highest elevation of the field in proposed irrigable area plus 2.0 m).

The proposed conveyance routes in the respective sites are as drawn in the general plans compiled in the other volume "DAM SITE INVENTORY".

The concrete lined trapezoidal canal (cast in situ) is widely prevailing over the existing similar irrigation schemes in the Province since the construction method has been established. However, they are often damaged by the external causes within a short period after construction.

Since the carrying capacity is small in this project, the reinforced precast concrete flume (rectangular shape) is planned to be used taking into account the strength, speed and easiness of construction etc.

It has the most advantageous cross sectional area and gradient as shown on Table II-3-9 in order to avoid excessive velocity in view of the flow quantity, topographical feature, constructional matter and maintenance aspect after completion. The typical section is shown in Figure II-3-4.

For such a purpose, a lot of drop structures may be installed in the canal. However, it should be considered in design to keep minimum velocity of the flow not less than 0.6 m/s in any time in order to prevent the endemic Bilharzia parasites from their growth in the facilities.

The standard drop height is preliminarily decided at 30 cm in one drop structure. The wasteways will also be installed in the suitable places for the periodical desiccation of the facilities for the same purpose as mentioned above.

The staff gauges will be installed at the suitable points in the canals and distribution facilities (such as off-take etc.) in order to measure water level and quantity for the sake of better operation and management of the facilities.

The siphon, aqueduct or culvert will be properly planned to be constructed in each place where the route will run across streams, rivers, roads and so on as listed on Table II-3-9.

The pipeline may be adopted if it is more advantageous than open canal in view of topographical condition, evaporation and seepage losses.

2) Facilities for Maintenance

The canal and the associated structures are required to be entirely enclosed with stable fences. The maintenance road with 4 m in effective width is planned along the canal. The standard section is as shown in Figure II-3-4.

3.6.5. Facilities to Convey the Irrigation Water by Pumps

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 capacities of introduced pumps, pipelines and storages should be considered in the same way as aforementioned in 3.6.4. for the case of gravity conveyance.

However, the maximum running hours should be 16 hours a day even in peak season taking into account the custom and social environment of inhabitants in the Province.

1) Kind and Diameter of Pumps

Centrifugal pumps are to be adopted in view of small capacity but relatively high lift in this project.

The diameters of pumps and pipeline shall be selected considering the pump efficiency related to the flow quantity and lift so that the costs of construction, operation and maintenance of pump house and pipeline may be the most economical.

Two (2) sets of pumps and one (1) standby pump are to be installed to avoid the risks of unexpected trouble or accident. The pump should have enough size of diameter to ensure the required flow quantity in peak season by two (2) sets of pumps simultaneously running for 16 hours a day.

The diameter, total head and required horsepower in respective sites are summarized on Table II-3-9 and the hydraulic dimensions of the pumps in each site are worked out and shown in Annex D.

2) Power

The diesel engine is planned to be adopted in principle for the power of pumps except for the place where the electricity may be supplied. Even though electricity is easily obtained, the diesel generators or the engine pumps should be installed to cope with the electrical power cut.

3) Pipeline

The high-pressure pipe is used for the pipeline to be installed between pump house on dam site and night storage reservoir at the field edge in order to tolerate the pressure at the water conveyance and water hammer.

The required length and diameter have been worked out and shown on Table II-3-9.

In addition, the suitable crossing structures are required to be constructed at the number of places as shown on the same Table in order to maintain the pipeline in safety after completion.

3.6.6. Field Plan and Associated In-field Facilities

The gravity method is adopted for irrigation manners as well as distribution of water from night storage reservoir to the field.

1) Farmland Block Plan

The size and shape of field lot and field block differ with the farming organization and system to be introduced in each proposed project site. The most optimum and recommendable farming system will be decided for each project site until the F/S stage by investigating and understanding the policy, development strategy, movement and trends of socio-economy, marketing plan and so on.

The decision of size and shape of the standard unit of field lots and blocks is to be made following the decision of the farm organization and farming system to be introduced.

2) Plan of In-field Irrigation System

Although the concrete lined trapezoidal channel (cast in situ) is widely prevailing over the existing similar irrigation schemes, the reinforced precast concrete flume (rectangular shape) is adopted as the same reasons as described in 3.6.4.

The distribution channel network should have main and branch channels which enable every unit lot to be received the peak amount of water decided with the kind of crops, irrigation hours per day, water amount by one irrigation and irrigation interval related to the rotational irrigation to be planned. Each channel is designed to have the most advantageous cross section to avoid excess velocity of flow taking into account the topographical and maintenance aspects.

The consideration will be carefully taken for the minimum velocity of flow, avoidance of stayed water (pools) and periodical desiccation of the distribution system in order to prevent Bilharzia parasites from their growth.

The leading of water to the lots is made by means of plastic siphon tubes set in front of the checks (i.e. small structures for water level adjustment) installed in every tertiary channel.

In each field, one of the most suitable irrigation methods will be selected and adopted among the furrow irrigation, border strip irrigation, contour ditch irrigation and basin irrigation in view of crops and their cultivation methods.

3) On-farm

Farm roads are planned for easy farming practice and management. The road network will consist of trunk roads, lateral roads and branch 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 which are existing or planned.

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 subgrade and base course should be filled with laterite and 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 15 cm higher than the field and paved with gravel. The branch road is planned to the border on one side of the lot (i.e. the smallest unit of field) and the width will be 2 m.

4) Drainage Plan

The large scale drainage system is not considered necessary to be extended to every field lot because upland farming is planned in the project area where the precipitation is not 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.

While, it is a very important standpoint that the drainage canals (open surface collector drains) will not become the suitable habitat for the snails which are well known as the hosts of Bilharzia parasites.

In case that the salt injury or rise of water table by excessive irrigation will be anticipated through our further investigation and study, the full scale surface drain and/or underground drain system should be planned to cope with those phenomena.

5) Plan of Other Farming Facilities

The common utilities such as offices, warehouses, workshops, inland fishery facilities and other accommodations for settlers will be planned taking into account the farm organization and farming system which will be decided by the time of F/S stage.

3.6.7. Facilities for Livestock Water and Domestic Water (excluding potable water)

1) Direct Use of Stored Water

In order to secure the water for livestock near the dam sites, the surroundings of reservoirs are planned to be free of access for livestock to the stored water. However, neither drinking basins nor tubs are planned to be installed in the reservoir, because it can not cope with the seasonal fluctuation of water level in reservoir.

It is not recommendable that the inhabitants use the stored water for living from the viewpoint of prevention against schistomiasis.

2) Water Distribution from Conveyance Canal

The small turn-outs (off-takes) are planned to be installed at the suitable places just downstream from dams and along the conveyance canals in order to supply the livestock water and domestic water for inhabitants.

The following problems should be studied and solved in the F/S stage for the successful water distribution.

The problems to be solved are such as the locations and numbers required to be installed, the operation and control method for allocation rate to irrigation water, allocation manner and water right etc.

The drinking basins for livestock and washing and bathing place for inhabitants will be designed and installed having supply taps to flush the water and drain taps to desiccate the water tubs and basins.

The water pressure caused by the difference of height between canal and supply tap can be used to generate high velocity and turbulent flow of water for the sake of prevention against schistosomiasis.

Table II-3-9 (1)

MAJOR FEATURES OF WATER RESOURCE AND CONVEYANCE FACILITIES

District	Water Resource				Water Conveyance			Irrigable Area				Pump			Pipe-Line	Flume			Crossing (PLC)					N. Storage R.	
												2 – sets													
	Name of Dam	No. of Dam	1/10 Yr. Yield 10³ (m³)	L.W.L. (m)	Method	Distance (km)	Flow Q (lit./s)	Net at 1/10 Yr. (ha)	Gross (ha)	Max. El. (m)	Diff. Height (m)	Dia. (mm)	T.Head (m)	Engine (HP)	Dia. (mm)	Width B (m)	Height H (m)	GRD I	River	Stream Gully	Main Road	Track	Nos. of Drops (pc)	Cap'ty 10³ (m³)	Dis-charge (m³/hr)
BATANAI	Cheshanga	I-1-1	74	668	Gravity	4.5	6.9	3.7	5	655	13	–	–	–	–	0.25	0.20	1/400	2	5	1	5	0	0.6	58
	Sipala	1-2	84	621	Pump	1.0	7.8	4.2	5	640	Δ 19	65	42.4	9.0	100	–	–	–	0	5	0	3	–	0.7	66
	Dengenya	1-3	56	559	Pump	0.7	7.8	2.8	4	620	Δ 21	65	37.9	8.0	100	–	–	–	1	0	1	1	–	0.5	44
	Musaverema	2-1	801	676	Gravity	1.9	74.5	40.1	50	668	8	–	–	–	–	0.50	0.35	1/400	1	4	1	2	10	6.5	626
	Zvirikure	2-2	447	625	Gravity	2.4	41.6	22.4	28	618	7	–	–	–	–	0.40	0.35	1/400	0	5	0	4	1	3.6	350
	Chingami	2-3	277	598	Pump	1.7	38.8	13.9	17	620	Δ 22	100	48.3	35.8	200	–	–	–	1	0	1	1	–	2.2	217
	Mushava	2-4	30	601	Gravity	2.5	2.8	1.5	2	590	11	–	–	–	–	0.25	0.20	1/300	1	4	0	1	5	0.2	24
	Boyi	2-5	81	586	Pump	1.0	11.4	4.1	5	600	Δ 14	65	30.4	8.5	125	–	–	–	1	2	0	1	–	0.7	64
BIKITA	Murwira	II-1-1	272	918	Pump	1.2	41.2	16.0	20	920	Δ 2	125	23.1	18.1	200	–	–	–	0	3	0	1	–	2.4	231
	Musukutwa	1-2	208	838	Pump	1.2	31.4	12.2	15	850	Δ 12	100	25.4	15.5	200	–	–	–	1	1	1	2	–	1.8	176
	Mutsinzwa	1-3	347	768	Pump	0.5	52.6	20.4	25	775	Δ 7	125	12.9	12.5	250	–	–	–	1	0	0	2	–	3.0	295
	Maranganyika	1-4	208	801	Pump	3.0	31.4	12.2	15	823	Δ 22	100	53.1	32.4	200	–	–	–	1	9	0	3	–	1.8	176
	Mundzami	1-5	293	809	Gravity	1.5	26.5	15.4	19	800	9	–	–	–	–	0.35	0.30	1/400	0	3	0	3	16	2.3	223
	Chinyamatumwa	1-6	659	742	Pump	1.0	100.0	38.8	48	770	Δ 28	200	35.0	58.3	350	–	–	–	0	0	0	0	–	5.7	560
	Chanyau	1-7	406	1,000	Pump	0.9	61.6	23.9	30	1,025	Δ 25	150	37.0	41.2	250	–	–	–	0	0	1	0	–	3.5	345
	Beta	1-8	345	796	Gravity	3.0	34.9	20.3	25	760	36	–	–	–	–	0.35	0.30	1/400	1	5	0	5	87	3.0	293
	Chikuku	1-9	363	817	Gravity	3.0	36.8	21.4	27	810	7	–	–	–	–	0.35	0.30	1/500	0	10	2	2	0	3.2	309
	Chigumisirwa	1-10	319	783	Gravity	2.7	32.3	18.8	23	775	8	–	–	–	–	0.35	0.30	1/400	0	2	1	1	2	2.8	272
	Boora	1-11	275	757	Gravity	2.0	27.8	16.2	20	750	7	–	–	–	–	0.35	0.30	1/400	0	3	1	1	5	2.4	234
	Mashoko	2-1	248	651	Gravity	1.4	25.1	14.6	18	638	13	–	–	–	–	0.35	0.30	1/400	0	2	0	2	30	2.2	211
	Zindove	2-2	138	632	Gravity	1.2	13.9	8.1	10	620	12	–	–	–	–	0.25	0.20	1/300	0	0	0	1	25	1.2	118
	Mafaune	2-3	112	561	Gravity	4.0	17.0	6.6	8	550	11	–	–	–	–	0.25	0.20	1/400	0	9	1	6	4	1.0	95
GAZA KOMANANI	Majijimba	III-1-1	16	396	Gravity	1.0	1.5	0.8	1	390	6	–	–	–	–	0.25	0.20	1/300	0	1	0	1	7	0.1	13
	Chanyenga	1-2	11	439	Gravity	2.8	1.1	0.6	1	433	6	–	–	–	–	0.30	0.25	1/600	0	6	1	6	2	0.1	10
	Mpagati	1-3	12	425	Gravity	0.8	1.1	0.6	1	423	2	–	–	–	–	0.25	0.20	1/400	0	2	0	1	0	0.1	10
	Malisanga	1-4	12	381	Gravity	5.8	1.1	0.6	1	375	6	–	–	–	–	0.30	0.25	1/1000	1	8	0	3	0	0.1	10
	Chingelelani	1-5	67	389	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Chisakwasi	2-1	277	411	Gravity	0.6	25.8	13.9	17	408	3	–	–	–	–	0.35	0.30	1/400	0	1	1	0	3	2.2	217
	Chegwama	2-2	21	430	Gravity	2.0	2.0	1.1	2	425	5	–	–	–	–	0.25	0.20	1/400	0	3	0	5	0	0.2	17
	Chompimbi	2-3	45	409	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Chitsa	2-4	1	381	Gravity	2.1	0.2	0.1	1	370	11	–	–	–	–	0.25	0.20	1/300	0	2	0	1	11	0.1	2

Table II-3-9 (2)

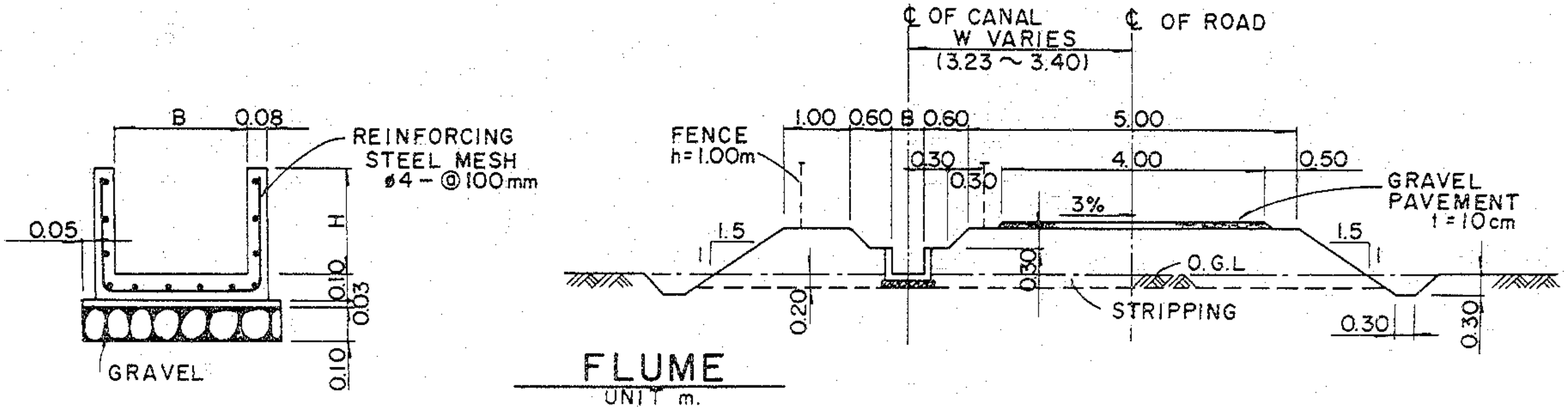
MAJOR FEATURES OF WATER RESOURCE AND CONVEYANCE FACILITIES

District	Water Resource				Water Conveyance			Irrigable Area				Pump			Pipe-Line	Flume			Crossing (PLC)				Nos. of Drops (pc)	N. Storage R.	
												2 – sets													
	Name of Dam	No. of Dam	1/10 Yr. Yield 10³(m³)	L.W.L. (m)	Method	Distance (km)	Flow Q (lit/s)	Net at 1/10 Yr. (ha)	Gross (ha)	Max. El. (m)	Diff. Height (m)	Dia. (mm)	T.Head (m)	Engine (HP)	Dia. (mm)	Width B (m)	Height H (m)	GRD I	River	Stream Gully	Main Road	Track		Cap'ty 10³(m³)	Dis-charge (m³/hr)
GAZA KOMANANI	Chitsazani	III-2-5	75	372	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Dumezo	3-1	2	474	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Shavani	3-2	22	476	Gravity	2.5	2.0	1.1	2	460	16	–	–	–	–	0.25	0.20	1/300	1	5	0	1	25	0.2	17
	Malibangwe	3-3	8	401	Gravity	1.6	0.7	0.4	1	388	13	–	–	–	–	0.25	0.20	1/300	0	2	0	1	24	0.1	6
	Gezani	3-4	2	363	Gravity	2.5	0.2	0.1	1	350	13	–	–	–	–	0.25	0.20	1/300	1	1	1	0	12	0.1	2
	Chomnanga	3-5	2	307	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Mangezi	3-6	1	233	Gravity	3.3	0.2	0.1	1	215	18	–	–	–	–	0.25	0.20	1/300	0	0	1	1	29	0.1	2
	Grootvlei	3-7	2	218	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Thinana	3-8	2	406	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
GUTU	Mutema	IV-1-1	423	1,160	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Gabriel	1-2	469	1,155	Gravity	2.7	47.4	27.6	34	1,148	7	–	–	–	–	0.40	0.35	1/500	1	2	2	4	3	4.1	398
	Chimedza	1-3	301	1,216	Gravity	2.4	30.4	17.7	22	1,210	6	–	–	–	–	0.35	0.30	1/500	1	1	0	2	2	2.6	255
	Mukaro	1-4	125	1,304	Gravity	1.0	12.7	7.4	9	1,298	6	–	–	–	–	0.25	0.20	1/300	0	0	0	1	7	1.1	107
	Chimombe	2-1	293	1,226	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Gondongwe	3-1	436	1,411	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Vushe	3-2	772	1,387	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Chinyika	4-1	144	1,109	Pump	0.8	21.9	8.5	10	1,120	Δ 11	80	29.0	12.6	150	–	–	–	0	0	0	1	–	1.3	123
	Chatikobo	4-2	350	1,154	Gravity	3.0	35.4	20.6	26	1,138	16	–	–	–	–	0.35	0.30	1/400	1	3	1	7	23	3.0	297
	Maruta	4-3	198	1,099	Gravity	2.7	19.9	11.6	14	1,085	14	–	–	–	–	0.25	0.20	1/300	0	5	2	3	13	1.7	167
	Mutero	4-4	386	1,071	Gravity	2.0	39.0	22.7	28	1,066	5	–	–	–	–	0.35	0.30	1/400	1	3	0	6	1	3.4	328
	Sinbanegavi	4-5	477	1,206	Gravity	1.4	48.3	28.1	35	1,195	11	–	–	–	–	0.40	0.35	1/400	0	2	1	2	24	4.2	406
	Mushangwe	4-6	70	975	Gravity	3.5	7.0	4.1	5	960	15	–	–	–	–	0.25	0.20	1/300	0	4	0	6	8	0.6	59
	Chingai	4-7	56	901	Gravity	3.0	5.7	3.3	4	878	23	–	–	–	–	0.25	0.20	1/300	1	6	1	5	27	0.5	48
	Mutanda	4-8	220	847	Pump	1.2	33.2	12.9	16	870	Δ 23	100	37.6	24.2	200	–	–	–	0	2	0	2	–	1.9	186
	Mukuro	4-9	190	1,130	Pump	0.9	28.9	11.2	14	1,140	Δ 10	100	19.1	10.8	200	–	–	–	0	0	0	2	–	1.7	162
	Munjanganja	4-10	584	1,144	Gravity	4.2	59.1	34.4	43	1,130	14	–	–	–	–	0.40	0.35	1/400	0	7	0	10	9	5.1	496
	Masunda	4-11	36	1,099	Gravity	2.6	3.6	2.1	3	1,090	9	–	–	–	–	0.25	0.20	1/300	0	5	0	2	2	0.3	31
MASVINGO	Munongo	V-1-1	12	905	Gravity	0.8	1.2	0.7	1	895	10	–	–	–	–	0.25	0.20	1/300	0	1	0	0	23	0.1	10
	Musingarabwe	1-2	270	871	Pump	0.9	37.4	14.5	18	880	Δ 9	100	22.8	16.3	200	–	–	–	1	2	1	1	–	2.1	209
	Matsikidzi	1-3	1,313	748	Pump	1.1	198.9	77.2	96	780	Δ 32	250	39.9	109.6	450	–	–	–	0	0	0	1	–	11.4	1,114
	Makwawa	2-1	534	868	Pump	1.3	80.9	31.4	39	880	Δ 12	150	23.8	33.4	300	–	–	–	0	0	0	3	–	4.6	453

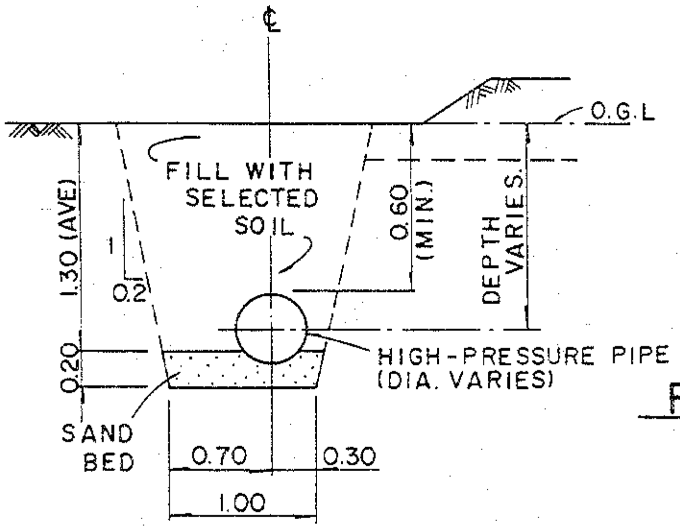
Table II-3-9 (3)

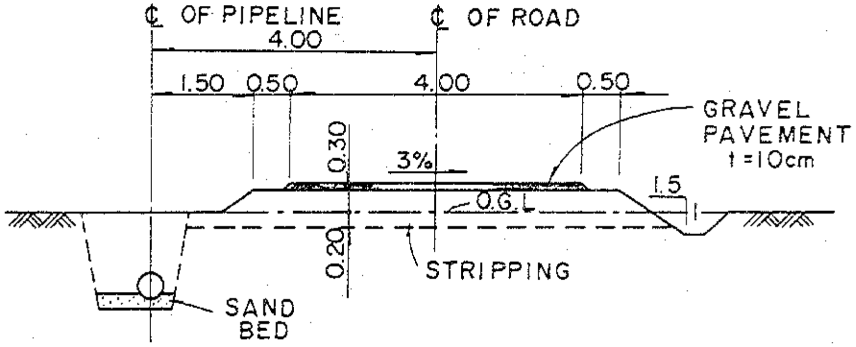
MAJOR FEATURES OF WATER RESOURCE AND CONVEYANCE FACILITIES

District	Water Resource				Water Conveyance			Irrigable Area				Pump			Pipe-Line	Flume			Crossing (PLC)					N. Storage R.	
	Name of Dam	No. of Dam	1/10 Yr. Yield $10^3 (m^3)$	L.W.L. (m)	Method	Distance (km)	Flow Q (lit./s)	Net at 1/10 Yr. (ha)	Gross (ha)	Max. El. (m)	Diff. Height (m)	2 – sets			Dia. (mm)	Width B (m)	Height H (m)	GRD I	River	Stream Gully	Main Road	Track	Nos. of Drops (pc)	Cap'ty $10^3 (m^3)$	Discharge (m^3/hr)
												Dia. (mm)	T.Head (m)	Engine (HP)											
MASVINGO	Uzeze	V-2-2	776	864	Pump	2.0	117.5	45.6	57	900	Δ36	200	52.4	98.9	350	–	–	–	1	2	0	2	–	6.7	658
	Majiri	2-3	745	707	Pump	1.3	112.9	43.8	54	735	Δ28	200	38.5	70.5	350	–	–	–	1	0	0	2	–	6.5	632
	Chatikubo	2-4	732	681	Pump	1.8	111.1	43.1	54	700	Δ19	200	32.6	58.9	350	–	–	–	0	2	1	0	–	6.4	622
	Maramwidze	3-1	556	738	None	0	0	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Fusira	3-2	1,128	563	Pump	1.2	171.1	66.4	83	570	Δ 7	250	17.9	44.4	400	–	–	–	0	0	0	0	–	9.8	958
	Magudu	3-3	954	519	Gravity	6.0	96.4	56.1	70	495	24	–	–	–	–	0.50	0.40	1/400	2	7	1	8	26	8.3	810
	Marongera	4-1	170	1,258	Pump	1.5	25.8	10.0	12	1,295	Δ37	100	48.8	24.8	200	–	–	–	0	0	0	3	–	1.5	144
	Nacheka	4-2	326	1,219	Gravity	2.4	33.0	19.2	24	1,210	9	–	–	–	–	0.35	0.30	1/400	0	1	3	1	8	2.8	277
	Mahoto	4-3	275	1,141	Gravity	5.0	27.8	16.2	20	1,130	11	–	–	–	–	0.35	0.30	1/500	2	2	5	5	3	2.4	234
CHIVI	Chirongwe	VI-1-1	108	811	Pump.	0.6	9.5	3.7	5	820	Δ 9	65	16.9	4.1	125	–	–	–	0	0	1	0	–	0.5	53
	Nemavuzhe	1-2	60	736	Gravity	3.6	6.0	3.5	5	730	6	–	–	–	–	0.30	0.25	1/700	1	2	1	5	3	0.5	50
	Madzivire	1-3	13	609	Gravity	3.0	1.4	0.8	1	600	9	–	–	–	–	0.25	0.20	1/400	0	4	1	0	1	0.1	12
	Musuvovi	1-4	22	672	Pump	1.0	3.4	1.3	2	700	Δ28	65	67.9	7.2	65	–	–	–	0	2	0	2	–	0.2	19
	Magwari	1-5	63	678	Gravity	3.5	6.4	3.7	5	671	7	–	–	–	–	0.30	0.25	1/500	1	2	0	7	–	0.5	54
	Zifunzi No.2	1-6	62	671	Pump	0.5	9.3	3.6	5	700	Δ29	65	35.6	8.6	125	–	–	–	0	0	0	1	–	0.5	52
	Takavarasha	1-7	109	814	Pump	0.7	16.5	6.4	8	820	Δ 6	80	16.0	5.7	150	–	–	–	0	1	0	1	–	0.9	92
	Nyamakwe	1-8	183	823	Gravity	2.5	16.1	9.4	12	810	12	–	–	–	–	0.25	0.20	1/300	0	4	0	3	9	1.4	134
	Mukovoriri	2-1	51	926	Gravity	6.0	5.2	3.0	4	910	16	–	–	–	–	0.25	0.20	1/400	2	14	0	10	4	0.4	44
	Madangombe	2-2	23	990	Pump	0.9	3.6	1.4	2	1,010	Δ20	65	59.9	6.7	65	–	–	–	0	0	0	1	–	0.2	20
ZAKA	Zishiri	VII-1-1	981	1,033	Pump	1.3	148.7	57.7	72	1,060	Δ27	200	36.3	81.7	400	–	–	–	0	1	1	0	–	8.5	833
	Chida	1-2	500	977	Pump	2.1	75.8	29.4	37	1,000	Δ23	150	39.2	52.1	300	–	–	–	0	3	0	2	–	4.4	424
	Veza	1-3	549	754	Gravity	2.0	55.5	32.3	40	740	6	–	–	–	–	0.40	0.35	1/400	0	5	2	1	1	4.8	466
	Zinguo	1-4	302	675	Gravity	2.0	30.6	17.8	22	669	6	–	–	–	–	0.35	0.30	1/400	0	5	1	2	0	2.6	257
	Nemakau	1-5	475	801	Pump	1.0	71.1	27.6	34	840	Δ39	150	55.7	70.1	250	–	–	–	0	1	2	0	–	4.1	398
	Siyawarewa	1-6	430	692	Pump	0.9	65.2	25.3	32	705	Δ13	150	26.1	30.6	250	–	–	–	0	1	1	2	–	3.7	365
	Manjeru	1-7	263	731	Gravity	3.5	26.6	15.5	19	720	11	–	–	–	–	0.35	0.30	1/400	1	11	1	1	3	2.3	224
	Chenyu	1-8	1,443	676	Gravity	3.0	145.9	84.9	106	669	7	–	–	–	–	0.60	0.45	1/500	1	5	1	2	1	12.6	1,226
	Maraire	1-9	234	718	Gravity	2.6	23.7	13.8	17	710	8	–	–	–	–	0.35	0.30	1/400	0	6	0	5	2	2.0	200
	Chivamba	1-10	506	704	Pump	0.8	76.8	29.8	37	720	Δ16	150	23.3	31.3	300	–	–	–	0	1	0	1	–	4.4	430
	Fuve	1-11	996	681	Pump	2.0	151.0	58.6	73	720	Δ39	200	52.9	120.1	400	–	–	–	0	1	1	3	–	8.7	846
	Mabvuti	1-12	1,265	635	Pump	1.1	191.7	74.4	93	680	Δ45	250	57.1	153.1	400	–	–	–	0	1	1	0	–	11.0	1,074
	Mujena	1-13	844	613	Pump	1.1	127.8	49.6	62	680	Δ67	200	78.1	157.1	350	–	–	–	0	2	0	1	–	7.3	716

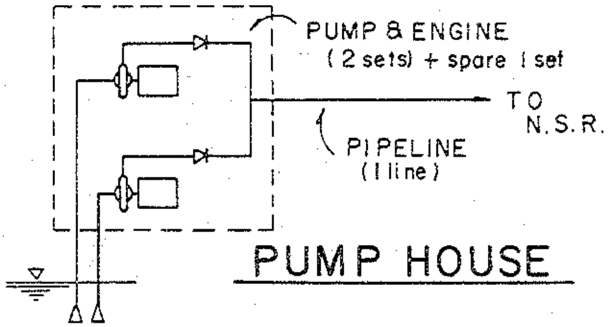


FLUME
UNIT m.





PIPELINE
UNIT m.



PUMP HOUSE

FIGURE Ⅱ-3-4 TYPICAL SECTION OF IRRIGATION FACILITIES

3.7. Land Use

Land use in communal areas in the Province has a typical contrast between two areas, i.e., intensive farming in the northern east area, and extensive, sedentary farming in the southwestern area.

In the northern area, grazing lands are increasingly encroached by the expansion of cropping plots, under a high population density, causing serious problems of overgrazing and the following land erosion along stream banks.

At the same time, current land use in the communal lands seems to have much room for further improvement to achieve more rational, and intensive farming.

In this context, irrigated farming provides small farmers with a powerful tool in realizing what is desirable to the land use maximization, provided that it is well planned as well as properly utilized in taking water supply, crop husbandry and land conservation into full account.

Generally, most parts of arable lands in communal areas in the northern Province topographically show either undulating or slopy profiles with relatively infertile sandy soils. However, some areas are likely suitable for irrigation, because they form fairly flat uplands and their soils have higher clay contents.

As regards to the southern areas, where most farmers depend primarily upon livestock rather than crop raising due to insufficient and unstable rainfall, people are bestowed with abundant arable lands with high irrigation potentiality derived from flatness and fertileness of the soils.

A comprehensive evaluation from agronomical and agroeconomical points of view has been given to each proposed project. The evaluation criteria is shown below:

Suitability a:	A fairly extended tract land under cultivation is available, accompanied with fine-textured soils and easy market access.
Suitability b:	A limited irrigable tract of land under cultivation or a fairly extended tract of either furrow or grazing land is available with soils having acceptable texture, and market access is not too difficult.
Suitability c:	Only scattered plots are existing or only grazing areas are available with some soil limiting factors, like coarse-textured, stony or shallow soils and located in remote, isolated areas.

In this respect, existing cropping patterns under irrigation projects are entirely different from those in dry land where highly drought resistant crops are predominant, and relevant crops and varieties are introduced from the standpoint of water use efficiency, yield response or economic aspects. Accordingly, considerably high yield levels are expected from irrigated farming through high yielding varieties and high cropping intensity. However, limitation of available water resources will confine the size of the allocated irrigable plot to a family, so that the produced effects may be distributed among as many beneficiary farmers as possible.

3.8. Agriculture Plan and Cropping Pattern

3.8.1. Major Roles of Irrigated Farming

The roles of irrigated farming would be as follows:

1) Irrigation firstly serves to stabilize production level, but too intensive cropping or inadequate crop rotation might undermine the effect of irrigation by dwindling the soil fertility, whereas too extensive cropping gives low benefit.

2) The crops, especially vegetables, before incorporating into the cropping patterns have to be guaranteed their market access or outlet. That is to say, unless the farmers' produce bring them stable and remunerative gains, it would be no more than home consumptive food and the rest be left on the plots unharvested.

3) The actual area of irrigated plots, or the duration of the irrigated period are quite limited depending on the scale of water sources and water availability from it. The precious water can irrigate only a tiny part of dry land in the communal lands. This is the reason why the irrigable plots are equitably shared by as many farmrs as possible. In the proposed projects the same concept is to be pursued so that the benefit from social investment may be reached by as many individuals as possible.

4) At present, the extent of irrigated areas is still limited, and in the new irrigation areas proposed it is necessary to lead farmers to become aware of irrigation effect.

5) One of the important roles of irrigation projects is to enable farmers who used to work only in rainy season, to be engaged in full time farming, and the irrigation farming, especially labour management, should also be planned from this point of view.

3.8.2. The crops to be introduced

Taking basic principles as mentioned above and stipulated in the *National Five-Year Development Plan*, *natural conditions*, *current level of* farmers' experiences, marketing and other socio-economic conditions, crops suitable for irrigation farming can be generally concentrated on the following:

maize
wheat
groundnuts
sugar beans } can be sold to GMB
green maize
vegetables
cotton

Maize is the most important crop for a staple food in communal lands. The country as a whole, it will continue to be the most desirable crop for the farmers in communal lands. Particularly under irrigation, maize acts as a major crop because the crop under irrigation brings several times of yield as that in dry land.

Wheat is one of the typical winter crops and is so difficult to grow without irrigation in the Province that it is mainly introduced to commercial areas at present. But more wheat should be introduced to the irrigated areas in communal lands in order to make possible effective rotation in these area and to supplement maize as an another excellent grain.

Groundnuts are grown in all the communal lands though its cultivation area is not so much. Recently groundnuts are taking a more important role in terms of nutrition and economy, and increase of production is worth while as a cash crop.

As a winter crop under irrigation, sugar bean is highly suitable to grow and the beans can be sold to the GMB.

Various vegetables can be grown all around the year in the communal lands if sufficient irrigation water is available. However attention must be paid that the function of marketing is too primitive to accept these products.

Though cotton is a drought tolerant crop, the supplementary irrigation is very effective to increase the yield. But introduction of cotton may be limited to the areas with well-drained deep and heavy soils.

3.8.3. Farm allotment

To attain equitable benefit among the farmers in irrigation area, each individual allotment size of the irrigation farm may be inevitably minimized. An average allotment size will be decided at around 0.2 ha which has been adopted in the existing irrigation schemes. While, in southern areas, each allotment size may not be so minutely divided, and an average size more than 0.4 ha may be individually allotted because of low population density, though it is necessary to keep the balance of incomes from crop farming and those from livestock raising.

3.8.4. Proposed Cropping Patterns

Strictly speaking, the most desirable cropping pattern could be different from place to place, due to physical, social and economic situations. To decide a cropping pattern in each proposed area, a more detailed survey should be conducted in future to formulate an optimum cropping system. However, fundamental cropping patterns are illustrated in Figure II-3-5. Proposed cropping patterns are based on the following characteristics.

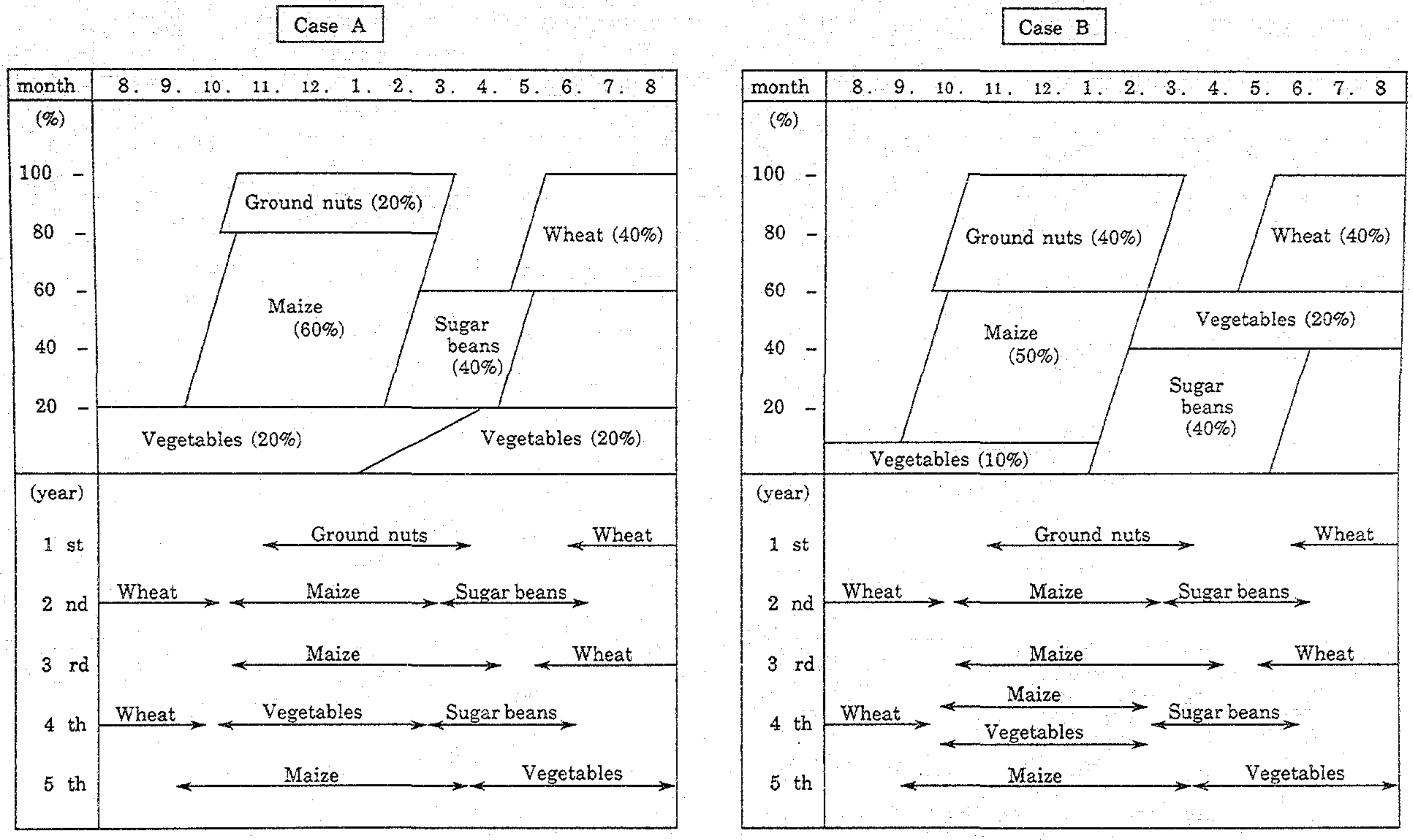
Case A: Transportation and accessibility: convenient, northern part of the Province (Gutu, Bikita except Massai, Masvingo, Zaka and Chiki District)
Clay content in soil: relatively high.

Case B: Transportation and accessibility: easy and soil: sandy and poor.

Case C: Transportation and accessibility: inconvenient comparatively favourable southern part of the Province (Batanai, Gaza Komanai District and Massai)
Clay content in soil: relatively high.

Case D: Transportation and accessibility: inconvenient soil: sandy and poor.

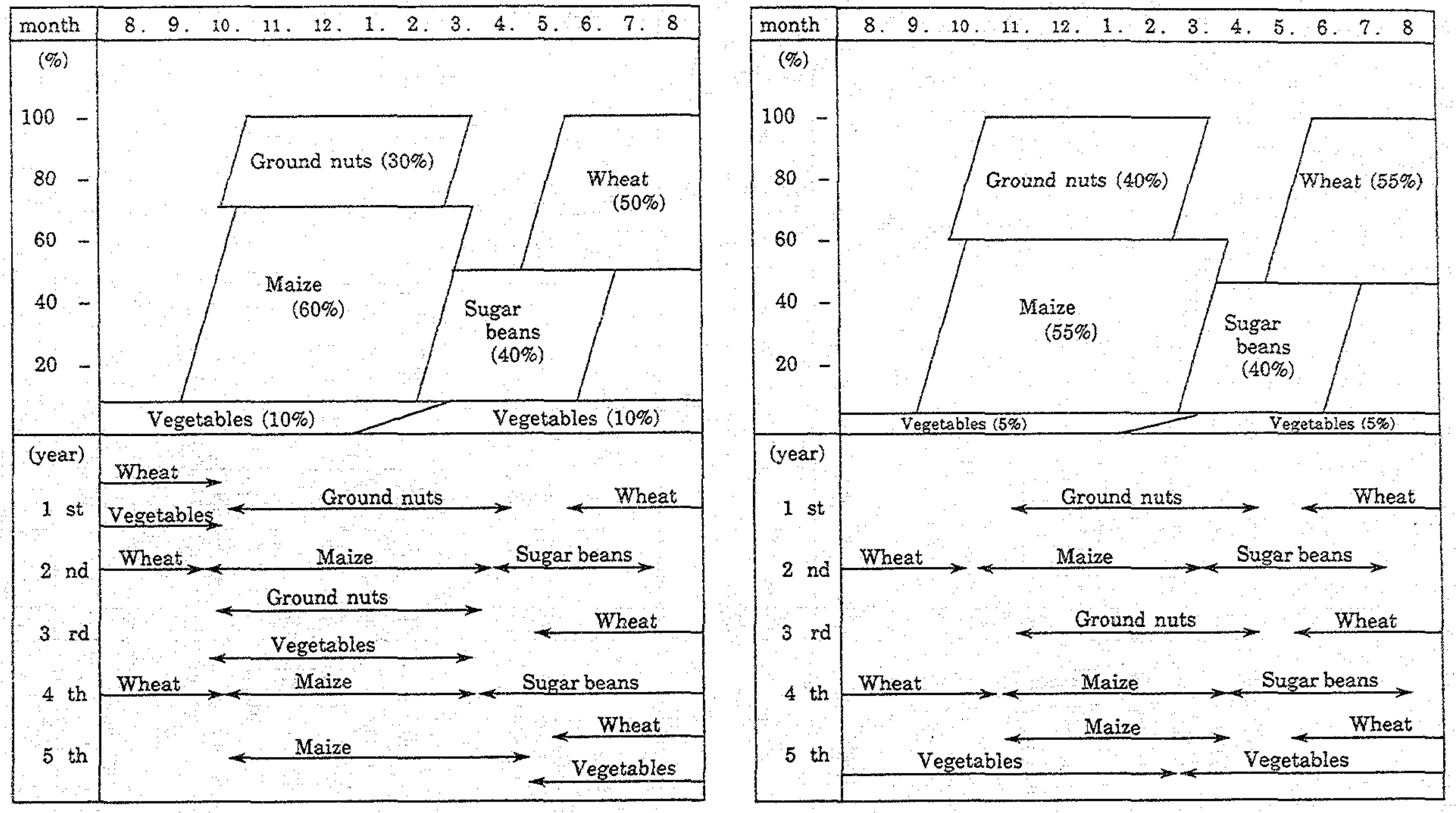
Figure II-3-5 Cropping Pattern and Rotation (Case A , B)



Case A

Case B

Figure II-3-5 Cropping Pattern and Rotation (Case C, D)

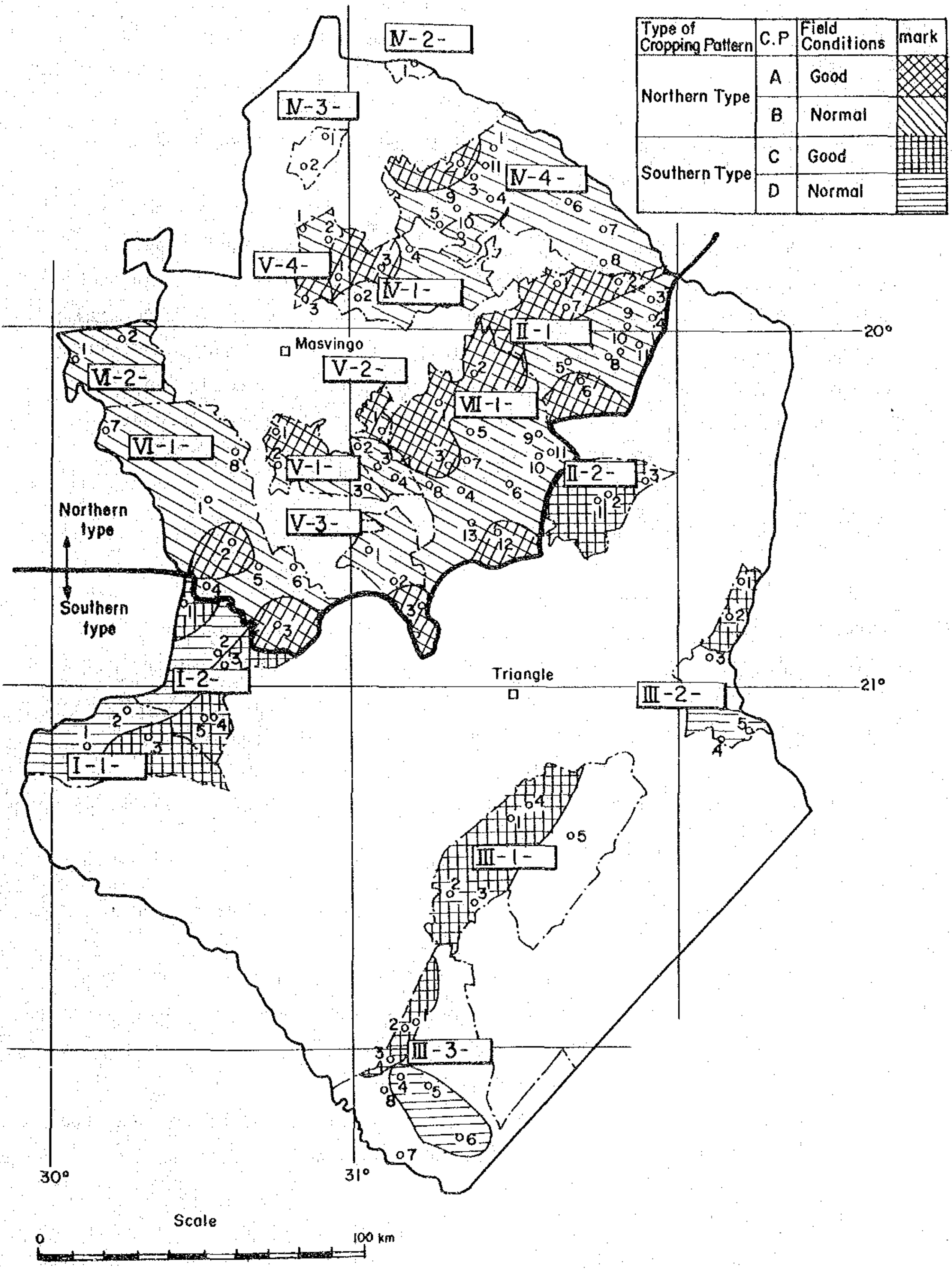


Case C

Case D

Figure II-3-6

MAP OF PROPOSED CROPPING PATTERNS



Note : c.f. Chapter 4.4.2. Although the proposed cropping patterns are determined by specific field conditions and not by regions, their distribution can be roughly identified from this map.

Irrigation farm allotment per household would be so small that the high cropping intensity will be realized by ample labour supply. In these cropping patterns maize is assumed to include green maize to some extent and vegetables implies various kinds of vegetables suitable for irrigation. Because of unreliable marketing conditions, the ratio of vegetables are suppressed as low as possible.
Especially in case D, most of them were regarded as for home consumption. Besides these particularities in case C, a part of the cropping pattern is replaceable to cotton, owing to the easier approach to Cotton Marketing Board. Maize in case C and D may partly be replaced to sorghrum according with meal customs. Furthermore if farmers can learn the technique to frow soybeans or tobacco, these crops are recommendable to introduce in above cropping patterns in future. The distribution of the above cited cropping patterns within the project area is illustrated in Figure II-3-6.

3.8.5. Projected Crop Yield

Although the current yield levels are exceedingly low, they are usually greatly raised and stabilized by irrigation, as observed in the existing irrigation schemes. Yet, even after the conversion into irrigated lands, they are forecast to vary to a fairly significant extent from place to place, depending upon various land conditions, such as gradient of arable land, size of arable tract, soil properties and gravel or stone content. These conditions are classified for each proposed cropping pattern into three levels as follows:

a: higher projected yield levels for the sites with fine-textured soils and flat, concentrated tract for irrigation,
b: standard ones for those with intermediate land conditions
c: lower ones for those with coarse textured soils and slopy or undulated, scattered pieces of cropland

The target yields are given in Table II-3-10. These yields are expected to reach within five years after irrigation is applied.

Table II-3-10 Projected Yields for Cropping Pattern

Unit: ton/ha

Cropping Pattern	A			B			C			D		
Suitability / Crops	a	b	c	a	b	c	a	b	c	a	b	c
Maize	9	8	7	7	6	5	9	8	7	7	6	5
Groundnut	3.5	3	2.7	3	2.7	2.5	3.5	3	2.7	3	2.7	2.5
Wheat	4	3.5	3	3.5	3	2.7	4	3.5	3	3.5	3	2.7
Sugarbeans	3	2.7	2.5	2.7	2.5	2.3	3	2.7	2.5	2.7	2.5	2.3
Tomato*	20	16	12	16	12	8	20	16	12	16	12	8
Cotton	-	-	-	-	-	-	3.5	3	2.5	-	-	-

* Only market-oriented harvest is counted, and the total yield is twice as much as these levels.

These target yields were established with reference to the performances achieved by existing irrigation schemes in communal lands, target yield levels for proposed irrigation schemes as well as performances in large scale commercial farm irrigation schemes.

3.9. Farm Management

3.9.1. Basic Principle

The approach to introduce irrigation into a part of dry land farming in communal lands has already been practised in various schemes in the Province. The farm produce obtained should first meet basic needs as home consumption. Then, if a farmer in the irrigated farm allows to sell his produce as a surplus, it can be sold either to marketing organization or to open markets. Staple foodcrop is essential to comprise major part of the produce under irrigation. There are many economic constraints in communal lands among which the following should be noted:

1) Transport costs are met by farmers to carry their produce as far as district depots, although a price support system is maintained for statutory items.

2) Marketing systems in communal lands are still in an incipient stage of development with very weak purchasing power amongst local population.

3) Difficulty arises in the access of markets because it takes a long period to improve the present technical situation to meet the demand in terms of quality and supplying capacity.

The farming system planned in this survey is highly labour intensive, in which family labour balance should be properly kept between irrigated and dry plots in rainy season. A higher level extension activity is to be followed as participant farmers get accustomed to irrigation practices, aiming at lower cost of farm management through collective practices, etc. Whereas the risk pertaining to vegetable marketing should be as far mitigated as possible through diversification of crops and varieties as well as dispersion of cropping season throughout the year, paying due attention to market price fluctuations.

Allocation of irrigable areas among as many farmers as possible is adapted to the planning in pursuance of the basic principle "Growth with Equity". Relevant size of individually allocated irrigable area is decided at 0.1 - 0.2 ha per family in northern part of the Province and 0.4 - 0.5 ha per family in southern part of it. A larger size of allocated plot would result in management problems of labour competition with dry farming and delayed technical follow-up.

3.9.2. Extension of Irrigation Techniques

One of the essential approaches is to clarify current issues in the existing irrigation schemes to reflect in projected farming. In order to make rather costly water from medium size dams enough viable, the following factors are essential; 1) soil fertilization, 2) prevention of continuous cropping injury, 3) adjustment of cropping to marketing trends, and 4) efficient water use. Here, soil fertilization is hardly achieved unless it is well-linked with livestock sector. Secondly, detrimental effects are often observed in the existing irrigation schemes, arising from the case of continuous cropping, entailing the replacement of local varieties with high yielding ones suitable for irrigated cropping.

As regards marketing access for speculative crops, most irrigation projects are subject to price drop followed by overproduction. As to water use, it is essential to make full use of water resources so that water loss through evaporation or percolation can be minimized.

3.9.3. Strategies for Farm Management

Under the irrigated farming, much sophisticated crop production techniques including water management and application of fertilizers and chemicals are required. Accordingly, farmers should take advantage of cooperative activities in order to cheaply and timely purchase agricultural inputs. Especially in case a project site is located remote from existing markets, or G.M.B. depots, cooperatives should play a vital role to secure transportation means. So far as speculative crops are concerned, it is imperative to timely grasp seasonal demand in markets, thereby promoting diversification of crops and economic risks by dispersing cropping season, especially introducing less perisheable vegetables (for instance, squash,

Table II-3-11 Prices of Farm Produce

(unit: Z$/ton)

Commodity	Retail	Farmgate	Blended price	Price	%	Price	%	Price	%	Price	%
White maize	-	-	179.6	180.00	89	178.15	10	176.25	0	156.25	1
Yellow maize	-	-	180.0	180.00	100	178.15	0	176.25	0	156.25	0
White surghum	-	-	172.6	180.00	68	168.00	17	153.00	4	140.70	11
Groundnut	-	-	457.3	488.00	50	446.00	0	427.00	50	-	-
Soyabean	-	-	322.4	357.00	0	340.00	63	292.50	37	-	-
Mhunga	-	-	241.2	250.00	56	230.00	44	-	-	-	-
Rapoko	-	-	286.8	300.00	47	275.00	53	-	-	-	-
Sunflower	-	-	335.4	340.00	83	323.00	13	278.00	3	-	-
Sugarbean	-	-	437.6	450.00	59	420.00	41	-	-	-	-
C.M.B. cotton	-	-	540.0	-	-	-	-	-	-	-	-
Tomato	0.90∿1.00	0.30/kg									
Beef	4.00∿5.90	1.33/kg									
Fish	5.99	2.00/kg									

Table II-3-12 Projected Farm Budget per Ha.

(unit: Z$/ha)

Cropping Pattern	Aa	Ab	Ac
Gross income	4 693	3 947	3 237
Production cost	1 047 ∿ 1 608	971 ∿ 1 433	842 ∿ 1 238
Net income	3 646 ∿ 3 085	2 976 ∿ 2 514	2 395 ∿ 1 999

Cropping Patter	Ba	Bb	Bc
Gross income	3 507	2 908	2 351
Production cost	888 ∿ 1 284	802 ∿ 1 132	737 ∿ 1 012
Net income	2 619 ∿ 2 223	2 106 ∿ 1 776	1 614 ∿ 1 339

Cropping Pattern	Ca	Cb	Cc
Gross income	3 772	3 228	2 730
Production cost	931 ∿ 1 382	870 ∿ 1 266	767 ∿ 1 097
Net income	2 841 ∿ 2 390	2 358 ∿ 1 962	1 963 ∿ 1 633

Cropping Pattern	Da	Db	Dc
Gross income	2 766	2 376	2 036
Production cost	778 ∿ 1 108	718 ∿ 993	659 ∿ 890
Net income	1 988 ∿ 1 658	1 658 ∿ 1 383	1 377 ∿ 1 146

The range of production cost is attributed to the distances from the project area to markets.

onion and potatoes etc.). It must be worth while trying to collect up-to-date market information by the coordinated committee of irrigation projects, especially when cropping programs are to be formulated. Among future tasks, grouped plot rotation and collective farming practices will be the focal point so that better management of irrigation water, collective spray of agricultural chemicals and labour saving can be realized.

3.9.4. Farm Budget

Farm incomes were estimated from 1986 government purchase prices, proposed cropping patterns and target yields, the results of which is shown in Table II-3-12. The results obtained imply that northern part of this province has generally higher level of crop income than that of southern part. However, such locational differences are also influenced by the convenience of transportation or present yield levels of dryland crop. Agricultural returns were calculated from the characteristic of this type of the project, i.e. irrigation of very limited area under labour intensive farming. It is noted that crop residue is found to be valuable as cattle feed because it contains around ten per cent of total digestable nutrient (T.D.N.), especially that of maize stalks, stover and bean husks. Hence it was advised to incorporate the utilization of crop residue into farming program, taking account of its various merits such as future potentiality for commercial livestock sector, supply of manure for soil organic matter.

3.10. Operation and Maintenance

The facilities of the Project will be managed by the two Ministries, viz., MEWRD and MOA. The facilities are divided into two parts, viz., water source facilities and on-farm facilities. The former, including dams, pumps, conveyance canals and other facilities up to the field edge will be managed by MEWRD, while the latter, including night storage reservoirs and field canals as well as drainage facilities, will be maintained by AGRITEX, MOA. Both sides will take charge of the management of on-farm facilities through mutual cooperation.

Besides, farmers participating in an irrigation project will organize an irrigation management committee which, under the relevant guidance of the extension worker in charge of the project, decides details of the project management, such as field-plot allocation, irrigation programme etc.

3.11. Project Cost

3.11.1. Estimation of Construction Cost

MEWRD has so far carried out construction works of medium size dam projects on force account or on the contract basis. In principle, government projects should be implemented by the MEWRD itself. The provincial office finds it difficult to implement a few projects of such scale at one time other than on the contract basis. Therefore, the estimation is made on the contract basis accordingly in this study.

The base unit rates of preliminary cost estimation of dams and canals issued by the MEWRD in November 1985 are applied for preliminary estimation of the construction cost in this study. The issue on preliminary cost estimation has been provided for carrying out the cost estimation in feasibility study level.

The base unit rates are applicable to any construction works to be commenced after November 1985, however the following adjustments are required;

Miscellaneous (minor) items = 10%
Preliminary and General items on Contract = 20%
Contingency = 15%
(Cumulative percentage of aboves = 52%)
Price escalation = 20% per annum based on a positive deflator of 1.5% per month.

Thus, the unit rates as of November 1986 are estimated by applying the above percentages.

Because of a limited number of construction of pumping station by MEWRD the construction cost of pumping stations in this study is estimated with reference to the contracted prices in October 1985 applying the same escalation rate for dam and canal works. The base unit rate is applied to pipeline with steel pipe in the same manner as dam and canal works.

Most of on-farm facilities have been constructed by the AGRITEX itself, but some on-farm facilities construction were recently carried out on the contract basis.

For estimating the construction cost of on-farm facilities, the contract prices of Fuve-Panganai Irrigation Project which was contracted in October 1986 are referred to in this study applying the same escalation rate.

3.11.2. Construction Cost

The construction cost consists of direct construction cost and engineering and administration expenses of 15% to direct construction cost.

The adjusted base unit rates as of November 1986 are as below:

	Item	*Unit Price*
		Z$
1.	Clear site	4,400/ha
2.	Grout curtain, 6m stage	645/N.S
3.	Excavation (stripping)	$3/m^3$
4.	Excavation (soft)	$7/m^3$
5.	Excavation (hard)	$40/m^3$
6.	Embankment (incl. excavation less than 1.5 km)	$4.6/m^3$
7.	Trimming	$8/m^3$
8.	Rock rip-rap	$33/m^3$
9.	Crusher run filter	$73/m^3$
10.	Concrete (Mass) incl. forme	$230/m^3$
11.	Concrete (Reinforced) incl. forme	$370/m^3$
12.	Concrete (Underground) incl. forme	$415/m^3$
13.	Reinforcement	2,100/t
14.	Steel piping	1.3/m per mm dia

1) Direct Construction Cost

(a) *Dam*

The direct construction cost of dam is preliminarily estimated with the adjusted base unit rates multiplying the estimated quantities of works.

However, the cost of spillway is estimated.

Type	Flood Capacity (m^3/sec)	Direct Const. Cost (Z$/m)
A	less than 100	3,770
B	100 ∿ 300	5,910
C	more than 300	7,910

(b) Canal

The direct construction costs of canal with different sections are preliminarily estimated as below.

Type	Section Width x Height (m) (m)	Direct Const. Cost (Z$/m)
A	0.25 x 0.20	153
B	0.35 x 0.30	175
C	0.40 x 0.35	188
D	0.50 x 0.35	194
E	0.50 x 0.40	206
F	0.60 x 0.45	220

Pipeline (Steel pipe) : Z$1.3/m per dia. (mm)

(c) Pumping Facilities

Each pumping station is to have three pumps equipped with separate diesel engine (one set is for spare). The direct construction cost for pumping facilities includes each cost of pumping station and pipeline until the night storage reservoir.

Pumping station : Z$1,000/dia. (mm)
Pipeline (Steel pipe) : Z$1.3/m per dia. (mm)

(d) On-farm Facility

Referring to the existing on-farm facility of the similar irrigation scheme, its topographical inclination is around 1/150. The main canals on the farm were constructed at right angle with contour lines and the lateral canals were installed along the contour lines. Farm Area is in this case nearly 46 ha. Referring to the above-mentioned conditions, the cost is estimated as follows:

o Night Storage Reservoir

Type	N.S.R Capacity (m^3)	Direct Const. Cost (Z$/N.S)
A	1,000	27,000
B	3,000	39,000
C	6,000	45,000
D	9,000	49,000
E	12,000	56,000
F	15,000	59,000
G	18,000	66,000
H	21,000	69,000

o On-Farm Facility

Type	Direct Const. Cost (Z$/ha)	Remarks
A	4,000	No land clearing and leveling
B	4,200	With leveling
C	4,400	With land clearing and leveling

2) Engineering and Administration Cost

The engineering and administration costs are estimated at 15% of direct construction cost and include such expenses of construction supervision, administration, and engineering contingency.

The construction costs by each project are shown in Table 4.13. For reference, the annual costs by project are also shown to compare the project cost in an equal condition.

Table II-3-13 (1) Construction Cost

				Dam			Irrigation Facilities						
Name of Dam	No. of Dam	1/10 Yr Yield $10^3(m^3)$	Irrigation area (ha)	Direct Construction Cost A Z$(000)	Construction Cost B-Ax1.15 Z$(000)	Dam Cost per Yield (m^3) Z$	Direct Construction Cost C Z$(000)	Construction Cost D-Cx1.15 Z$(000)	Irrigation Cost per Area (ha) Z$(000)	Total Construction Cost (ha) Z$(000)	Total Cost per Area (/ha) Z$(000)	Cost of pumps (n.s.) Z$(000)	Diesel Oil per Year Z$(000)
Cheshanga	I-1-1	74	3.7	732.4	842	11.4	673.0	774	209	1 616	437		
Sipala	1-2	84	4.2	1 056.5	1 215	14.5	370.5	426	101	1 641	391	195	3.2
Dengenya	1-3	56	2.8	656.5	755	13.5	325.3	374	134	1 129	403	195	2.8
Musaverema	2-1	801	40.1	1 517.7	1 745	2.2	597.5	687	17	2 432	61		
Zvirikure	2-2	447	22.4	1 709.2	1 966	4.4	567.7	653	29	2 619	117		
Chingami	2-3	277	13.9	972.2	1 118	4.0	836.6	962	69	2 080	150	300	12.4
Mushava	2-4	30	1.5	413.3	475	15.8	385.4	443	295	918	612		
Boyi	2-5	81	4.1	605.1	696	8.6	402.5	463	113	1 159	283	195	3.0
Murwira	II-1-1	272	16.0	1 638.6	1 884	6.9	796.4	916	57	2 800	175	375	5.7
Musukutwa	1-2	208	12.2	952.7	1 096	5.3	704.7	810	66	1 906	156	300	4.9
Mutsinzwa	1-3	347	20.4	1 713.8	1 971	5.7	666.3	766	38	2 737	134	375	3.9
Maranganyika	1-4	208	12.2	815.2	937	4.5	1 172.7	1 349	111	2 286	187	300	10.0
Mundzami	1-5	293	15.4	1 456.1	1 675	5.7	351.2	404	26	2 079	135		
Chinyamatumwa	1-6	659	38.8	1 108.3	1 275	1.9	1 198.0	1 378	36	2 653	68	600	17.8
Chanyau	1-7	406	23.9	2 065.3	2 364	5.8	892.7	1 027	43	3 391	142	450	12.7
Beta	1-8	345	20.3	973.1	1 119	3.2	613.1	705	35	1 824	90		
Chikuku	1-9	363	21.4	1 350.1	1 553	4.3	617.7	710	33	2 263	106	*Operater Z$2,000/year	
Chigumisirwa	1-10	319	18.8	741.8	853	2.7	549.6	632	34	1 485	79		
Boora	1-11	275	16.2	2 691.8	3 096	11.3	432.7	498	31	3 594	222	Machine check Z$1,000/year	
Mashoko	2-1	248	14.6	1 558.0	1 792	7.2	326.2	375	26	2 167	148		
Zindove	2-2	138	8.1	534.6	615	4.5	240.5	277	34	892	110		
Mafaune	2-3	112	6.6	390.0	449	4.0	623.5	717	109	1 166	177		
Majijimba	III-1-1	16	0.8	1 281.3	1 473	92.1	172.1	198	248	1 671	2 089		
Chanyenga	1-2	11	0.6	1 492.5	1 716	156.0	470.1	541	902	2 257	3 762		
Mpagati	1-3	12	0.6	2 095.1	2 409	200.8	150.6	173	288	2 582	4 303		
Malisanga	1-4	12	0.6	3 602.3	4 143	345.3	955.0	1 098	1 830	5 241	8 735		
Chingelelani	1-5	67	-	3 596.5	4 136	61.7	-	-	-	4 136	-		
Chisakwasi	2-1	277	13.9	1 479.7	1 702	6.1	198.6	228	16	1 930	139		
Chegwama	2-2	21	1.1	1 185.6	1 363	64.9	315.8	363	330	1 726	1 569		
Chompimbi	2-3	45	-	490.3	564	12.5	-	-	-	564	-		
Chitsa	2-4	1	0.1	647.5	745	745.0	318.9	367	3 670	1 112	11 120		

Table II-3-13 (2) Construction Cost

				Dam			Irrigation Facilities						
Name of Dam	No. of Dam	1/10 Yr Yield 10^3(m^3)	Irriga-tion area (ha)	Direct Construc-tion Cost A Z$(000)	Construc-tion Cost B-Ax1.15 Z$(000)	Dam Cost per Yield (m^3) Z$	Direct Construc-tion Cost C Z$(000)	Construc-tion Cost D-Cx1.15 Z$(000)	Irriga-tion Cost per Area (ha) Z$(000)	Total Construc-tion Cost (ha) Z$(000)	Total Cost per Area (/ha) Z$(000)	Cost of pumps (n.s.) Z$(000)	Diesel Oil per Year Z$(000)
Chitsazani	III-2-5	75	-	1 948.8	2 241	29.9	-	-	-	2 241	-		
Dunezo	3-1	2	-	1 265.2	1 455	727.5	-	-	-	1 455			
Shavani	3-2	22	1.1	1 112.0	1 279	58.1	383.2	441	401	1 720	1 564		
Malibangwe	3-3	8	0.4	1 138.2	1 309	163.6	252.2	290	725	1 599	3 998		
Gezani	3-4	2	0.1	1 258.7	1 448	724.0	379.2	436	4 360	1 884	18 840		
Chomnanga	3-5	2	-	1 596.6	1 836	918.0	-	-	-	1 836	-		
Mangezi	3-6	1	0.1	805.2	926	926.0	482.1	554	5 540	1 480	14 800		
Grootvlei	3-7	2	-	992.7	1 142	571.0	-	-	-	1 142	-		
Thinana	3-8	2	-	462.1	531	265.5	-	-	-	531	-		
Mutema	IV-1-1	423	-	764.5	879	2.1	-	-	-	879	-		
Cabriel	1-2	469	27.6	1 523.9	1 752	3.7	651.4	749	27	2 501	91		
Chimedza	1-3	301	17.7	512.4	589	2.0	501.7	577	33	1 166	66		
Mukaro	1-4	125	7.4	1 580.2	1 817	14.5	213.5	246	33	2 063	279		
Chimombe	2-1	293	-	831.5	956	3.3	-	-	-	956	-		
Gondongwe	3-1	436	-	1 206.1	1 387	3.2	-	-	-	1 387	-		
Vushe	3-2	772	-	1 395.8	1 605	2.1	-	-	-	1 605	-		
Chinyika	4-1	144	8.5	744.6	856	5.9	469.0	539	63	1 395	164	240	4.0
Chatikobo	4-2	350	20.6	778.4	895	2.6	620.6	714	35	1 609	78		
Maruta	4-3	198	11.6	2 118.9	2 437	12.3	466.7	537	46	2 974	256		
Mutero	4-4	386	22.7	1 105.9	1 272	3.3	458.2	527	23	1 799	79		
Sinbanegavi	4-5	477	28.1	1 250.6	1 438	3.0	419.5	482	17	1 920	68		
Mushangwe	4-6	70	4.1	732.4	842	12.0	532.8	613	150	1 455	355		
Chingai	4-7	56	3.3	2 063.8	2 373	42.4	607.6	699	212	3 072	931		
Mutanda	4-8	220	12.9	3 367.2	3 872	17.6	702.6	808	63	4 680	363	300	7.8
Mukuro	4-9	190	11.2	656.0	754	4.0	622.3	716	64	1 470	131	300	3.4
Munjanganja	4-10	584	34.4	1 190.9	1 370	2.3	935.3	1 076	31	2 446	71		
Masunda	4-11	36	2.1	603.0	693	19.3	414.2	476	227	1 169	557		
Munongo	V-1-1	12	0.7	427.3	491	40.9	144.5	166	237	657	939		
Musingarabwe	1-2	270	14.5	1 258.8	1 448	5.4	631.0	726	50	2 174	150	300	5.1
Matsikidzi	1-3	1 313	77.2	1 308.8	1 505	1.1	1 789.2	2 058	27	3 563	46	750	32.3
Makwawa	2-1	534	31.4	1 066.9	1 227	2.3	1 127.6	1 297	41	2 524	80	450	10.4

Table II-3-13 (3) Construction Cost

				Dam			Irrigation Facilities						
Name of Dam	No. of Dam	1/10 Yr Yield $10^3(m^3)$	Irrigation area (ha)	Direct Construction Cost A Z$(000)	Construction Cost B-Ax1.15 Z$(000)	Dam Cost per Yield (m^3) Z$	Direct Construction Cost C Z$(000)	Construction Cost D-Cx1.15 Z$(000)	Irrigation Cost per Area (ha) Z$(000)	Total Construction Cost (ha) Z$(000)	Total Cost per Area (/ha) Z$(000)	Cost of pumps (n.s.) Z$(000)	Diesel Oil per Year Z$(000)
Uzeze	V-2-2	776	45.6	913.0	1 050	1.4	1 750.5	2 013	44	3 063	67	600	29.3
Majiri	2-3	745	43.8	713.4	820	1.1	1 433.2	1 648	38	2 468	56	600	21.3
Chatikubo	2-4	732	43.1	792.3	911	1.2	1 640.4	1 886	44	2 797	65	600	18.0
Maramwidze	3-1	556	-	1 046.2	1 203	2.2	-	-	-	1 203	-		
Fusira	3-2	1 128	66.4	1 923.8	2 212	2.0	1 722.2	1 981	30	4 193	63	750	13.7
Magudu	3-3	954	56.1	1 156.7	1 330	1.4	1 454.2	1 672	30	3 002	54		
Marongera	4-1	170	10.0	934.6	1 075	6.3	773.0	889	89	1 964	196	300	7.7
Macheka	4-2	326	19.2	1 030.1	1 185	3.6	508.3	585	30	1 770	92		
Mahoto	4-3	275	16.2	1 182.4	1 360	4.9	941.0	1 082	67	2 442	151		
Chirongwe	VI-1-1	108	3.7	736.1	847	7.8	335.0	385	104	1 232	333	195	1.3
Nemavuzhe	1-2	60	3.5	443.0	509	8.5	624.8	719	205	1 228	351		
Madzivire	1-3	13	0.8	341.2	392	30.2	450.2	518	648	910	1 138		
Musuvovi	1-4	22	1.3	394.1	453	20.6	312.0	359	276	812	625	195	2.3
Magwari	1-5	63	3.7	575.0	661	10.5	610.1	702	190	1 363	368		
Zifunzi No.2	1-6	62	3.6	176.9	203	3.3	319.1	367	102	570	158	195	2.7
Takavarasha	1-7	109	6.4	492.0	566	5.2	429.1	493	77	1 059	165	240	1.8
Nyamakwe	1-8	183	9.4	636.3	732	4.0	428.4	493	52	1 225	130		
Mukovoriri	2-1	51	3.0	447.3	514	10.1	905.2	1 041	347	1 555	518		
Nakangombe	2-2	23	1.4	933.0	1 073	46.7	304.0	350	250	1 423	1 016	195	1.8
Zishiri	VII-1-1	981	57.7	735.4	846	0.9	1 555.8	1 789	31	2 635	46	600	24.5
Chida	1-2	500	29.4	723.1	832	1.7	1 080.6	1 243	42	2 075	71	450	16.0
Veza	1-3	549	32.3	1 080.2	1 242	2.3	548.1	630	20	1 872	58		
Zinguo	1-4	302	17.8	1 061.1	1 220	4.0	446.6	514	29	1 734	97		
Nemakau	1-5	475	27.6	1 663.3	1 913	4.0	935.9	1 076	39	2 989	108	450	21.2
Siyawarewa	1-6	430	25.3	615.2	707	1.6	888.7	1 022	40	1 729	68	450	9.4
Manjeru	1-7	263	15.5	1 188.5	1 367	5.2	687.3	790	51	2 157	139		
Chenyu	1-8	1 443	84.9	2 812.7	3 235	2.2	1 055.4	1 214	14	4 449	52		
Maraire	1-9	234	13.8	1 401.2	1 611	6.9	526.1	605	44	2 216	161		
Chivamba	1-10	506	29.8	1 019.7	1 173	2.3	706.1	812	27	1 985	67	450	9.6
Fuve	1-11	996	58.6	829.2	954	1.0	1 946.8	2 239	38	3 193	54	600	35.1
Mabvute	1-12	1 265	74.4	1 575.9	1 812	1.4	1 705.4	1 961	26	3 773	51	750	44.4
Mujena	1-13	844	49.6	1 125.0	1 294	1.5	1 367.7	1 573	32	2 867	58	600	45.5

3.11.3. Operation and Maintenance Cost

The annual running costs are estimated at $250/ha for water source and conveyance facilities and at Z$150/ha for on-farm facilities to be spent after completion of construction. These estimates are based on the following data by DERUDE (Department of Rural Development.)

The average costs are given in the published DERUDE report for small scale schemes in communal lands as Z$138/ha and Z$269/ha for the whole Zimbabwe and Masvingo district for water source and conveyance facilities. Taking the scale merit and inflation effect into consideration, reasonable ranges of running costs for the proposed projects should converge around Z$200 - 300 for water source and conveyance facilities and Z$200 for on-farm facilities.

3.12. Project Benefits

3.12.1. Basic Concept of Benefits

The proposed projects generally enable to convert a part of exisitng crop fields into a highly productive irrigated tracts of land, and the following benefits are expected from them.

Direct Benefits ..... Crop Benefits (from crop diversification, increased yields and elevated cropping intensity)
..... Livestock Benefits (from utilizing crop residue, or introducing pasture)
..... Fishery Benefits (from available water surface of dam for fish farming)

Indirect Benefits ..... Fostering the development of agro-pastoral related industries to create labour opportunities
..... Mitigating severe, continued drought damage to establish food security and stabilize settlement
..... Preventing large scale cattle loss from drought by cattle water supply
..... Supplying domestic water other than potable water
..... Saving labour for watering herds or for carrying domestic water by means of creating watering sites

Of these benefits, only the direct, tangible ones were analysed in this stage. The tangible benefits for the proposed project are increase of crop production and cattle fattening by crop residue, and production from fish farming in reservoirs. While those without irrigation area in the vicinity of project sites are estimated from cattle fattening by reclaiming cultivable fields for pasture grasses on the area adjacent to the proposed dam sites, instead of crop residue, and from fishery in reservoirs. The project life of 40 years is adopted, and the stabilized production stage was projected at 5 years after the completion of construction works. Net production values per annum at the stabilized stage were estimated in 1985/86 price.

3.12.2 Methods of Benefit Measurement

1) Crop Benefits

Crop benefits are measured according to the baseline that benefits of crop increase stem from existing cropland, and the net benefits are obtained from target yield levels proposed for "with project", subtracted by the present yield levels of "without project" from which net incomes were calculated for all the proposed sites.

On the other hand, the present yield levels are based on the 1985/86 crop yield estimation by AGRITEX by crop-regions and by crops in the Province. Prior to the application of these data, they are also subdivided into three levels applicable to the proposed sites with different drought susceptibility levels within the same regions, which were also applied to all the proposed sites.

Production costs are based on the current 1985/86 input prices where different amounts of inputs correspond with different yield levels. Family labour costs and irrigation charges are excluded from total costs. Transportation charges are calculated from the distance between the proposed site and nearby G.M.B. depot, which is in most cases deemed as an average distance to markets, and from the rate, 30 Z$ per ton per km. For farm gate prices, weighted averages or "blended" prices are calculated from 1985 G.M.B. grading records and homogeneously applied to all the statutory items produced from the proposed area. Official procurement price is adopted for the farm gate price of cotton, while prices of other items are determined as a third of current retail price level in urban markets.

2) Livestock Benefits

Crop residue, by-product of irrigated crops, can be converted into beef if it is collected and fed to cattle kept in pens and kraals before marketing. The benefit from livestock is obtained from the amount of available residue, with the conveyance and feeding losses, through the conversion into daily gain, which in turn is reconvertible as a return by multiplying the estimated farm gate price of beef equivalent to a third of urban retail prices. Here production and marketing costs are estimated at 10 percent of gross profits. For the proposed projects without crop irrigation schemes, such pasture grasses as berseem and canary grass are introduced into veld or natural range near the proposed dam to produce fodder for cattle fattening, and similar conversion is made to obtain the value of livestock benefits.

3) Fishery Benefits

Projection is made with reference to the present blueprint of AGRITEX, to introduce fish farming into reservoirs. The benefits from fishery are calculated with the following premises: A half of the full water surface of the reservoir is available for fish farming. The yield is estimated at 200 kg per hectare at maturing stage which should be reached at five years after the dam construction. The rate of catch is fixed at 80 per cent of the total production, of which half the catch is deemed to be marketable and the rest is for home consumption. The farm gate price is estimated at a third of current retail price. Annual production costs consisted of seed fry (equivalent to Z$4 per hectare) usually supplied from the Lake Kyle, and necessary equipment and inputs equivalent to 20 per cent of gross sales of fish.

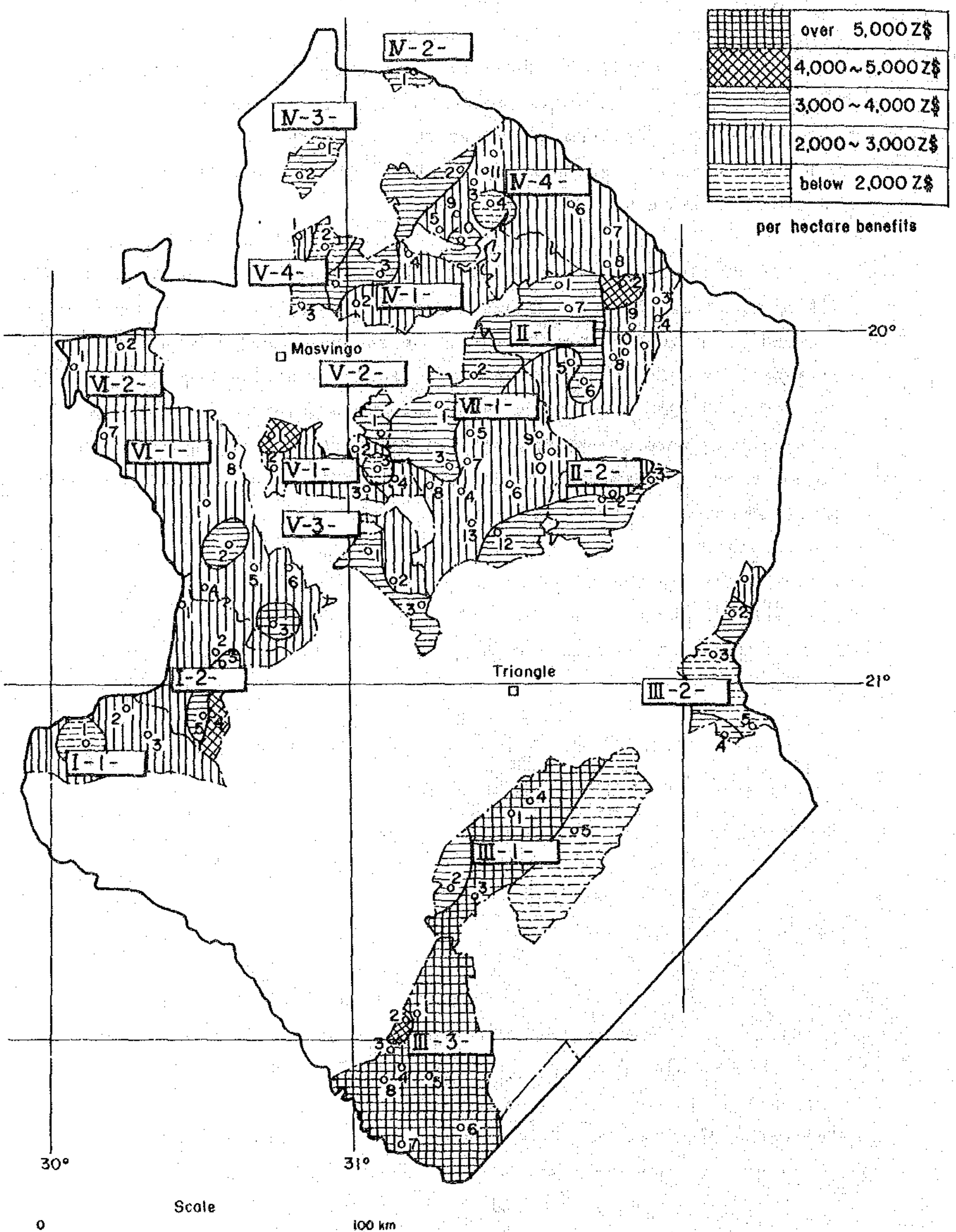
3.12.3. Direct Benefit Measurement

Expected "with project" gross incomes from crop production per hectare are in the range of Z$1,400 ∿ 3,500 according to the cropping conditions in the proposed project, and those "without project" ranged Z$10 ∿ 170 per hectare, hence crop production benefits per hectare are projected as around Z$1,300 ∿ 3,300.

In addition, livestock benefits from crop residue amount to Z$130 ∿ 250 per hectare cropped acreage under irrigation, whereas those from pasture are measured at Z$310 per hectare. As regards fishery benefits, it is estimated at Z$30 ∿ 40 per hectare of full water surface of the proposed dam. Speculative crops like tomato are judged to be feasible from the viewpoint of moderate marketing ratio and limited cropping coverage of 5 ∿ 20 per cent. The results of estimation is illustrated in Figure II-3-7 proposed sites.

Figure II-3-7

Map of Benefit Per Hectare



Note : c.f. Chapter 4.13.3 Since the benefits of a project are of specific nature pertaining to it, this map shows only. High benefits in the area III are attributable to fishery benefits.

3.12.4. Social Effect

The implementation of the medium size dam project in communal lands would generate various benefits. It is anticipated that the indirect benefits, though intangible it may be, security of foodstaff, expansion of employment and alleviation of the disparity of living standards would outweigh the direct tangible benefits.

In Zimbabwe with her dualistic society, development projects in communal lands can be referred to as social projects rather than economic development projects which aim at the efficiency of national capital.

For the purpose of evaluating the magnitude of social impact from the Project, the project effects in terms of the following components are analyzed;

1) the diffusion of the project impact
2) security of foodstuff for communal people
3) water supply for livestock, and
4) water supply for domestic use

In the evaluation, a point scoring method is applied based on data concerning the present situation, where the respective effects in the four components are expressed as 'A', 'B', 'C', and 'D'.

Some indicators which represent the features of each component are selected and those are computed by using the relevant primary data which had been obtained at ward level. The project effects in terms of the components are evaluated for all the proposed sites. Indicators used and criteria for evaluation are attached in the ANNEX.

In the evaluation of the effect of domestic water supply, the role of deep wells seems so important for communal people so that higher weight is given thereon.

For the possible dam sites, the evaluations of the social effects derived from the Project are summarized in ANNEX. Social needs for the implementation of the Project are high, much social impacts would be expected in the areas with high population densities where the present situations of food security and the water supply remain in the low level. The comprehensive evaluation in terms of the four components is not made because the priority for the composition of components are different among the proposed dam sites.

The evaluations are based on the primary data of the wards which include the proposed dam sites. But some of the data are different from the statistics derived from other sources and information through the field survey. However, in the evaluation by a point scoring method, those data seem to be worth being employed.

3.13. Project Evaluation

3.13.1. Basic Principles

A salient feature of medium size dam projects in its economic context is higher share of food crops for home consumption and lower weight of more profitable commercial crops. It also lies in relatively higher water cost derived from limited size. This feature, and general objective of the study suggest that the investment effects can be evaluated by a conventional method for selecting priority dam sites. It is therefore particularly considered relevant to justify the proposed projects by not only evaluating from the standpoint of free economy but also from social point of view.

Although various justification factors could be considered for evaluating projects from both social and economic points of view, it is very difficult to evaluate social effect in quantitative terms. It is therefore decided to justify 94 proposed project by means of economic internal rate of return.

It is affirmed that when economic internal rate of return is adopted as major evaluation criteria to evaluate the projects, various indirect effects are somewhat inevitably included in them. From this aspect, a detailed project evaluation was made by means of economic internal rate of return in which importance is attached more to economic aspect for ninety-four proposed dam sites, based on the results of field survey and on the collected data.

The reason why investment efficiency ratios were deemed as major criteria lies in the fact that effects of increased production of farm produce can be directly measured from tangible benefit measurement and that generally speaking the wider the irrigable area the less expensive the construction cost because relative costs for dam construction and other irrigation facilities are economized.

3.13.2. Project Evaluation

Project evaluation in terms of economic internal rate of return has been carried out based on the following criteria and assumptions.

1) Project Life and Basic Price

   a) 1985/86 prices are adopted as the base prices for economic evaluations.

   b) The construction of major works is planned to be completed in two years, while the benefit is generated from the third year after the project implementation to reach the target yield after irrigation is applied.

   c) Project life of 40 years is adopted. However, pumps are to be replaced in the twentieth year after installation.

   d) Those projects with narrow irrigable area, for which the total benefits throughout the project life fall short of the investment costs, are excluded from the calculations of economic internal rate of return (E.I.R.R.).

2) Benefits

   a) As to the products traded in the international markets, the most up-dated import or export prices are adopted as the economic prices.

   b) Economic prices of vegetable and fish, which are not internationally traded commodities in Zimbabwe, are estimated from the domestic prices by multiplying the conversion factor of 0.9 for overall domestic products.

   c) Import tax is neglected in the calculation of economic prices of all producers' goods for agricultural input.

3) Costs

1985/86 standard unit prices by the Government are adopted as investment costs. The economic prices are estimated by means of the following conversion factors; 0.45 for unskilled labour costs and 0.9 for domestically available materials. Integrated conversion factors are calculated for each item of investment as follows;

a)	Construction costs for dams	0.87
b)	Construction cost for irrigation and on-farm facilities	0.78
c)	Operation and maintenance costs	0.86

3.13.3. Result of Evaluation

Based on the projects features described in the dam site inventory and the assumed implementation schedule mentioned in the foregoing clause, a preliminary economic evaluation in terms of economic internal rate of return has been carried out.

The major features of the economic evaluation are shown in Table II-3-14.

Table II-3-14 Economic Evaluation (1)

Site No.	Area ha.	Cropping Pattern	Gravity Pattern	Total Economic Benefit	Dam Construction Cost	Other Facility Cost	O.M. Cost	Pump Replacement Cost	Total Economic Cost	B/C	E.I.R.R.	Ranking
I-1-1	3.7	Dc	G	8.1	531	437	0	0	968	0.32	-	C
-2	4.2	Db	P	12.8	766	241	2	121	1 193	0.41	-	C
-3	2.8	Cb	P	10.0	476	211	2	121	865	0.44	-	C
-2-1	40.1	Ca	G	155.0	1 100	388	0	0	1 488	3.96	8.9	A
-2	22.4	Da	G	65.4	1 239	369	0	0	1 608	1.54	2.1	B
-3	13.9	Ca	P	57.4	705	544	7	187	1 683	1.46	1.3	B
-4	1.5	Ca	G	8.2	299	250	0	0	549	0.57	-	C
-5	4.1	Ca	P	20.8	439	262	2	121	883	0.89	-	C
II-1-1	16.0	Aa	P	76.4	1 188	518	3	234	2 054	1.41	1.8	B
-2	12.2	Aa	P	56.7	691	458	3	187	1 435	1.50	2.4	B
-3	20.4	Bb	P	54.3	1 243	433	2	234	1 986	1.04	0.2	B
-4	12.2	Bb	P	32.4	591	762	5	187	1 738	0.71	-	C
-5	15.4	Bb	G	42.6	1 055	228	0	0	1 283	1.26	0.9	B
-6	38.8	Aa	P	184.0	804	779	9	374	2 310	3.03	8.9	A
-7	23.9	Aa	P	113.6	1 490	580	7	280	2 601	1.66	3.2	B
-8	20.3	Bb	G	54.7	705	398	0	0	1 103	1.88	3.4	B
-9	21.4	Bb	G	58.1	979	401	0	0	1 380	1.60	2.2	B
-10	18.8	Ba	G	64.1	538	357	0	0	895	2.72	5.9	A
-11	16.2	Bb	G	44.4	1 952	281	0	0	2 233	0.76	-	C
-2-1	14.6	Ca	G	58.1	1 130	212	0	0	1 342	1.65	2.5	B
-2	8.1	Cb	G	28.0	388	157	0	0	545	1.95	3.6	B
-3	6.6	Ca	G	26.7	283	405	0	0	688	1.47	2.2	B
III-1-1	0.8	Ca	G	9.4	929	112	0	0	1 041	0.34	-	C
-2	0.6	Ca	G	3.6	1 082	306	0	0	1 388	0.10	-	C
-3	0.6	Ca	G	6.4	1 519	98	0	0	1 617	0.15	-	C
-4	0.6	Ca	G	7.2	2 612	620	0	0	3 232	0.08	-	C
-5	-	Cb	G	7.5	2 607	0	0	0	2 607	0.11	-	C
-2-1	13.9	Ca	G	52.5	1 073	129	0	0	1 202	1.66	2.6	B
-2	1.1	Ca	G	5.6	859	205	0	0	1 064	0.20	-	C
-3	-	Ca	G	3.4	356	0	0	0	356	0.36	-	C
-4	0.1	Db	G	1.7	470	207	0	0	677	0.10	-	C
-5	-	Db	G	5.4	1 413	0	0	0	1 413	0.15	-	C
-3-1	-	Db	G	1.9	917	0	0	0	917	0.08	-	C
-2	1.1	Ca	G	6.4	806	249	0	0	1 055	0.23	-	C
-3	0.4	Ca	G	4.2	825	164	0	0	1 989	0.16	-	C
III-3-4	0.1	Db	G	1.6	913	246	0	0	1 159	0.05	-	C
-5	-	Db	G	1.4	1 157	0	0	0	1 157	0.05	-	C
-6	0.1	Db	G	1.3	584	313	0	0	897	0.06	-	C
-7	-	Cb	G	1.7	720	0	0	0	720	0.09	-	C
-8	-	Ca	G	1.6	412	0	0	0	412	0.15	-	C
IV-1-1	-	Bc	G	21.0	554	0	0	0	554	1.44	1.6	B
-2	27.6	Bb	G	78.6	1 104	423	0	0	1 527	1.96	3.7	B
-3	17.7	Aa	G	82.2	371	326	0	0	697	4.48	9.9	A
-4	7.4	Bb	G	23.8	1 145	139	0	0	1 284	0.70	-	C
-2-1	-	Bb	G	15.2	603	0	0	0	603	0.96	-	C
-3-1	-	Aa	G	21.1	874	0	0	0	874	0.92	-	C
-2	-	Aa	G	38.0	1 012	0	0	0	1 012	1.43	1.6	B

Table II-3-14 Economic Evaluation (2)

Site No.	Area ha.	Cropping Pattern	Gravity Pattern	Total Economic Benefit	Dam Construction Cost	Other Facility Cost	O.M. Cost	Pump Replacement Cost	Total Economic Cost	B/C	E.I.R.R.	Ranking
-4-1	8.5	Bb	P	24.5	540	305	2	150	1 075	0.87	-	C
-2	20.6	Aa	G	98.8	564	403	0	0	967	3.89	9.2	A
-3	11.6	Bb	G	35.0	1 536	303	0	0	1 839	0.72	-	C
-4	22.7	Bc	G	52.2	802	298	0	0	1 100	1.80	3.1	B
-5	28.1	Bb	G	79.2	907	272	0	0	1 179	2.55	4.8	B
-6	4.1	Bb	G	12.0	531	346	0	0	877	0.52	-	C
-7	3.3	Bb	G	10.4	1 496	395	0	0	1 891	0.21	-	C
-8	12.9	Bb	P	35.6	2 441	457	4	187	3 241	0.42	-	C
-9	11.2	Bb	P	32.5	475	405	2	187	1 135	1.09	0.5	B
-10	34.4	Aa	G	163.7	864	608	0	0	1 472	4.23	9.5	A
-11	2.1	Bb	G	7.1	437	269	0	0	706	0.38	-	C
V-1-1	0.7	Aa	G	4.2	310	94	0	0	404	0.40	-	C
-2	14.5	Bb	P	39.3	913	410	3	187	1 613	0.93	-	C
-3	77.2	Ba	P	247.7	949	1 163	17	467	3 221	2.92	8.8	A
-2-1	31.4	Aa	P	143.2	774	733	5	280	1 992	2.73	7.3	A
-2	45.6	Bb	P	118.6	662	1 137	15	374	2 754	1.64	4.3	B
-3	43.8	Bb	P	111.1	517	931	11	374	2 240	1.88	4.8	B
-4	43.1	Ba	P	135.4	574	1 066	9	374	2 371	2.17	5.7	A
-3-1	-	Bc	G	27.0	758	0	0	0	758	1.35	1.2	B
-2	66.4	Bb	P	179.8	1 394	1 119	7	467	3 254	2.10	5.0	A
-3	56.1	Aa	G	265.6	838	945	0	0	1 783	5.66	12.6	A
-4-1	10.0	Bb	P	29.5	678	502	4	187	1 519	0.74	-	C
-2	19.2	Bc	G	41.8	749	331	0	0	1 080	1.47	1.8	B
V-4-3	16.2	Aa	G	78.3	857	611	0	0	1 468	2.03	3.8	B
VI-1-1	3.7	Bb	P	11.9	534	218	1	121	900	0.50	-	C
-2	3.5	Aa	G	18.0	321	406	0	0	727	0.94	-	C
-3	0.8	Aa	G	6.1	247	293	0	0	540	0.43	-	C
-4	1.3	Bb	P	4.9	286	203	1	121	656	0.28	-	C
-5	3.7	Bb	G	12.0	417	397	0	0	814	0.56	-	C
-6	3.6	Bb	P	10.9	128	207	1	121	509	0.81	-	C
-7	6.4	Bb	P	19.3	357	279	1	150	820	0.89	-	C
-8	9.4	Bb	G	27.6	461	279	0	0	740	1.42	1.6	B
VI-2-1	3.0	Bb	G	10.2	324	588	0	0	912	0.43	-	C
-2	1.4	Bb	P	4.9	676	198	1	121	1 029	0.18	-	C
VII-1-1	57.7	Aa	P	270.1	534	1 010	13	374	2 404	4.27	13.9	A
-2	29.4	Aa	P	136.2	524	702	8	280	1 825	2.84	8.3	A
-3	32.3	Aa	G	154.7	783	356	0	0	1 139	5.16	11.6	A
-4	17.8	Bb	G	50.5	769	290	0	0	1 059	1.81	3.2	B
-5	27.6	Bb	P	76.8	1 206	608	11	280	2 516	1.16	0.7	B
-6	25.3	Bb	P	72.2	446	577	5	280	1 489	1.84	4.4	B
-7	15.5	Bb	G	44.5	862	446	0	0	1 308	1.29	1.0	B
-8	84.9	Bb	G	236.8	2 039	686	0	0	2 725	3.03	7.4	A
-9	13.8	Bb	G	39.0	1 016	342	0	0	1 358	1.09	0.4	B
-10	29.8	Bb	P	83.6	739	459	5	280	1 668	1.90	4.5	B
-11	58.6	Bb	P	161.7	601	1 265	18	374	2 935	2.09	5.7	A
-12	74.4	Aa	P	358.9	1 142	1 108	23	467	3 599	3.79	12.1	A
-13	49.6	Bb	P	139.3	816	889	24	374	2 983	1.77	4.6	B

CHAPTER 4. PRIORITY PROHECT AND PROJECT SELECTION

4.1. Priority Project

Priority ranking of the project implementation should be studied based on not only economic viability but also need and support from the inhabitants, governmental policy of area development, budget and implementation schedule. In the stage of inventory study, however, the priority ranking is evaluated according to the economic viability only. Based on the economic internal rate of return, the marks 'A', 'B' and 'C' have been given to each project. Each mark shows the following:

A: Economic internal rate of return more than or equal to 5 per cent
B: Economic internal rate of return more than zero per cent but less than 5 per cent
C: Economic internal rate of return less than zero

The result of ranking by economic internal rate of return for 94 dam sites is summarized as follows:

Rank	Economic Internal Rate of Return	Number of Sites
A	more than 5 per cent	17
B	more than zero but less than 5 per cent	32
C	less than zero per cent	45

The distribution of the project ranking in each communal land is shown in Figure II-4-1.

The major features of the 17, A'ranked priority projects are shown in Table II-4-1. These 17 'A' ranked projects have relatively large irrigable areas ranging from 20 ha to 80 ha. As for water conveyance method, eight projects among 17 adopt gravity method and the other nine adopt pumping method.

4.2. Project Selection for the Feasibility Study

Based on the Dam Site Inventory in the Interim Report, meetings were held among the Study Team, MEWRD and AGRITEX, and the following priority projects were selected.

	No.	Name	District	Communal Land	Irrigable Area (ha)	Irrigation Method	Ranking
(1)	I-2-1	Musaverema	Mwenezi	Matibi I	40.1	Gravity	A
(2)	II-1-6	Chinyamatsumwt	Bikita	Bikita	38.8	Pump	A
(3)	II-2-1	Mashoko	Bikita	Matsai	14.6	Gravity	B
(4)	IV-4-10	Munjanganja	Gutu	Gutu	34.4	Gravity	A
(5)	V-3-3	Magudu	Masvingo	Nyajena	36.1	Gravity	A
(6)	VII-1-12	Mabvute	Zaka	Zaka	74.4	Pump	A

The locations of the selected six projects are shown in Figure II-4-2.

This selection was based on:

(i) The area irrigated.

(ii) The ranking according to the EIRR.

(iii) Preference for gravity fed schemes although MEWRD requested some pump schemes as a trial.

(iv) The current projects being planned for implementation.
The reason for dropping projects in Chivi and Chiredzi District was that Mbindangombe Project in Chivi and Chironga Project in Chiredzi are already being implemented there.

(v) The areas that are most in need of irrigation.
Region IV Gutu and Region V Nyajena.

The reason for selecting Mashoko Project is as follows

- There has been very little development in that area.
- There is ardent support from the people for the irrigation project.
- Economic viability of the project is fairly good.

Figure II-4-2
Selection of Dam Site for Feasibility Study

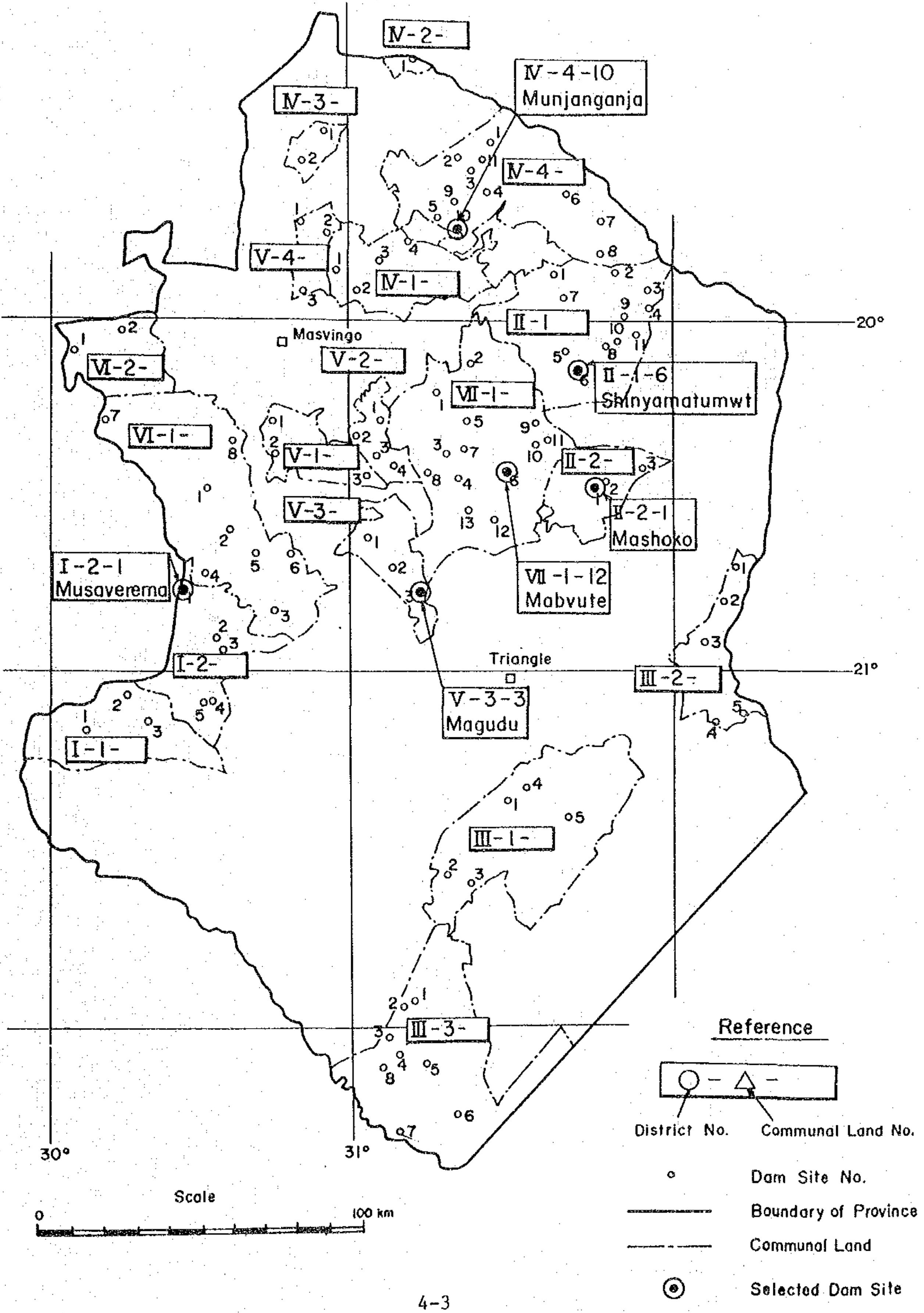


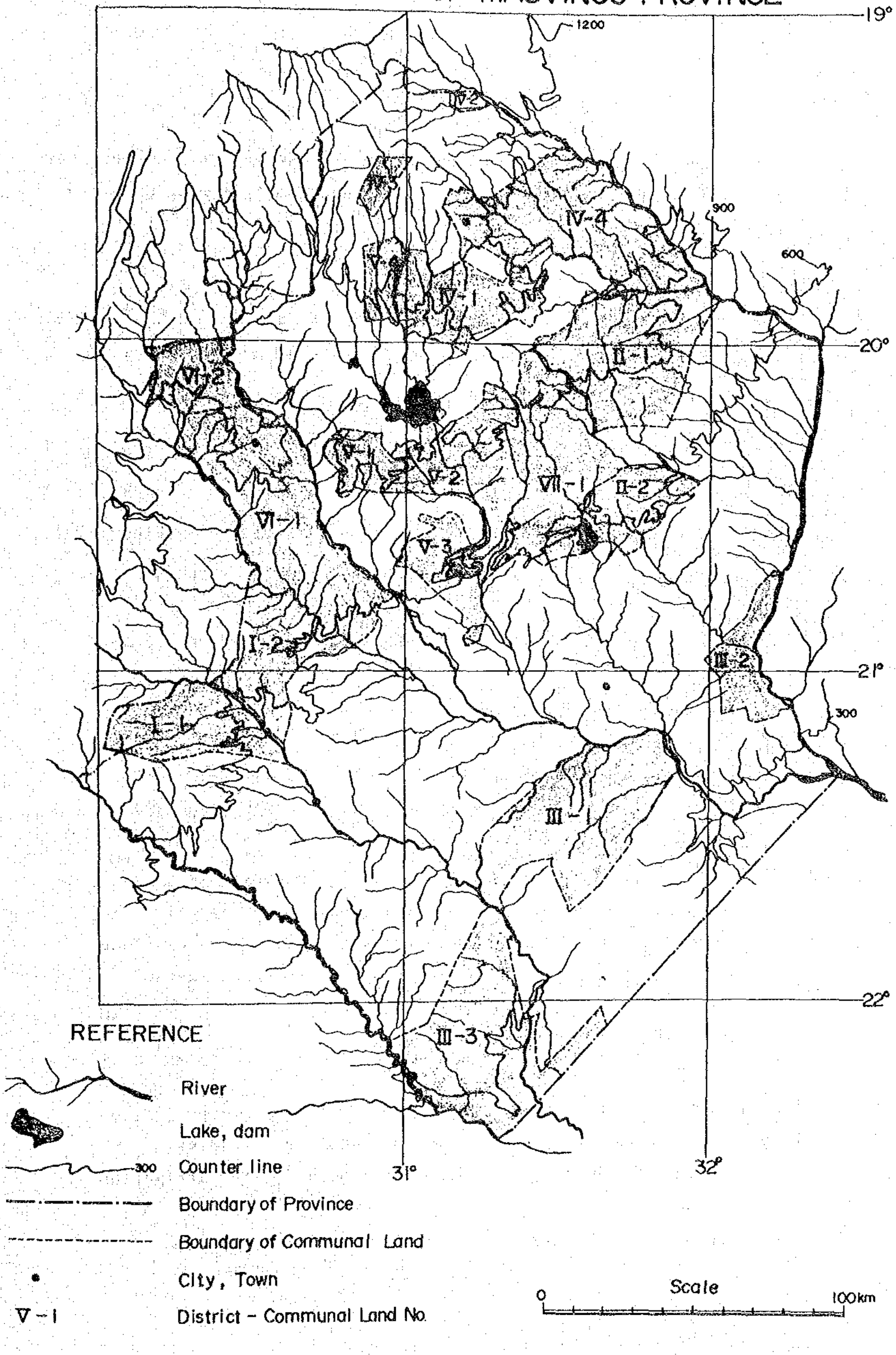
Table II-4-1 Summary of Priority Project

Location			Hydrology			Dam		Irrigation		Cost	Benefit	Evaluation
District	No.	Name	Catch-ment (km²)	Capacity (10³m³)	Yield (10³m³)	Height (m)	Embank-ment (10³m³)	Area (ha)	Method	Total (10³Z$)	(10³ Z$/yr.)	EIRR
Mwcnezi	I-2-1	Musaverema	131.0	4 780	801	10	105	40.1	Gravity	1 488	155	8.9
Bikita	II-1-6	Chinyamatumwa	16.4	2 450	659	18	115	38.8	Pump	2 310	184	8.9
	II-1-10	Chigumisirwa	16.3	1 500	319	15	81	18.8	Gravity	895	64	5.9
Chiredzi												
Gutu	IV-1-3	Chimedza	11.8	1 770	301	11	55	17.7	Gravity	697	82	9.9
	IV-4-2	Chatikobo	17.5	1 390	350	13	82	20.6	Gravity	967	99	9.2
	IV-4-10	Munjanganja	52.8	1 240	584	18	133	34.4	Gravity	1 472	164	9.5
Masvingo	V-1-3	Matsikidzi	48.7	4 270	1 313	18	147	77.2	Pump	3 221	248	8.8
	V-2-1	Makwawa	16.0	700	534	18	53	31.4	Pump	1 992	143	7.3
	V-2-4	Chatikubo	20.5	1 750	732	18	90	43.1	Pump	2 371	135	5.7
	V-3-2	Fusira	30.8	3 000	1 128	18	152	66.4	Pump	741	180	5.0
	V-3-3	Magudu	41.9	5 780	954	17	129	56.1	Gravity	1 783	266	12.6
Chivi												
Zaka	VII-1-1	Zishiri	14.0	1 670	981	18	84	57.7	Pump	2 404	270	13.9
	VII-1-2	Chida	20.0	440	500	18	83	29.4	Pump	1 825	136	8.3
	VII-1-3	Veza	18.3	1 500	549	18	128	32.3	Gravity	1 139	155	11.6
	VII-1-8	Chenyu	25.1	4 500	1 443	18	220	84.9	Gravity	2 725	237	7.4
	VII-1-11	Fuve	48.1	2 790	996	15	89	58.6	Pump	2 935	162	5.7
	VII-1-12	Mabvute	31.1	2 930	1 265	17	99	74.4	Pump	3 599	359	12.1

LIST OF ANNEXES

ANNEX A. TOPOGRAPHY AND GEOLOGY

Figure A-1
DRAINAGE SYSTEM OF MASVINGO PROVINCE



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