4.6 Irrigation System's Operation and Maintenance Plan

(1) System's Level Operation and Maintenance Plan

Several manuals pertaining to the operation and maintenance (O&M) of irrigation systems had already been developed by MoIWD under the technical assistances by the related donors and NGOs. The common objectives of these manuals are to have an efficient operation and maintenance of an irrigation system aimed at increasing production and improving farming techniques and to prolong the service life of the system.

Although upland crop irrigation plan in these manual is discussed under the medium-scale irrigation scheme, it is foreseen that the operation and maintenance (O&M) aspects of the schemes will not be altered, since the schemes are farm level-based projects, which are within the O&M jurisdiction of the farmers or farmers' group.

As such, the usual O&M planning programs of the irrigation systems will still have to be followed particularly on the different aspects as presented below;

- Hydro-meteorological data collection,
- Water management parameters,
- Programmed area and date of initial water delivery for cropping season,
- Cropping calendar
- Water distribution schedule, and
- System's level maintenance plan.

The approaches dealing with these parameters were discussed in details in the following Manuals;

- Field Guide on Irrigated Agriculture for Field Assistants, Food and Agriculture Organization (FAO) in April 2001,
- Surface Irrigation Systems Practiced in Malawi, Department of Agricultural Extension Services (DAES) in 2007

(2) Types and Selection of Irrigation Methods

In general, irrigation methods applicable for upland crops could be divided into following four types;

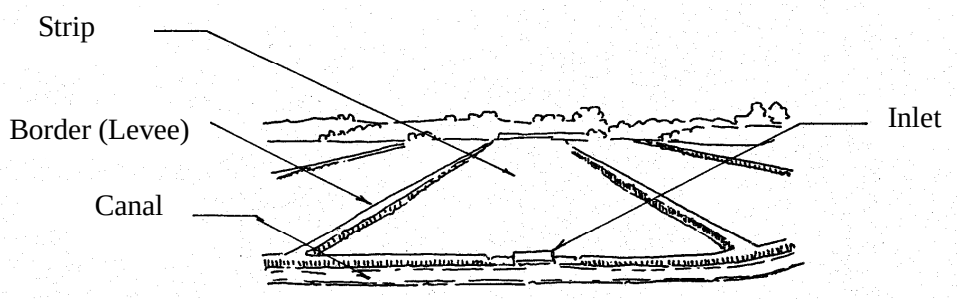
- Surface irrigation – basin, furrow and border strip (see **Figure 4-4**),
- Overhead irrigation – watering-can/bucket and sprinkler,
- Micro-irrigation – drip, micro-sprinkler, mini-sprays and mini-sprinkler, and
- Sub-surface irrigation – shallow ground water or active control of groundwater to permit cropping in the dry season.

Each irrigation method has advantages and disadvantages that should be taken into consideration when choosing the most suitable irrigation method. The factors influencing selection of the type of irrigation methods are listed below;

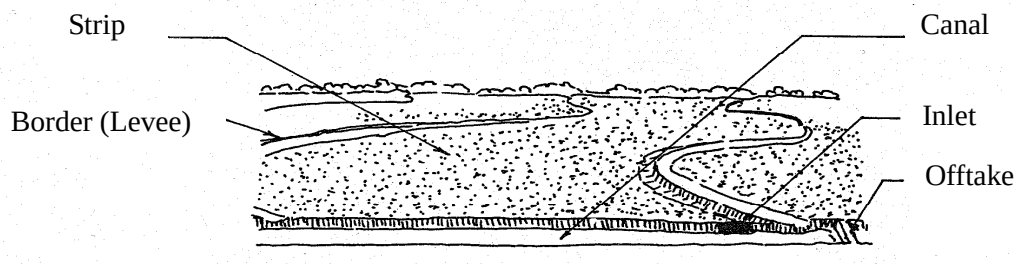
- Natural conditions (soil type, slope, climate, water quality and quantity),
- Type of crops to be grown,
- Farmers' previous experience of irrigation, and
- Capital and operational costs,

The subsequent discusses more details on the surface irrigation methods such as basin and furrow (ridge) irrigation methods, which are widely and commonly applied in Malawi.

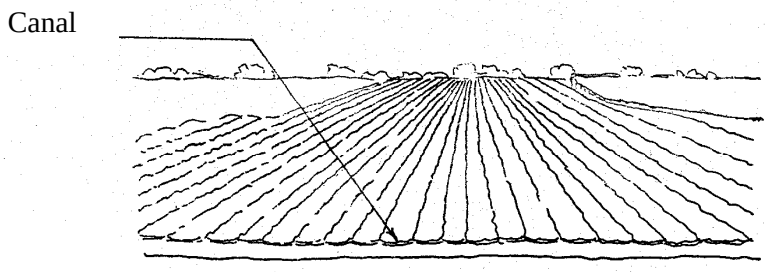
Figure 4-4 Typical Layout of Surface Irrigation Methods



Basin Type with Level Border of Surface Irrigation



Basin Type with Contour Levee of Surface Irrigation



Basin Type with Level Furrow (Ridge) of Surface Irrigation

a) Basin Irrigation Methods (Flat Bet, Raised Bed, Ridged Bed)

Basin is a leveled area of land with strips enclosed by earthen border ridges of levees, witch is totally flooded during irrigation. Water is held on the surface of the basin until it goes into the soil. Water is normally brought to the basin in earth canal using gravity. Where water is pumped from the water source, it should be pumped to a high portion and distributed in canals under gravity. Basins could be flat, either sunken or raised or ridged. In all cases good basin irrigation requires the ground surface to be level.

Basin irrigation is suitable for many crops. The advantages are; a) right amount of water can be given with a minimum amount of labour if the beds are well leveled, b) water losses could be kept low by minimum run-off, and c) basins last for a long time once they are constructed.

On the other hand, the basin irrigation needs a good water supply to fill the basin quickly. This in turn requires accurate land leveling and field layout from the start, which may need a lot of manual labour. Prolonged ponding and crop damage could occur in poorly managed flat beds. There is also the risk of soil erosion in the supply canal as a result of the high speed of the water.

The systems on level strips are classified as the level system. The classification of the surface level system is summarized as follows;

- Level border : Basin type with level border
- Contour level : Basin type with contour levee
  Basin type with level furrow (ridge)

Level Border

The level border type of surface system consists of a level area enclosed by earthen border ridges of levees. When irrigating, designed amount of water is turned on the strip and allowed to spread until it is absorbed.

For a uniform distribution of water, the rate at which the water is turned onto each strip should be at least twice as the succeeding one as along as soil can absorb it. This rate gets water over the entire strip as quickly as possible. Otherwise, more water than the necessary is absorbed near the head ditch. For this reason, level border system must be constructed so that at least 3.5 lit/sec/ha of water is available for strip. Another feature that will increase the speed of water flow across the strip is to construct a slight grade. It may also help prevent water from pounding in low spot.

Contour Levee

The contour levee type of surface system is similar to the level border system except that it is adapted to the sloping land. The strips should be graded until they are level. Instead of rectangular fields bordered by dikes or levees, the fields are bound on the contour by levees at the lower edge of the strip.

When watering, the procedure is the same at that for the level border system. Water is applied from farm ditch at one ends of the strip. It spreads rapidly over the area where it remains until water becomes absorbed, unless extra water is applied for weed control.

Since contour levee systems are leveled areas on the side of a slope. There are often two or more such strip below the highest one. Ib that case, water can be released from the higher strips to the lower strips. Water is held at the desired level on each sttip by small spillways in the levees. They allow excess water from one strip to spill over onto the strip immediately below. If there is too much water for the lowest strip, it is drained into a farm drain at the lower edge of the field.

Level Furrow (Ridge)

The level type of surface system is the same as the level border type except for the addition of furrows. There is a little slope. The size and shape of the furrow depends on the crop grown,

equipment used and spacing between the rows.

When irrigating, a stream as large as the furrow can withstand is turned into each furrow by siphon tubes or pipes. It is allowed to flow until the amount needed is obtained. The water stands in the furrow until it would be absorbed into the root zone below the furrows and in the ridges between the furrows. It is said that with this type of system, about 15 percent more than that is needed to obtain enough water on the entire strip will generally be required. The reason is that more water is absorbed by the area next to the farm ditch where the water is applied.

b) Furrow Irrigation Methods

Furrow irrigation is generally used on farms having large uniform fields, where long furrows can be formed, usually using a tractor. They are not appropriate for very small-scale irrigation where farmers' plots are small and irregular in shape.

Under furrow irrigation water is taken to the plant through long, narrow canals (furrows) formed in the soil at regular intervals, between the crop rows (ridges). It is important to use the right shape of furrow, furrow spacing and length. Good water management is important for the method to work well. If managed well, furrow irrigation has the following advantages;

- Moderate and high irrigation efficiency,
- Less danger of leaching nutrients from the soil than with basin method,
- Crop stems are not wetted, and
- Even soils, which form a surface crust when flooded, can be irrigated as water moves laterally from the furrow into the ridge, below the level of plant growth.

The disadvantages of furrow irrigation are listed as follows;

- Erosion could occur if slope is two steep,
- Labour requirement may be high as the streams must be carefully regulated to achieve uniform water distribution,
- Salts from the soil or water supply may concentrate on the top of the ridge and eventually cause damage to young crops planted there,
- Lateral spread of water in coarse textured soils may not be enough to wet the soil between the furrows, and
- Careful land leveling is required for uniform furrow slope an shape.

(3) Distribution of Irrigation Water and Plan of Irrigation Schedule

a) General Methods of Water Distribution

Following two types of water distribution methods are generally applied at present;

- Simultaneous distribution, and
- Rotational distribution

1) Simultaneous Distribution

This method involves simultaneous supply of water to all the canals.

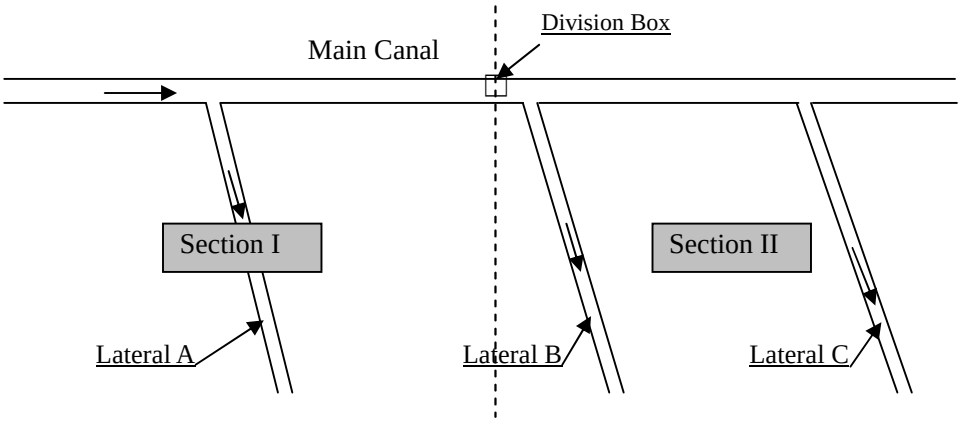
2) Rotational Distribution

Rotational distribution is practiced by rotating the supply of water to different areas. Under this method there are three practices as shown below, namely:

- Rotation by section in main canal
- Rotation by section or turnouts in the lateral/feeder canals
- Rotation by section in the farm ditch

Rotation by Section in Main Canal

Irrigation water is conveyed by rotation to different sections in the main canal (refer to the following figure). This method requires bigger capacities for both conveyance and distribution systems.



According to the field survey conducted at eight "Verification Sites", all the irrigation schemes are supplying irrigation water applying this type of rotational methods. Following table shows the current and/or previous irrigation water supply methods at the "Verification Sites".

Current Irrigation Water Supply Methods

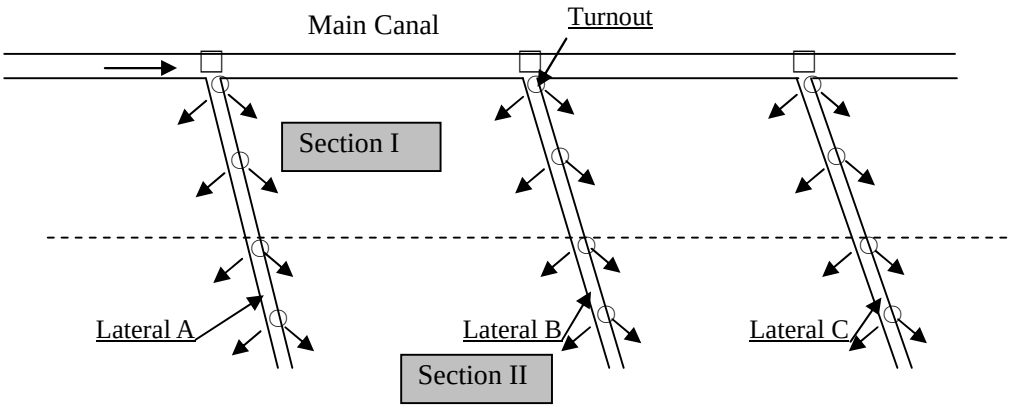
Irrigation Scheme	Irrigation Area (ha)	Irrigation Interval	Frequency of Irrigation	Water Supply Period	Operation Hours (hr)
1. Bethani (Mz-21)	22.0	5-day Rotation	Once a week	2-day	24 (R)
2. Mantha (Mz-4)	5.0	3-day Rotation	Once a week	2-day	4-5 (P)1/
3. Chiwoza (kas-46)	10.0	5-day Rotation	Once a week	2-3 day	8 (D+P)
4. Kachere (Kas-40)	6.4	5-day Rotation	Once a week	2-day	10 (P)
5. Titukulane (kas-47)	7.0	3-day Rotation	Twice a week	2-day	24 (R)
6. Chaseta (Li-2)	12.0	5-day Rotation	Once a week	2-day	2 (P)
7. Bawi (Li-21)	14.7	3-day Rotation	Once a week	2-day	24 (R)
8. Chibwana (Ma-1)	85.0	5-day Rotation	Once a week	2-day	24 (R)

1/ : P: Motorized pump, R: River Diversion, D: Impounding dam
D+P: Combination with impounding dam and motorized pump

As is seen in the above table, it could be proved that the 3-day to 5-day rotational water supplies are prerequisite conditions in the Medium-Scale Irrigation Schemes, so that irrigation interval in each scheme should be carefully checked and determined, based on the soil characteristics, estimated crop water requirement, canal and pump capacity, etc.

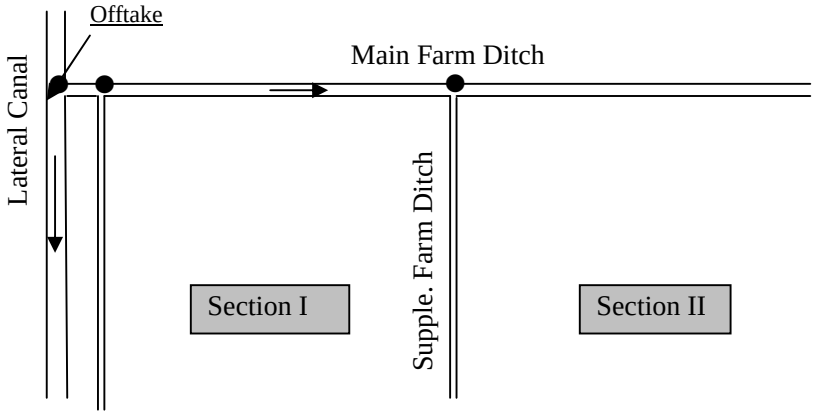
Rotation by Section or Turnouts in Lateral/Feeder Canals

The main canal conveys a continuous flow while the water is rotated by the section or turnouts of the lateral/feeder canal (refer to the following figure)



Rotation by Section in Farm Ditch

Water is rotated only in rotation area in the farm ditch, and conveyance of water in the main canal and lateral/feeder canals are continuous.



b) Comparison on the Water Distribution Methods

1) Advantages of Rotational Distribution Methods

Advantages of rotational water distribution are as follows;

- Water can be reasonably regulated and evenly distributed over the upper, middle and lower reaches of canal systems to meet the requirements for reducing and/or eliminating the droughts in the spot areas, when the water resources is scarce.
- It may save water which can be used for either extension of new irrigation areas or can be supplied for fish culture uses.
- Furthermore, the farmers will retain confidence in getting timely delivery of a limited amount of irrigation water during dry (summer) season and drought year.

2) Advantages of Simultaneous Water Distribution Methods

When the water resource is abundant, this method has the following advantages.

- The investment in the irrigation system is less because of fewer water control structures and measuring devices in the system.
- Less labour is used in simultaneous irrigation as compared with rotational irrigation.

c) Examination of Irrigation Schedule

In order to properly manage and operate the irrigation facilities, an irrigation schedule should be prepared. Irrigation schedule shows an irrigation interval, date and water supply duration of time,

when the farmer may irrigate. Irrigation interval should not exceed a permissible maximum irrigation interval, which will be determined based on soil holding capacity of the soil. Though the maximum irrigation interval depends on the soil characteristics, it can be said that the interval, in general, would be preferable within a week in the most cases.

To examine the optimal irrigation interval for selected eight verification sites, the irrigation schedule inclusive of irrigation schedule, date and water supply duration of time was studied considering the concepts of Readily Available Soil Moisture (RAM). For optimum growth of crops, the crops will be losing water at a rate equivalent to Crop Water Requirements (ETc). The number of days for crops to deplete available soil moisture (irrigation interval : Id) can be obtained from the following equation;

Id = RAM / ETc

Where ; Id = Irrigation interval (day)
RAM = Sa x P x D x C
Sa = Available soil moisture (mm/m)
P = Fraction of available soil moisture
D = Rooting depth (m)
C = Correction for ETc
ETc = Evapo-transpiration by crop (mm/day)

Irrigation interval for selected eight irrigation schemes was examined based on the above equation, and **Table 4-3** shows the results of examination. Proposed irrigation interval for winter season crops are summarized as follows;

Proposed Irrigation Interval for Winter Crops

Irrigation Scheme	Type of Scheme	Irrigation Area (ha)	Proposed Irrigation Interval (day)
1. Bethani Scheme	River Diversion	22	3
2. Mantha Scheme	Motorized Pump	5	4
3. Chiwoza Dam	Impounding Dam	10	4
4. Kachere Scheme	Motorized Pump	6.4	5
5. Titukulane Scheme	River Diversion	7	3
6. Chaseta Scheme	Motorized Pump	12	5
7. Bawi Scheme	River Diversion	14.7	3
8. Chibwana Scheme	River Diversion	85	5

On the other hand, water supply duration of time for each crop was calculated on the basis of following equation, and their results were shown in **Table 4-3**.

Sd = Di x A x 10 / (Qw x 3,600)

Where ; Sd = Water supply duration (hr)
Di = Depth of irrigation (mm)
A = Irrigation area (ha)
Qw = Available water (lit/sec)

As the results, water supply duration by crop was calculated as follows;

Calculated Water Supply Duration by Crops

Crops	Water Supply Duration (hr)	
	Present	Calculated
Maize	6	-
Onion	7	-
Cabbage	5	-
Tomato	5	-
Bean	3	-

Table 4-3 Examination of Irrigation Schedule for Verification Sites

Irrigation Scheme	Irrigation Area	Irrigation Water Source		Irrigation Conditions								Readily Available Soil Moisture (RAM)						Irrigation Interval				Water Supply Duration	
		Type of Scheme	Available Water (Dry Season)	Crops		Soil		ETc		Rooting Depth	Irrigation Efficiency	Available Soil Moisture	Fraction of Available Soil Moisture	Readily Available Soil Moisture per Meter	Correction for ETc	Readily Available Soil Moisture (RAM)	Depth of Irrigation	Calculated Irrigation Interval			Proposed Irrigation Interval	Calculated Water Supply Duration	Present Practice
				Crops	Type	Soil Texture	Soil Type	Max.	Ave.									by Max. Eto	by Ave. ETo				
	(A)		(Qw)							(D)	(Ef)	(Sa)	(P)	(Sa x P)	(C)	(Sa x P x D x C)	(Di)	(In)	(In)		(In)	(Sd)	(Sd)
	(ha)		(lit/sec)					(mm/day)	(mm/day)	(m)	(%)	(mm/m)		(mm/m)		(mm)	(mm)	(day)	(day)		(day)	(hr/0.1ha)	(hr/0.1ha)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)		(20)	(21)	(22)
1. Bethani (Mz-11) Bethani A : 8 ha Bethani B : 14 ha	22	River Diversion	10.0	Maize	S-Ma	Clay Loam	Medium	4.1	3.2	1.35	50	140	0.60	84	1.0	113	226	27.6	35.3			6.3	6
				Tomato	S-To			4	3.9	1.15	50	140	0.40	56	1.0	64	128	16	16.4			3.6	5
				Maize	W1-Ma			5.6	4.1	1.35	50	140	0.60	84	1.0	113	226	20.2	27.6			6.3	6
				Irish Potato	W1-Ip			5.4	4.3	0.5	50	140	0.20	28	1.0	14	28	2.6	3.3	*	3 (3)	0.8	
				Maize	W2-Ma			6.4	4.7	1.35	50	140	0.60	84	1.0	113	226	17.7	24			6.3	6
				Onion	W2-On			5.7	3.8	0.45	50	140	0.25	35	1.0	16	32	2.8	4.2			0.9	7
2. Mantha (Mz-4)	5	Motorized Pump	13.0	Maize	S-Ma	Sandy Loam	Light	4.5	3.6	1.35	50	130	0.60	78	1.0	105	210	23.3	29.2			4.5	6
				Maize	W1-Ma			4.8	3.6	1.35	50	130	0.60	78	1.0	105	210	21.9	29.2			4.5	6
				Cabbage	W1-Ca			4.5	3.9	0.45	50	130	0.45	58.5	1.0	26	52	5.8	6.7	*	4 (6)	1.1	5
				Maize	W2-Ma			7.1	5.2	1.35	50	130	0.60	78	1.0	105	210	14.8	20.2			4.5	6
				Tomato	W2-To			6.8	6.2	1.15	50	130	0.40	52	1.0	60	120	8.8	9.7			2.6	5
3. Chiwoza Dam (Kas-46)	10	Impounding Dam	15 (pump) 20 (gravity	Maize	S-Ma	Sandy Loam	Light	4.5	3.4	1.35	50	130	0.60	78	1.0	105	210	23.3	30.9			1.9	6
				Paprika	W-Pa			5.2	3.2	0.75	50	130	0.25	32.5	1.0	24	48	4.6	7.5			0.4	
				Maize	W1-Ma			5.7	4.3	1.35	50	130	0.60	78	1.0	105	210	18.4	24.4			1.9	6
				Cabbage	W1-Ca			5	4.6	0.45	50	130	0.45	58.5	1.0	26	52	5.2	5.7	*	4 (5)	0.5	5
				Maize	W2-Ma			5.8	4.4	1.35	50	130	0.60	78	1.0	105	210	18.1	23.9			1.9	6
				Tomato	W2-To			5.6	5.2	1.15	50	130	0.40	52	1.0	60	120	10.7	11.5			1.1	5
4. Kachere (Kas-40)	6.4	Motorized Pump	10.7	Maize	S-Ma	Clay Loam	Medium	4.5	3.4	1.35	50	140	0.60	84	1.0	113	226	25.1	33.2			5.9	6
				Maize	W-Ma			6	4.5	1.35	50	140	0.60	84	1.0	113	226	18.8	25.1			5.9	6
				Cabbage	W1-Ca			5	4.6	0.45	50	140	0.45	63	1.0	28	56	5.6	6.1	*	5 (5)	1.5	5
				Tomato	W2-To			5.6	5.2	1.15	50	140	0.40	56	1.0	64	128	11.4	12.3			3.3	5
5. Titukulane (Kas-47)	7	River Diversion	10.0	Maize	S-Ma	Clay Loam	Medium	4.8	3.4	1.35	50	140	0.60	84	1.0	113	226	23.5	33.2			6.3	6
				Tomato	S-To			4.9	4	1.15	50	140	0.40	56	1.0	64	128	13.1	16			3.6	5
				Maize	W1-Ma			4	3	1.35	50	140	0.60	84	1.0	113	226	28.3	37.7			6.3	6
				Carrot	W1-Car			3.3	3.1	0.75	50	140	0.35	49	1.0	37	74	11.2	11.9			2.1	
				Cabbage	W1-Ca			3.7	3.3	0.45	50	140	0.45	63	1.0	28	56	7.6	8.5	*	3 (8)	1.6	5
				Maize	W2-Ma			6.2	4.5	1.35	50	140	0.60	84	1.0	113	226	18.2	25.1			6.3	6
				Tomato	W2-To			6	5.4	1.15	50	140	0.40	56	1.0	64	128	10.7	11.9			3.6	5
6. Chaseta (Li-2)	12	Motorized Pump	18.0	Maize	S-Ma	Clay Loam	Medium	4.8	3.7	1.35	50	140	0.60	84	1.0	113	226	23.5	30.5			3.5	6
				Beans	W1-Be			3.6	2.4	0.75	50	140	0.45	63	1.0	47	94	13.1	19.6			1.5	
				Cabbage	W1-Ca			3.7	3.3	0.45	50	140	0.45	63	1.0	28	56	7.6	8.5	*	5 (8)	0.9	5
				Maize	W2-Ma			6.2	4.5	1.35	50	140	0.60	84	1.0	113	226	18.2	25.1			3.5	6
				Tomato	W2-To			6	5.4	1.15	50	140	0.40	56	1.0	64	128	10.7	11.9			2	5
7. Bawi (Li-21)	6.3	River Diversion	23.4	Maize	S-Ma	Sandy Loam	Light	5	3.8	1.35	50	130	0.60	78	1.0	105	210	21	27.6			2.5	6
				Maize	W1-Ma			6.1	4.5	1.35	50	130	0.60	78	1.0	105	210	17.2	23.3			2.5	6
				Cabbage	W1-Ca			5.5	4.4	0.45	50	130	0.45	58.5	1.0	26	52	4.7	5.9	*	3 (5)	0.6	5
				Maize	W2-Ma			6.8	5.1	1.56	50	130	0.60	78	1.0	122	244	17.9	23.9			2.9	6
				Tomato	W2-To			6.5	6.1	1.15	50	130	0.40	52	1.0	60	120	9.2	9.8			1.4	5
				Sugarcane	Sc			7.1	5.1	1.50	50	130	0.65	84.5	1.0	127	254	17.9	24.9			3	
8. Chibwana (Ma-1)	34	River Diversion		Paddy Rice	S-Ri	Clay Loam	Medium	9.1	8.1		58	140						0	0				11
				Maize	W-Ma			6.8	5.2	1.35	50	140	0.60	84	1.0	113	226	16.6	21.7				6
				Tomato	W-To			6.5	6.1	1.15	50	140	0.40	56	1.0	64	128	9.8	10.5	*	5 (10)		5

Note :
(10) : Referred to Table 39 in FAO Irrigation and Drainage Paper, Technical Series No.24
(12) : Referred to Table 38 in FAO Irrigation and Drainage Paper, Technical Series No.24
(13) : Referred to Table 39 in FAO Irrigation and Drainage Paper, Technical Series No.24
(14) : Readily Available Soil Moisture per meter = Sa x P (mm/m)
(15) : When ETc is 3mm/day or smaller, the readily available soil moisture can be increased by some 30 %, but when ETc is 8 mm/day or more, it should be reduced by some 30 %.
(16) : Readily Available Soil Moisture (RAM) = Sa x P x D x C (mm)
(17) : Depth of Irrigation (Di) = RAM/Ef (mm)
(18) : Irrigation Interval (In) = RAM/ETc (day), Asterisk (*) shows restricted crop during the winter season.
(20) : Figures in parentheses show calculated day of irrigation intervals
(21) : Water Supply Duration (Sd) = Depth of Irrigation (Di) x Irrigation Area of 0.1 ha (A)/Available Water (Qw)
(22) : Derived from verbal information from farmers groups.

d) Examination of Irrigation Interval

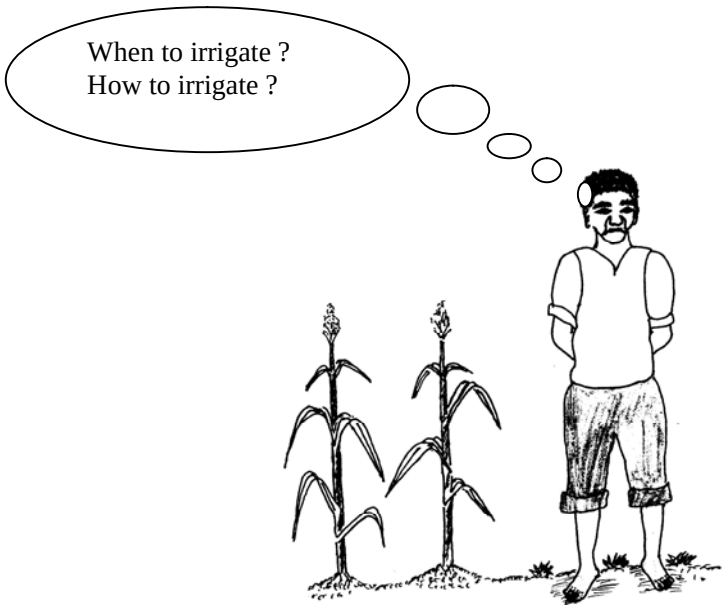
Irrigation interval, which stands for the frequency of irrigation water supply, was analyzed based on the collected information obtained through monitoring survey conducted by the Study Team during the 2008 dry season. As a result, irrigation interval for maize being major crops in the Verification Study area was revealed to be different from scheme to scheme, that is, once/2 week, once/week, and twice/week, of which details will be referred to **Table A. 3-3**.

(4) Operation and Maintenance and Water Management Plans at Farm Level

a) Water Allocation and Distribution Schedule to Target Farm Area

According to the rotational irrigation schedule as discussed in the above, water supply amount, supply duration and irrigation interval to the terminal rotation unit should be determined in each scheme as outputs in the irrigation schedule. The terminal rotation unit (TRU) is here defined as a group of fields to which irrigation water is supplied as a rotation unit by a supplemental farm ditch as shown in **Figure 4-5**.

Figure 4-6 shows an output example wherein the terminal irrigation unit is the area served by supplementary farm ditch (SFD). The final output of operation plan for crops should therefore, answer specific questions raised by farmers in each field or water distribution unit (refer to the following figure).



Expected Farmer's Questioned on Crop Irrigation Operation

Although farm level irrigation schedule should be prepared in the planning/design stage, the schedule would be based on a representative field size and crops. The specific operation schedules, thus, should be made considering the design components such as; the design irrigation efficiency, the maximum permitted length of furrow or border to maintain the level of the design irrigation efficiency, and the design furrow rate of discharge/border stream size.

b) Water Management Parameters

Terminology Definitions of Parameters

Terminology definition for the following parameters should be cleared;

- Number and size of terminal rotation unit (TRU),
- Design flow rate of discharge (Qd) = gross irrigation water requirement (GWR) x whole Irrigation area (A),
- Water supply rate at the inlet (Qs),
- Furrow discharge or Stream Size (q)
- Design furrow rate of discharge or border stream size (qd)
- Irrigation interval (In),
- Design irrigation duration for crops (Tud), (Tpd),
- Design maximum permitted length of furrow or border (Lmax), and
- Design irrigation efficiency (IE) ,

Parameters Determination Principles

Considering the size of the programmed are which is small and the real conditions of farm level practices, the following principles will be adopted to simplify the procedures;

- Terminal rotation unit (TRU) is divided into irrigation blocks to simplify the operation. Simultaneous irrigation is applied within each block.
- Earthen off-take is applied to simplify the regulation of water. Thus, Qs value is used as the supply volume ay each unit.
- Bar-chart presentation od cropping pattern or schedules is applied, because the size of each unit may suggest early completion of farming activities such as seedling, transplanting, and harvesting
- The design irrigation efficiencies (IE) is applied for calculating the amount of water supply (irrigation water requirement, IWR) considering the size of the irrigation area.

Parameters given from the Planning/Design Stage

The following parameters should be defined;

- Amount of water supply at the inlet (Qs) (lit/sec),
- Supply duration of on upland crops (Tud) (hr),
- Supply duration of paddy rice (Tpd) (hr),
- Irrigation Interval (In) (day)
- Design furrow rate of discharge or border stream size (qd) (lit/sec) per furrow or unit border strip width,
- Design maximum permitted length of furrow or border (Lmax) (m)
- Design irrigation efficiency (IE) (%)

Actual Maximum Length (Lmax) of Furrow or Border and Minimum Furrow Rate of Discharge or Border Stream Size (qmin)

By analyzing the map or through reconnaissance field survey, identify the longest furrow length or border strip length (Lmax) within the TRU. Considering the flow direction, the actual discharge or stream size (q) should be calculated during the preliminary blocking. The largest block is applied to estimate the minimum q (qmin).

Figure 4-5 Schematic Illustration of Terminal Rotation Unit (TRU)

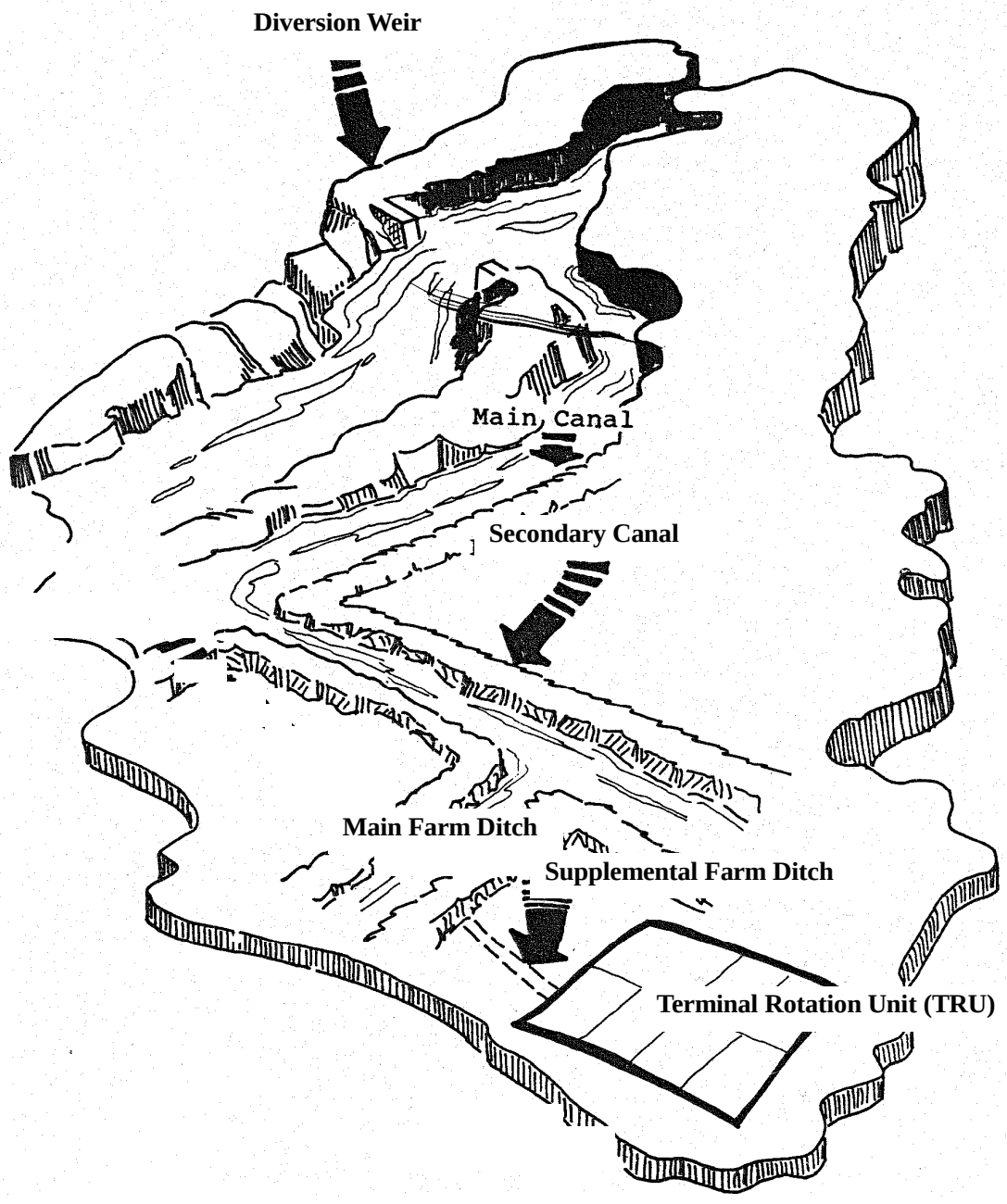
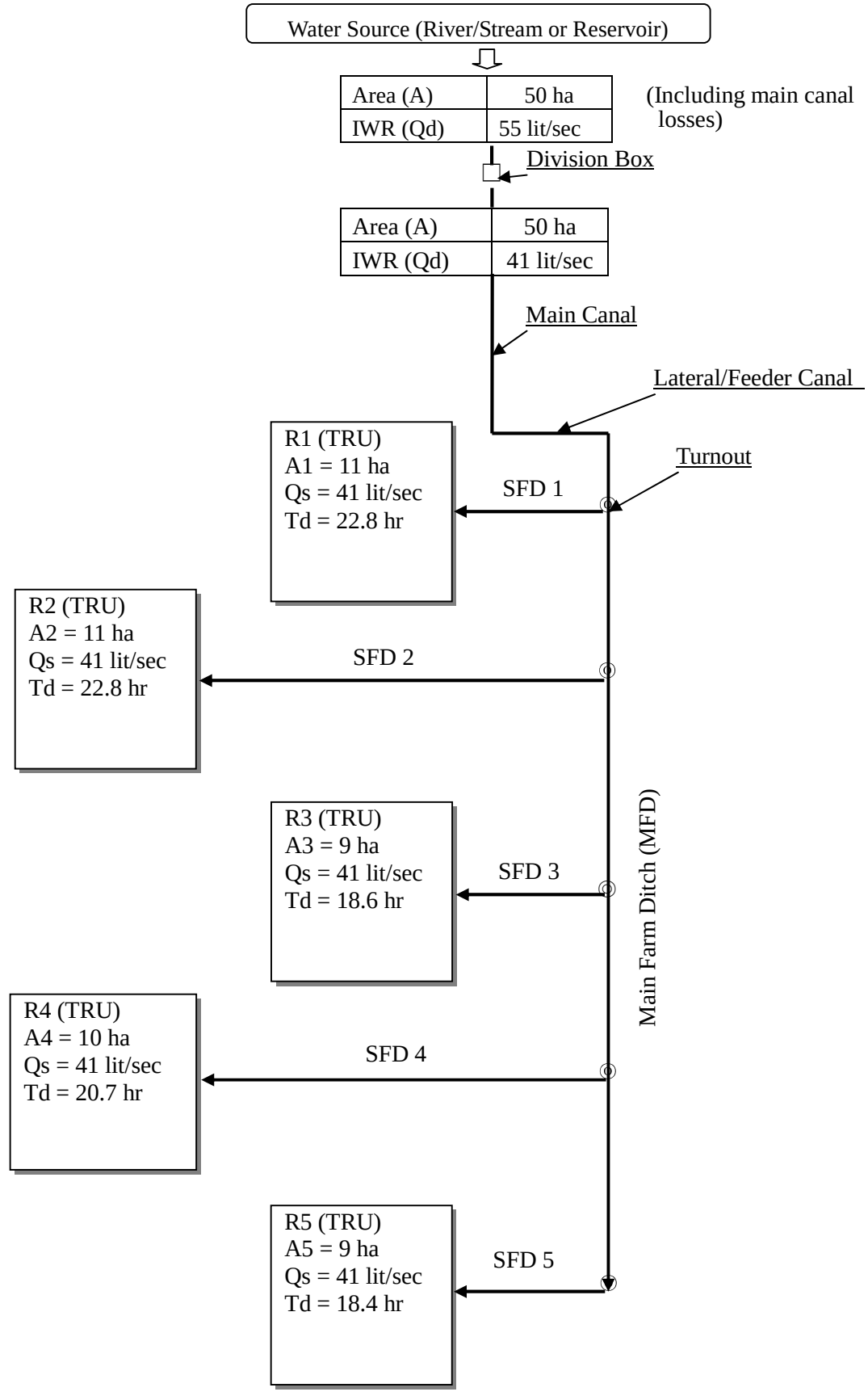


Figure 4-6 Example of Irrigation Network Diagram for Rotational Irrigation



For the furrow irrigation, if total number of furrow is equal to Nmax;

qmin = Qs /Nmax (lit/sec/furrow)

Where; Nmax = maxim number of furrow for furrow irrigation or maximum distance in meter of border width for border irrigation

Example: If the total numbers of furrows are estimated to be 50, and Qs = 41 lit/sec, qmin is calculated as:

Qmin = 41 lit/50 x 60 sec= 49 lit/min/furrow

Block Hectare (Ai) and Consumptive Use (CU)

Dividing TRU into blocks is done considering the cropping pattern, land topography and block size for operation. The blocks and corresponding hectarage should be delineated in the map. Consumptive use (CU) is applied only to upland crops. For paddy rice, this is referred to as the water requirement in depth.

Required Irrigation Water Supply per Application (V)

For upland crops, V is given as:

$V = CU \times In \times A \times 10 / IE$

Where; V = Volume of water irrigated per application (cu.m)
CU= Daily consumptive use (mm)
In = Irrigation interval (day)
A = Irrigation area (ha)
IE = Design irrigation efficiency (%)

Water Supply Duration (Td)

Water supply duration is given as:

$Td = V / 3.6Qs$

Where; Td = Water supply duration (hr/application)

c) Crop Hectarage and Cropping Pattern

In accordance with the crop allocation, crop hectarage should be decided. The draft of blocking the area (dividing the terminal rotation unit (TRU) area into a number of blocks should be finalized with specific crop allocation. The following criteria should be considered in the blocking design:

- Same crops or crops with similar water consumption are planed in a block to ease up simultaneous application of a uniform irrigation depth over the same block,
- Same irrigation method is applied within a block, and
- Based on experiences at each irrigation scheme, the water supply duration is summarized as shown below per application to avoid wet damage on crops.

Water Supply Duration by Crops

Crops	Water Supply Duration (hr)	Crops	Water Supply Duration (hr)
Maize	6	Radish	5
Onion	7	Beans	3
Cabbage	5	Paddy	11
Tomato	5		

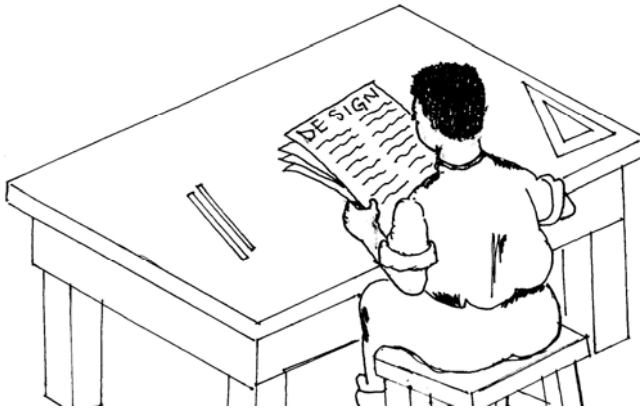
Source : Verbal information from farmers

d) Water Allocation and Delivery Schedule

The scheduling includes following five steps, namely; a) defining the designing stage parameters, b) preliminary blocking and evaluation, c) deriving crop hectarage, pattern and blocking terminal rotation unit (TRU), d) calculating water supply durations (Td), and e) determining water allocation/delivery schedule and dissemination.

Step-1. Defining the Design Stage Parameter

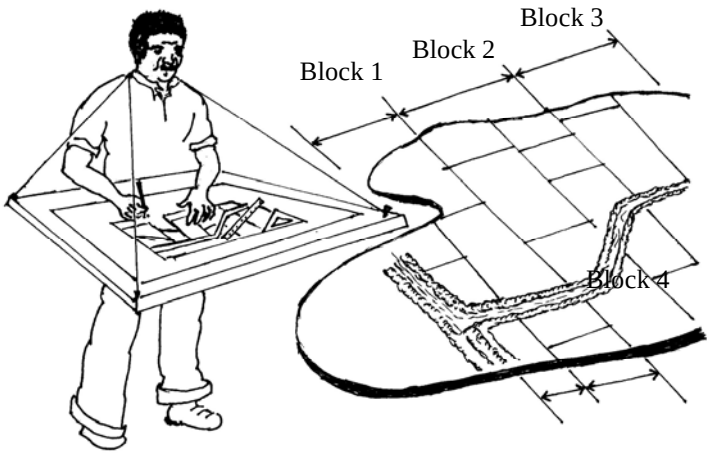
Define the following parameter, namely; TRU, Qd, Qs, q, qd, In, Td, Lmax and IE (refer to the following figure).



Defining Design Parameters

Step-2 Preliminary Blocking

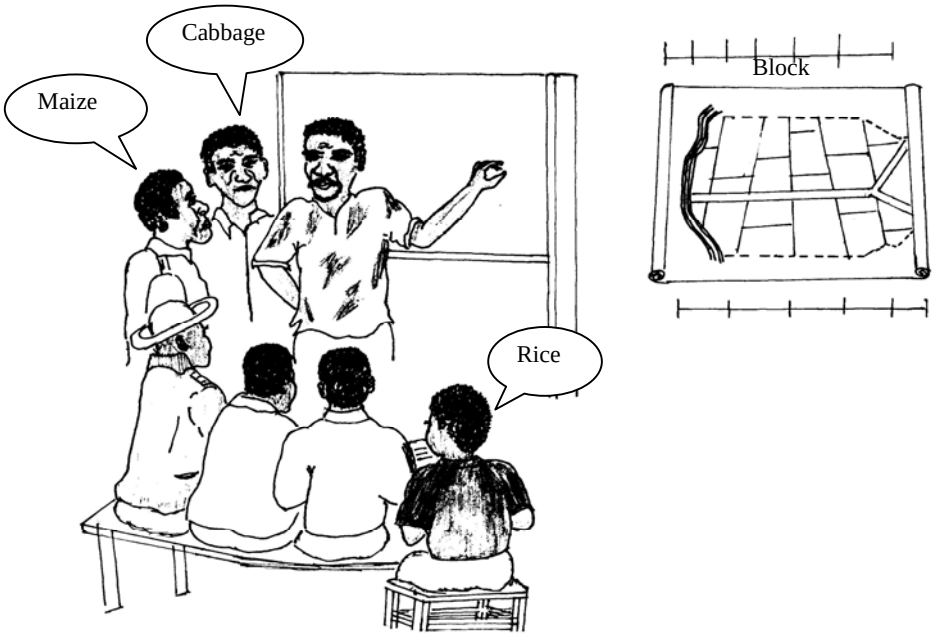
Preliminarily, divide the fields in the TRU into a number of blocks considering the existing farming conditions, topography and other physical features. Blocking is done by firstly analyzing the map. If there are doubts in the topography, reconnaissance survey should be undertaken (refer to the following figure)



Preliminary Blocking of Irrigation Area

Step-3 Determining Cropping Hectarage and Pattern and Blocking TRU

Review the design cropping pattern, hectarage and crop water requirements (CWR) values for crops. If different cropping patterns are suggested from the design, re-determine the new hectarage, cropping pattern and CWR values. Then the specific planting area allocation would be obtained in the map and check with the preliminary blocking draft to assign single cropping pattern to one block (refer to the following figure)



Determining Crop Hectarage and Cropping Pattern and Final Blocking

An example of blocking draft is shown in the following table;

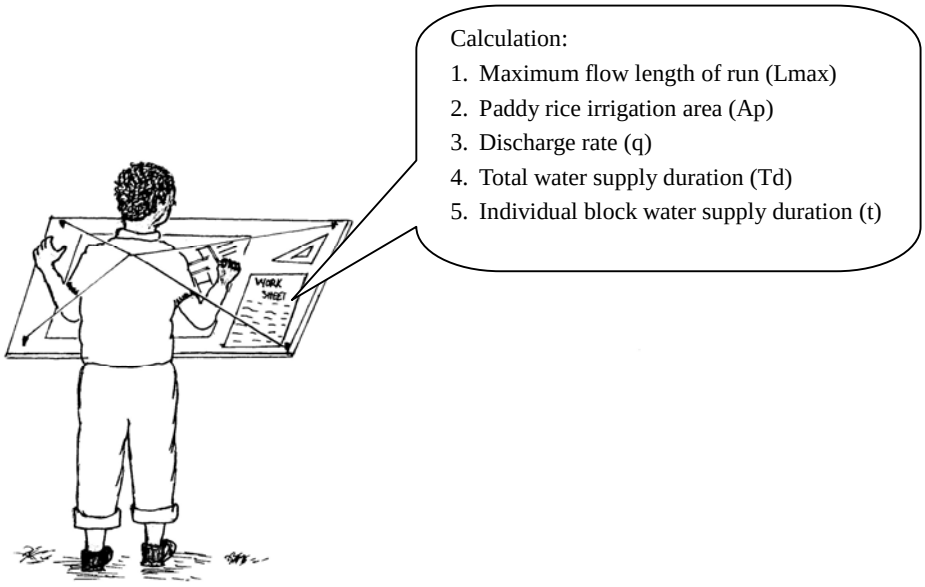
Summary of Crop Hectarage and Cropping pattern within a TRU

Block No	Crop/ CWR(mm/month)	Wet Season					Total Hectarage (ha)
		Nov..	Dec.	Jan.	Feb.	Mar.	
1 - 6	Maize CWR(mm/day)	2.5	3.0	4.5	4.5	4.5	8
7 - 11	Tobbaco CWR	2.5	2.5	3.5	4.0	4.0	6
						Total	14

Step-4. Calculating Water Supply Duration

Based on the blocking draft, water supply duration of each block would be determined by the following calculation and evaluation procedures;

- Maximum flow length of run,
- Paddy rice irrigation area with night time irrigation,
- Discharge rate per furrow or unit border width,
- Total water supply duration, and
- Individual block water supply duration (refer to the following figure).



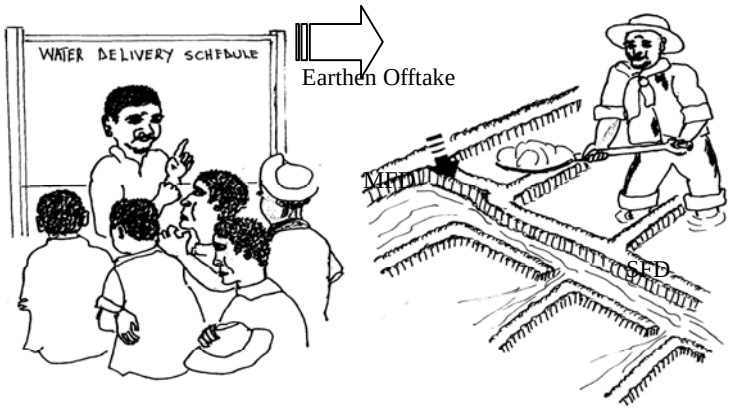
Calculating Water Supply Duration

Step-5. Determining Water Allocation/Delivery Schedule and Dissemination

Based on the required water supply durations, determine the time table of water delivery in each block for each month considering the followings;

- Rotational irrigation schedule,
- Allocating water for paddy farm during night time,
- Allocating water from upper farms to lower farms,
- Farming activities,
- Weather conditions,
- Plant conditions, and
- Others.

Then disseminate the schedules to farmers (refer to the following figure). **Table 4-4** shows a sample of water allocation / delivery schedule.



Determining Water Allocation and Delivery Schedule and Dissemination

(5) Maintenance of On-Farm Facilities

The operation and maintenance (O&M) plan of the irrigation systems emanates from the farm level. The success therefore, of the system's O&M depends on how the plans at the on-farm level are being prepared and executed. In many instances, the O&M of the system is not properly executed and sometime neglected thereby shortening the service life of the irrigation facilities.

The introduction of upland crop to the irrigation systems requires well-managed O&M planning and implementation. The success therefore, of the irrigation scheme would rely on how the O&M activities are being planned and executed. Following the concept for upland crop irrigation, due attention on the maintenance of on-farm level facilities would be necessary. Further, as the on-farm level maintenance of irrigation facilities is within the jurisdiction of the farmers or the farmers' group, following discussions would show the facilities that need to be maintained and how it should be done.

Turnout (TO)

The turnout (TO) is a structure constructed at the point where secondary irrigation canal branches out from the main canal to regulate or control water flowing into the secondary canal. This usually consists of an inlet with simple flashboard to control or regulate the flow of water passing through.

The farmers /farers' group within the target area should undertake maintenance works of the turnout, including desilting the box structure and cutting grasses around it to ease up irrigation application.

Farm Ditch (FD)

The farm ditch (FD) is a farm level irrigation canal provided after the turnout to deliver irrigation water to the field. This is categorized as main farm ditch (MFD) and supplemental farm ditch (SFD).

Farmers should undertake the maintenance work by cleaning farm ditches, repair and reinforcement of embankment and paddy ridges adjacent to their fields. Following figure shows a typical maintenance works performed by farmers.

Typical Maintenance Works within a Canal

Table 4-4 Example of Rotational Irrigation for Water Allocation and Delivery

TRU	Block No	1-day				2-day				3-day				4-day				5-day				Irrigation Duration (Td) (Min)
		AM		PM		AM		PM		AM		PM		AM		PM		AM		PM		
		6-9	9-12	12-3	3-6	6-9	9-12	12-3	3-6	3-6	6-9	9-12	12-3	3-6	6-9	9-12	12-3	3-6	6-9	9-12	12-3	
R1	R1-1	—																				
	R1-2		—																			
	R1-3			—																		
	:																					
	:				—																	
R2	R2-1					—																
	R2-2						—															
	R2-3							—														
	:																					
	:								—													
Rn	Rn-1																					
	Rn-2																					
	Rn-3																					
	:																					
	:																					
R5	R5-1																	—				
	R5-2																		—			
	R5-3																			—		
	:																					
	:																				—	

Offtake (OT)

The offtake (OT) is a pre-fabricated facility or just bunds of soils installed or provided at the beginning of the internal ditches which controls and regulates the water flowing to the individual or group of farms.

The maintenance of this facility would be automatically the concern of individual or group of farmers to be served. As these are only temporary in nature at the farm level, maintenance is so minimal which is just checking the leakage during operation.

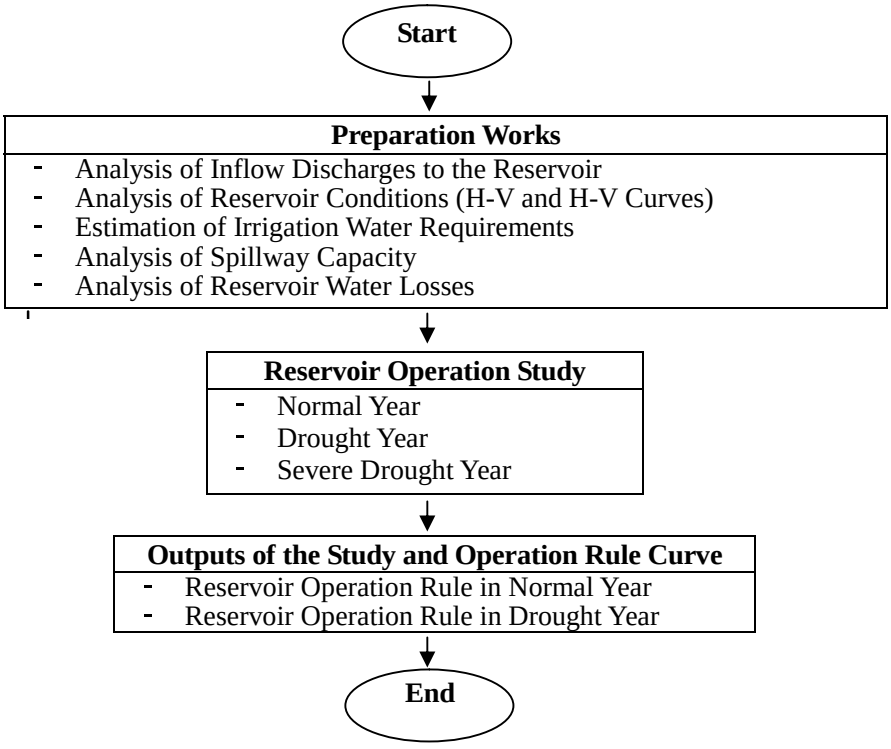
4.7 Formulation of Reservoir Operation Rule Curve

Chiwoza Irrigation Schemes has a water-impounding dam with total storage capacity of about 65x103 m3, of which capacity effective storage capacity is about 47x103 m3. This Chiwoza dam should be effectively utilized for irrigation purposes after rehabilitation works for necessary irrigation structures. However, the effective storage capacities of 47x103 m3 would be no sufficient to meet necessary irrigation water requirements for an area of 10 ha in the winter (dry) season, even thought average (normal) year.

Under the situations of the dam, formulation of adequate reservoir operation rule curve is essential and prerequisite to the scheme, to carry out effective crop and water managements in the scheme. The subsequent discusses procedures to formulate reservoir operation rule curve and their outputs of the analysis.

(1) Procedures to Formulate Reservoir Operation Rule Curve

To formulate adequate reservoir operation rule curve to meet changeable meteorological conditions around the areas, following cases of reservoir water balance studies will be needed, that is, normal, drought and severe drought years. Following figure shows the flow of the procedures to formulate reservoir operation rule curve.



(2) Preparation Works for the Study

a) Analysis of Runoff Inflow Discharges to the Reservoir

Runoff inflow discharges to the reservoir could be calculated by the following equations;

$Qin = A \times R \times F \times 10^3$ (m^3)

Where ; A : Catchment area (Km^2)
R : Probable rainfall (mm)
F : Runoff coefficient (60 % : undulating topography with farm and brush land)

In the above equation, probable rainfalls in cases of normal, drought and severe drought- years are estimated as shown below applying the "Iwai Methods" as shown in **Figure 4-7**, of which detailed analysis is shown in **Table A. 3-1** in the Attached Data.

Monthly Distribution of Probable Rainfall (Station: Kasungu)

Month	Case Study		
	Normal Year (1996/1997)	Drought Year (2005/2006)	Severe Drought Year (1994/1005)
July	0	0	0
Aug.	0	0	0
Sept.	0	0	0
Oct.	0.6	0	0.3
Nov.	0	86.4	13.3
Dec.	256.4	91.4	46.7
Jan.	119.6	137.2	264.8
Feb.	340.5	55.1	139.3
Mar.	52.7	150.6	14
Apr.	86.6	30	20.8
May	0	2.4	0
June	0	0	0
Total	856.40	553.1	499.2

Normal Year : Probability F=1/1.25 (80 %)
Drought Year : Probability F=1/5 (20 %)
Severe Drought Year : Probability F=1/10 (10 %)

b) Analysis of Reservoir Conditions (H-V and H-V Curves)

On the basis of the initial rough reservoir area survey, the volume of water to be stored in a reservoir can be estimated using the following equation, so called as "the one-sixth rule".

$V = L \times D \times T/6$

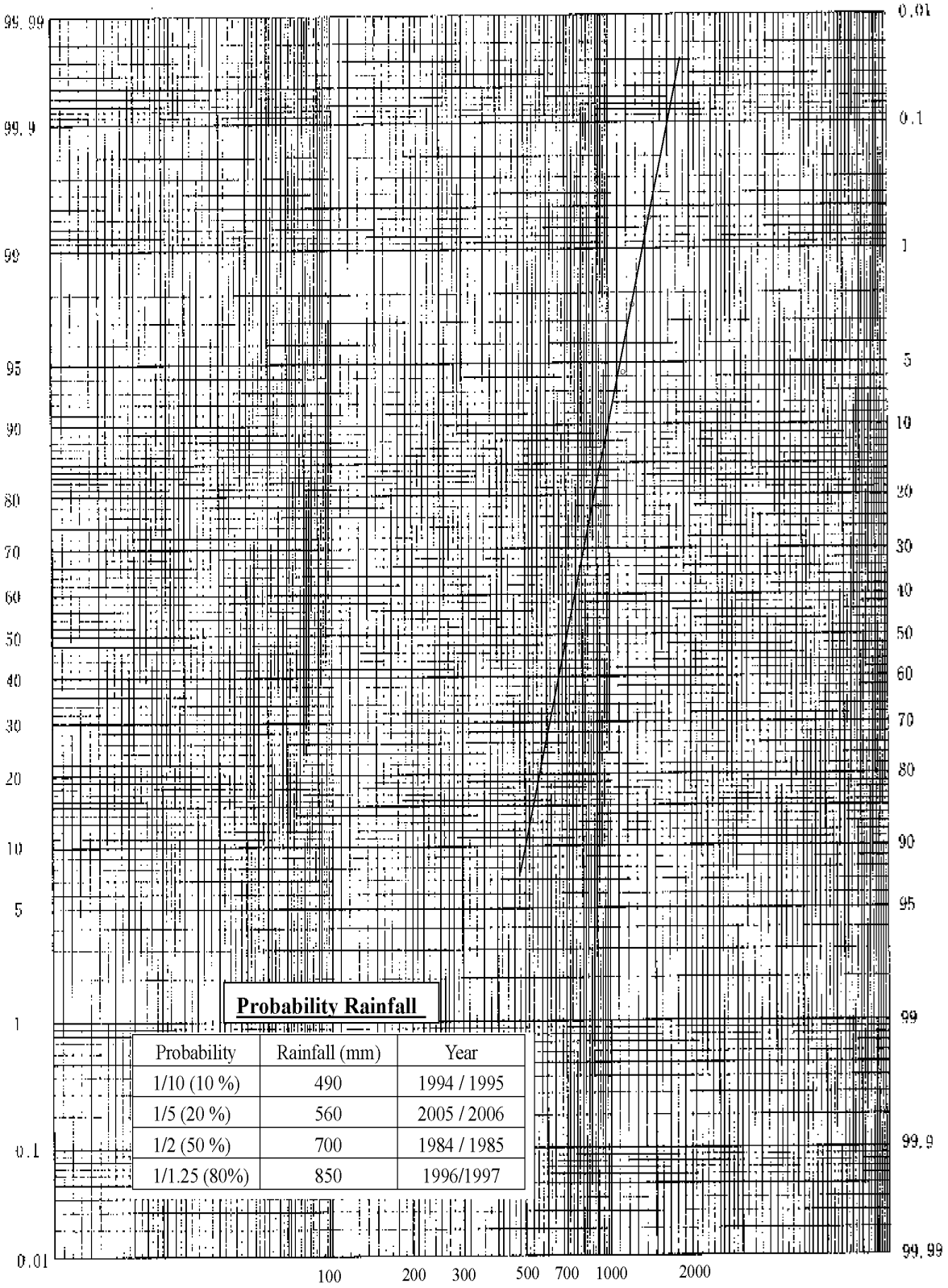
Where;
V : Volume of stored water in reservoir (m^3)
L : Length of water line along embankment (m)
D : Depth of water just behind the dam (m)
T : Distance from the dam embankment to the tail of water surface (m)

The relations between reservoir stage (H) - capacity (V) and reservoir stage (H) - area (A) will be presented in equation. In case of Chiwoza dam, these relations are expressed as shown below;

Stage (H) – Capacity (V) curve : $Y = 5.3475 X^2 - 3.2703 X + 1.455$
Stage (H) – Area (A) curve : $Y = 2.4217 X^2 + 18.31 X – 0.4911$

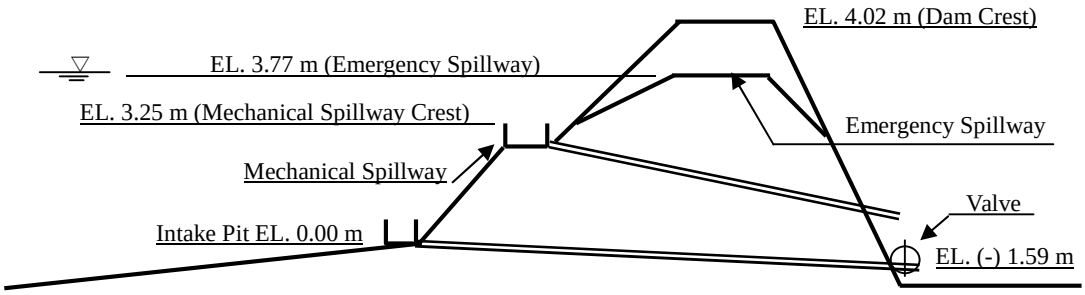
Elevations of the related structures such as mechanical and emergency spillways and intake pit are shown as follows;

Figure 4-7 Probability Annual Rainfall (Kasungu Station)



Probability	Rainfall (mm)	Year
1/10 (10 %)	490	1994 / 1995
1/5 (20 %)	560	2005 / 2006
1/2 (50 %)	700	1984 / 1985
1/1.25 (80%)	850	1996/1997

Elevation of Related Structures of Chiwoza Dam



c) Estimation of Irrigation Water Requirements

The amounts of irrigation water requirements are different depending on rainfalls in accordance with probable rainfall mentioned in the above. Therefore, following three cases of irrigation water requirements should be estimated.

- Normal year
- Drought year
- Severe drought year

Irrigation water requirements could be estimated applying the method of "CROPWAT 4" for Windows computer software, which was discussed in the previous paragraph of "4.5 Estimation of Irrigation Water Requirements".

The estimated irrigation water requirements are given in **Table A. 3-2** in the Attached Data.

d) Analysis of Spillway Outflow Capacity

In case of the Chiwoza Dam, two types of spillways are provided to discharge flood water; one is mechanical spillway connected with concrete conduit, and the other is emergency spillway connected with open flood way as illustrated in the above. Outflow discharge form these spillways are presented below;

Outflow from Mechanical Spillway (Qom);

$Q_{om} = C \times A \times \sqrt{2gh}\ (m^3/sec)$

where ; C : Coefficient 0.62
A : Cross sectional area of spillway (m^2)
H : Overflow depth (m)

Outflow from Emergency Spillway (Qoe);

$Q_{oe} = K \times B \times \sqrt{H^3}\ (m^3/sec)$

where ; K : Coefficient 1.7
B : Width of weir (m)
H : Overflow depth (m)

e) Analysis of Reservoir Water Losses

As the reservoir water losses, following losses should be counted in the water balance study;

Evaporation Losses from Water Surface (V_{ETo})

$V_{ETo} = ETo \times WA / 1{,}000\ (m^3)$

where ; ETo : Evapo-transpiration (mm)
WA : Water surface area (m^2)

Reservoir Losses (Seepage Losses) (R_{lo})

R_{lo} = V x 1/100 (1%)

Where ; V : Reservoir storage capacity (m^3)

(3) Study on Reservoir Water Balance and Their Results

Three cases of reservoir water balance studies were made on accordance with the above mentioned procedures, and the calculations are referred to **Table A. 3-4** in the Attached Data. On the basis of the calculations, reservoir water level behaviors in the three cases could be shown in **Figure 4-8**.

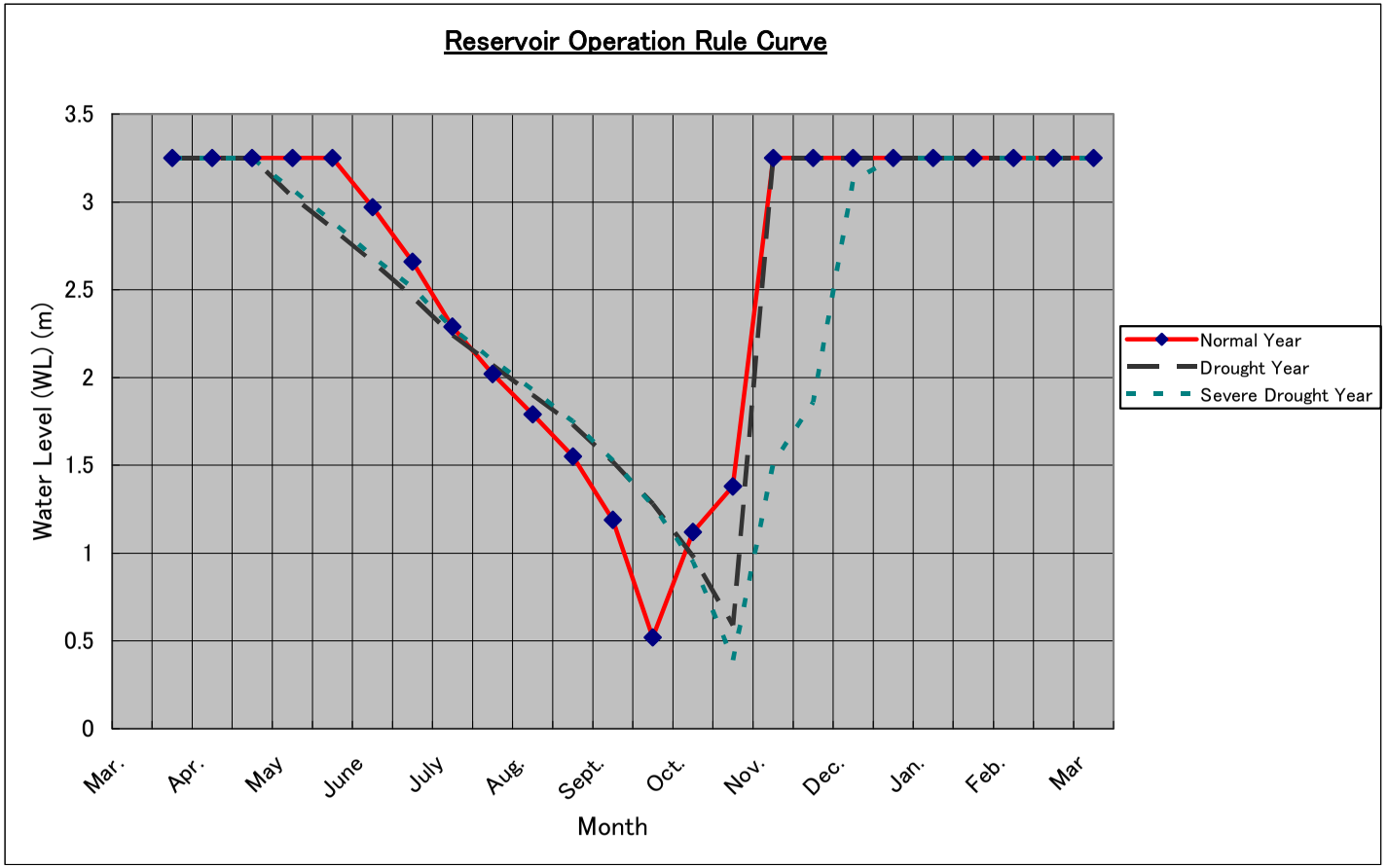
From the results of the reservoir water balance studies, following reservoir operation rule for the Chiwoza Dam could be suggested.

- No observation of reservoir capacity carry over even in drought year with the return period of 1/5 and 1/10, and reservoir water level will be recovered to the full-water level of 3.25 m (crest elevation of mechanical spillway) by the beginning of November for the normal and drought years, and by the middle of December for severe drought year.
- Irrigable areas for the winter (dry) season in case of the normal year with return period 1/1.25 are 4.6 ha, equivalent to 46 percent of the total irrigable areas of 10 ha, although these areas for summer (wet) season is 10 ha with the whole areas. On the other hand, irrigable areas for the winter (dry) seasons in case of the drought years are 1.8 ha, equivalent to 18 percent of the total irrigable areas.
- Decisions of the adequate extents of cropping areas for the winter (dry) season would be made depending on the reservoir water level at the beginning of winter (dry) season,

    - Namely, in case the reservoir water level is kept at the full-water level of 3.25 m by the end of May, 4.6 ha of land will be cropped for the winter (dry) season crops.
    - However, in case the reservoir water level is lower than 3.25 m at the beginning of May, cropping areas for the winter (dry) season should be reduced to 1.8 ha, considering the occurrence of drought year.

Figure 4-8 Study Results on Chiwoza Dam Reservoir Operation Rule Curve

Month		Watre Level (m)		
		Normal Year	Drought Year	Very Drought Year
		P = 1/1.25	P = 1/5	P = 1/10
Mar.	1			
	2	3.25	3.25	3.25
Apr.	1	3.25	3.25	3.25
	2	3.25	3.25	3.25
May	1	3.25	3.03	3.07
	2	3.25	2.85	2.89
June	1	2.97	2.66	2.69
	2	2.66	2.46	2.51
July	1	2.29	2.24	2.28
	2	2.02	2.07	2.1
Aug.	1	1.79	1.9	1.93
	2	1.55	1.73	1.75
Sept.	1	1.19	1.52	1.53
	2	0.52	1.28	1.27
Oct.	1	1.12	0.98	0.95
	2	1.38	0.59	0.39
Nov.	1	3.25	3.25	1.51
	2	3.25	3.25	1.86
Dec.	1	3.25	3.25	3.12
	2	3.25	3.25	3.25
Jan.	1	3.25	3.25	3.25
	2	3.25	3.25	3.25
Feb.	1	3.25	3.25	3.25
	2	3.25	3.25	3.25
Mar	1	3.25	3.25	3.25



Irrigation area ;

Case	Summer (Wet) Season	Winter (Dry) Season
Normal Year	10 ha(100%)	4.6 ha (46%)
Drought Year	10 ha(100%)	1.8 ha (18%)

4.8 Record Keeping Methods for Irrigation Water Management

In order to undertake effective and sustainable irrigation water supply to the scheme, record keepings in terms of the water management of the scheme is important. The types of irrigation technology for the schemes are classified into three types; a) gravity diversion weir type, b) water impounding dam type, and c) motorized pump type. These technology-wised record keeping formats were tentatively formulated for the time being, although these formats should be finalized through the implementation of actual water management at each Verification Sites.

Relations between irrigation technology and types record keeping format are presented as follows. **Table 4-5** show the formulated record keeping formats in cases of three types of technologies mentioned in the above.

Relation between Irrigation Technology and Type of Record Keeping Formats

Irrigation Technology	Irrigation Scheme	Type of Record Keeping Formats
1. River Diversion Type	Bethani, Bawi, Chibwana	Form-1
2. Water Impounding Dam Type		
2.1 with Motorized Pump	Chiwoza	Form-2
3. Motorized Pump Type	Mantha, Kachere, Chaseta	Form-3

Table 4-5 (1) Water Management Record Formats for River Diversion Type

Year : _____

Month : _____

Week (Date)	Discharge Records			Location of Irrigation Area	Irrigated Area (ha)	Water Surplus/ Shortage	Major Farming Activities	Encountered Problems
	Canal Water Depth (m)	Diverted Q (lit/sec)	Required Q (GWR) (lit/sec)					
1st Week (-)								
2nd Week (-)								
3rd Week (-)								
4th Week (-)								

Table 4-5 (2) Water Management Record Formats for Water Im ıding Dam Type

Year : _____

Month : _____

Date	Dam/Reservoir		Water Supply by Gravity			Water Supply by Pump Irrigation					Water Surplus/ Shortage	Major Farming Activities	Encountered Problems
	Water Level (m)	Stored Water (1,000xm	Location of Irrigation Area	Irrigation Area (ha)	Water Demand (GWR) (lit/sec)	Location of Irrigation Area	Irrigation Area (ha)	Water Demand (GWR) (lit/sec)	Pump Operation Hours (hr)	Consumed Fuel (lit)			
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
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Table 4-5 (3) Water Management Records for Motorized Pump

Year : _____

Month : _____

Date	**River Water Level** (m)	**Water Supply**			**Pump Operation**				**Water Surplus/ Shortage**	**Major Farming Activities**	**Encountered Problems**
		Location of Irrigation Area	Irrigation Area (ha)	Water Demand (GWR) (lit/sec)	Actual Head (Ha) (m)	Pump Discharge (Q) (lit/sec)	Operation Hours (hr)	Fuel Consumption (lit)			
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
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4.9 Improvement of Drainage Conditions (Water Logging) at Farm Level

(1) Present Drainage Conditions at Motorized Pump Areas

Out of eight "Verification Study" sites, three sites of Mantha, Kachere and Chaseta Irrigation Schemes are of the motorized irrigation schemes in categories. These irrigation schemes are confront with drainage problems such as water loggings at farm level during the summer (wet) season. The extents of such water logging problems areas are about half of the irrigation areas of each scheme, which are lying in the gentle slopping areas adjacent to the slopping areas in the upper portions.

It is considered that these water loggings are caused by the following reasons;

- Motorized pump irrigation areas are originally located in the areas closing to the relatively big rivers with abundant perennial flow such as the Bua and Lilongwe Rivers. Therefore, ground-water level around the gentle slopping areas is high during the wet season.
- In addition to these hydro-geological conditions in the areas, excess water caused by rainfall is inflowing into the areas from their upper catchments.
- No provision of adequate drainage systems in the areas, because of low priority for drainage sector, in comparison to that for irrigation sector, from view point of urgent needs of project facilites.

Due to these poor drainage conditions, there exist no cultivation activities for the summer (wet) season cropping to avoid high risk of low productivities of crops. Under these situations, drainage improvement at farm level by means of low investment with the simple ways/structures manageable by farmer's groups.

(2) Drainage Improvement Methods

To improve the drainage situations in the irrigation schemes, following earthen farm and main drains should be provided at farm level by farmers themselves.

Farm Drains

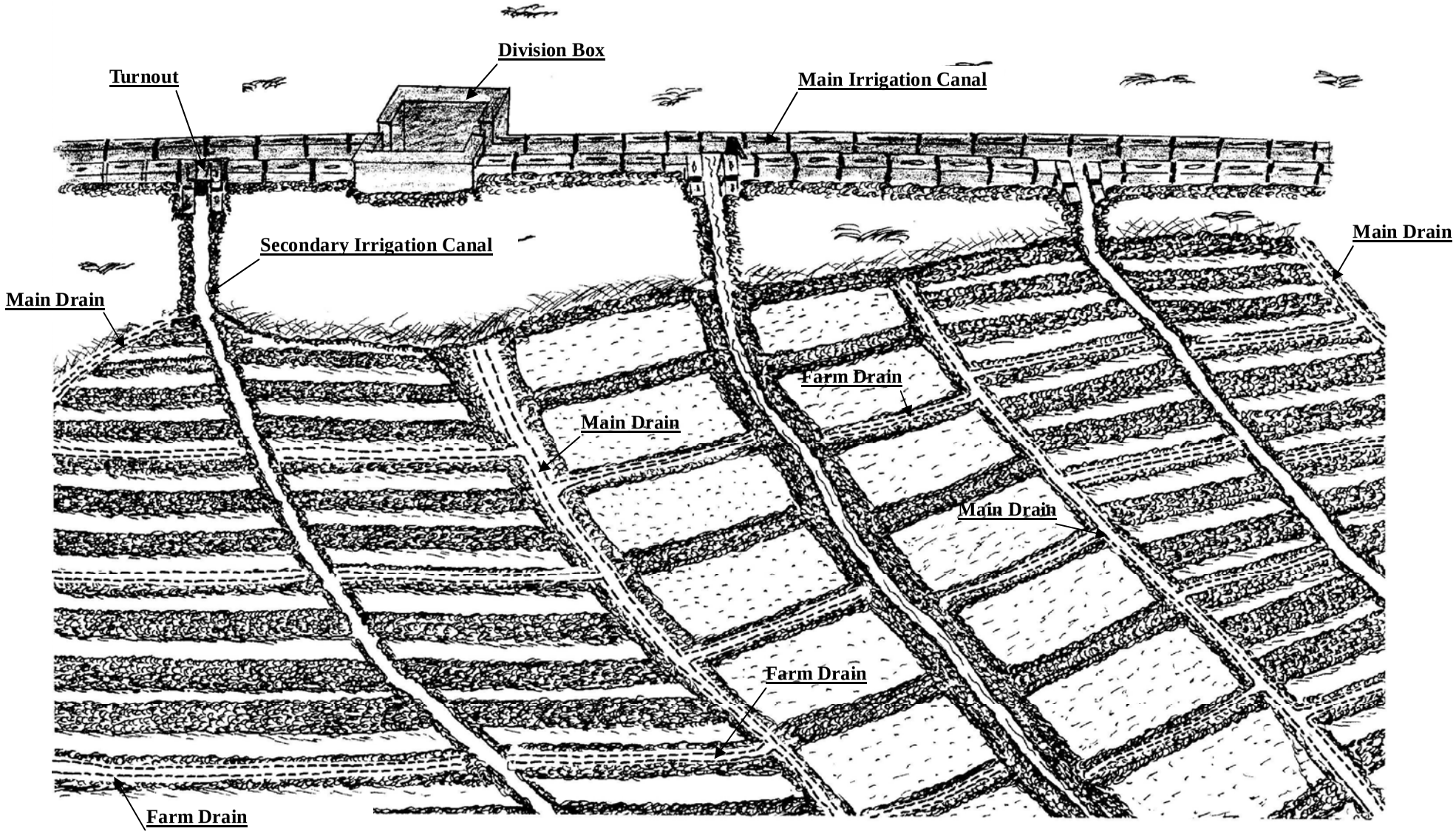
Earthen farm drains will be excavated along the contour line with adequate interval less than 30-40 m, considering the topography around the area, although detailed hydrological analysis on rainfall, river water level, groundwater level, etc. will be needed. An adequate grasses will be planted in the drains to protect soil erosion.

Main Drains

Earthen main farm drains will be excavated at a right angle to the contour line between secondary irrigation canals. As same as farm drains, Vetiver grasses will be planted in the main drains to protect soil erosion. After collecting excess water by the main drains, the water will be drained to the neighboring main river.

Figure 4-9 shows the layout of the proposed drainage systems in the scheme.

Figure 4-9 Proposed Drainage Systems at Farm Level



CHAPTER 5 FARM MANAGEMENT AND AGRICULTURAL EXTENSION

5.1 Introduction

Smallholder farmers in Malawi have encountered land shortage and farm fragmentation problem. This has forced most of them to undertake continuous cropping of the available marginal lands. The resultant effects on soils have been observed to be; deteriorated soil structure, depletion of nutrients and organic matters and excessive soil erosions. Almost all the developed medium irrigation schemes in such marginal lands need appropriate land husbandry such as soil conservation measures and soil fertility improvement. Currently, most farmers depend upon on the use of chemical fertilizers for crop production. There is an extensive cultivation with limited application of chemical fertilizers with no/limited supply of composts.

The major challenge today is that of identifying sustainable ways in agricultural production i.e. employing environmental friendly farming system. The application of organic manures and soil conservation measures should therefore be emphasized. One way of achieving this is the application of improved quality organic manures, and top dress with liquid fertilizer or reduced chemical fertilizers. The package targets at establishing sustainable farming system with rather low-input under irrigation. The strategy also promotes the adoption of a combination of high-input technologies and low-input technologies.

5.2 Investigation of Natural Conditions

Before engaging into any farm management conservation measures, it is necessary to investigate natural conditions existing in the area. The activity assists in the planning and designing of specific structures for the purpose of conserving and maintaining soil conditions. Some of these factors include; topography and hectarage, meteorological data, soil investigations etc.

(1) Topography and Hectarage

1) Topography

The boundary and topography of irrigation beneficiary area should be indicated on the topography map using a scale between 1/2.500 to 1/5,000 and a contour interval between 1.0 to 2.5 m.

2) Hectarage

Beneficial area for whole irrigation area as well as each irrigation rotation area should be estimated based on the topography map.

(2) Meteorological Data

Past representative meteorological data from meteorological stations should be collective for over 10 years for annual/monthly rainfall, including the monthly average data on pan evaporation, minimum, maximum and mean temperature.

(3) Soil

Existing soil map and land classification map should be collected to clarify the distribution of soil units and related soil land classes in the irrigable area. If any, soil conditions; acidic and salinity should be identified to find possible amendment in cultivation of these soils. Related physical and chemical soil analysis for soil texture, pH, EC, CEC and contents of macro and micro nutrients should be tested and observed from representative soil samples according to their necessity. These analyses are done by Agricultural Research Centers upon requests by the EPAs.

5.3 Investigation on Umbrella Projects

A consolidated District Development Plan should be investigated both at district and village level.

Consolidated data from the District Development Plan ensures that there is no duplication of work in an area where a project is to be implemented. Some of the data that should be investigated include;

- Rural and agricultural plan
- Farmland conservation plan
- Agricultural marketing plan, credit and others

5.4 Farm Management Development Plan

Participatory planning by holding effective workshops among stake holders should be undertaken and supplemented by collecting data of specific features. Baseline survey on existing farm management and farmer's intention survey on irrigated agriculture development should also be considered for the development of the plan.

(1) Land Use Plan

1) Identification of Agro-climatic Conditions

Strategic crops for the development of irrigated agriculture should be identified based on crop suitability to meteorological, geographical and soil conditions in the irrigation service areas. For this purpose, the agro-climatic characteristics of the irrigation scheme area should be classified based on three regions as follows;

Table 5-1 Agro-Climatic Region

Area	Altitude	Ave. Temperature	Ave. Rainfall	Rainy Season	Example Areas
	(m)	(°C/year)	(mm/year)	(month)	
Low-Altitude	<600	>30	700-800	3-4	Lakeshore Plain, Upper Shire Valley to Mangochi Plain
Medium Altitude	600 -1,300	30-20*	800-1,000*	4-5*	Lilongwe to Kasungu Plain, Upper Southern Rukuru
High-Altitude	>1,300	<20*	1,000*	>5*	Dedza and Dowa Hills, Nyika Plateau

Note: *---estimated

Source: Guide to Agricultural Production and Natural Resources Management in Malawi, Ministry Agriculture, 2004.

2) Land Tenure and Farm Size

The system of farming, land ownership and the sizes of the farm plots should be identified. The average farm size by category of land ownership assists in the process of identifying the best suitable conservation measures for a particular location.

3) Type of Farm Management

Type of farm management should be identified with respective average farm size and management scales of crops and animals.

(2) Crop Selection and Cropping Pattern

1) Crop Selection

The irrigation scheme area of medium scale irrigation consists of upland and lowland areas.

(a) Upland Areas

Wet season crop is normally planted with crops like maize, vegetables etc. For dry season, grain maize is grown as a major dry season crop in the areas to supplement serious food deficit. In other upland areas, cash crops like green maize, vegetables, spicy crops and Paprika are usually selected as major

crops. There are normally two dry season cropping periods within a year, first cropping (April to July) and second crop (August to November) for the irrigation scheme areas.

For medium scale irrigation, there is a limitation in perennial cropping of sugarcane and fruit trees. However if such are to be planted, temperature and altitude adaptability to economical production should be examined. For example, mango is suitable between 0 to 750 m above the sea level.

(b) Lowland Areas

The lowland irrigation scheme areas are mostly located in the area with altitude of less than 600 m above the sea level. Wet season is normally planted with rice due to water logging conditions under rain fed conditions. Where there is adequate irrigation, the crop can also be planted in the dry season. There is an extensive growing of local rice varieties in areas where there is a need to introduce improved and certified rice varieties such as Kilombero, Faya, etc. Diversified crops such as grain or green maize and other kinds of crops like tomato, watermelon and sweet potato could be selected especially in the areas where water resources are insufficient.

2) Cropping Pattern with Irrigation

In the upland irrigation scheme areas, the following three types of cropping pattern are recommended.

i) "Grain maize (Wet) + Grain maize or Green maize (Dry) "(two crops a year). ii) "Grain maize (Wet) + First dry crop (April to July) + Second dry season crop (August to November) "(three crop a year)"
Where,
Such cash crops as green maize, vegetables and spicy crop should be elected for the dry season crops.

(iii) "Perennial crops like sugarcane and fruit trees (banana, lemon, orange, mango and others)"

For the first cropping of maize; double or triple cropping should be practiced in food deficit areas. The second cropping has two dry season crops; first dry season crop and the second dry season crop. For dry season crops such cash crops as green maize and various kinds of vegetables (tomato, cabbage and other leafy vegetables, onion and others) should be selected where markets for these crops are available. Paprika should be grown as a single crop in dry season because it has longer cropping period, especially in remote area. The third cropping pattern is applied in the limited area.

In lowland irrigation areas, following three cropping patterns are recommended in terms of availability of water and other farm management conditions;

i) Rice (Wet) + Rice (Dry),
ii) Rice (Wet) + Grain maize (Dry)
iii) Rice (wet) + Green maize and vegetables (watermelon, tomato and others)

The first cropping is applicable only in the areas where sufficient water resources for irrigation for dry season rice are available. Areas which have a limited water resource, the second and third cropping patterns are applicable. For the areas where have markets for green maize and vegetables, the third cropping pattern should be introduced.

3) Crop Rotation

Vegetables are classified into following four groups;

Group 1: Solanaceae crop - Tomato, green pepper, Paprika, Irish potato
Group 2: Cruciferous crop -Cabbage, Chinese cabbage
Group 3: Root/bulb crops and legumes-onion, garlic, carrot, beans
Group 4: Cucurbit -water melon, cucumber

Crop rotation is needed to reduce building up of insects and diseases common to a particular crop family. Such crops as tomato, green pepper, Paprika, tobacco, Irish potato and eggplant belong to same

family of crops. These crops should not follow the same family crops in rotation until three years.

Examples of the cropping patterns for the above-mentioned second cropping are shown below;

- First year : Grain maize (wet) + Group 1 (1st dry crop) + Group 2 (2nd dry crop)
- Second year : Grain maize (wet) + Group 3 (1st dry crop) + Group4 (2nd dry crop)
- Third year : Grain maize (wet) + Green maize (1st dry crop) + Green maize (2nd dry crop)

(3) Farmland Conservation and Preparation

The irrigation service areas of most upland irrigation schemes have undulated topography, where protection of topsoil from erosion is essential, especially highly slope land. Efficient use and distribution of irrigation water is a key to successful development of irrigated agriculture. The appropriate farmland conservation and land preparation related it is discussed below;

1) Management of Steep Slope Land

Furrow irrigation with the limited length is applicable in the slope land of more than four percent. In the respective area, protection of farmland from soil erosion is indispensable. For this purpose, existing ridges should be realigned with preparation of the marker ridges. To make stable ridge markers, the hedgerows should be established on the ridges (refer to the **Figure 5-1**). The ridging should be made along the maker ridges which have the hedge growth in wet season. For the purpose of securing moisture between the ridges, tie ridge box can be prepared between aligned ridges in the area where rainfall amount is insufficient. The ridges for dry season crops should be prepared just along trace of the wet season ridges. Irrigation efficiency of furrow irrigation with ridge alignment should be raised much more to compare with ridging without ridge markers.

Figure 5-1 Hedge Rows on Ridge Markers

2) Management of Gentle Slope Land

Basin irrigation is applicable in the slope land of less than about four percent for efficient use and distribution of water and also for uniform growth of crops. The basin irrigation is not applicable in the areas where drainage is poor. In such conditions both irrigation and drainage conditions have to be improved. The ditches and passages in basin plot can be left even during wet season in the area where there are no water logging conditions. Adequate high ridges should be prepared during wet season to grow crops under rain-fed condition (refer to the **Figure 5-2**).

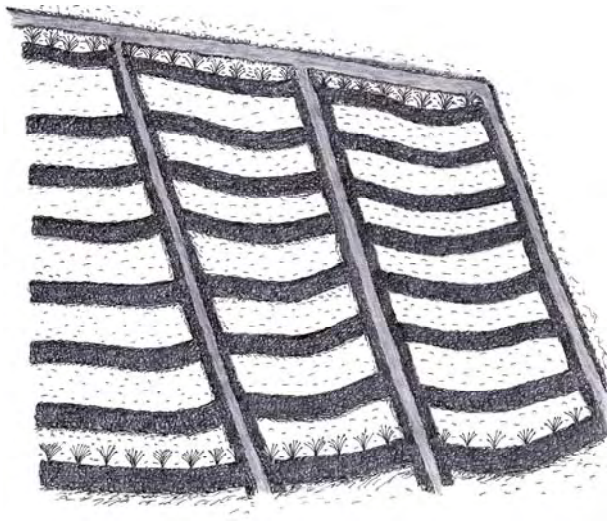


Figure 5-2 Furrow Irrigation on aligned Ridges

3) Management of Low Land

Irrigation areas in the lowland are generally flat. However, there are some undulating farmlands in the micro-scale which require land leveling to efficiently use water and for better crop management. The basin has two rows of crops in each basin. One row sunken basin should be prepared instead of basin plot in very flat land areas including the irrigation areas of lowland schemes (refer to the **Figures 5-3 and 5-4**). This may also suppress weed growth. The narrowing of plot size makes land leveling operation easy. The yearly preparations of ploughing and paddling also contribute to land level. Most of lowland irrigation scheme areas experience water logging land during wet season due to poor drainage designing. Water logging would even take place in dry season if excess water is supplied in the poorly designed areas i.e. both improvements on irrigation and drainage need to be considered.

Figure 5-3 Basin Plot with two Rows

Figure 5-4 Sunken Row Basin Plots

4) Soil Dressing

In irrigation scheme area which have sandy soils e.g. Chiwoza Dam irrigation scheme site, soil dressing should be applied to improve the soil conditions. When dredged soils in the reservoir are available, the dredged soils should be used for dressing.

(4) Soil Fertility Improvement and Fertilization

1) Soil Fertility Improvement

Over dependency to chemical fertilizers in fertilization is prevailing among farmer, where application of compost / organic manures as a mere mean to improve soil structure. Recently, it is recognized that composts / organic have following various effects, namely

(i) to increase useful soil micro-organisms,
(ii) to increase of soil nutrients,
(iii) to improve soil structure by forming crumb structure,
(iv) to suppress soil acidification,
(v) to decrease water stress in the soils.
(vi) to provide discomposed proteins which are directly absorbed by maize, sweet pepper, carrot, broccoli and other crops. Amino-acidic nitrogen and inorganic nitrogen are also provided from the discomposed protein.

Although the Malawi government has promoted application of organic manure as animal manure / compost in crop production, majority of farmers tend to apply only chemical fertilizer. Little amount of chemical fertilizer is applied under the condition that the chemical fertilizer is too expensive for the most farmers. As a result, the soil fertility tends to be degraded year by year.

One NGO, “Lipangwe Organic Manure Demonstration Farm (LOMADEF)” in Manjawira EPA, Ntcheu District has so far trained 1,546 farmers on compost making and application of organic fertilizer. 400 farmers of the group grew wet season maize by applying ordinary types of composts (basal fertilizer) and Liquid Manure (additional fertilizer) in 2006. Liquid Manure was made through

fermenting just cow or any other animal droppings with water. The average hybrid and OPV maize yields attained were 4.5 ton/ha and 3.7 ton /ha respectively. 100 farmers out of 400 farmers have applied Windrow Compost instead of ordinary types of composts (basal fertilizer) and liquid Manure (additional fertilizer) in wet seasons in 2007/08 and 2008/09. The Windrow Compost is comprised of six kinds of materials, crop residuals like maize stover, fresh green leaves of grasses or trees, cow or any other animal manure, maize husk, virgin soils and ashes. After each layer, a considerable amount of water is applied. The compost is stored for about six months. According to the result of chemical analysis for the Windrow Composts which was made by the trained farmers in Verification Study, Windrow Compost has almost same level of nitrogen content to that of Bocashi compost as shown below;

Table 5-2 Result of Chmical Analysis by Type of Compost

Type	%N	%P	%K	Source
Windrow Compost	2.13	2.24	0.96	JICA Study Team
Bocashi Compost	2.05	0.04	0.43	JICA Study (*)
FarmersCompost	1.10	1.13	17.37	3EPA in Lilongwe District (**)
Japanese Compost	1.6-2.1	1.5-3.5	2.0-4.0	Average of cattle dung composts

Note: *----JICA, "Study on Capacity Building and Development for Smallholder Irrigation Scheme"
**--Arthur Buxtone Mpama "Value of Compost as a Basal Dressing Nutrient for Maize Production in Lilongwe"
Source: JICA Study Team

Bocashi compost has a disadvantage at high labor requirement, which limits application area. Windrow Compost can be made with less labor, using wider range of locally available materials.

Liquid Bocashi Pesticide was conceived from Bocashi compost, which had been introduced by the JICA study team for "Study on Capacity Building and Development for Smallholder Irrigation Scheme", by a horticulturist, RUSAGU GARDENS in Lilongwe District. Initially tobacco stems were used to make Liquid Bocashi Pesticide. Tobacco stems were replaced to other kinds of botanical pesticide plants of Tephrosia Vogelii, Mpugawi and others to avoid suffering from virus diseases among Solanaceous crops. Liquid Bocashi Pesticide works for not only repelling insects but also making crop growth vigorous. Liquid Bocashi Pesticide is just a mixture of Liquid Bocahi and botanical pesticide. RUSAGU GARDENS is using Liquid Bocashi and botanical pesticide separately to grow various vegetables with high yield presently, provided with improved top soils at the depth of about 30 to 40 cm. The nitrogen content of Liquid Bocachi is higher than Liquid Manure. The nitrogen content of Liquid Bocashi is higher than Liquid Manure too according to the result of chemical analysis for the Liquid Bocashi made by the trained farmers in Verification Study. (Refer to **Table 5-3**)

Table 5-3 Comparison among Windrow Compost, Liquid Bocashi and Bocashi Compost

Item	Windrow Compost	Liquid Bocashi	Bocashi compost
Materials	Water, maize stover or rice straw, fresh green leaves of grasses or trees, cow or any other animal manure, maize husks, Legume crop residues or leaves of legume trees, wooden ashes, and virgin soils and anthill soils.	Water, animal dropping, maize husks, commercial yeast and wooden ashes	Water, plant residues, animal manures, local beer residues or fruit residues, virgin soils, charcoal, ashes
Making method	Spread each material vertically at the depth about 5 to 20 cm, depending upon material, with watering. Then cover the heap with virgin soils and anthill soils with watering, having the height of less one meter. Finally cover the heap with a plastic sheet. After maintain the heap for one month, mix the heap with watering. Cover the heap with the plastic sheet again. Maintain the heap for 30 to 60	Mix the material with water. Maintain the solution with stirring twice a day for ten days.	Mix a small portion of each material together with watering to make a heap. Cover the heap with banana leaves, etc. If the temperature is more than 50 centigrade, break down the heap

	days.		and make a heap again.
Time to make	2-3 months	10 days	2 to 3 weeks
Nitrogen content	2.1%	0.3%	2.1%
Storage method	Keep dry and cool places under shed	Keep the fermented solution as it is.	Keep dry and cool places under shed
Application method	Basically as basal fertilizer	Apply as additional fertilizer with frequency of ten to 14 days depending upon kind of crops through making a hole between planting stations and covering soils without dilution. However, dilute the Liquid Bocashi when it is applied as Liquid Bocashi Pesticide.	Both as basal and additional fertilizers

It is considered that application of the organic manures or the organic manures with reduced chemical fertilizers should be promoted not only to decrease the cost of chemical fertilizers but also to improve soils for improvement of the upland crop cultivation.

2) Fertilization

The Verification Study on improvement of upland crop cultivation with applying three kinds of organic manures, namely Windrow Compost, Liquid Manure and Liquid Bocashi Pesticide was conducted in this study. Based on the study, following facts were revealed regarding to fertilization with applying these organic manures;

- Three kinds of organic manures were effective to grow upland crops,
- Liquid Bocashi and botanical pesticide can be separately applied respectively as additional fertilizer and botanical pesticide, and
- Bocashi Liquid can be applied preferably as an additional fertilizer to Liquid Manure.

The treatment of "Windrow Compost as basal fertilizer and Liquid Bocashi as additional fertilizer" is proposed to apply basically for further Verification Study by Study Team. A combination of organic manures and chemical fertilizers for either basal or additional fertilizers at half dosage of standard rate is included in the treatments, considering that most farmers cultivated eradiated soils. The dosages of Windrow Compost and Liquid Bocashi are respectively two hands full and 100 ml (a teacup) per planting station. As a general, Liquid Bocashi can be applied once every two weeks for maize and fruit vegetables or once ten days for leaf vegetables. Liquid Bocashi should be applied at least tree times for growth period, depending upon the length of growth period.

Basically the application of these kinds of organic manures shall be accompanied with long-term soil improvement which can be made through applying the organic manures and taking any possible measures of soil improvement, for example application of such organic matters like crop residues and green manure (weeds). As the soils get fertile, only organic manures may work in fertilization of crops.

2) Conservation and Planting of Trees

In Malawi a variety of trees are spreading in the farmland of the upland irrigation scheme areas. It is well known that such trees of Faidherbia albida and Tephrosia vogelii are effective for maintenance/improvement of soil fertility. The Tephrosia vogelii can be used as botanical pesticides. Besides the maintenance /improvement of soil fertility, they can also secure other benefit like supplying materials of composts, timber and charcoal, medicine, conservation of trees and newly tree planting in the field and also along canals and plot boundaries should be promoted.

(5) Nursery Management

1) Use of Quality Seeds

The use of quality seeds with appropriate selected varieties is essential to increase the production as

well as to improve the quality, although many farmers use their own recycled seeds even for hybrid seeds. The other seeds named Open Pollinated Variety (OPV) for maize, rice, beans are supplied by the Association of Smallholder Seed Multiplication Action Group (ASSMAG). The OPV maize and OPV rice are recyclable for three years. Use of recycled rice seeds should be limited to three cropping seasons. Preferably farmers multiply the certified seeds by group. The ASSMAG is responsible to train the farmers regarding to the training on seed multiplication procedure.

The commercial seeds of hybrid maize and vegetables are supplied from seed companies, Agricultural Input Supplies within the mother body Seed Traders Association of Malawi (STAM). Most of the vegetable seeds are hybrid ones. Therefore, farmers have to procure these seeds for every cropping.

2) Improvement of Nursery Management

Most vegetable crops including tomatoes, cabbages and onions should start from the nursery, where the following nursery requirements are necessary;

- Seed sterilization
- Sterilization for seedbed soils
- Preparation of raised seedbed
- Row planting of seeds
- Mulching
- Thinning

Improvement of rice nursery management is required in the following;

- Seed selection, disinfection and soaking
- Leveling in preparation of seedbed
- Appropriate seed rate per unit area of seedbed

(6) Crop Management

Integrated pest management should be applied in crop management. It is comprised of cultural and direct control measures. Cultural control measures such as selection of pest resistant varieties, use of grafted seedlings, planting time, crop rotation, field sanitation, isolation from host crops and plants of pests and others should be taken in the integrated pest control. The direct control involves removable of pests, infested crop residues and plants, which is also important.

As of recent, Liquid Bocashi pesticides has been introduced in Malawi. It has since been tried to vegetables by a horticulturist in Lilongwe District and is composed of the following materials, maize bran, commercial yeast, tobacco stems, firewood ashes and chicken dropping. The concept of the botanical pesticide was conceived from Bocashi compost, which was introduced by the said JICA Study team. It may not only repel insects but also control some kinds of insects. It may also work as a liquid fertilizer, activating crop growth in the same way Bocashi compost does. The extracts from hot chili and garlic, and bamboo liquid droppings of processing charcoal repel insects. Therefore, from this concept it was proven that intercropping of any other crop with onion and garlic as well as planting of lemon grass along plot boundaries helps in repelling insects.

Thus, the use of the said botanical pesticides should be applied not only to save the cost of pest control but also to enhance vigorous crop growth. The use of chemical pesticides should be applied with careful observation on possible damages of supplement pesticides. The sterilization of seedbed soils and seeds disinfection should be incorporated in the integrated pest control to control the diseases, which are infested from seeds or seedbed soils. Rice seed disinfection by soaking seeds in hot water or water mixture with vinegar could be used to save the cost of disinfection chemicals.

(7) Post Harvest Handling and Marketing

1) Post Harvest Handling

It is estimated that the post harvest losses account to about 30 % of production. This can even go up to

100% due to farmer-negligence especially with presence of Larger Grain Borers. The Government has been conducting trainings on post harvests for bag storage of shelled grain with use of pesticides. Furthermore, in current year, the national wise project on storage of grain with improved granary has been initiated. Above training and project assists farmers to solve the problems of grains including rice. On the other hand, the storage of perishable produce like vegetables is still a problem especially in the remote areas, where vendors visit the site irregularly. For perishable produce like tomato, rice straws could be laid on the floor for storage.

2) Marketing Arrangement

Non-availability of ready market for fresh produces has been a commonly recognized problem amongst irrigation schemes beneficiaries, located in remote areas. Expensive transportation costs, undeveloped marketing system and limited purchasing power emanate from the problem. The direction to solve the problems is to promote group marketing i.e. to sell the fresh products to the public institution customers like hospitals, secondary schools and universities and also to private customers like hotels and restaurants. In such scenarios, the group marketing through tendering is recommendable. Other organizations have assisted a number of farmers in different capacities in the schemes, for example NASFAM; has assisted on the marketing arrangement of maize, rice and CHEETAH limited; has assisted marketing arrangement for Paprika. It is hoped that these assistances to continue.

5.5 Agricultural Extension

One of the strengths which the MoAFS has, is the structure; ADD, DAO and then EPA. At frontline there is an extension officer who manages a section of an EPA. On average, each AEDO manages 1000 to 2000 households (recommended is 700 households/AEDO) with each household possessing about 0.7 ha piece of land. If these frontline officers are well equipped with smallholder irrigated agriculture technology and are involved in the dissemination of information, the potential farmers can no longer necessarily wait for external expertise to assist. AEDO should have the adequate capacity in caring out agricultural extension services with assistance from AEDC and subject matter specialists of DAO office. There is a need of full participation of this extension system from ADD to EPA in this study for the capacity development of smallholder farmers for self help irrigation development. The capacity development should be extended to other schemes to rehabilitate and develop the irrigation schemes.

The whole structure (ADD-DAO-EPA) should be mobilized in the verification study to provide any necessary assistance to the farmers. AEDO play an important role in execution of verification schemes to assist farmers' organization in plan formulation and implementation and monitoring and evaluation of the plan. Organizational assistance in the execution of verification should therefore be established at DAO-AEDO level before other institutions are involved.

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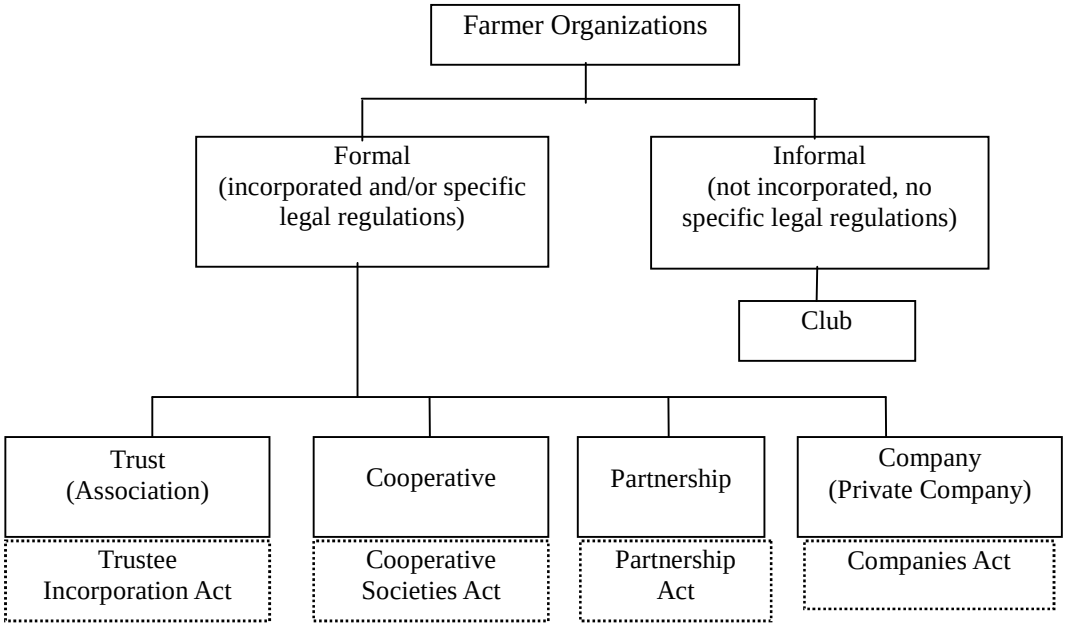
CHAPTER 6 MANAGEMENT OF FARMERS GROUP

6.1 Types of Farmer Organization

Farmer organizations are classified into informal and formal entities (refer to the **Figure 6-1**). Informal organizations are those which are not incorporated and not registered legally. Farmer groups and clubs are categorized as informal groups. Numerous farmer clubs emerged in 1970s as self-help groups with encouragement of government on the other hand formal organizations are those which are incorporated or registered legally based on the specific regulations. Organizations such as trust, cooperative, company, etc. are included in this category. There are very few formal organizations in the category of the medium scale irrigation schemes.



Source: Guide to Agricultural Production

Figure 6-1 Types of Farmers' Organizations

Organizations registered under the Trustees Incorporation Act are called Trusts or Trust Companies. They are usually known as "Farmer Associations". Their aim is not to make profits but to provide services for the members. Profits made are reinvested into the corporation for the betterment of their activities.

A cooperative can be registered under the Cooperative Societies Act. A cooperative can have a legal status as a corporation. The purpose of a farmers' cooperative is to improve the economic conditions of its members by increasing their profits from farming. Services provided by a cooperative may include input supply, marketing, training and credit schemes.

In the case of irrigation schemes, formation of irrigation club, irrigation association or water users association (WUA) is recommended by the government. Formation of such organizations is greatly beneficial for the smallholder farmers in increasing their income level through the improved agricultural productivity.

6.2 Process for the Establishment of Farmer Organizations

Process for the establishment of a farmer organization is needed in a case where there is no farmer organization for the scheme or where there is only a pre-farmer group that is not well established.

The following steps of group formation and group development is necessary for the establishment of a farmer organization. In this process, agricultural extension services staffs from relevant district and EPA offices assume the role of facilitators.

1) Step 1: Farmer sensitization and mobilization
2) Step 2: Committee formation and training for the committee members
3) Step 3: Development of a constitution for the club / association

(1) Step1: Farmer Sensitization and Mobilization

This is the process of creating awareness among the farmers for the agricultural development activities including irrigated agriculture. Farmer sensitization and mobilization (**Figure 6-2**) are conducted in a form of consciousness-raising in a participatory manner.

Figure 6-2 Sensitisation and Mobilisation Meeting

At the first step, the facilitators (e.g. AEDO) collect as much information as possible for the related irrigation scheme from the concerned farmers and contact GVH or village headperson(s) to brief them on the subject.

Farmers are invited by the village headperson(s) to the meeting. After introductory session, participants are divided into several groups for the discussions. The problems in the farming activities are identified by each group. Then the solutions to overcome the problems are discussed. The identified problems and solutions should be presented by each group. These problems and solutions should then be summarized by the facilitator.

Expected outputs from the discussions are identification of needs for: (i) farmers' cooperation improvement; (ii) water management related activities; and (iii) more formalized farmers' cooperation. Taking into consideration those outputs, the facilitator proposes the formation of a club or association for the interested farmers and set the next meeting date.

(2) Step 2: Committee Formation and Training for Committee Members

In the second farmers' meeting, formation of a committee is discussed and if agreed, the selection of the committee members is made, refer to **Figure 6-3**. The roles and responsibilities of the committee members are explained by the facilitator(s). The need for preparation of the constitution should also be explained.

Figure 6-3 Meeting for Committee Formation

After the selection of the committee members, training should be conducted by AEDO for the selected committee members. Training should be made under support from extension officers of DAO. Items for the training include: (i) definition of a club or association; (ii) reasons for formation of a club or association; (iii) role and responsibilities of group members; (iv) roles

and responsibilities of the committee members; (v) good leadership; (vi) group conflict management; and (vii) record keeping.

(3) Step 3: Development of a Constitution/ Bye Law

The committee members should conduct workshops for the development of a constitution of the club; refer to the **Figure 6-4**. At the first meeting, the need and advantages of having a constitution are explained by the secretary of the main committee. After the explanation, an interim constitution development committee should be established in the club and timeframe for the preparation of the constitution should be decided. At the second meeting, a secretary of the committee should read the draft constitution prepared by the interim constitution development committee to discuss among the members. After discussions and amendment of the draft constitution, a final version of the constitution should be prepared by the interim constitution development committee and read by the secretary of the committee for the confirmation of the scheme members. In the process of development of the constitution, AEDO and other service providers should support them.

Figure 6-4 Constitution/Bye Low Formulation

6.3 Process for the Strengthening of Farmer Organizations

Implementation of irrigation development works are carried out in parallel with strengthening (empowerment) of farmer organizations. In this process, agricultural extension services staff from relevant DAO and EPA offices assume the role of facilitators.

The process of strengthening of farmer organizations is needed for an existing farmer organization (e.g. irrigation club). The capacity development trainings are carried out in the following steps.

1) Step 1: Capacity development of the management committee members
2) Step 2: Capacity development of the sub-committee members
3) Step 3: Capacity development of Club / WUG committee members

Water User Groups are normally formed to manage blocks in an irrigation scheme and report to their activities to the main committee, Water Users Association (WUA)

(1) Step1: Capacity Development of Committee Members

This is the process of strengthening the management capacity of the committee members in the existing schemes.

The first step is to review the structure of the existing committee, and to conduct capacity development of the committee members, refer to **Figure 6-5**. In order to strengthen the committee's performance, it is necessary to check whether the current committee has proper structure to conduct its roles and responsibilities. The items to be checked are (i) appropriate number of the committee members; (ii) proper selection of the sub-committee; and (iii) appropriate number of sub-committee members.

Figure 6-5 Meeting for Capacity Building

Most of the existing committee have 10 members or more. It should be considered whether it is reasonable to have the committee members of more than 10 persons. The second check item is whether the sub-committees are established properly in consideration of the required activities of the scheme. It is also necessary to check whether the number of the sub-committee members is appropriate or not.

The review of the existing committee structure should be conducted by the committee members together with several advisers (e.g. AEDO) invited by the committee. The results of the review should be explained to the scheme members in the general meeting. In the case of the re-organization of the committee structure, the selection of the new committee members should be made in the general meeting.

In order to improve the performance of the committee members, training should be conducted by relevant AEDO for the committee members under support from irrigation officers and extension officers from DAO. Training normally has two sessions, i.e. group dynamics and technical sessions.

The group dynamics session has such items as: (i) definition of a club or association; (ii) reasons for club or association formation; (iii) role and responsibilities of group members; (iv) roles and responsibilities of the committee members; (v) definition of executive committee; (vi) definition of each sub-committee (discipline, finance, marketing, crop inspection, etc.); (vii) roles and responsibilities of the executive committee and sub-committees; (viii) good leadership; (ix) group conflict management; and (x) record keeping.

The technical session has the following: (i) water distribution system; (ii) preparation of irrigation schedule; (iii) operation and maintenance of irrigation systems; (iv) calculation of O&M costs; and (v) collection of water charge and book keeping.

(2) Step 2: Capacity Development of Sub-Committee Members

In order to improve the performance of the sub-committee members, training should be conducted by the scheme committee members under support of the relevant AEDO. Training should have group dynamics and technical sessions.

The group dynamics session has the following items: (i) definition of a club or association; (ii) reasons for formation of a club or association; (iii) role and responsibilities of group members; (iv) roles and responsibilities of the committee members; (v) definition of executive committee; (vi) definition of each sub-committee (discipline, finance, marketing, crop inspection, etc.); and (vii) roles and responsibilities of the executive committee and sub-committees.

The technical session has the following items: (i) preparation of irrigation schedule; (ii) operation and maintenance works required for the irrigation systems; and (iii) O&M cost necessary for the scheme.

(3) Step 3: Capacity Development for Club / WUG Committee Members

In the schemes with several irrigation blocks, it is recommended to formulate a sub-group at each tertiary irrigation block. These sub-groups of 30 to 40 members should have their own committee (club / WUG committee) to manage their activities. The club / WUG committee should have about 5 committee members who are selected by the sub-group members. After the formation of such club /WUG committee, a training program should be conducted by relevant AEDO. The training items include the following: (i) preparation of irrigation schedule; (ii) operation and maintenance works required for the irrigation systems; and (iii) O&M cost necessary for the scheme.

6.4 Management Structure of Farmers Group

(1) General Meeting

In most organizations, it is required that an annual general meeting should be held for the presentation and approval of the overall activities of the committee members and scheme members in general. The general meeting is the place where basic policy for the organization's activities is decided and election

of the committee members is made.

(2) Executive Committee

Every functional irrigation scheme must a scheme committee to manage the activities of the organization. Such a committee is usually called as a management committee or executive committee.

Management Committee (or Executive Committee) controls the work of the group or association on behalf of the group members in accordance with the terms and conditions as specified in the constitution (bye-law). The committee members consist of a chairperson, secretary, treasurer and other members. When necessary, a vice-chairperson and vice-secretary can be elected.

A chairperson is the chief elected representative of the group members and is responsible for supervising the work of the committee members. A secretary is appointed by the management committee as the chief administrative officer of the group / association. He or she is responsible to the committee for the daily control of the committee's operation. A treasurer is responsible for all the financial matters in the scheme including preparation of annual budget, record of financial books, and other financial management. Other committee members have specific tasks as such crop inspection, discipline and security, water management, etc. i.e. according to the needs of the organization's activities.

Main role of the management committee is to control the work of the farmers group or association on behalf of the group members on the basis of the terms and conditions as specified in the constitution. Functions of the management committee include (i) water management; (ii) financial management; (iii) marketing arrangement; and (iv) security and discipline activities. The roles and responsibilities of the committee are: (i) to hold meetings (general meeting, committee meeting, and other meetings); (ii) to approve the new applicants to join the group; (iii) to resolve conflicts among the members; (iv) to receive and take action on the reports from each sub-committee; and (v) to keep record of all group assets and financial management.

(3) Sub-Committees

There are several kinds of sub-committees that can be established under the management committee. A farmer organization can establish some of these sub-committees according to the needs of the group activities.

1) Discipline Committee: Main function of this committee is to look into the matters of discipline and recommend corrective measures to the Management Committee.
2) Finance Committee: Main function of this committee is to be responsible for coordination of annual budget preparation and fund management for the group members.
3) Loan Committee: Main function of this committee is: (i) to prepare loan application forms; (ii) to ensure that all fees are paid; (iii) to arrange transportation of inputs; (iv) to ensure receipt of inputs by every applicant; (v) to ensure that treasurer has opened club and member repayment ledgers.
4) Crop Inspection Committee: Main function of this committee is to ensure that members follow recommended production practices; to ensure that inputs are correctly used for right purpose; to check on the post harvest treatment of the members; to organize group members to help the cultivation of the sick members.
5) Marketing Committee: Main function of this committee is to ensure that members secure the best price for their produce. This committee provides the marketing information to the members.
6) Water Committee: Main function of this committee is to organize all the water management activities such as preparation of irrigation schedule, allocation of irrigation water, etc. Function of operation and maintenance works can be included in this committee.

7) Operation and Maintenance Committee: Main function of this committee is to arrange the works for operation and maintenance of the irrigation facilities.

(4) Irrigation Club or Water Users Group at Irrigation Block

In addition to the management committee, it is necessary to establish an irrigation club or a water users group (WUG) at each irrigation block to paste management of the farmers groups. Each club or WUG should have 20 to 40 members. The club / WUG committee consists of a chairperson, secretary, treasurer and other sub-committee members. Main functions of the club / WUG committee are (i) to collect water charge in terms of membership fee1 and / or water fee2; (ii) to arrange the operation and maintenance of irrigation facilities; (iii) to carryout crop inspection to ensure that the member farmers follow the farming practices as recommended in the members meeting; and (iv) to keep security and discipline of the group members. In an event, where a cooperative has been adopted, the water committee should be responsible for all water related problems as there is no WUA.

(5) Group Members

Each member of a farmers group (e.g. irrigation club) or water users association (WUA), works in accordance with set roles and responsibilities stipulated in the constitution. Each member is obliged to the following; (i) Attend the meetings; (ii) Pay membership fee or any other fees as stipulated in the constitution; (iii) Maintain order in the group; (iv) Give constructive ideas during the meetings; (v) Actively participate in development work as agreed in the meetings; (vi) Be active and cooperative; (vii) to be trustworthy; and others.

(6) Proposed Committee Structure for Management of Farmers Group / Association

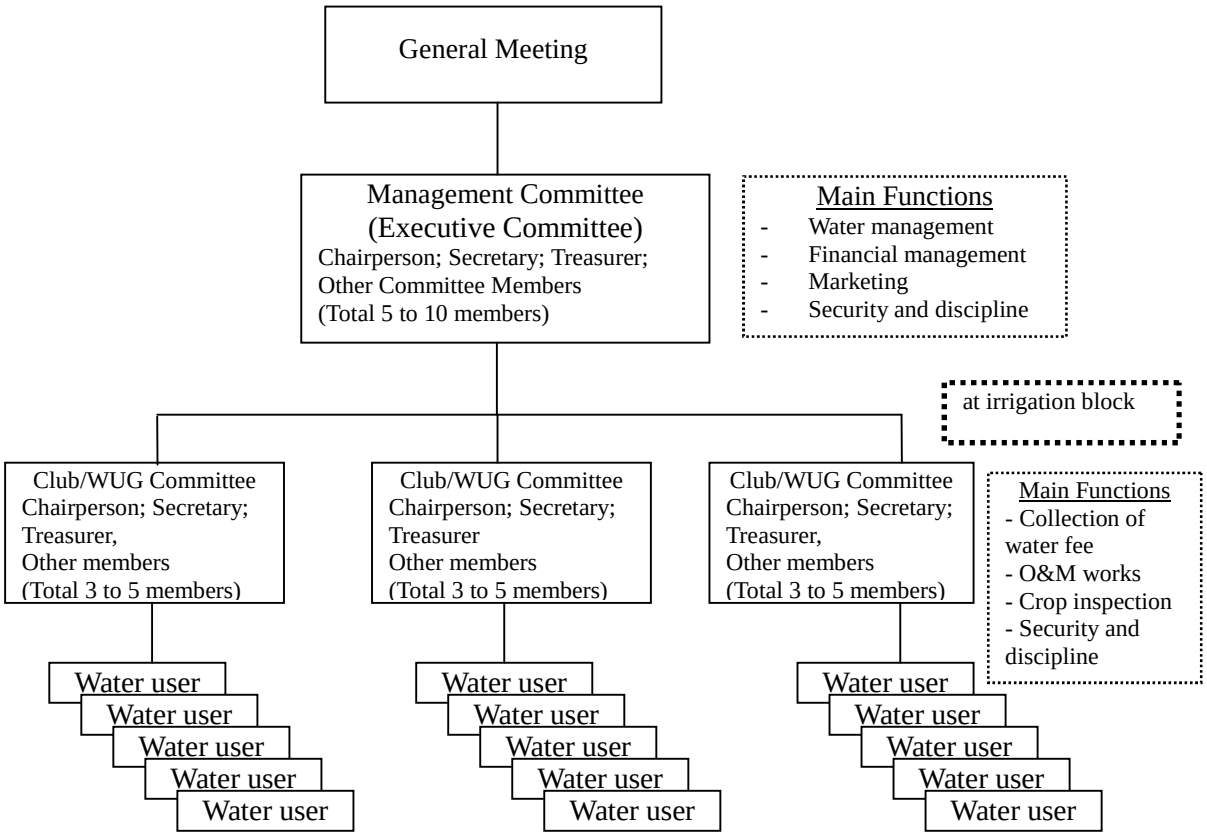
Based on the roles and responsibilities of group members and committee members as mentioned above; for better management of the organization of the Scheme the following has been proposed.

The management committee should consist of a chairperson, secretary, treasurer and other committee members. The chairperson should oversee all the activities of the committee members. A secretary is the chief administrative officer of the group / association. He or she is responsible to the committee for the daily control of the committee's operation. A treasurer is responsible for all the financial matters in the committee including preparation of annual budget, record of financial books, and other financial management. Other committee members should be responsible for such specific tasks as water management, operation and maintenance of the irrigation facilities, crop inspection, etc.

In the case of the irrigation schemes (with irrigation blocks) the irrigation club or water users groups (WUGs) should be formulated at each irrigation block. Main functions of the WUG committee are as reported in section 6.4 (4).

The proposed committee structure is presented in **Figure 6-6** below;

[1] Membership fee is usually collected to cover the administrative costs of the irrigation schemes.
[2] Water fee is usually collected to cover the operation costs of the irrigation schemes.



* Note: Some sub-committees can be established within the Management Committee

Figure 6-6 Proposed Committee Structure for the Medium-Scale Irrigation Schemes

6.5 Training Guidelines for Group Dynamics and Leadership Session

Group dynamics and leadership session must be conducted for the newly established farmer organizations and for the farmer groups that are not well established.

6.5.1 Objectives

At the end of the session participants should be able to:

(a) define a club or association
(b) state the reasons for formation of a club or association
(c) state the roles and responsibilities of group members
(d) state the roles and responsibilities of the committee members
(e) define good leadership
(f) state group conflict management

6.5.2 Group Formation

(1) Farmer Sensitization and Mobilization

Objective: To create awareness among the farmers for the agricultural development activities including irrigated agriculture in a form of consciousness-raising participatory manner.

1) At the first step, the facilitators (e.g. AEDO) collect as much information as possible for the related irrigation scheme from the concerned farmers and contact GVH or village headperson(s) to brief them on the subject.

2) Farmers are invited by the village headperson(s) to the meeting. After introductory session, participants are divided into several groups for the discussions. The problems in the farming activities should be identified by each group. Then the solutions to overcome the problems should be discussed. The identified problems and solutions should be presented by each group. These problems and solutions should be summarized by the facilitator.
3) Expected outputs from the discussions are identification of needs for: (i) farmers' cooperation improvement; (ii) water management related activities; and (iii) more formalized farmers' cooperation. Taking into consideration those outputs, the facilitator should propose the formation of a club or association for the interested farmers and set the next meeting date.

(2) Committee formation and training for the committee members

1) Steps for the formation of the committee
   - Discussions at farmers' meeting on the formation of a committee
   - Selection of the committee members
   - Clarification of the roles and responsibilities of the committee members by a facilitator
   - Explanation of the need for preparation of the constitution by a facilitator
2) Training of the committee members by a facilitator (AEDO)
   - Training should be conducted by a trainer (AEDO) under support from extension officers of DAO
   - Training items should include: (i) definition of a club or association; (ii) reasons for formation of a club or association; (iii) role and responsibilities of group members; (iv) roles and responsibilities of the committee members; (v) good leadership; (vi) group conflict management; and (vii) record keeping.

(3) Development of a Constitution

1) Steps for the development of a constitution
   - Explanation of the need and advantages of having a constitution
   - Formation of an interim constitution development committee
   - Preparation and Presentation of the draft constitution by the committee
   - Discussions and amendment of the draft constitution among the members
   - Preparation of a final version of the constitution by the committee
2) Approval of the constitution
   - Presentation of a final version of the constitution by the committee in the meeting
   - Approval of the constitution by the members

6.5.3 Group Dynamics

(1) Presentation by a facilitator (AEDO) on the importance of group dynamics

a) Success of the group depends on how well group members know and interact with each other;
b) Group spirit is raised by intense collaboration and cooperation;
c) Total output of members working as a group is more than that of a member working alone;
d) Individual members can fulfill their needs through participation in the group;
e) A group is able to survive in the event of difficult situations such as sickness, funeral, etc.

(2) Presentation by a facilitator on the indicators of group dynamics

a) Group synergy[3] is important because the total output of members working as a group is more than that of a member working alone. The output can be income, productivity, success, energy and power.
b) Group cohesion[4] is important because it can bring about high morale and productivity. Group cohesiveness can be realized through: (i) members sharing common perspective in terms of

[3] Is the total output of an effective, cohesive and productive group
[4] Is the amount of unity in a group and the degree to which members contribute towards achieving a similar goal

age, education, outlook, ethnic and social origin; (ii) members' activities resulting in achieving the group's goals; (iii) ease of communication within the group; (iv) applying punishment and rewards; (v) higher rate of contact among the members; and (vi) limited number (small size) of the group.

c) Group solidarity[5] can be realized through: (i) sharing the same feelings, opinions, aims and goals; (ii) unity under leadership; (iii) strong support of leadership; and (iv) keeping a single line of leadership.
d) Group consensus[6] is an agreement after all opinions have been heard. Disagreement and minority viewpoints are discussed fully. Climate setting is important so that all members feel free to express their opinions.

(3) Definition of Farmer Club

A farmer club is a group of individual farmers having the same objectives or a common goal who have agreed to cooperate and work together to achieve their goal for own mutual benefits. Therefore, members of the club should ideally:

a) Know each other
b) Live close to each other
c) Trust each other
d) Interact with each other

(4) Reasons for Formation of Clubs

Clubs are formed because of the following reasons

a) For members to share knowledge about their activities
b) Share payment of the cost of inputs
c) Facilitate group approach of communication with the system outside the club
d) Ensure timely operation of tasks
e) Enable members to qualify for a license to perform certain activities
f) Help one another to solve various community and social problems
g) Provide a starting point for the development of a self sustaining organization that is able to mobilize savings, organize purchase of inputs and sell produce for the group as a whole.

(5) Some of the roles and responsibilities of the group members

Each member of a farmers group (e.g. irrigation club) or water users association (WUA), should work in accordance with roles and responsibilities described in the constitution. Each member is obliged to; (i) attend the meetings; (ii) pay membership fee or any other fees as stipulated in the constitution; (iii) maintain order in the group; (iv) give constructive ideas during the meetings; (v) actively participate in development work as agreed in the meetings; (vi) be active and cooperative; (vii) be trustworthy; etc.

6.5.4 Leadership

(1) Definition of Group Leader

A leader is a person who initiates awareness of the situation. In an organization he or she is elected by the people in the organization to guide them in various activities. This person influences the behaviour of others so as to achieve the goals of this group, organization or community.

(2) Qualities of Good Leaders

a) Enthusiasm: A good leader must be eager and have determination to do things. This entails personal sacrifice and the will to serve others
b) Willingness to accept responsibility: Accepting responsibility is crucial for leadership because a leader is assigned numerous tasks that have to be performed within a specific period.

[5] An emotional output that comes about as a result of strong group attraction
[6] An agreement which often involve compromises or combination of various possibilities after all opinions are heard

c) Emotional stability: The trait of not easily getting annoyed, disappointed, is vital for good leadership. In fact the best leaders are those that remain cool and calm in a situation that is annoying, frustrating and disappointing.
d) Ability to promote group action: Any group is formed to achieve a specific goal. Attainment of that goal requires that certain activities be done. A good leader should therefore stimulate the member into action so that these activities are done.
e) Identification with the group: A good leader must feel that he or she is part of the group. The leader must consult group members on important decisions and actions that must be done. In fact he must avoid doing things single-handedly as if he or she does not belong to a group.
f) Consideration of others: It is necessary that a leader first puts the interests, wants, needs of group members before presenting his own. Consideration for others shows that the leader is caring and values the presence of others.
g) Cheerfulness: The quality of smiling, good sense of humor, makes others feel warm and good and therefore feel relax to participate in group activities.

(3) Leadership Roles in Groups

a) Listener: Ability to listen when other group members are talking. This is important for the better understanding between the leader and the members. A leader can know people's feelings, wants, desires, aspirations, and ambitions, if he or she listens.
b) Initiator: A leader is supposed to be innovative. In other words he or she must be able to lead and be the first one to do. The leader must steer the other group members into action.
c) Decision maker: Ability to make sound, practical and timely decisions is important for any group. In fact inability to make decisions often results into confusion among group members.
d) Mediator: A good leader must be able to assist two parties in conflict to understand the issue at hand, what went wrong, who was at fault, and assist parties to forgive and compromise with each other.
e) Observer: Because people sometimes learn through keen observation, a leader must observe so that he or she understands what is going on and be able to teach others.
f) Authority: This role refers to a situation where a leader gives instructions, suggestions, order and the group members obey him or her without hesitation.
g) Advisor: A leader must advise his group members on what is right or wrong or how best the members can do a certain activity.
h) Communicator: This role involves speaking, writing very well so that the group members can understand the message on how things are, should be and what has to be done.
i) Friendly: This role makes it possible for the group members to express their thoughts because they feel free, warm and relaxed with the leader.
j) Advocator: The leader must promote certain ideas, approaches, practices that he or she believes are a solution to certain problems that the group is currently facing. He or she persuades the members to adopt these practices and approaches.
k) Confident: This is a role whereby the leader makes a deliberate effort to keep secrets of the group members and the group to which he or she belongs.

6.5.5 Group Structure

(1) Functions of Scheme Committees

a) Executive Committee

Main role of the Executive Committee (or Management Committee) is to control the work of the farmers group or association on behalf of the group members on the basis of the terms and conditions as specified in the constitution. Functions of the management committee include (i) water management; (ii) financial management; (iii) marketing arrangement; and (iv) security and discipline activities. The roles and responsibilities of the committee are: (i) to hold meetings (general meeting, committee meeting, and other meetings); (ii) to approve the new applicants to join the group; (iii) to resolve conflicts among the members; (iv) to

receive and take action on the reports from each sub-committee; and (v) to keep record of all group assets and financial management.

b) Sub-Committees

There are several kinds of sub-committees that can be established under the management committee. A farmer organization can establish some of these sub-committees according to the needs of the group activities.

- Discipline Committee: Main function of this committee is to look into the matters of discipline and recommend corrective measures to the Management Committee.
- Finance Committee: Main function of this committee is to be responsible for coordination of annual budget preparation and fund management for the group members.
- Loan Committee: Main function of this committee is: (i) to prepare loan application forms; (ii) to ensure that all fees are paid; (iii) to arrange transportation of inputs; (iv) to ensure receipt of inputs by every applicant; (v) to ensure that treasurer has opened club and member repayment ledgers.
- Crop Inspection Committee: Main function of this committee is to ensure that members follow recommended production practices; to ensure that inputs are correctly used for right purpose; to check on the post harvest treatment of the crops; to organize group members to help the cultivation of the sick.
- Marketing Committee: Main function of this committee is to ensure that members secure the best price for their produce. This committee provides the marketing information to the members.
- Water Committee: Main function of this committee is to organise all the water management activities such as preparation of irrigation schedule, allocation of irrigation water, etc. Function of operation and maintenance works can be included in this committee.
- Operation and Maintenance Committee: Main function of this committee is to arrange the works for operation and maintenance of the irrigation facilities.

(2) Roles and Responsibilities of Group Members

Each member of a farmers group (e.g. irrigation club) or WUA works in accordance with set roles and responsibilities based as described in the constitution.

Each member is obliged to: (i) attend the meetings; (ii) pay membership fee or any other fees as stipulated in the constitution; (iii) maintain order in the group; (iv) give constructive ideas during the meetings; (v) actively participate in development work as agreed in the meetings; (vi) be active and cooperative; (vii) be trustworthy; and others.

6.5.6 Group Conflict Management

(1) Types of Group Conflict

a) Blips (low intensity): These are conflicts of minor importance that are resolved or disappear on their own. The anger among group or individuals is mild and goes away after some minor annoyance. Groups maintain sufficient trust, affection and openness toward each other.
b) Clashes (medium intensity): These are conflicts that, once disregarded, impair the capacity of relationships to satisfy the needs of groups. Individuals and groups feel the stress, tension, or anger when interacting with the other individuals or groups.
c) Crisis (high intensity): These are conflicts that threaten the continuation of relationship amongst group and individuals. Risk of physical violence or other extreme retaliation exists, if the conflict is not resolved.

(2) Causes of Conflicts in Groups

a) Mismanagement of resources and funds

b) Lack of transparency
c) Failure of some group members to follow group norms
d) Difference in perception
e) Poor communication among group members
f) Differing individual needs, values and interests versus group objectives and goals
g) Lack of tolerance amongst group members
h) Power hungry members
i) Personal greed
j) Poor leadership
k) Jealousy amongst group members
l) Laziness amongst group members
m) Socially unfaithful wives / husbands
n) Using bad language / approach during meetings
o) Overstepping into somebody's responsibilities
p) Monopoly of group assets
q) Unfair distribution of group profits
r) Favoritism
s) Backbiting amongst members
t) Lack of confidentiality.

(3) Consequences of Conflicts

a) Loss of confidence by outsiders and communities
b) Loss of support from the authorities
c) Collapse of group
d) Loss of group property, assets
e) Loss of direction
f) Disintegration of a group
g) Poor attendance during meetings and group activities
h) Quarrelling among group members
i) Dropping out of group members
j) No growth in membership
k) Misuse of group assets and funds
l) Group constitution not followed

(4) Ways of Managing a Conflict

a) Use of internal disciplinary committee
b) Use of traditional leaders
c) Respect of group norms, by-laws and constitution
d) Taking action urgently
e) Seek assistance from relevant government officials
f) Transparency in all group transactions and activities
g) Contact and dialogue
h) Regular meetings
i) Observance of one's responsibility
j) Pass fair judgment, penalties and fines
k) Elect only trustworthy people in leadership positions

6.6 Training Guidelines for Small-Scale Farming Business

6.6.1 Introduction

The guidelines have been developed with an objective of assisting to improve farmers' skills and knowledge on farm business management with a view to transform subsistence agriculture into commercial farming. Increased agricultural production supported by good skills in agribusiness help to

directly reduce the poverty level in the Malawian rural communities as farmers are not only able to produce more but also find good market for their excess produce.

6.6.2 Farm Business Planning

(1) Definition

A Farm Business Plan is a guide prepared by the farmer or farmer group to show what has to be followed during business operation. This plan is prepared before any farm work is done.

(2) Objectives of a Business Plan

Objectives of preparing a business plan are:

(a) To create vision for the members of the organization so that the farmers can think of a better future situation after production and sales;
(b) To provide a guide for checking work progress in the business;
(c) To understand an overview of the business before any production is made so that the farmer can be able to produce based on the market information;
(d) To obtain external assistance including money lending institutions

(3) Components of a Business Plan

A business plan is composed of the following;

a) Marketing Plan

Before production is made, the farmer or farmer group should state:

- What they want to produce in the farm
- Quantities to produce
- Where to sell the produce
- How the produce will be delivered to the customer
- Who else is producing the same type of enterprise at the moment
- What are the prices of the intended produce at present
- How will the farmer(s) promote their produce for marketing

b) Production Plan

Production plan include the following information:

- Production resources (farm size, farm equipment, production inputs)
- Technology and practices
- Quality control

c) Organization and Management Plan

This refers to roles and responsibilities amongst the group members during the production and marketing of farm produce.

d) Financial Plan

This refers to the planning and management of financial resources in a business.

- Details of capital requirement, sales projection
- Cash flow
- Projected profits and loss statements

6.6.3 Marketing Planning

In most village communities, the common buyers are the fellow villagers. In the event that the farmer will sell his or her farm products beyond the village, the farmer needs to design marketing strategies before the products are ready to sell. It is very uneconomical to start producing crops for sale without knowing who the buyer is or without knowing the market.

(1) Market Research

a) Where to sell the produce: The produce can be sold in the village or outside the village. Possible potential buyers include: supermarkets; schools; universities; restaurants; middlemen; health centers; hospitals; local produce markets and so on.
b) Demand and supply on the market: The farmer needs to establish the level of demand and supply on the market.
c) Sales of the product on the market: The farmer needs to get information on the type of products needed in the existing market. Some crop sales may be poor because buyers do not have information on how to prepare the crop for consumption. The farmer also needs to establish current selling prices in different market prices so that he/she can sell the produce at higher prices. The farmer should visit the market to see how the prices vary, to set the price that can attract customers.

(2) Channels for Marketing

Usually the marketing process involves many transactions from one trader to another until the products reaches its final consumer. Type and volume of business determine which channel is most useful and economic. The longer the chain the more the transaction costs. The farmer can use any of the channels to make more money to gain profits. However, if the farmer wants to bypass some of these channels, they have to consider if they can fulfill the functions of the players in the same or even in a better and more cost effective way. Some of the most common market channels involve the following players as outlined in the **Figure 6-7** below.

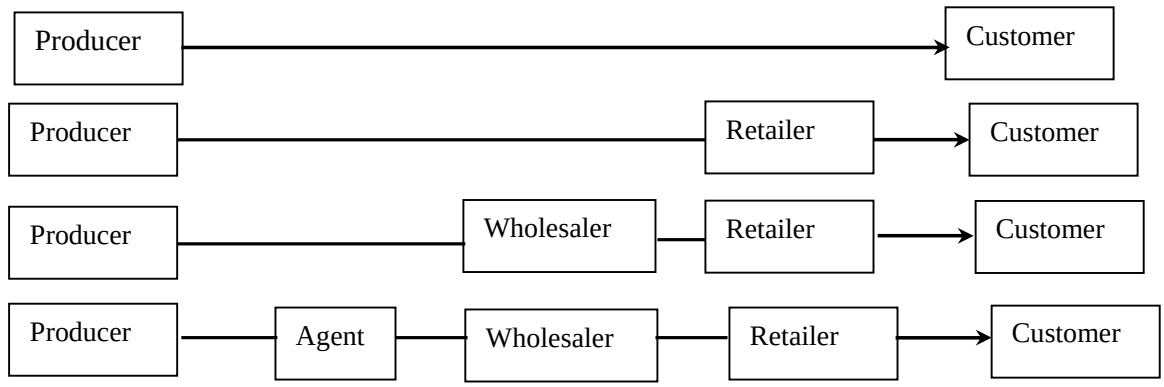


Figure 6-7 Common Market Channels

(3) Fixing Selling Price

The selling price of a product determines whether the seller will make a profit or not on his / her produce. In an open market, demand and supply control prices. If the supply is low and many people want the product, the price goes up. When there is plenty supply and few buyers, the price fall. In order to maximize profits, planning should be properly done so that harvesting should fall in a period when prices are high.

In the "Cost plus Method", the calculation is Cost of production (K15, 875) divided by Estimated crop produce (11,000 cobs) = Selling price (K1.45 per cob), at no profit/loss. In this calculation, the costs of production include the fixed and variable costs.

(4) Gross Margin Analysis

1) Gross Margin

Gross margin is the remaining income from an enterprise after variable costs are deducted. It can be calculated on a per hectare basis, or as a return to labour, based on a number of days worked by the farmer or his/her family and can be expressed as MK/ha, MK/worker or MK/person day respectively.

Every farmer should know the cost of production and be able to calculate the gross margins. This allows the farmer to analyze the current performance of an enterprise using current prices and input-output information. Using the gross margins he/she can make a budget from which the profitability of an enterprise can be calculated. Gross margin, is therefore a tool which is used for assessing the comparative profitability of different enterprises or technologies

2) Steps for Calculating Gross Margins

(a) Determine the average yield per hectare for the enterprise
(b) Determine the average farm gate price for the enterprise [Note: The farmer or extension worker will need to take the information on prices available in the market and deduct all the marketing costs from the farm gate to the market].
(c) Calculate the gross income per ha (i.e. average yield/ha multiplied by the price at the farm gate)
(d) Calculate the non-labour variable cash costs of inputs and materials per hectare for the enterprise. These should include the costs of seeds, fertilizer, pesticides, machinery services etc.
(e) Estimate the labour costs per hectare per activity for each enterprise (e.g. land preparation, sowing, weeding, harvesting, etc.)
First : Determine the number of hired person-days required per activity per hectare
Second : Determine the rate of pay for the hired labour
Third : Calculate the cost of hired labour by multiplying the number of hired persons day days per activity by the current wage rate for each activity
(f) Calculate the cost of family labour by multiplying the number of family labour person day days per activity by the opportunity cost of family labour (i.e. current wage rate, as in step (e).
(g) Calculate the total variable costs by summing the cost of inputs and materials, hired labour and family labour.
(h) Calculate the gross margin per hectare by subtracting variable costs from the gross income
(i) Repeat these calculations for each enterprise on the farm
(j) Compare the gross margins among the enterprises and determine which is more profitable.

6.6.4 Record Keeping

Records are all the data or information that is written to keep track of all internal operations on the farm as well as all external operations and financial transactions of the farming business. Record keeping is the act of storing information / data so that it is easily accessible at a later date. Records can be sub-divided into physical and financial records.

(1) Physical Records

Physical records are books keeping data on physical business activity outputs. The data will help the farmer or group of farmers manage quantity and quality using well defined indicators.

(k) Daily Records

All activities done in a day are recorded by the farmer or group secretary of the farmer organization. An example of daily record is given in **Table 6-1** below.

Table 6-1 Daily Farm Activity Record (Example)

Date	Activity	Output
12/04/2007	Made manure heap	1
13/04/2007	Made manure heaps	2
16/04/2007	Constructed basins/ridges	12
22/04/2007	Plant maize SC 403	22 basins

(l) Monthly Records

Monthly records are the aggregation of all daily records in a month. All similar activities are added up and outputs are added together to make one figure for the month' achievement. Refer to **Table 6-2** below.

Table 6-2 Monthly Farm Activity Records (Example)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1	Made manure heaps		2	4	5			5	5
2	Constructed basins/ridges			300	400			300	400
3	Basins/ridges planted – maize								
4									
5									

Individual farmer records can be combined to make group records. These records can be kept by the farmer group secretary. At group level, activities can be recorded independently in separate record books / pages.

An example of ridging / basin construction records is given in **Table 6-3** below.

Table 6-3 Collective Ridge Making Records for Farmers (Example)

	Name of Member	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1	A			80	140				
2	B			90	158				
3	C			90	78				
4	D			40	220				
5	E			30	240				
6									
	Group totals								

(2) Financial Records

Book-keeping is simply the writing down of all financial transactions arising from the business, as well as the filing of physical paper documents such as receipts, delivery notes, etc.

1) Farm Inventory and Valuation Book

This is list of all that a farming business owns and all that it owes, at a given time, with the kwacha value for each item. This is usually taken at the beginning and ending of the business year and it is a must for all serious farming business groups. All business assets, raw materials, livestock, work in progress and finished products should be valued in Malawi kwacha and every item listed on the inventory sheet. Depreciation of assets for the enterprise should be calculated using the straight line method. A straight line is calculated by using the formulae [Purchase Price (MK) / Useful Life (years)] **Table 6-4** shows an example of an Inventory and Valuation Book.

Table 6-4 Inventory and Valuation Book (Example)

Items	Quantity	Unit Prices	Total Costs	Depreciation	
				Years	Amount
Borehole	1	350,000	350,000	20	70,000
Buildings					
Office	1	3,000,000	3,000,000		
Store	1	2,700,000	2,700,000		
Warehouse	1	350,000	350,000	20	17,500
Greenhouses	1	150,000	150,000	20	7,500
Equipment					
- Motorized pump	3	195,000	585,000	10	58,500

- Treadle pump	8	12,500	100,000	10	10,000
- Shovels	10	1,057	10,570	10	1,057
- Weighing scale	2	7,500	15,000	10	1,500
- Measuring tapes	2	1,400	2,800	5	560
- Rakes	20	450	9,000	10	900
- Hoes	81	350	28,350	10	2,835
- Crates	81	450	36,450	10	3,645
- Water cans	81	450	36,450	10	3,645
- Hand shellers	81	175	14,175	10	1,418
- Sprayers	4	6,500	26,000	10	2,600
- Axes	4	295	1,180	10	118
- Garden folks	81	695	56,295	10	5,630
- Stakes	3,000	1	3,000	10	300
- Poles	-	50	-	10	
- Seed boxes	10	1,500	15,000	10	1,500
- Protective clothing	8	5,950	47,600	3	15,867
- Haversacks	2	2,000	4,000	3	1,333
- Cyphone pipes	8	7,500	60,000	10	6,000
Vehicles		-			
- Bicycles	2	-	15,000	7	2,143
- Wheelbarrows	10	9,900	99,000	7	14,143
- Ngolo	2	56,000	112,000	7	16,000
- Oxen	4	50,000	200,000	5	40,000
Total			2,385,620		296,443

2) Cash Book

A cash book, **Figure 6-5** is used for recording cash transactions. It shows the actual cash that goes in and out of a business; hence, it help to explain how cash is used. A cash book has two books combined, a cash account and a bank account and has basically two sections, i.e. “in section” and “out section”.

Table 6-5 Cash Book Layout

In Section				Out Section			
Date	Details	Cash	Bank	Date	Details	Cash	Bank
		(all money withdrawn from the bank to be kept in hand)	(all money deposited)			(all expenses paid by cash)	(all money withdrawn) (all money paid by cheque)

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