JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF IRRIGATION (DOI)
MINISTRY OF AGRICULTURE (MOA)
REPUBLIC OF MALAWI

THE STUDY ON THE CAPACITY BUILDING AND DEVELOPMENT FOR SMALLHOLDER IRRIGATION SCHEMES IN THE REPUBLIC OF MALAWI

COMPREHENSIVE GUIDELINE

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Foreword

This Comprehensive Guideline is a part of Smallholder Irrigation Development Package produced under the Study on the Capacity Building and Development for Smallholder Irrigation Schemes in the Republic of Malawi. The Study was carried out from January 2003 to February 2004 in partnership with all those concerned officers of the Ministry of Agriculture. The Study produced the following dissemination materials for smallholder irrigation development, which altogether consist of the Package.

1) Comprehensive Guideline
2) Technical Manual
3) Posters (5 sheets of A-2 size)
4) Leaflets (English and Chichewa versions)
5) Picture Stories

This Guideline is fully based on the experiences of the Study, which included the implementation of verification projects to examine the best approach of promoting smallholder irrigation suitable in the context of Malawi. The Study tried out various hypotheses on promoting irrigation as a culture that is transmitted over generations and came up with some ideas of improving rural living standard and thereby reducing rural poverty. Though the ideas resulted from the Study should not be over generalized, they are expected to be tools of practical application to extend smallholder irrigation development over the Country.

This Guideline is structured with 13 modules that start with Rational, Development Objectives and Strategy, and cover a wide range of topics as Participatory Planning, Irrigation Type, O&M, M&E, Public Equity in Irrigation Development, Appropriate Farming in Irrigated Agriculture, etc. As such, the Guideline incorporates wide range of subjects from soft to hardware as well as agriculture components which make this guideline comprehensive. Therefore, those who need specific technical guideline should refer to the Technical Manual listed above.

Readers of this Guideline are therefore to be the government officers in DOI, ADD and RDP first and foremost, and then EPA should also be given as a reference. We expect the readers to utilize this Guideline in fit of each condition, but also to try out the disciplines asserted throughout the text in practice. Being still humble enough for over generalization, experiences in the verification projects are incorporated corresponding to the general description of the ideas to indicate where the ideas came from. However we also believe that the actual experience is the living source of the text to be conveyed from its origin to various contexts.

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ACRONYMS AND ABBREVIATIONS

ADB	African Development Bank
ADD	Agricultural Development Division
ADC	Area Development Committee
DDC	District Development Committee
DOI	Department of Irrigation
FAO	Food and Agricultural Organization
GOM	Government of Malawi
GVH	Group Village Headman
IFAD	International Fund for Agriculture Development
IFIC	Institute for International Cooperation (under JICA)
IPM	Integrated Pest Management
JICA	Japan International Cooperation Agency
MOA	Ministry of Agriculture
NGO	Non-Government Organization
NRC	Natural Resource College
ORT	Other Recurrent Transaction (government recurrent budget)
O&M	Operation and Maintenance
PRA	Participatory Rural Appraisal
RDP	Rural Development Project
SHIP	Smallholder Irrigation Project
TA	Traditional Authority
UNDP	United Nations Development Project
VH	Village Headman

CURRENCY EQUIVALENTS (as at December 10, 2004)

1 US$ = 110.00 Malawi Kwach (TTB)
1 US$ = 101.50 Japanese Yen (TTB)
1 MK = 0.0091 US$
1 MK = 0.9227 Japanese Yen
1 JY = 1.0837 MK

MALAWIAN FISCAL YEAR

July 1 to June 30

UNIT CONVERSIONS

1 meter (m) = 3.28 feet
1 kilometer (km) = 0.62 miles
1 hectare (ha) = 2.47 acres
1 acre = 0.405 ha

1 cubic meter per second (m^3/s) = 35.31 cubic feet per second
1 cubic foot per second (cusec) = 28.3 liters per second (l/s)
1 cubic meter per hour (m^3/h) = 0.28 liters per second (l/s)
1 kilowatt (kw) = 1.34 horsepower (hp)
= 1 kilovoltamp (KVA)

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MODULE 1 DEVELOPMENT OBJECTIVES, STRATEGY AND PROCEDURES

1.1 Rationale

Smallholder farmers have been heavily damaged by natural vagaries such as heavy rainfall and also drought. Especially erratic rainfall in the years of 2000/01 and 2001/02 had caused national level food shortage associated even with famine. Only rain-fed agriculture, which has long been the core of Malawian's agriculture, can no longer span their life from a season to next season. Before next harvesting season comes, many farmers just end up with no food, which implies even no seed left for the next season.

"The National Irrigation Policy and Development Strategy, 2000" (NIPDS) aims at poverty alleviation by targeting resource poor smallholder farmers by irrigation development. Irrigation raises self-sufficiency rate of food, and enables smallholder's life stable. Ministry of Agriculture's vision also states "a nation with sustainable food security and reduced poverty", in line with which DOI has the vision of "Prosperity through Irrigation by the year 2020".

Current situation the Country is facing and the above mandate provide the rationale of promoting smallholder irrigation development. Hence, a comprehensive guideline with dissemination materials, which themselves together are the Package for smallholder irrigation development, is prepared in order to facilitate the nationwide development of smallholder irrigation. The Package is therefore composed of: 1) a comprehensive guideline, 2) technical manual, 3) posters, 4) leaflets, and 4) picture stories.

The comprehensive guideline, which is this Volume, will be mainly for DOI, ADD and RDP irrigation officers, technical manual mainly for RDP irrigation officers, AEDOs and also AEDCs, and leaflets, posters as well as picture stories chiefly for the front line of AEDOs and the farmers. This cascaded dissemination materials aim at contributing to the promotion of smallholder irrigation development throughout the Country.

1.2 Definition of Smallholder Irrigation

Smallholder Farmers are by definition those who hold farms less than two (2) ha on customary land[1]. The Smallholder Irrigation is therefore defined as the irrigation that is realized, operated and maintained by those smallholder farmers. Throughout the process of construction, operation and maintenance, the farmers discharge the maximum role with the Government as facilitator. The farmers are the project owner since the onset of the development while the Government is the participant to their project.

In terms of physical scale, the smallholder irrigation sets 10ha as the probable maximum service area though not necessarily always limited. A two-year trial on the ground in 2003 and 2004 has developed 287 sites with total area of 358ha, arriving at an average service area of 1.2ha per site. Since targeted schemes are to be constructed by smallholder farmers, the physical scale hardly surpasses 5ha as experienced; hence the probable maximum service is

[1] According to "2. Objectives of the Study" of M/M of the Scope of Work for the Study on the Capacity Building and Development for Smallholder Irrigation Schemes in the Republic of Malawi agreed upon between the Ministry of Agriculture of Malawi (MOA) and JICA on November 5, 2001.

set at 10ha.

The type of the smallholder irrigation this Package purses is gravity irrigation and in case combined with treadle pump. Gravity irrigation is the cheapest and most maintainable irrigation hence most sustainable. Farmers may use treadle pump lifting the water from the gravity canal to the upper side of the farmland. Therefore, the smallholder irrigation may be combined with treadle pump but in any case gravity irrigation is the core.

1.3 Objectives of Smallholder Irrigation Devlopment (SHID)

The objectives relevant to the smallholder irrigation development are categorized into three; namely,

SHID Overall Goal: Poverty among rural population is alleviated through promoting broad agriculture development based on increased agriculture production and productivity.

SHID Purpose: Food security for smallholder farmers is increased through promoting irrigated agriculture with an emphasis on dry season cultivation that fulfills the gap between the seasons.

SHID Outputs: Institutional capacity such as facilitation and technical knowledge and skills relative to smallholder irrigation development is built among government officers.

Farmer organizations responsible for constructing, operating and maintaining smallholder irrigation schemes are established with facilitation from the extension officers concerned.

Small-scale irrigation schemes are established through mostly self-effort of the farmers with the government technical assistance and, if needed, plus minimum level of physical assistances from the government, types of which are gravity diversion.

Dry season irrigation and supplemental irrigation during lean rainy season are established in the smallholder irrigation sites with appropriate agriculture extension services from the government.

Where:

SHID Overall Goal: the development effect(s) expected as a result of the achievement of the SHID Purpose,

SHID Purpose: the objective that is expected to be achieved within the project implementation period or upon completion of the project, and

SHID Outputs: objectives that have to be realized through the project activities in order to achieve the SHID purpose.

1.4 Strategy of Smallholder Irrigation Development

1) Pursuing Self-effort to the Largest Extent

Faced with a budgetary constraint, there is a difficulty for GOM to provide enough physical assistance to the farmers who are to develop smallholder irrigation schemes. Even if physical investment from the GOM is programmed, it may take long time to realize letting the farmers just wait. Cost recovery may be a solution to cope with the budget constraint, however most farmers are in subsistence who suffer from hunger or just end up with what they have cultivated.

Smallholder irrigation schemes that the Package pursues should, therefore, be those to the largest extent that are CONSTRUCTED BY THE FARMERS with the GOM technical assistance and, if needed, plus minimum level of physical assistance. "Pursuing FARMERS' SELF-EFFORT AS MUCH AS POSSIBLE rather than expecting government intervention in terms of physical investment" is the key principle in promoting nationwide smallholder irrigation development.

Designing of irrigation systems envisaged, for example, should be done in such a way of not engaging any heavy equipment nor engaging local contractor in the construction. Those irrigation schemes are, of course, fully managed, operated and maintained by the smallholder farmers. The position of the GOM is the facilitator and technical advisor, and relevant government officers are the ones who participate in the farmers' project.

2) Extending Smallholder Irrigation from Farmer to Farmer

Pilot project should be traced in other areas in purpose of multiplying fruits from the projects. However, it has hardly been traced so far due probably to non-participation of the farmers, unmanageable size of the project, non-copiable design, non-maintainable facilities, and so on. When aiming at nationwide dissemination, the scheme should always be designed to be copiable by fellow farmers. It is therefore stressed to bring the irrigation system into being due in the farmers' locality by USING LOCAL MATERIALS as much as possible.

In addition to above, an inter-site monitoring tour by the farmers should be considered. There are double effects from this sort of inter-site monitoring tour. The farmers implementing a project could be proud of showing their achievement, so that they become more active in their activities, while the visitors could also be motivated by seeing. Thus, the visitors are often so motivated that they think they are also capable of starting similar project. Implementing smallholder irrigation schemes as a cluster could also minimize the cost required for the tour.

3) Developing a Cluster of Smallholder Schemes by a Task Force Team

There are about 30 % vacancies in the posts of front line extension officers. Technical officers in RDP lack transportation expenses for their activities (usually limited to 250 km per month per officer). Limited supportive capacity of administration could be a constraint for extending the smallholder irrigation scheme over the irrigation potential areas in the Country.

Taking into account the situation, facilitating farmers onto the irrigation development should always be planned under minimum level of budgetary allocation. A smallholder irrigation scheme should therefore be implemented with several neighboring project sites as a cluster. Then, frontline officers with RDP irrigation officer will be organized into a task force team and work together to support the farmers. A task force system for facilitating irrigation development, visiting around the clustered sites, would cope with the budgetary constraints.

4) Achieving Food Security as the Priority

Irrigation realizes dry season agriculture as well as can supplement rainy season agriculture especially at the beginning. Irrigation produces supplementary food and also cash crops, contributing to food security even in a food scarce dry season. Dry season agriculture supported by irrigation will fill the gap between the seasons. Given an example of the critical food shortage in 2001/02, smallholder irrigation should achieve food security with high priority.

Local level seed production, for example open pollinated variety of maize, can also be facilitated under irrigation. Improved maize seed in this Country tends to be short. Seed production during rainy season needs a lot of care, while the production during dry season can easily be done due to less opportunities of cross-pollination since the cropped area is certainly limited within the irrigable area. Local seed production with irrigation can also contribute to the local food security.

5) Producing Marketable Crops

Irrigation produces cash crops such as tomato, potato, onion, radish, etc. Cash crops have an opportunity of boosting the farmers' income, thereby directly alleviating the poverty prevalent in most of the rural areas. Aside from giving the first priority to the food security, cash crops should also be tried especially in those areas proximate to tarmac roads or townships. Vegetable growing during dry season reduces the risk of pest infection, and also the quality is usually better than those during rainy season.

1.5 Implementation in Technical and Administrative Lines

Implementation arrangement follows the existing government organizational setting up consisting of ADD, RDP and EPA, and also should involve local administrative lines from the view point of advancing extension to larger extent. Responsibility at different levels of the technical line can be summarized as:

Central level (DOI):	Irrigation trainings for AEDOs/AEDCs, irrigation officers in RDPs and ADDs, monitoring and evaluation of smallholder irrigation development at national level, banking of appropriate irrigation technologies/experiences and these dissemination, and facilitating the exchange of the technologies among ADDs,
ADD level:	Technical advices to the RDP irrigation officers concerning smallholder irrigation schemes development, monitoring and evaluation at ADD level, facilitating the exchange of irrigation experiences among RDPs,
RDP level:	Technical advices to the EPA officers concerning smallholder irrigation schemes development, monitoring and evaluation at RDP level, and facilitating farmer-to-farmer-visit over an EPA, and
EPA level:	Identification of potential areas for smallholder irrigation schemes, facilitation of the farmers including identification of the potential beneficiaries, arrangement of farmer-to-farmer visit in the EPA,

organizing them into group/club, facilitation of the construction work, follow-up of operation and maintenance, etc.

In addition to above lines, local administrative structure should also be involved. Over the Country, there are 20,721 village headmen (VH), 2,360 group VHs, and 160 Traditional Authorities (TA)[2]. If smallholder irrigation development ends up in village-by-village, concerned local authority is the village headman only. However, this Package proposes cluster-wise development, for which number of potential sites ought to be developed simultaneously. If the concerned group VH is well informed of the development, dissemination from one site to another within the cluster could be advanced.

Considering there are 186 EPAs nationwide, the jurisdiction of a TA could be more or less same as the coverage of a typical EPA. It implies that if TA is well informed of the development, there should be an opportunity that dissemination at EPA level, which means beyond a cluster, could be facilitated. Corresponding to EPA coverage, there is a development committee called Area Development Committee. Above this, there is District Development Committee at district level.

Table 1.1 Technical and Administrative Lines

Technical Line		Local Administrative Line	
Coverage	**Responsible**	**Dissemination Catalyst**	
DOI	Director	(be informed and invited to study tours)	
ADD	DIO		
RDP	IO		District Development Committee
EPA	AEDC	Traditional Authority	Area Development Committee
Cluster	AEDO	Group Village Headman	
Project	AEDO	Village Headman	

IO: Irrigation Officer, DIO: Divisional IO

Village headman is automatically involved since the beginning of the development. Aside from him/her, it is recommended that group VH, TA, Area Development Committee, and District Development Committee should also be informed of the development. Involvement of this local administrative structure could catalyze the extension of the smallholder irrigation development from one site to another in a cluster, beyond the cluster, and then beyond an EPA. Study tour involving group VH and TA should also be considered in this matter.

1.6 Implementation on the Ground

Implementation responsibility, especially on the ground, should center on EPA level with technical assistances from relevant irrigation officer(s) at RDP level. A task force team is arranged at this EPA level being the core of pursuing the implementation; namely, composed of AEDOs, AEDC being the leader and RDP irrigation officer as the technical advisor. The team may ask advices from crops officer at RDP as moving to planting season. General procedure of implementing smallholder irrigation projects is described as follows:

1. Identify the potential smallholder irrigation projects by EPA base based on the information from concerned AEDOs and farmers, and also with reference to inventories carried out under previous studies,

[2] Ministry of Local Government, February 2003

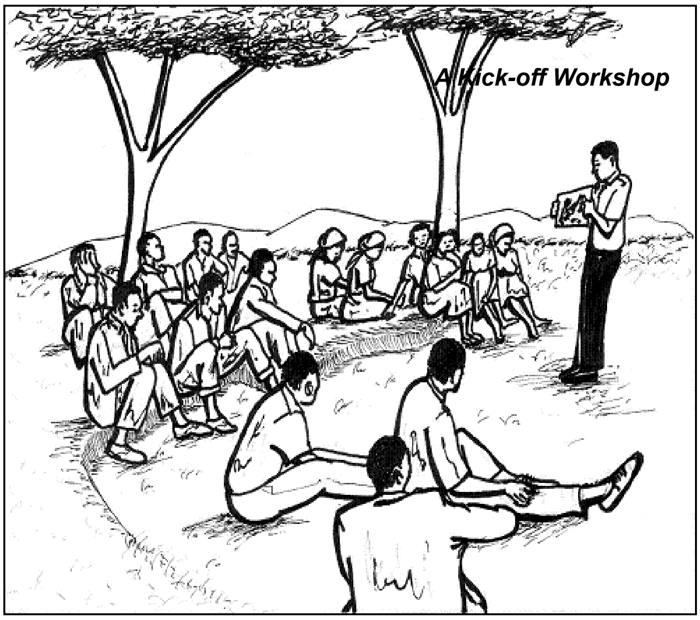
Responsibility: AEDC with AEDOs
Support: RDP irrigation officer

2. Cluster a couple to several number of potential projects in each EPA, which are located nearby each other into a group, and select one each with the highest potential among the group members on basis of water availability and farmers willingness to develop,

   Responsibility: AEDC with AEDO
   Support: RDP irrigation officer

3. Make physical observation at the highest potential site by the RDP irrigation officer of RDP, the AEDC and the AEDO, and confirm the farmers' willingness to develop smallholder irrigation scheme,

   Responsibility: AEDC with the AEDO(s) concerned
   Support: RDP irrigation officer



4. Hold a kick-off workshop to embark on the smallholder irrigation development: the workshop consists of two sessions; namely, introductory session at the village and plenary session at the site, and agenda can be as:
   1) Introductory Session (at the village)
      1.1) Opening and self-introduction
      1.2) Village profile establishment
      1.3) Problem analysis
      1.4) Introduction to irrigation
   2) Plenary Session (at the site)
      2.1) Preliminary siting of the diversion site
      2.2) Viewing of the service area
      2.3) Discharge observation (measurement)
      2.4) Next action

   Responsibility: AEDC with the AEDO(s) concerned
   Support: RDP irrigation officer

5. Hold a feasibility workshop with the following agenda to confirm the feasibility of the irrigation scheme especially in terms of knowing the gravity canal alignment can be done or not by using line level: this means actual canal alignment to be done in the site for the first, say, 100 meters,
   1) Siting of the diversion site
   2) Preliminary discussion of the diversion structure
   3) Canal alignment for the first 100 m with line level

4) Preliminary delineation of the service area
5) Preliminary identification of the potential irrigators

Responsibility: AEDO
Support: AEDC and RDP irrigation officer

6. Upon confirmation of the feasibility and the farmers' willingness to develop, hold a planning workshop consisting of: 1) listing of the potential irrigators with farm size, 2) action plan formulation composed of: e.g. canal construction, weir construction, plot layout, irrigation, planting, review workshops, etc. together with the time schedule, responsible person, necessary tools, who to arrange the tools, etc.,

   Responsibility: AEDO
   Support: AEDC and RDP irrigation officer

7. Facilitate, during the planning workshop, their discussion to arrive at their decision of what weir structure with what sub-components to be realized considering the availability of local materials, their own financial burden, construction period, etc., what assistance to be available from the government,

   Responsibility: AEDO
   Support: AEDC and RDP irrigation officer

8. Facilitate farmer leaders identified during the series of workshops to mobilize his/her fellow farmers in proceeding to the construction work according to the action plan,

   Responsibility: AEDO with AEDC
   Support: RDP irrigation officer

9. Conduct periodical monitoring and evaluation meeting/workshop to solicit lessons that are to be forwarded to the successive stages, to refine the project design, to re-align task responsibilities, to adjust the construction period, etc.,

   Responsibility: AEDO with AEDC
   Support: RDP irrigation officer

10. Gather farmers in another potential area which is located in the same cluster; namely, located near the on-going project site, and bring them to the construction site in order to motivate them to embark on the same activities, and

    Responsibility: AEDO with AEDC
    Support: RDP irrigation officer

11. Conduct same procedure from above item No.4 to succeed the smallholder irrigation projects in the same cluster, and the prime responsibility should be now with the EPA and RDP irrigation officer stands as ad hoc basis technical advisor.

MODULE 2 PARTICIPATORY PLANNING

This Package advocates that participatory development does not necessary mean only farmers' participation but rather defined as participation of all the stakeholders/actors involved in the smallholder irrigation projects such as farmers, village headmen, front line extension officers, irrigation officers, and other officers in the related fields, TA, NGOs, etc. The development project is therefore a venue, from the viewpoint of participatory development, where all the stakeholders/actors who have some common interests in the project participate, share the information, experiences and knowledge, and work together for the development of all the stakeholders/actors.

Participatory workshop can be held at any levels of national, ADD, RDP and also villages. National level workshop can identify the stakeholders and general problems surrounding smallholder irrigation sector in Malawi. Workshop at ADD level can learn the problems for regional agriculture from the officers' point of view. Workshop at village level can identify the structure of the problems specific to the village from the farmers' point of view and let them prioritize the problems so that the project can incorporate several sub-components, especially site-specific ones.

As national level and ADD level workshops need particular logistics, these workshops may be conducted once a year only. The workshop should also incorporate the evaluation of the past year's performance and also the planning of the following year's action program with the target. Workshop at RDP level including EPA officers should be held at least two per season, preferably every beginning and end of dry season, and at village level whenever irrigation project is to start and as required on the course. The following are the general procedure of the planning workshop at RDP/EPA and village levels:

2.1 Workshop at RDP including EPA officers

Workshop at RDP is staged into two; 1) stakeholder analysis and 2) problem analysis. Stakeholder analysis is to identify the concerned stakeholders in the area with their weaknesses and strengths. Basic structure of the problems in the villages of Malawi and their solutions can be illustrated in a prototype problem and solution tree (see Figure 2.1).

- Carry out Stakeholder Analysis by RDP and EPA officers to identify the stakeholders and general problems of the area,
- Write down all the possible stakeholders/main actors (note that the interest groups, organizations, agencies and individuals who would be involved to the smallholder irrigation scheme may be different from one scheme to another),
- Categorize the interest groups, organizations, agencies and individuals into such groups as funding organization, service provider, facilitators, etc.,
- Discuss the strengths and weaknesses, opportunities and threats of each stakeholders/actors (this is called Detailed Stakeholder Analysis),
- Review the causes of the prototype by Problem Analysis of RDP and EPA officers (note that the causes should be different from area to area. For example, livestock problems might show up in Mzuzu, Machinga and Shire Valley ADDs),
- Review the solutions and program components corresponding to the causes identified (at this stage, sub-component may be identified to improve the villagers' livelihood in addition to the irrigation component), and
- Also, identify the potential areas or potential watershed (catchment area) for

smallholder irrigation development by EPA base, based on which limited number of RDP technical staff can concentrate on the high potential areas.

Table 2.1 An Example of Stakeholder Analysis

Group 1. Funding Organizations	Donors	Non-governmental organizations	Financial institutions						
Group 2. Service Providers	Marketing organizations	Equipment suppliers	Input suppliers	Traders	Local artisans				
Group 3. Facilitators	MoAI	Irrigation Department	ADD	RDP	Extension workers	Non-governmental organizations	Other departments	Health workers	Environmental workers / specialists
Group 4. Beneficiaries	Farmers	Women Groups	Youth Clubs						
Group 5. Local Institutions	District Assemblies	Area Development Committees	T.A. & other local community leaders	Village Headmen	Counselors	Politicians	Religious leaders		

Table 2.2 An Example of Detailed Stakeholder Analysis

Detailed Stakeholder Analysis of DoAI	General Characteristics	Strength	Weaknesses	Problems
	8 ADDs, 32 RDs, 186 EPAs	Agro-economical setting	Low staff / farmer ratio (1/2,000)	Lack of motivation
		Strategic location of extension staff		
Capacity	Most posts vacant	Structure in place	Bureaucratic procedures	Staff attrition
	Gender imbalance		Poor institutional memory	Lack of replacement
				Inadequate specialized/trained personnel
Resources	Budgetary constraints	Offices available	Under-provision of financial resources	Lack of mobility
		Government commitment	Poor generation of resources	Inadequate resources
		Prioritization of activates		Dwindling resources for implementing programs
Information flow	Inadequate feedback	Data available	Limited access to data available	Poor quality data
	Poor coordination at all levels		Poor institutional capacity to build database - equip	Unreliable data

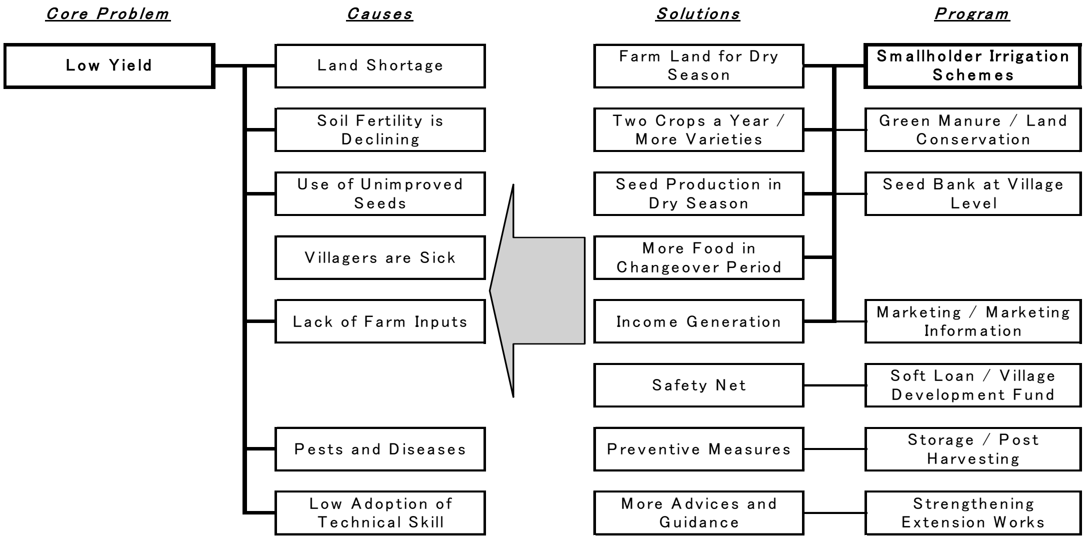


Figure 2.1 A Prototype Problem Analysis and Solutions

2.2 Workshop at the Villages

Planning workshop at village level is staged into three: 1) problem analysis & prioritization, 2) selection of the project design option, and 3) action plan formulation. Problem analysis will identify the problems in the villages and the prioritization will identify necessary components in addition to the irrigation development. The problem analysis & prioritization workshop is held in such manner of:

- Choose a wider Core Problem so that almost all the problems which the villagers are facing can be covered by Problem Analysis (note that "Villagers are in hunger" may fulfill the purpose under present conditions),
- An AEDO, an RDP officer, one of the village leaders or a young farmer can write down the problems on a big khaki paper in the workshop for the participants, and
- Prioritize the problems by using Scoring; one of RRA tools.

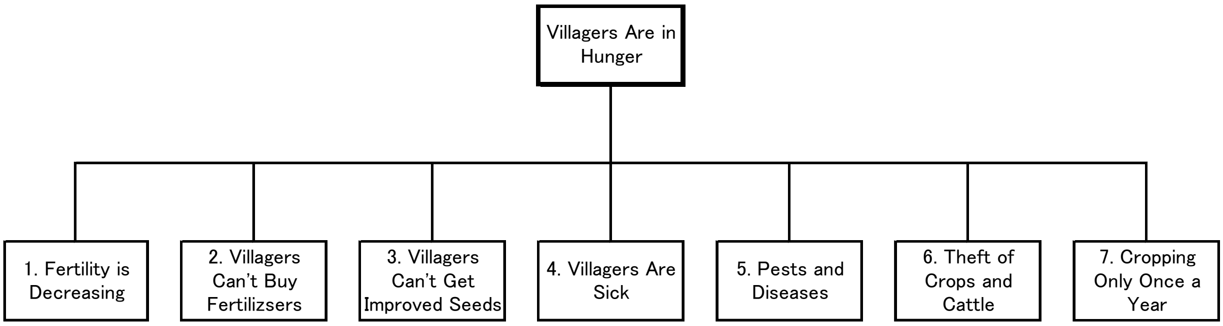


Figure 2.2 An Example of Problem Analysis and Prioritization at Village Level

Right after the problem analysis workshop or in parallel with it, the concerned AEDO together with AEDC and RDP irrigation officer prepare several options/alternatives of the project design for the smallholder irrigation schemes, which are technically feasible for those prospective areas. Options include, for example, the diversion weir is made of sand bag, brush dam, masonry, etc., taking into due account farmers' self-effort to the largest extent while minimum level of outside physical assistance.

Table 2.3 An Example of Comparison of Options for Project Design

	Option A	Option B	Option C
Expected Irrigated Area	15 ha	30 ha	40 ha
Major Work	Intake improvement	Intake improvement and canal expansion	Intake improvement, canal expansion
Major Input	Local material, labor	Local material, cement, labor, skilled labor	Local material, cement, labor, skilled labor, a treadle pump
Necessary Cash Contribution	MK100 / HH	MK500 / HH	MK1,000 / HH
Amount of Labor Necessary	100 MM	150 MM	150 MM
Operation and Maintenance	MK50 / HH / Year	MK100 / HH / Year	MK200 / HH / Year

Now it will be the decision of the farmers to choose, but the facilitation can be given in such a way for the farmers to select labor-intensive and less-cost option[3]. If they choose labor-intensive option, they do not need to pay money. Though less cost option needs many laborers, it can be renewed every time before irrigation season starts if they are well organized.

[3] As the first option, labor-intensive and less-cost option should be recommended taking into account the rural condition prevalent almost throughout the country.

After basic project design is decided, an action plan is formulated at the village. The purpose of formulating the action plan is to clarify and to let all the stakeholders/actors understand the project design, responsibilities, obligation and conditions (see the table below for an example). Software part of the projects will also be designed in this stage. Several components such as seed multiplication, seed bank, revolving fund, exchange-visits, introduction of green manure, compost manure making, land conservation etc. need to be designed.

Table 2.4 An Example of Action Plan

Activities	Expected Results	Indicators	Schedule	Main Actor(s) - Responsible Person(s)	Actors	Risks, Remarks
2-1 Collection of stones	Enough stones are delivered to the site	100 kg of stones collected	2nd-6th June 2003	Chairman of Irrigation Club	All the members of Irrigation Club	Availability of Transportation, Absenteeism Fee, MK50 per day

In allocating the responsibility between the villagers and outsiders, the issue in mind is that the smallholder irrigation scheme is a self-help type of project, for the owner of the scheme is obviously the farmer from the beginning. It should be rather government participation to the farmer's projects than farmer's participation to the government projects.

Therefore, farmers are expected to do whatever they can do with maximum efforts, while the government does the rest. For example, all the labors and locally available material are automatically from the farmers for their own projects and the government provides technical assistances for designing, construction, operation and maintenance, and essential tools for the construction such as wheelbarrow, pick, shovels, etc.

MODULE 3 IDENTIFICATION OF THE PROJECT SITES

Developing smallholder irrigation exclusively depends on the natural resource that is water. Needs for irrigation from the farmers therefore do not always meet the commencement of smallholder irrigation project. Potential in terms of stream flow as well as topographic condition, whether gravity diversion is feasible or not within the farmer's self-effort, should be examined as the first step.

3.1 Irrigation Type

Topography in Malawi, in view of irrigated agriculture, can be divided into three types, namely, mountainous areas, highland hills and lowland plains. Mountainous areas and highland hills are physically not very convenient to build large-scale irrigation schemes due to its hilly and undulating topography, however they have good potential for smallholder gravity irrigation systems, on which this Package put the priority, depending on farmland distribution and water abstraction easiness.

On the other hand, lowland plains very often accompany wide dambo wetland in marshy areas alongside river as well as flat lakeside areas where relatively large-scale systems can be established. In such lowland plains, however, large diversion dams across rivers or motorized pumps to lift water for irrigation use are essentially required. Therefore less potential is usually found in the lowland areas for smallholder irrigation development. Figure 3.1 presents typical irrigation systems located along rivers in Malawi. They are categorized into seven types as below, of which this Package undertakes Types of A, B, C:

Table 3.1 Irrigation Type seen in Malawi

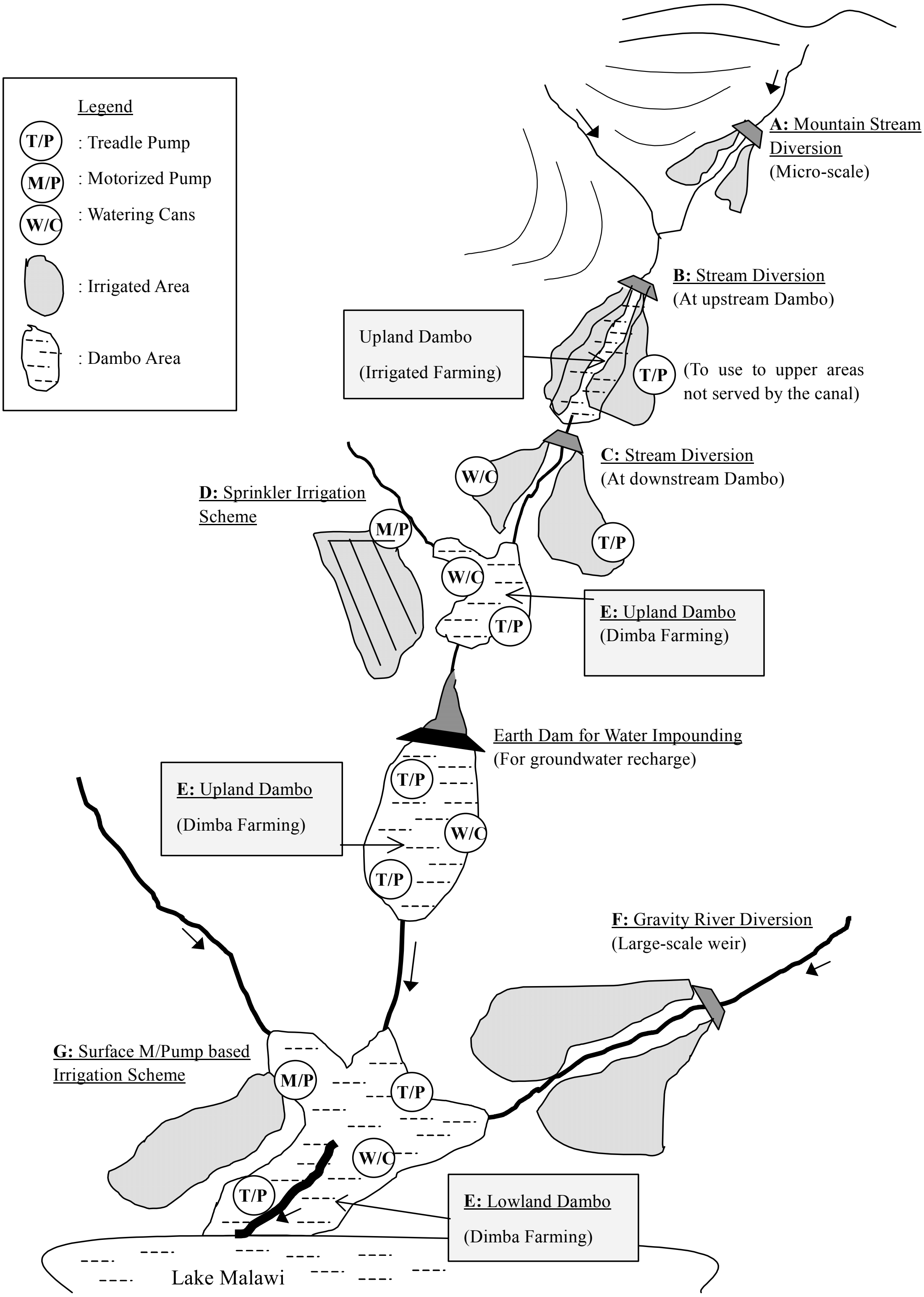
Type	Specification	Remarks
A: Mountain Steam Diversion	This type is located at the most upstream of rivers where the river slope is relatively steep. Irrigation system is normally at micro-scale as the water flow is small. Key factors to plan this type of irrigation systems are water abstraction to be easy by gravity, farmlands to be situated nearby water source, and mountain/hill slope not to be quite steep.	**UNDERTAKEN**
B: Stream Diversion located at Upstream Dambo	This type is situated at upstream of upland dambo where surrounding areas are topographically hilly. Treadle pumps and watering can may be utilized by taking canal water to irrigate upper land where it can not be covered by gravity from canals. A diversion weir will be located at starting point of dambo or just inside dambo area.	
C: Stream Diversion located at Downstream Dambo	Stream/river diversion sites are located at river course but immediately downstream dambo area. Irrigation system at this part of the river is still small-scale, however floods must be taken into account in the location and design of river/stream diversion structures. Treadle pumps and/or watering cans may also be utilized to take water same as the type (B) above.	
D: Sprinkler Irrigation	This irrigation system consists of only 4.0% of overall existing irrigation systems in Malawi in terms of service area for smallholder sub-sector. This type usually involves motorized pumps for water abstraction and pressure pipes to deliver water.	NOT UNDERTAKEN
E: Dimba Farming at Dambo	In many cases, dimba farming takes place together with earth dam for water impounding. The dam reservoir is utilized for the purpose of domestic water supply, livestock water supply, and sometimes fishery. This earth dam also replenishes the groundwater downstream, thereby enhancing the dimba agriculture at downstream of the dam. Also, very often used for the dimba framings are shallow wells.	
F: Gravity River Diversion	This type is usually built at middle-stream to downstream of rivers, providing relatively large-scale diversion weirs (barrages) and intake structures for water abstraction, and an extensive gravity canal network system. This type needs government/ donor intervention.	
G: Pump Irrigation	To irrigate plains by abstracting water running fairly below the farm, lifting water from the rivers/ lakes will not be avoided and such lifting measures are either type (D) above or this type (G). Treadle pumps will also be used at very small-scale, which maximum manageable area is about 0.3 ha only. The capacity of pumps depends on required pump head and service area.	

Dimba farming, Type E, has been promoted by the government as one of the major activities in the irrigation sector. Often associated with this dimba farming is earth dam. There are more than 800 earth dams throughout the Country, most of which need rehabilitation such as setting-up of conduit intake pipe, and de-siltation. However, rehabilitation of earth dams can hardly be done by farmers' self-effort due mainly to: 1) very little intensives since the rehabilitation would not usually enlarge the irrigation area[4], 2) heavy siltation of the reservoir

[4] DAPSP I planned 16 dams rehabilitation, out of which only two have been intervened. The reason is said that lead-time was not enough, implying farmers pace does need much longer than planner thinks. Aside from

which can hardly been de-silted since most of the dams do not have drain conduit (dry work mostly impossible), 3) long duration to be required (more than one year construction hardly attracts smallholder farmers, etc. Therefore, Type E is not undertaken in this Package.

Figure 3.1 Typical Irrigation System in Malawi



this, little incentive from the rehabilitation must be attributable to the low accomplishment.

3.2 Stream Flow

Stream flow is almost entirely corresponding to rainfall. Upon the onset of rainfall, stream flow starts increasing, and then as rainy season comes to the end the flow also starts retarding. Throughout the dry season, almost all the streams in Malawi continue reducing the flow and in some cases dry up. Discharge record is not available for those relatively small streams this Package targets. No one knows in fact how much the flow is to decrease. Given this situation, following can be given as an idea of how the stream potential is assessed;

- Visit the potential diversion site and observe the flow with the concerned farmers and ask them "if this stream dries up on the course of dry season or continues flowing until the next rainy season". If the answer is "dries up", abandon the site and move next potential site. If the stream is perennial;
- Ask the farmers "how much flow will decrease towards the end of dry season". They may answer "the flow reduces to less than half or less than one-third as compared to the flow at the beginning of the dry season". According to observations for some sites conducted on the course of producing this Package, retarding of stream flow is very much dependent on the catchment area condition and also the location along the stream whether it is upstream side or downstream side (see box for examples).
- Try to measure the stream flow. There are two methods as shown in Figure 3.1: 1) V-notch or rectangular notch measurement, and 2) float measurement. Notch measurement usually gives accurate results, while float measurement is convenient if the stream is considerably big. It is noted that the flow measured at the beginning of dry season does not directly entail the possible irrigable area as the flow reduces towards the end of dry season. Therefore stream flow measured at this stage should be taken as reference only.

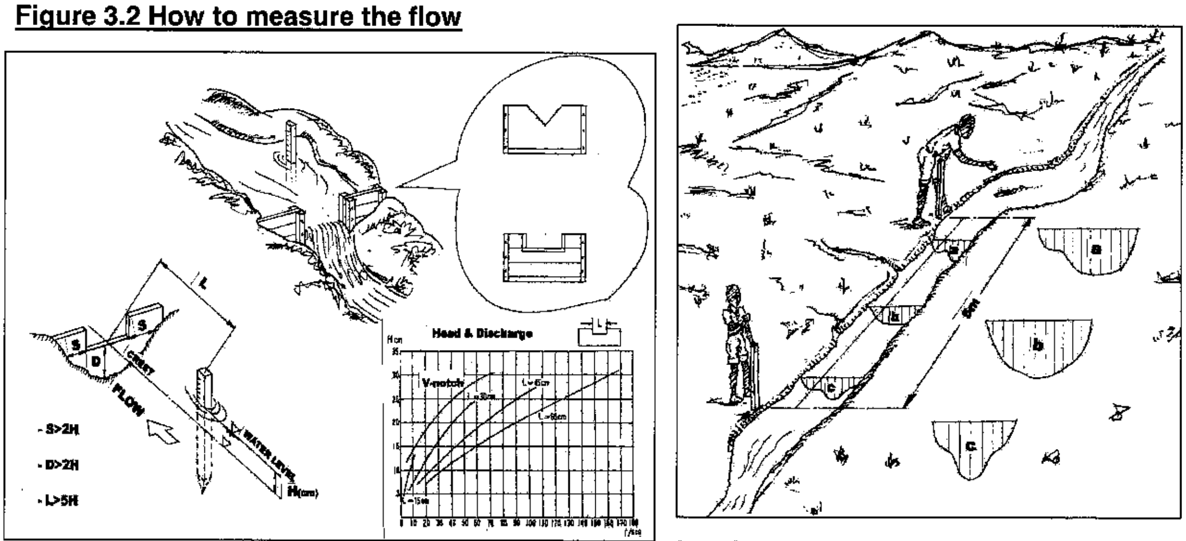
> **Examples of retarding rate:**
> At Bwanje site in Lilongwe ADD which is located far downstream from the source, flow in October usually becomes less than one-tenth of that in July. Within 4 months, the flow reduces to less than one-tenth.
>
> At Mphika site in Ntchisi RDP, the flow in November is almost same as that of beginning of dry season. This site is located about 10m downstream of the source which is natural spring. Spring usually generates constant flow throughout dry season. Other sites in this Ntchisi RDP do not retard so much since the area is still well covered with good vegetation.
>
> At many sites in Lilongwe area where vegetation is very poor, the retarding rate is big such as; the flow of Duwu site in Mpenu EPA reduces to less than one fifth in normal year, and in dry year it reduces to even less than one-tenth.
>
> At sites in Dedza Hills area, the retarding rate is also big since most of the potential catchment area is very small despite relatively good vegetation.

- Critical issue is how much water decreases towards the end of dry season. Though farmers may inform the reduction to about half or about one third, there is a tendency to always underestimate the retarding ratio[5], which inevitably causes abandoning of part of the irrigation service area. Therefore, it is recommended that at least at first year the development should not be ambitious or rather start with relatively small area. It is suggested that in any case no more than half of the potential area shall be developed even if the flow looks very constant, and in case that certain flow retarding is expected, the development at the first year should be limited to less than one-fifth to even one-tenth of

[5] This may be caused by too much expectation of the development and in cases there might be an expectation of free input such as seed and fertilizer to come with irrigation development.

the potential area depending on the vegetation condition and also the location along the stream[6].

Figure 3.2 How to measure the flow

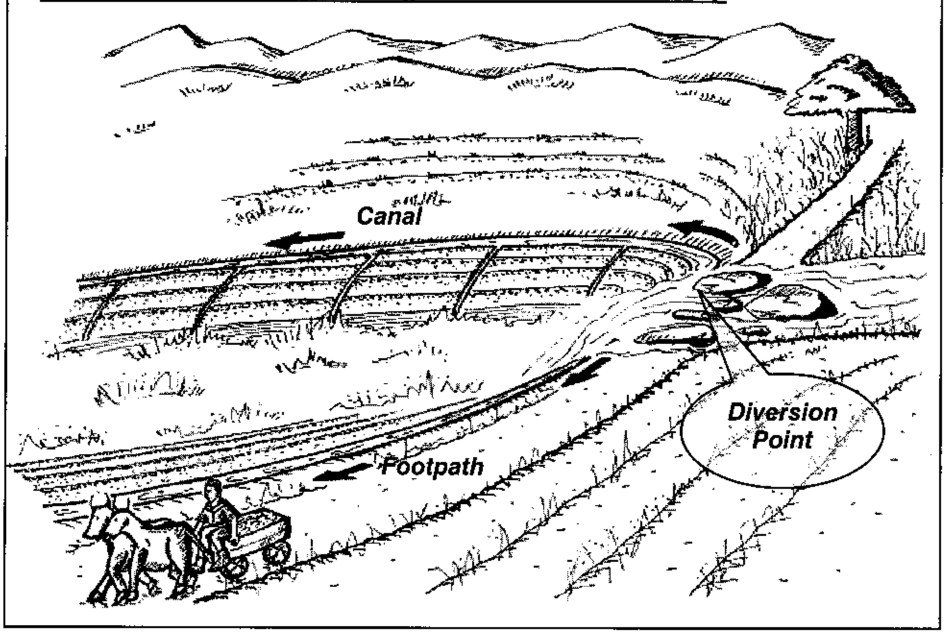


Use V-notch or Rectangular-notch

Use float, even leaf OK; 60% of the surface velocity into section area gives the flow

3.3 Diversion Site

Potential Site: Footpath crossing a Stream and Natural Drop



Gravity irrigation system starts with diversion weir. Potential diversion sites being blessed with perennial flow, the depth should not be very deep; preferably limited to 3m according to experiences. Good sites can very often be found at villagers' footpath which crosses a perennial stream and also at just upstream of natural drops (small fall). Footpaths usually traverse streams at a shallow place, forming a topographic condition of easily diverting and getting water onto the farms nearby downstream. Just upstream of natural drops (small fall) could easily lead the water into canal by gravity thanks to the elevation difference.

[6] Generally, sites located near the source of stream give not much retarding while sites located far downstream from the source usually have bigger retarding rate.

3.4 Development in a Stream

There may be a series of potential sites located nearby along a stream. Sometime after farmers have started irrigation development at a specific site, upstream farmers in the same stream may start irrigation development by seeing their peer's development. This may cause water deficit for the downstream site, creating water dispute among the concerned. Stream diversion as its nature always favors upstream sites thereby downstream farmers often result in at the mercy of the upstream farmers even if the downstream farmers who started irrigation earlier express their water right.

Village headman or group VH being involved, they may agree rotational allocation of the water between the sites. This arrangement will work to resolve the water dispute to some extent. However, water flow itself is limited in most of the smallholder irrigation potential sites. An arrangement therefore should be taken into account in case that there are several potential sites located nearby along a stream. The development in this case should always be tried from the upper most reach and then proceed to downstream according to the water availability.

Scramble for water may be expected to become a vital problem if all the villages in an area are to have their own smallholder irrigation schemes at the same stream. It needs to plot a map of all the irrigation schemes and also investigate major use of water (domestic use) in the area, to monitor the progress inclusive of flow condition in each year and to prepare for a place for discussion (ex. workshop) among the stakeholders in the same stream. Impact on other use of water such as for drinking and washing is also needed to be closely examined and as need arises AEDC/AEDO should arrange a venue of discussion wherein the concerned villagers are expected to devise mitigating measures such as rationing of water, reducing of irrigation area, etc.

MODULE 4 ORGANIZING FARMER IRRIGATION CLUB

4.1 Organizing Process

The process of implementing a smallholder irrigation project starts with participatory kick-off workshop. Following the kick-off workshop, feasibility workshop and then planning workshop will be held. Through the workshops, preliminary plan of the diversion structure will be discussed and preliminary canal alignment will also be done on the site. Then, the participants will formulate the action plan of activities for the implementation. Also, conducted at the workshops is the selection of the responsible person for each activity. The responsible persons could be potential leaders who will be the candidate of the committee members of their organization.

As to building an organization, the official registration or officers' setting-up is often made in advance to starting the activities; or start the activities right after the selection of the potential leaders in the initial process of the making organization. This Package proposes the latter approach (see Figure 4.1, for which middle to latter half of the whole process of building the organization will proceed parallel to the implementation of the project. In this case, the potential leaders are given roles of mobilizing the fellow villagers for labor work, arranging the local materials such as wooden poles, twigs, grasses, clay soils, etc., and collect sharing amount if cash contribution is required with strong leadership for organizing the members through the whole process. As for the potential leader, so to speak, it is as if taking examinations for becoming a leader in real meanings through on-the-job-training.

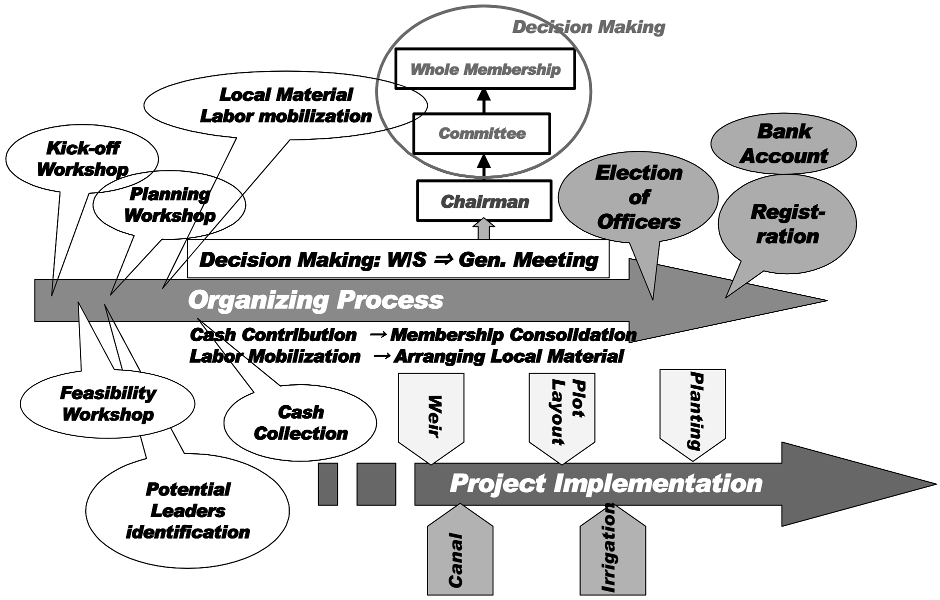
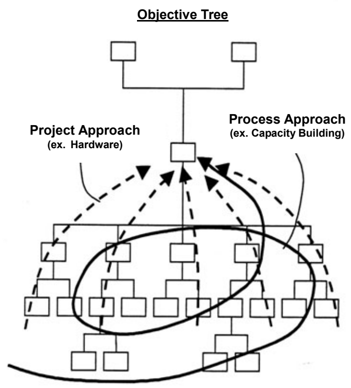


Figure 4.1 Organizing Process & Project Implementation

On concerning the important matter, such as cash contribution in case, it should be discussed and decided in the villagers' meeting and not in the workshops mentioned above that may have a possibility of calling only a limited number of participants. If there is an existing organization, utilize its general assembly meeting and not just committee members' meeting since there is a great possibility that the chairperson will behave beyond his/her authority for the decision-making. It is noted that the chairperson has also only one vote for decision-making as same as other members. The decision-making by the consensus in the villagers' meeting or in the general assembly would be the process, which the outsider should intervene properly.



Social development project definitely conceives dual objectives as very often recognized that the objectives of social development and project itself are different. For example, the objective of irrigation development project would be "to increase farm income by irrigation", but it would not be the objective of social development.

Important point is to realize that people or organizations become strong and/or capable of doing through the process of project implementation. In this sense, the project is defined as merely a tool or an opportunity for social development. The relation between project and capacity building with above understanding is illustrated, for example, as the figure left hand using the objective tree of PCM method.

Project is normally defined as an undertaking to directly tackle the problem (e.g. food shortage or low income) by applying a certain mean (e.g. irrigation development) in a prescribed period. In this case, the direct objective of the project is set to be "to secure enough food" or "to increase income", and based on the project, people will be empowered through its implementation (described as spiraling up on the figure above). This process itself is called capacity building or social development approach. Capacity building of people and organizations, in another word, the process approach is carried out with the irrigation project as a tool. This concept comes up with the idea of "learning by implementing, and building capacity by learning" as illustrated in the figure above.

In the time of completion of their due such as local material collection, cash payment in case, and mobilizing fellow farmers for the construction, the activities could be said as being well done on the way. In a sense, it could be said that the potential leaders pass the hardest process of implementing the project. In this stage, most of the villagers will already recognize who is appropriate for the chairperson, and other members of the committee such as vice-chairperson, secretary, treasurer, etc.

So, there comes a time to carry out the election (it is usually only the superficial procedure), decide the committee members, ratify the by-laws by all the members and in the end may register the organization officially with its by-law. In the case of handling certain amount of cash, the registered organization now opens the joint bank account under the name of the chairperson, vice-chairperson and treasurer.

4.2 Organization Internal Set-up

Role and authority on planning, decision-making and implementation should be clearly defined in a proper organization. For example, when a farmer organization thinks about the following dry season crop, they go through a process of planning of water use and allocation, decision-making of the plan, and execution of the approved plan. Authority for these three aspects must be independent.

If we consider the case of irrigation club, planning will be done by a group like agriculture development group or water management group formed by volunteers or elected persons within the club and decision on whether to execute the plan will be made by the General Assembly or the Representatives Committee. General assembly is composed of all the membership. Representatives from irrigation blocks such as upstream, mid-upstream, mid-stream, etc. usually form the Representatives Committee. Either the general assembly or the committee does the decision-making according to the significance of the issue[7].

Under the Representatives Committee, Management Committee is formed consisting of the chairman, vice chairman, secretary, treasurer, and auditor. The Management Committee will be in charge of the execution or day-to-day management according to the decision made by either the Representative Committee or the General Assembly (see Figure 4.2). In case the irrigation scheme is very small, the Representatives Committee composed of only several members can act as the Management Committee as well as be in charge of planning: that may be most of the cases in smallholder irrigation schemes (see Figure 4.3).

Difficulty concerned with irrigation club is that Management Committee members come out from the members of the Representatives Committee. For private companies, directors and managers are different personnel, but as per irrigation club, the Representatives Committee is usually formed by the representatives of each irrigation block and the members of the Management Committee including the chairman are selected from the members of the Representatives Committee.

Although the chairman is the chief executive officer, he has only one vote in decision-making in the Representative Committee and in the General Assembly as well. Sometimes the authority and duty of the chairman are mixed up. To prevent the authorities from being abused and promote transparency of the organization, such idea of decentralized

[7] Example is next season's water distribution can be decided by the Representatives Committee but issues entailing cash, which is very important, should be decided by the General Assembly.

organizational setting-up should be extended to all the membership.

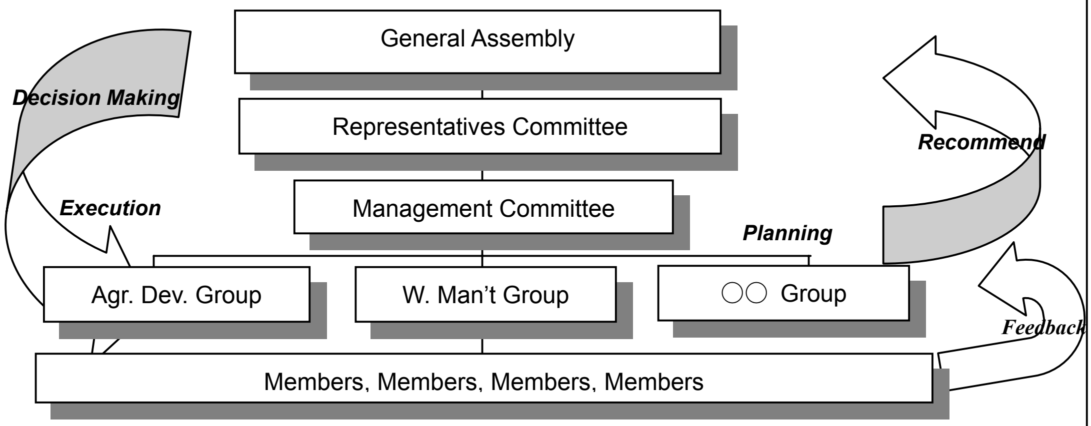


Figure 4.2 Internal Organization Setting-up (preferably over 50 members)

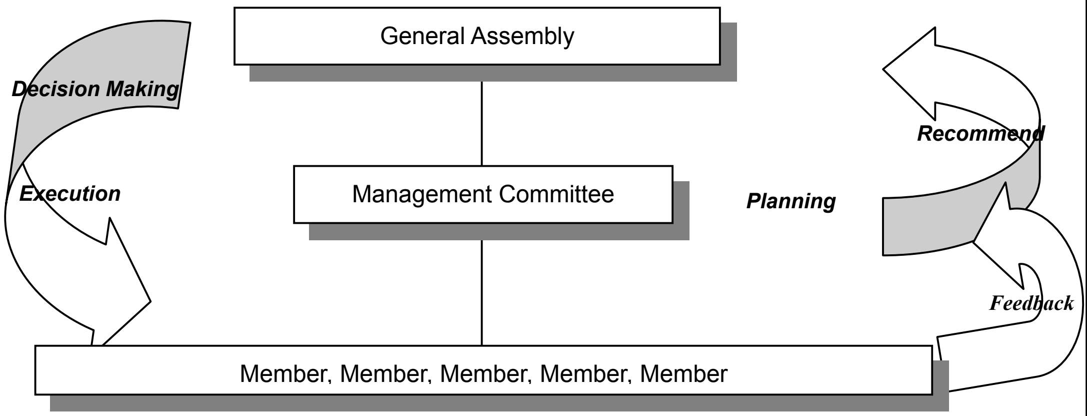


Figure 4.3 Internal Organization Setting-up (preferably less than 50 members)

The quality of leadership, more than any other single factor, determines the success or failure of an organization. The remarkable success of some of the farmer's organizations can be attributed largely to the leaders and the kind of leadership that they have used. Leadership is a process of influencing individual or group of individuals to achieve a collective response to resolve a particular problem or any given situation.

Collective style of leadership is a kind of leadership wherein the leading group organ, the Representatives Committee or the Management Committee in case of small irrigation club, stands as the united center of leadership; hence, all important issues are collectively tackled, decided upon and implemented. The united effort and integrated action of the members to perform their respective tasks promote initiative and reliance of every member in carrying out decisions by the collective. Under collective leadership, monopoly of one or few in making decisions and in running the organization is avoided.

Basically, Collective Leadership is the application of the principle of democratic centralism by the club's leadership. In essence this is the interplay of democracy and centralism or of freedom and discipline.

WHAT IS DEMOCRACY: Democracy is a system of exercising authority over farmer organization wherein the general membership holds the ruling. In case of the irrigation club the ruling power or authority is the general assembly composed of all the membership. All the important issues must be ruled by this general assembly.

WHAT IS CENTRALISM: Centralism is the principle or system of centralizing power or authority. In the irrigation club centralization is lodged in the Management Committee. Thus, the implementation of the irrigation club's policies, guidelines, the O&M responsibilities or all activities of the irrigation club for that matter is being centralized by the members of the committee.

Democratic-Centralism is the principle wherein utility of democracy and centralism or of freedom and discipline is the basis or guide of the leaders as well as the members of the club in the discharge of their functions and in the accomplishments of the assigned tasks. The system of democratic centralism is a distinct feature of irrigation club in its operation. Simply saying, any decisions must be decided democratically by the general assembly but once the decision is made the decision must be implemented in a centralized way under the supervision of the Management Committee. This mechanism ensures the irrigation club complete or total orientation with the fellow farmers' participation of regulation making process and in carrying out O&M tasks. Four rules that ensure organizational unity based on the principle of democratic-centralism are:

1) The individual is subordinate to the Irrigation Club. This means that the interest of the individual is under the interest of the Irrigation Club. Everyone must follow the club's constitution and by-laws, guidelines and rules of the club and all decisions and agreements made without personal reservations,

2) The minority is subordinate to the Irrigation Club. This means that the decision made on behalf of the whole club is based from the majority of the members. If ever there are other positionings of the minority these should be subordinated with the majority's collective decision,

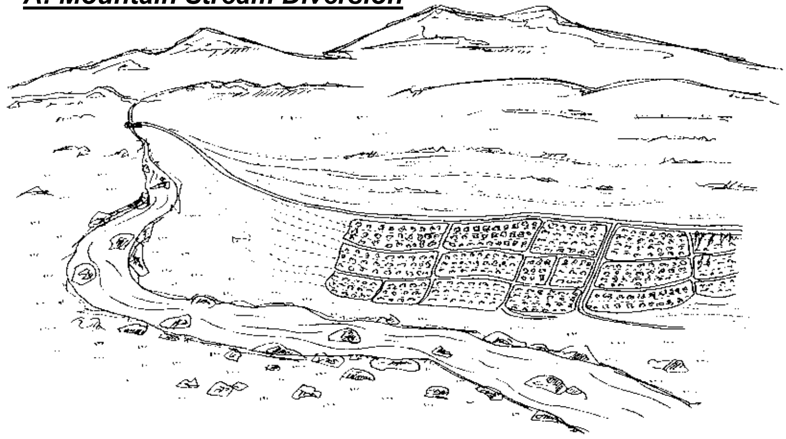
3) The lower organ is subordinate to the higher organ. This means that the decision and rules set by the higher organs which represent the broader scope of the club must be followed by the lower level. For example if the Representatives Committee which is the higher organ promulgate a regulation, irrigation blocks which are the lower organs are bound to abide by the regulation.

4) The whole Irrigation Club is subordinate to the general membership. This means that all decisions and policies coming from the general membership, as the lead organ, must be followed by all members of the Irrigation Club, of course inclusive of committee members.

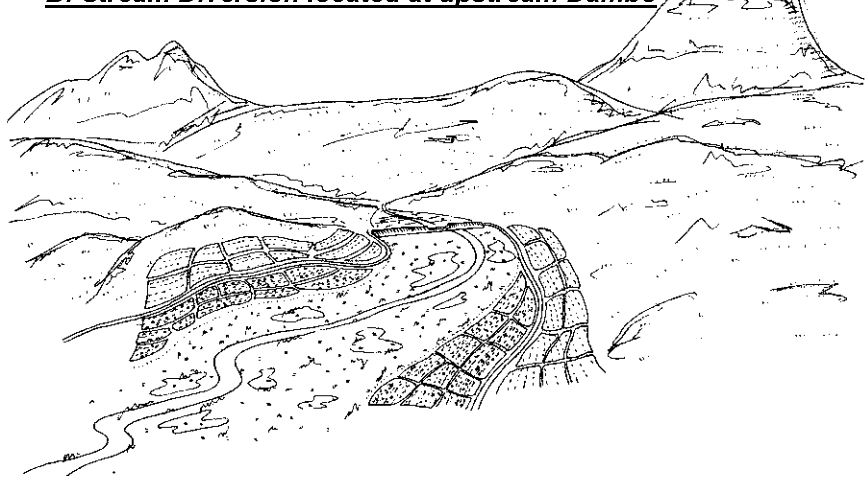
MODULE 5 DESIGN OF IRRIGATION FACILITIES

5.1 Diversion Weirs

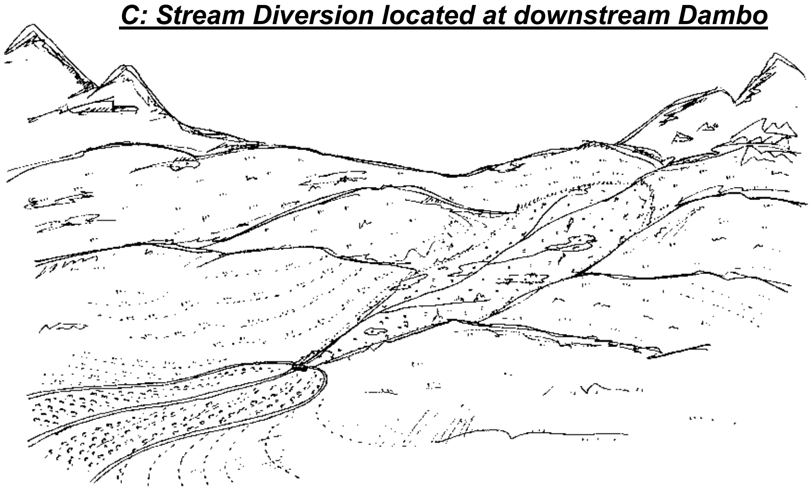
A: Mountain Stream Diversion



B: Stream Diversion located at upstream Dambo



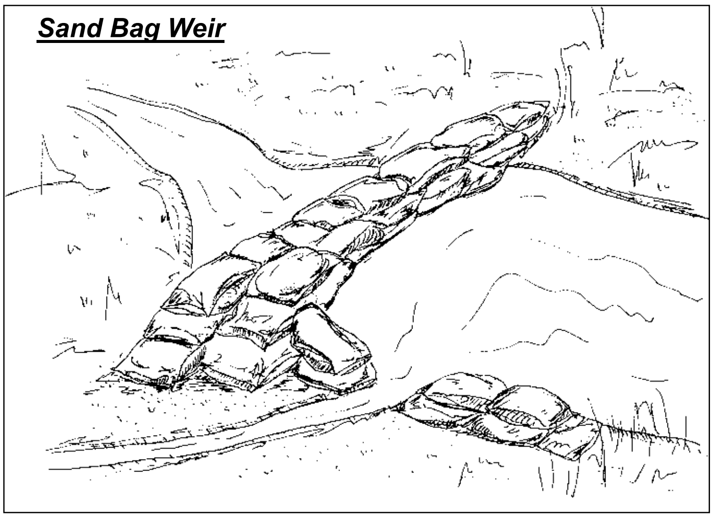
C: Stream Diversion located at downstream Dambo



Amongst different types of irrigation systems, recommendable types for self-help smallholder farmers are the small-scale with gravity irrigation such as type A: Mountain stream diversion, type B: Stream diversion located at upstream dambo, and type C: Stream diversion located at downstream dambo. Irrigation facilities for these types are mainly composed of: 1) diversion weir usually with intake structure, 2) main canal, and 3) other ancillaries including sub-canals and turnouts.

The diversion weir is categorized into two, temporary weir and permanent weir. The former is constructed by sand bags or of brush dam, and the latter by foreign materials such as gabion, masonry, and concrete. Temporary weir needs replacement every year but the permanent weir lasts for several years to more than 10 years depending on the material used. Though each type has advantages and disadvantages, this Package strongly recommends temporary weirs taking into account: 1) the farmers affordability, 2) easy construction with minimal, or almost nil, physical assistance from the Government, 2) easy operation and maintenance by the farmers, and 3) renew-ability of the facilities by the farmers every year, etc.

1) Sand Bags

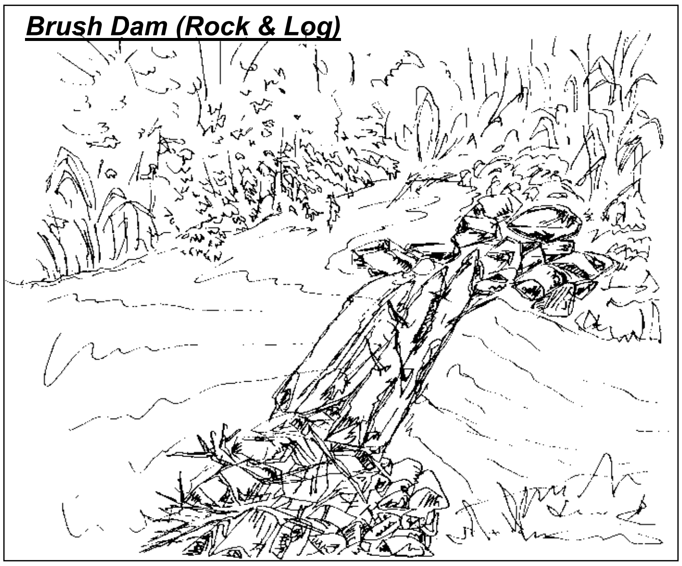


Sand bag weir is the most familiar at the existing diversion sites, and can be set up across both narrow and wide streams. This weir needs sand bags to be put up across the stream/river every time before irrigation season starts. Material put into the bags is locally available ones around the stream such as soil, sand, clay, but not rock. Putting up of sand bags is easy but the cost should always be considered since sacks need to be replaced almost every season due to the worn-out. It is therefore recommended that sand bag weir can be tried in case of very small stream or as a supplement to brush dam.

2) Brush Dam

This type of weir can also be seen in the existing diversion sites especially at upland dambo area. Setting up of brush dam is not costly at all since it is made of local materials such as stones and rocks, wooden logs, twigs, grasses, clay soils, and so on. The construction is of labor intensive but can be managed by the farmers themselves if they are well organized. According to experiences, farmers can construct most types of brush dams in just more than a half-day time if they have well prepared the necessary materials in advance.

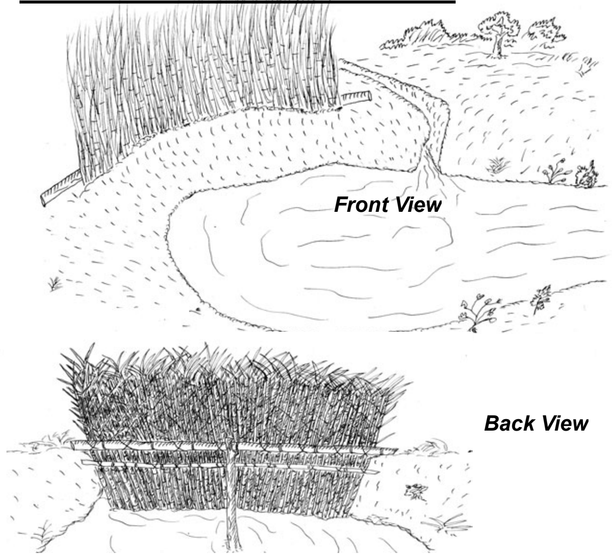
Though construction cost of those weirs is not expensive, flood, as a shortfall, would wash away almost every year, so that the farmers have to do the reconstruction every time before next season's irrigation starts. Major materials such as wooden pegs, logs and support props should be set aside right after the irrigation season has finished for the use of next season.



Brush dam made of rocks and logs can be set up very easily and applied in a stream which has relatively rich flow volume since it is of such structure allowing certain amount of leakage. In case of stream flow being small, this type of brush dam can hardly stop the leakage even if clay soil is put onto the weir body. This brush dam can be applied in both wide and narrow streams and required time for the construction may be less than a half-day only.

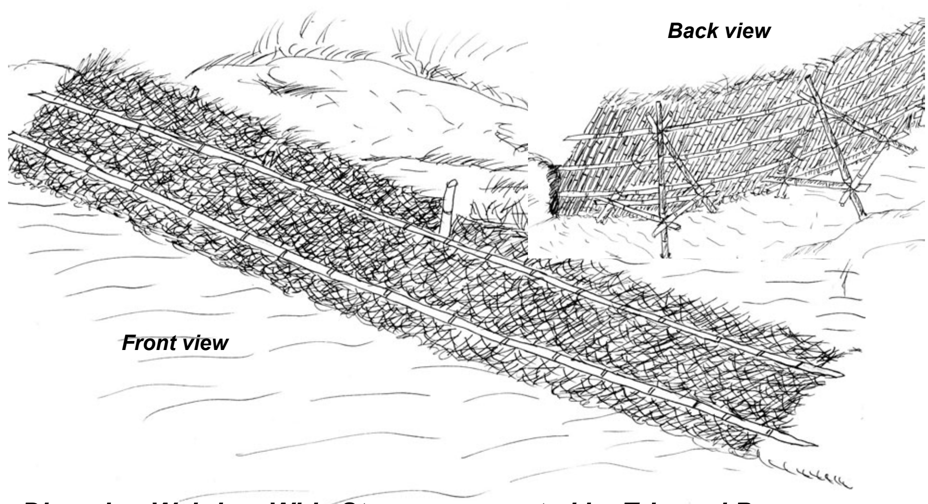
When the stream flow is not much, which is often the case in smallholder irrigation development, there has to be certain measure to minimize the leakage through the weir body. Putting clay soil onto the weir body could be the easiest way, and in some cases plastic paper may be used. To prevent the clay from washed away through the weir, the weir should consist of not only logs/ bamboos but also fine materials such as grasses.

Diversion Weir in a Narrow Stream



In case of narrow stream having small flow, constructing diversion weir is: 1) put a horizontal member (wooden log) astride the both banks preferably supported by a wooden prop, 2) place vertical members, on the horizontal member, of bamboo, twig, and reed inclined to downstream, 3) put grasses on the vertical members and then clay soil thereon. The clay soil can reduce the leakage through the weir.

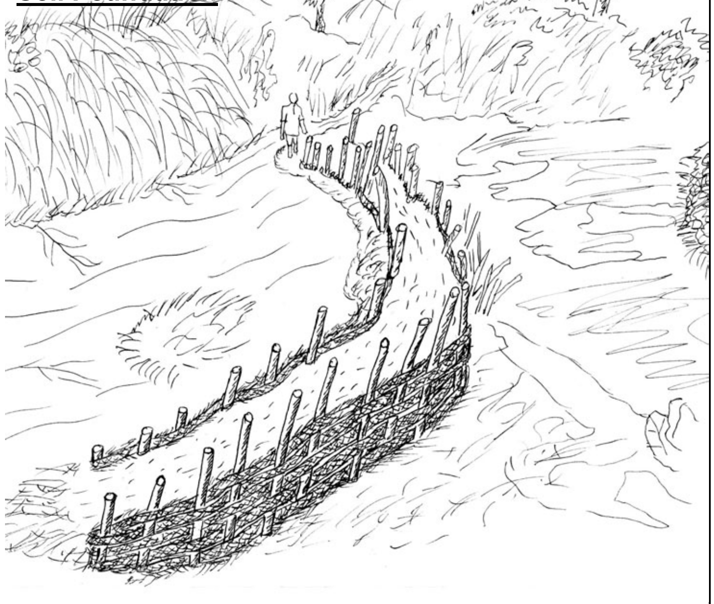
In case of wide stream yet having not so large flow, there are mainly two ways of constructing diversion weir depending on the foundation condition. A weir supported by a series of trigonal stand structures can be constructed on both foundations of either rock or soil. The construction procedure is to; 1) prepare trigonal prop stand structures which support the weir body from behind across the stream, 2) put horizontal members of twig or bamboo in front of the props preferably every 30 – 50 cm interval in vertical, 3) put vertical members of twig, bamboo and reed on the horizontal members, 4) put grasses and then clay soils thereon.



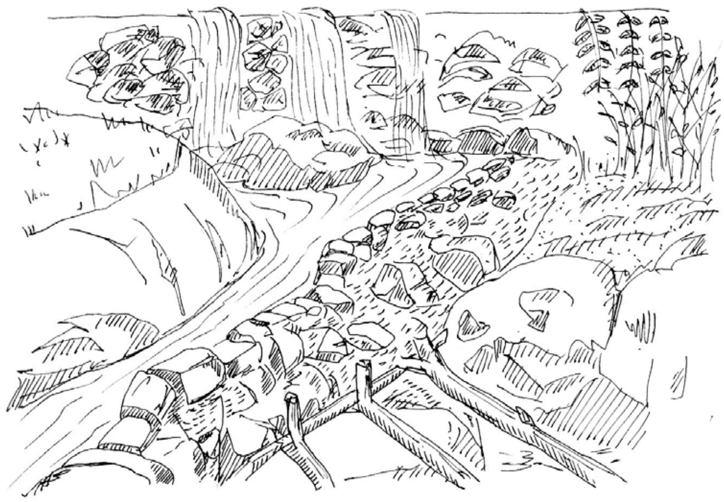
Diversion Weir in a Wide Stream: supported by Trigonal Prop

At soil foundation, there is another type of weir aside from the above trigonal method. The procedure of constructing the weir is to; 1) drive wooden logs into the foundation across the stream preferably 30 – 50 cm interval (therefore this weir is not applicable on rock foundation), 2) put grasses alternately through the logs like weaving the logs. If there is abundant water, this one line simple brush dam can easily raise the water level to about 50 cm.

Diversion Weir in a Wide Stream: Soil Foundation



Masonry Weir (mortar is clay soil)



However, where water is not much and leakage needs to be minimized; 3) make another line of the wooden-log woven with grasses about 50 – 70 cm downstream from the first line, 4) put clay soil in between the two lines and compact the soil by footing.

3) Masonry Weir

Masonry weir is made of stones/ rocks with mortar. Masonry weir is little familiar in Malawi but it can apply to an upland small stream where rock foundation can be found. Mortar which is usually applied is cement-mortar, but this Package recommends clay-mortar as the first step from the viewpoint of farmers' affordability.

Sometime after farmers have tried irrigation with the clay mortar masonry weir, they may upgrade to cement mortar masonry weir by using the benefit accrued from the irrigation. In this case, meandering of the stream should be well observed, and under the possibility for the stream to meander no this kind of permanent weir should be constructed. Progressive construction of this permanent masonry is recommend. For example, farmers place masonry in two layers (each 15 cm) in the first year, and on which clay mortar masonry is still placed. Next year, farmers who have acquired the technique of placing cement masonry proceed to placing another two layers, and so on until reaching the required level.

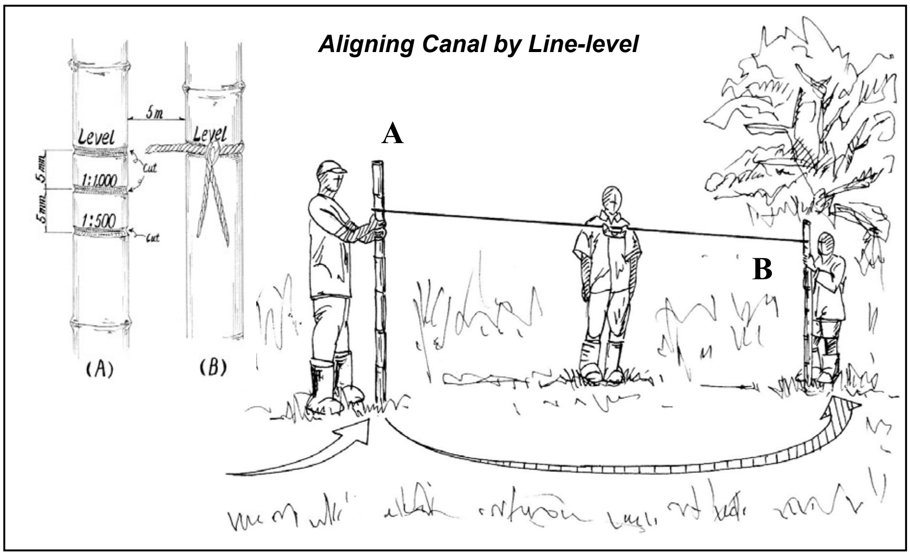
Concrete made weir functions almost same way as those of cement-mortar masonry weir. This, however, is the highest in construction cost and needs skilled labor or at least qualified technical assistance in mixing, placing and curing concrete. Therefore this Package does not recommend this type of weir. Sometime after the farmers get used to irrigation with temporal weir and have gained some benefit from the irrigation, the concrete weir may be tried as an upgraded irrigation system if the farmers are ready to make the investment. In this case, no possibility of stream meandering should be confirmed or otherwise high investment may result in vain.

5.2 Main Canal

Main canal conveys the diverted water from the intake point to the farming land. Difficulty associated with main canal is how to put suitable alignment according to the topographic condition without using sophisticated survey equipment. Construction, on the other hand, is not so difficult since most of the work required could be done with simple agriculture tools such as hoe, shovel and in cases pick.

1) Canal Alignment

The simplest way of aligning canal is to follow the water flow by gravity; namely, 1) dig the canal from the diversion point for example a 10 meter distance, 2) let the water flow in the dug canal, 3) deepen the canal and/or shift the canal alignment toward lower side (stream side), if the water does not well run, 4) repeat the process until the end point.



Aligning Canal by Line-level

Better way of canal alignment is to use line level. Interval of the two poles should preferably be 5 meter, and one side of the tied points should be 0.5 – 1 cm higher than the other. Pole with higher tied point should always be placed foreside, not like conventional alternate placing. 0.5 cm difference in 5 meter gives 1:1000 gradient suitable for gentle topography like dambo, and 1 cm gives 1:500 gradient adaptable for sloped topography.

2) Canal Lining

Canal is categorized into two; either non-lining or lined, and the lined canal is again categorized into temporally one or permanent one. Temporally lining is made of local material such as clay that can be often found in dambo area and plastic paper. Permanent lining is made of brick or masonry (concrete lining is sometimes seen but the cost beyond farmers' affordability excludes this option from the Package).

Earth canal is most commonly used in existing schemes. With simple tools such as hoe, hand shovel, and wheelbarrow, construction is very easy and cheap. Taking the concept of self-help development into account, this type of canal seems to be the most suitable for smallholders. However, since this is non-lining, water conveyance loss is high due to seepage/leakage and much maintenance works such as grass cutting, de-silting, reshaping of cross section and so on are needed in every season.

Lining can be done with clay soil, plastic paper, stone, brick, or masonry. Theses types of canals are hardly seen in the existing smallholder irrigation schemes but they have possibility to be applied. These canals reduce the canal conveyance loss and also minimize maintenance works as compared to earthen canal. In particular, reducing the canal conveyance loss becomes very important when diversion water is not enough to cover all the prospective service area. Lining can also prevent the canal from being eroded, which in turn minimizes the maintenance work and makes canal life longer.

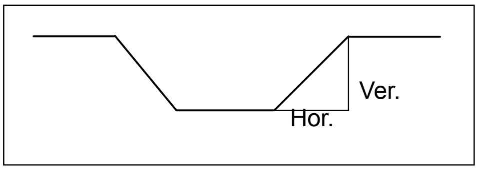
Investment for lining, on the other hand, is higher than earth canal except for clay, stone and recycled plastic paper linings. Clay, stone and plastic paper linings are of temporal but very cheap, so that these can be tried whenever the local material is available. Farmers in rural area make bricks by themselves. Therefore, brick lining is cheaper than masonry, and damaged parts or bricks can easily be replaced by the farmers. Masonry lining is more durable than brick, but requires cement, which may go beyond the farmers' affordability. Masonry with clay mortar can also be tired in this regard.

3) Canal Design

3.1 Cross-section and side-slopes

For earthen canals, standard trapezoidal shape is commonly used but in many cases side slope results in vertical due mainly to the easiness of hoe excavation. The side slope to be required depends on the stability of the soil and often becomes vertical if the soil is hard and very cohesive. Recommendable side slopes for different soils are given below:

Type of Soils	Recommendable Side Slope (Ver.) : (Hor.)
Clay	2 : 1～1: 0(vertical)
All other soils	1: 0(vertical)～1 : 1
Sand	1 : 1～0.5: 1



3.2) Freeboard

Freeboard acts as a reserve depth in a canal to allow some variations in water flow and irregularities in bank height. The freeboard is decided according to the planned discharge; more discharge higher free board and less discharge smaller free board. Irrigation schemes undertaken in this Package are small-scale, therefore a minimum 10 cm to maximum of about 20 cm free board is recommended.

3.3) Allowable flow velocity

The design velocity of canals must be determined within the limits of two factors; namely, 1) the minimum allowable velocity that causes neither accumulation of sediment of soils nor growth of waterweeds, and 2) the maximum allowable velocity that does not produce erosion of canal materials by the flow.

The minimum allowable velocity: 0.45 – 0.90 m/sec

> Within this range of mean velocity, soil sediments are not accumulated in a canal where the particle size of suspended sediment is not larger than silt. Waterweeds hindering the flow capacity of the canal will not grow when the mean velocity is more than 0.7 m/sec.

The maximum allowable velocity: As below depend on materials used for canal

Type of Canal Material	Maximum Allowable Velocity, (m/s)	Type of Canal Material	Maximum Allowable Velocity, (m/s)
Sandy soil	0.4 - 0.6	Thin concrete (approx.10cm)	1.5 - 2.5
Sand-loam	0.5 - 0.7		
Clay-loam	0.6 - 0.9	Brick masonry with concrete filled	2.50
Clay	0.9 - 1.5		
Rock	1.0 - 2.0		

3.4) Canal slope

Steep canal slope creates erosion due to its high flow velocity though it can reduce the canal section. On the other hand, too gentle slope cause heavy silting in the canal and also enlarges canal section to accommodate the required flow. Taking into account the two factors, table on the right hand shows the recommended canal slope:

Design (lit/s)	Minimum (%)	Maximum (%)
5	0.05 (1:2000)	1.00 (1:100)
10	0.05 (1:2000)	1.00 (1:100)
15	0.05 (1:2000)	1.00 (1:100)
30	0.05 (1:2000)	0.50 (1:200)
50	0.05 (1:2000)	0.33 (1:300)
100	0.05 (1:2000)	0.25 (1:400)

3.5) Canal dimension:

The recommended canal dimension; namely, bottom width, water depth and total depth (=water depth + freeboard) for different design discharges and canal slopes are summarized as follows:

Q=5 lit/s

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
5	0.30	0.05	0 : 1	0.148	0.113	0.111	0.30
5	0.25	0.10	0 : 1	0.137	0.146	0.111	0.25
5	0.25	0.20	0 : 1	0.105	0.190	0.109	0.25
5	0.25	0.25	0 : 1	0.097	0.206	0.109	0.25
5	0.25	0.33	0 : 1	0.088	0.228	0.109	0.25
5	0.25	0.50	0 : 1	0.076	0.264	0.109	0.20
5	0.25	1.00	0 : 1	0.060	0.336	0.110	0.20

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
5	0.25	0.05	2 : 1	0.135	0.116	0.110	0.25
5	0.25	0.10	2 : 1	0.110	0.150	0.109	0.25
5	0.25	0.20	2 : 1	0.089	0.192	0.108	0.25
5	0.25	0.25	2 : 1	0.083	0.208	0.108	0.20
5	0.25	0.33	2 : 1	0.076	0.230	0.108	0.20
5	0.25	0.50	2 : 1	0.067	0.264	0.108	0.20
5	0.25	1.00	2 : 1	0.054	0.336	0.110	0.20

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
5	0.25	0.05	1 : 1	0.119	0.114	0.109	0.25
5	0.25	0.10	1 : 1	0.098	0.146	0.108	0.25
5	0.25	0.20	1 : 1	0.081	0.187	0.107	0.20
5	0.25	0.25	1 : 1	0.076	0.202	0.107	0.20
5	0.25	0.33	1 : 1	0.070	0.224	0.107	0.20
5	0.25	0.50	1 : 1	0.062	0.258	0.108	0.20
5	0.25	1.00	1 : 1	0.051	0.327	0.109	0.20

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
5	0.25	0.05	0.5 : 1	0.104	0.105	0.108	0.25
5	0.25	0.10	0.5 : 1	0.087	0.135	0.107	0.20
5	0.25	0.20	0.5 : 1	0.073	0.174	0.107	0.20
5	0.25	0.25	0.5 : 1	0.069	0.188	0.107	0.20
5	0.25	0.33	0.5 : 1	0.064	0.208	0.107	0.20
5	0.25	0.50	0.5 : 1	0.057	0.241	0.107	0.20
5	0.25	1.00	0.5 : 1	0.047	0.307	0.108	0.20

Q=10 lit/s

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
10	0.35	0.05	0 : 1	0.213	0.134	0.116	0.35
10	0.35	0.10	0 : 1	0.164	0.174	0.113	0.30
10	0.30	0.20	0 : 1	0.148	0.226	0.113	0.30
10	0.30	0.25	0 : 1	0.136	0.246	0.113	0.25
10	0.30	0.33	0 : 1	0.122	0.273	0.112	0.25
10	0.25	0.50	0 : 1	0.126	0.319	0.114	0.25
10	0.25	1.00	0 : 1	0.097	0.412	0.115	0.25

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
10	0.35	0.05	2 : 1	0.167	0.138	0.113	0.30
10	0.30	0.10	2 : 1	0.149	0.179	0.112	0.30
10	0.25	0.20	2 : 1	0.135	0.233	0.112	0.25
10	0.25	0.25	2 : 1	0.126	0.253	0.112	0.25
10	0.25	0.33	2 : 1	0.116	0.280	0.112	0.25
10	0.25	0.50	2 : 1	0.102	0.324	0.113	0.25
10	0.25	1.00	2 : 1	0.083	0.415	0.115	0.25

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
10	0.30	0.05	1 : 1	0.160	0.136	0.112	0.30
10	0.30	0.10	1 : 1	0.132	0.175	0.111	0.25
10	0.25	0.20	1 : 1	0.119	0.227	0.111	0.25
10	0.25	0.25	1 : 1	0.112	0.246	0.111	0.25
10	0.25	0.33	1 : 1	0.104	0.273	0.111	0.25
10	0.25	0.50	1 : 1	0.092	0.316	0.112	0.25
10	0.25	1.00	1 : 1	0.076	0.404	0.114	0.20

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
10	0.30	0.05	0.5 : 1	0.138	0.125	0.110	0.25
10	0.25	0.10	0.5 : 1	0.124	0.163	0.110	0.25
10	0.25	0.20	0.5 : 1	0.104	0.210	0.110	0.25
10	0.25	0.25	0.5 : 1	0.098	0.228	0.110	0.25
10	0.25	0.33	0.5 : 1	0.091	0.253	0.110	0.25
10	0.25	0.50	0.5 : 1	0.082	0.293	0.110	0.20
10	0.25	1.00	0.5 : 1	0.069	0.376	0.112	0.20

・ Q=15 lit/s

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
15	0.40	0.05	0 : 1	0.253	0.148	0.119	0.40
15	0.40	0.10	0 : 1	0.194	0.193	0.116	0.35
15	0.35	0.20	0 : 1	0.171	0.250	0.115	0.30
15	0.35	0.25	0 : 1	0.158	0.272	0.115	0.30
15	0.30	0.33	0 : 1	0.165	0.303	0.116	0.30
15	0.30	0.50	0 : 1	0.142	0.264	0.113	0.30
15	0.30	1.00	0 : 1	0.110	0.455	0.118	0.25

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
15	0.35	0.05	2 : 1	0.214	0.154	0.116	0.35
15	0.35	0.10	2 : 1	0.173	0.198	0.114	0.30
15	0.30	0.20	2 : 1	0.155	0.257	0.114	0.30
15	0.30	0.25	2 : 1	0.144	0.279	0.114	0.30
15	0.30	0.33	2 : 1	0.132	0.310	0.114	0.25
15	0.30	0.50	2 : 1	0.117	0.358	0.115	0.25
15	0.30	1.00	2 : 1	0.094	0.458	0.117	0.25

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
15	0.35	0.05	1 : 1	0.186	0.150	0.114	0.35
15	0.35	0.10	1 : 1	0.154	0.193	0.113	0.30
15	0.30	0.20	1 : 1	0.137	0.251	0.113	0.25
15	0.30	0.25	1 : 1	0.129	0.272	0.113	0.25
15	0.30	0.33	1 : 1	0.119	0.302	0.113	0.25
15	0.30	0.50	1 : 1	0.106	0.349	0.114	0.25
15	0.30	1.00	1 : 1	0.087	0.446	0.116	0.25

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
15	0.30	0.05	0.5 : 1	0.169	0.105	0.112	0.30
15	0.30	0.10	0.5 : 1	0.142	0.180	0.112	0.25
15	0.30	0.20	0.5 : 1	0.120	0.232	0.111	0.25
15	0.30	0.25	0.5 : 1	0.113	0.252	0.111	0.25
15	0.30	0.33	0.5 : 1	0.105	0.279	0.111	0.25
15	0.25	0.50	0.5 : 1	0.101	0.327	0.113	0.25
15	0.25	1.00	0.5 : 1	0.085	0.421	0.115	0.25

- Q=30 lit/s

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
30	0.50	0.05	0 : 1	0.341	0.176	0.125	0.50
30	0.50	0.10	0 : 1	0.262	0.229	0.121	0.40
30	0.40	0.20	0 : 1	0.253	0.296	0.122	0.40
30	0.40	0.25	0 : 1	0.232	0.323	0.122	0.35
30	0.40	0.33	0 : 1	0.208	0.360	0.121	0.35
30	0.35	0.50	0 : 1	0.205	0.419	0.123	0.35
30	0.35	1.00	0 : 1	0.158	0.543	0.126	0.30

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
30	0.45	0.05	2 : 1	0.279	0.183	0.121	0.45
30	0.40	0.10	2 : 1	0.243	0.237	0.120	0.40
30	0.35	0.20	2 : 1	0.214	0.307	0.120	0.35
30	0.35	0.25	2 : 1	0.200	0.334	0.120	0.35
30	0.35	0.33	2 : 1	0.183	0.371	0.120	0.35
30	0.35	0.50	2 : 1	0.162	0.430	0.121	0.30
30	0.30	1.00	2 : 1	0.144	0.558	0.126	0.30

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
30	0.40	0.05	1 : 1	0.255	0.180	0.119	0.40
30	0.35	0.10	1 : 1	0.224	0.233	0.118	0.35
30	0.35	0.20	1 : 1	0.186	0.300	0.118	0.35
30	0.35	0.25	1 : 1	0.175	0.326	0.118	0.30
30	0.30	0.33	1 : 1	0.174	0.365	0.119	0.30
30	0.30	0.50	1 : 1	0.156	0.423	0.120	0.30
30	0.30	1.00	1 : 1	0.129	0.544	0.124	0.25

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
30	0.35	0.05	0.5 : 1	0.225	0.166	0.117	0.35
30	0.35	0.10	0.5 : 1	0.191	0.215	0.116	0.35
30	0.30	0.20	0.5 : 1	0.169	0.279	0.116	0.30
30	0.30	0.25	0.5 : 1	0.160	0.303	0.116	0.30
30	0.30	0.33	0.5 : 1	0.149	0.337	0.116	0.30
30	0.30	0.50	0.5 : 1	0.135	0.391	0.117	0.25
30	0.25	1.00	0.5 : 1	0.120	0.508	0.122	0.25

- Q=50 lit/s

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
50	0.60	0.05	0 : 1	0.418	0.200	0.131	0.60
50	0.55	0.10	0 : 1	0.350	0.260	0.128	0.50
50	0.50	0.20	0 : 1	0.296	0.337	0.127	0.45
50	0.45	0.25	0 : 1	0.304	0.365	0.128	0.45
50	0.45	0.33	0 : 1	0.272	0.408	0.128	0.45
50	0.40	0.50	0 : 1	0.264	0.474	0.130	0.40
50	0.40	1.00	0 : 1	0.202	0.618	0.134	0.35

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
50	0.50	0.05	2 : 1	0.355	0.208	0.127	0.50
50	0.45	0.10	2 : 1	0.307	0.270	0.125	0.45
50	0.40	0.20	2 : 1	0.268	0.350	0.125	0.40
50	0.40	0.25	2 : 1	0.251	0.380	0.125	0.40
50	0.40	0.33	2 : 1	0.230	0.422	0.125	0.40
50	0.35	0.50	2 : 1	0.221	0.493	0.128	0.35
50	0.35	1.00	2 : 1	0.179	0.635	0.133	0.35

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
50	0.45	0.05	1 : 1	0.318	0.204	0.124	0.45
50	0.45	0.10	1 : 1	0.265	0.264	0.122	0.40
50	0.40	0.20	1 : 1	0.231	0.342	0.122	0.35
50	0.35	0.25	1 : 1	0.231	0.373	0.123	0.35
50	0.35	0.33	1 : 1	0.214	0.415	0.124	0.35
50	0.35	0.50	1 : 1	0.192	0.482	0.125	0.35
50	0.30	1.00	1 : 1	0.159	0.620	0.131	0.30

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
50	0.45	0.05	0.5 : 1	0.268	0.189	0.121	0.40
50	0.40	0.10	0.5 : 1	0.235	0.245	0.120	0.35
50	0.35	0.20	0.5 : 1	0.207	0.317	0.120	0.35
50	0.35	0.25	0.5 : 1	0.196	0.345	0.120	0.35
50	0.35	0.33	0.5 : 1	0.183	0.383	0.120	0.35
50	0.35	0.50	0.5 : 1	0.165	0.445	0.122	0.30
50	0.30	1.00	0.5 : 1	0.146	0.577	0.127	0.30

・ Q=100 lit/s

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
100	0.80	0.05	0 : 1	0.526	0.238	0.140	0.70
100	0.70	0.10	0 : 1	0.463	0.308	0.137	0.65
100	0.60	0.20	0 : 1	0.418	0.399	0.137	0.60
100	0.60	0.25	0 : 1	0.383	0.435	0.136	0.55
100	0.55	0.33	0 : 1	0.376	0.484	0.138	0.55
100	0.55	0.50	0 : 1	0.321	0.566	0.139	0.50
100	0.50	1.00	0 : 1	0.272	0.734	0.147	0.45

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
100	0.70	0.05	2 : 1	0.440	0.247	0.134	0.60
100	0.60	0.10	2 : 1	0.392	0.321	0.133	0.55
100	0.50	0.20	2 : 1	0.355	0.416	0.134	0.50
100	0.50	0.25	2 : 1	0.332	0.452	0.134	0.50
100	0.50	0.33	2 : 1	0.305	0.503	0.134	0.45
100	0.45	0.50	2 : 1	0.287	0.586	0.138	0.45
100	0.40	1.00	2 : 1	0.251	0.760	0.147	0.45

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
100	0.60	0.05	1 : 1	0.408	0.243	0.132	0.55
100	0.55	0.10	1 : 1	0.352	0.315	0.130	0.50
100	0.50	0.20	1 : 1	0.305	0.408	0.130	0.45
100	0.45	0.25	1 : 1	0.300	0.444	0.131	0.45
100	0.45	0.33	1 : 1	0.278	0.494	0.132	0.45
100	0.45	0.50	1 : 1	0.250	0.573	0.134	0.40
100	0.40	1.00	1 : 1	0.218	0.743	0.143	0.40

Discharge (lit./s)	Bed Width (m)	Canal Slope (%)	Side Slope Ver.:Hor	Water Depth (m)	Vmax (m/s)	Freeboard (m)	Canal Height (m)
100	0.50	0.05	0.5 : 1	0.362	0.225	0.128	0.50
100	0.50	0.10	0.5 : 1	0.308	0.291	0.126	0.45
100	0.45	0.20	0.5 : 1	0.268	0.377	0.126	0.40
100	0.40	0.25	0.5 : 1	0.263	0.411	0.127	0.40
100	0.40	0.33	0.5 : 1	0.245	0.457	0.128	0.40
100	0.40	0.50	0.5 : 1	0.223	0.531	0.130	0.35
100	0.35	1.00	0.5 : 1	0.196	0.689	0.138	0.35

5.3 Ancillary Facilities

Ancillary facilities are turnout which distributes water equally among irrigation blocks, canal protection, connecting canal, gully/stream crossing, road crossing, farm land protection, etc.

1) Turnout

Turnout structures for distributing canal flow are seldom seen in the existing smallholders' irrigated fields. Farmers usually make temporary stoppage by using soil, grass, twigs, banana trunk, etc. to share the irrigation water. Farmers who have their land in upstream along the canal have advantage in terms of water availability, while farmers at downstream often suffer from water shortage and in some case no water reaches.

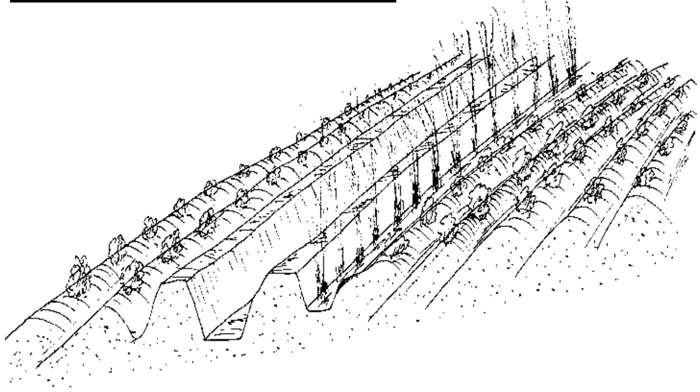
Materials used
(a) Soils often with grasses
(b) Banana trunk cut in 20-30cm
(c) Sand bags
(d) Brick with sand bags or stop-log
(e) Masonry with stop-log

To distribute fair amount of water among the member farmers, rotational irrigation among sub-canals (in most of the smallholder irrigation schemes, this is actually on-farm irrigation canal) should be introduced. With turnouts in place at every diversion points from the main canal to the sub-canals, rotational irrigation can be done. Table right shows the material used for intake and turnout. As descending in order, reliability increases but cost does the same.

2) Canal Protection

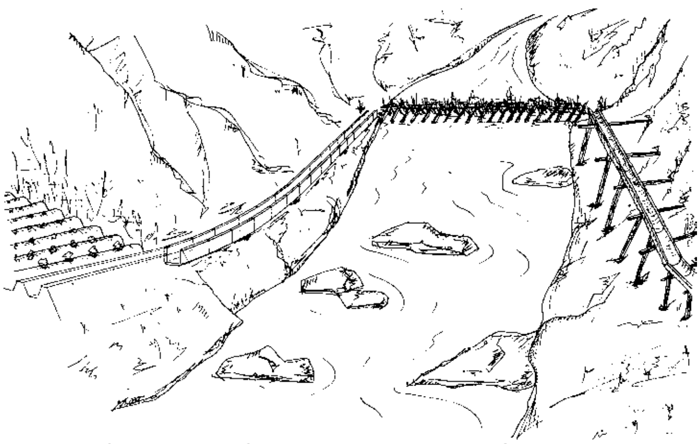
To plant vetiver grass is a conventional method used in farmland conservation from soil erosion, and this practice can be seen at many places throughout the Country. Planting vetiver grass just outside along the canal protects the canal from being eroded by rainfall and also prevents soils from getting into the canal. Vetiver grass thus not only protects the canal but also minimizes the canal maintenance work.

Canal Protection by Vetiver Grass



3) Connecting Canal

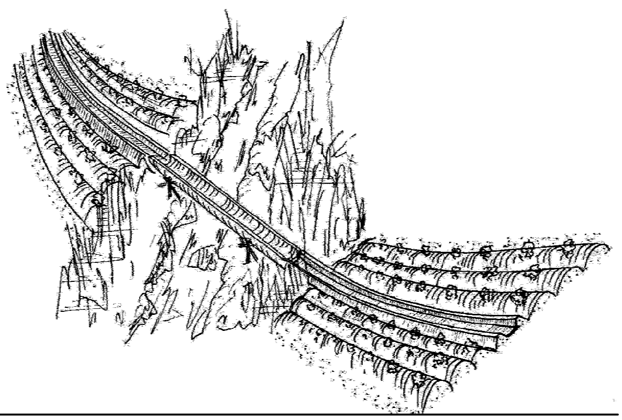
Diversion site is often associated with steep side slope of the stream. When a diversion weir is constructed in this situation, a connecting canal between the diversion weir and ordinary canal should be constructed. The connecting canal can be made of tree bark, logs, bamboo woven U-frame with plastic paper, and concrete flume but should in any cases be removable. During flood season, the connecting canal should be removed and set aside.



Connecting Canal at the Diversion Site Weir

While tree bark and log-made-canal is very cheap, concrete flume needs cement, sand, mold and technical skill. It is therefore recommended that EPAs prepare and keep the mold for the flume, and produce the flume with the farmers during rainy season. Placing concrete during rainy season requires little curing than during dry season. When dry season comes, the flumes are transported to the site, and put in place.

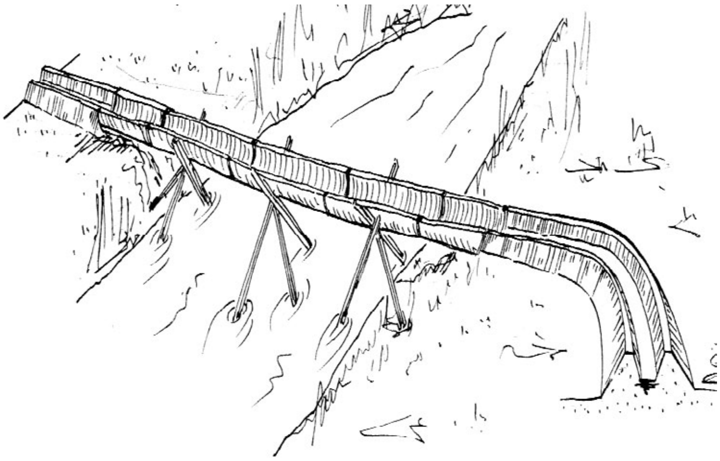
Gully Crossing Canal



4) Stream/Gully Crossing

There are some places where the prospective irrigation areas are big but divided into sub-areas separately by gully or even a stream. In these sites, crossing canal is planned to convey the water to the other side. This canal can be made of tree bark, logs, half-cut drum-can and concrete flume, and even a canal bridge can be set up made of locally available material such as twigs, striped bamboo, grasses and plastic paper. These canals are to be placed only during irrigation season, and should be removed during flood season.

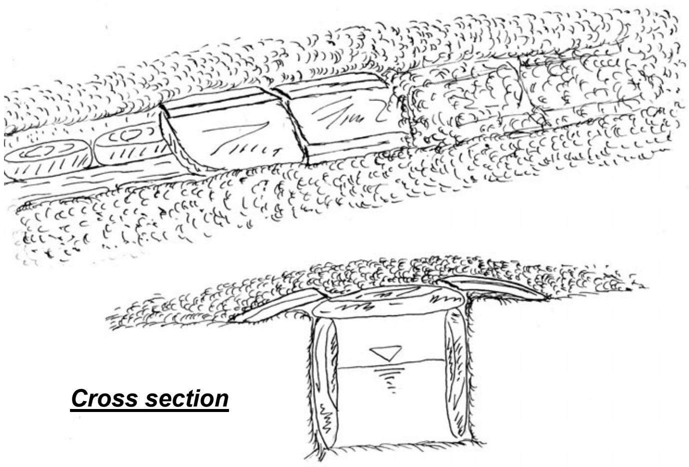
Stream Crossing Canal



5) Road Crossing

There are cases that canal should cross a road. Unless otherwise the road is designated one, locally available materials should be utilized to construct the water corridor under across the road. Suitable local materials are stones for both walls and roof portion, which shape should be flat, half cut banana trunk which is used to smoothen the contact portion between the roof stone and the side banks, etc. In case of the road being designated, consultation should be done with relevant district assembly as well as with regional office of the road authority.

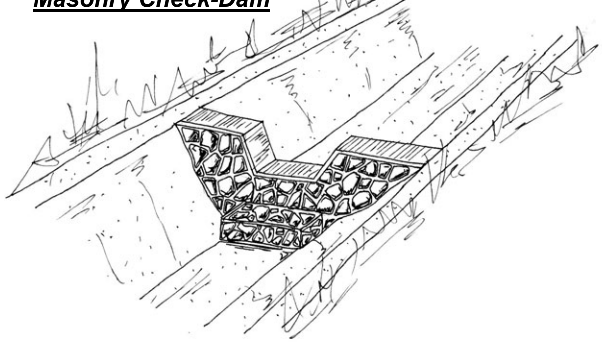
Road Crossing by flat stones

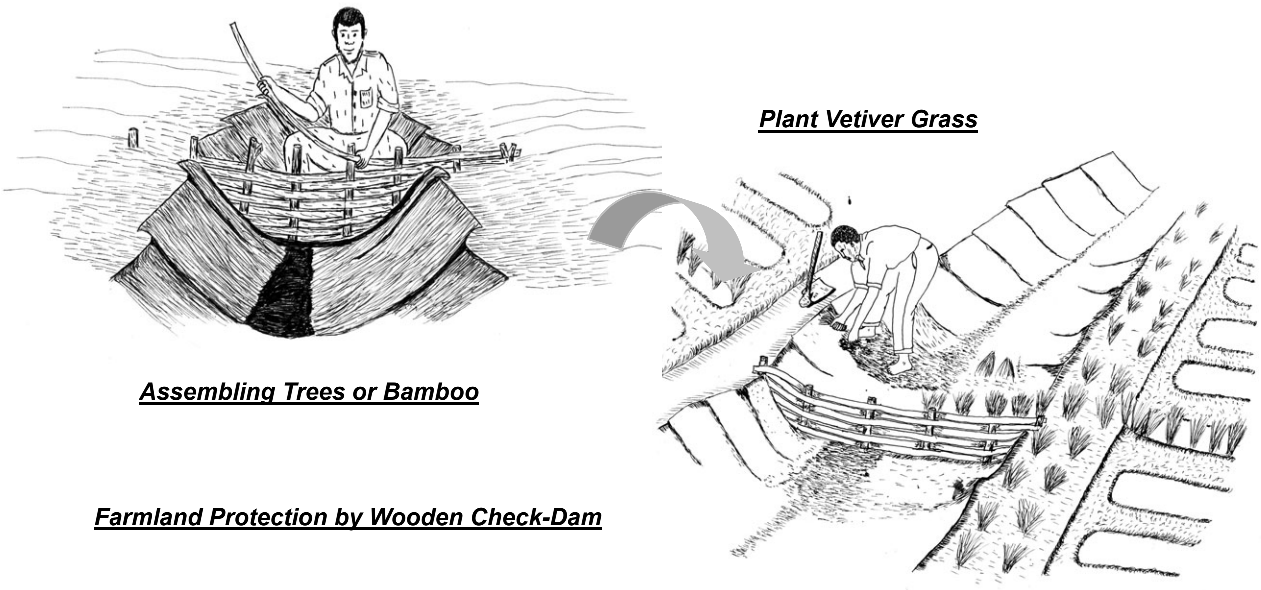


6) Farmland Protection

Some of farmlands spread on sloping land. For protecting those farmlands from being eroded or gully development, a check dam constructed by either masonry or wood can be the option. Masonry check dam is commonly used along roadside drains for gully protection. Since the structure itself is strongly built, this works effectively to prevent the expansion of the gullies but costly. While the masonry check dam is costly, wooden check dam can be constructed with only locally available material such as twigs and grasses.

Masonry Check-Dam





Farmland Protection by Wooden Check-Dam

MODULE 6 CONSTRUCTION

The irrigation facilities range from primitive but cheap one to modern but costly one. The selection should be made by the farmers taking into account their financial affordability first, together with availability of the work force and also level of capacity for the operation and maintenance. Considering the financial affordability of the farmers, the principle for the construction should center on labor manual work by the farmers themselves, or upgrade the facilities sometime after they are benefited from the irrigation.

Construction, therefore, will not employ any heavy equipment nor engage local contractor in principle. Even though the construction need to engage skilled labors such as masonry, EPA/RDP officers and the farmers should learn the technique at the beginning stage so that the employment can be minimized. EPA and RDP officers are also expected to furnish the technique they have acquired to other areas.

6.1 Work Scheduling

Construction works should be commenced as early as possible after rainy season has finished. Working hour is recommended from early morning to noon, such as 7:00 to around 12:00, in general though it is on the farmers' decision. According to field interviews, farmers usually do heavy work only in the morning because they can avoid hot weather of the afternoon and actually meager meal makes them difficult to work over noon.

Though it is ideal to start constructing irrigation facilities right after rainy season has finished; preferably in April, there may be some villagers still busy for harvesting sometime until June. Therefore, construction work carried out in early time such as April & May could be arranged to be only two to three times a week or otherwise by rotating the participants. Then, construction work after June can engage almost all the relevant members throughout weekdays since harvesting could be finished till then. As an example, construction work by rotation may be programmed as shown below:

Table 6.1 An Example of Work Rotation

Number of beneficiaries	Expected participants per day	Number of party organized	Working days per week	Working Rotation
< 30 households	10	2	6	Party-A: Mon., Wed. and Fri. Party-B: Tue. , Thur. and Sat.
> 30 households	20	2	6	Party-A: Mon., Wed. and Fri. Party-B: Tue. , Thur. and Sat.

On the course of the construction, AEDOs should facilitate farmer leaders to record the progress how much work has been done with how many labors. Sometime after the work has progressed, requirement-per-unit-work can be calculated based on the record. The estimated requirement-per-unit-work will help the participant to know; 1) how long the construction work takes to complete, 2) necessary modification of schedule inclusive of reinforcement of labors, and 3) also when to arrange necessary material as the work progresses.

An Example of Days required:
According to the experiences from the verification project, it usually takes just more than a half-day, say from 8:00 to 13:00, to construct most types of weirs should necessary materials such as wooden log, bamboo, and grasses be well prepared in advance.

As for canal digging, 20 members can excavate at least 50 meters length with about 30 – 40 cm depth. If all the 20 members concentrate on the canal digging only, even as long as 100 meters could be managed in one day.

6.2 Tool Arrangement

As heavy tools/equipments will not be employed, the construction should proceed with simple tools that are already familiar to the farmers. The tools to be used for the construction are: Panga, Hoe, Shovel, Trowel, Picks, Saw, Hammer, Spirit level, Wheel-barrow, Buckets, etc. Some tools that the farmers do not have, in most cases pick, big hammer, shovel and wheel barrow, should be arranged by concerned EPA/RDP and rented out to the farmers upon the request. Ox-cart which is available in some areas can also be used for transporting local material, tools, etc.

6.3 Materials

One of the basic implementation principles for smallholder irrigation schemes is to realize the irrigation facilities in the farmers' locality, which is to utilize the locally available material as much as possible. Locally available materials are: wooden log, twig, bamboo, reed, clay soil, etc. Most of the materials are actually available in the locality, and it would rather be easy to list up the foreign materials that the facilities have to use.

The foreign materials to be used may be: chemical fibered sacks, plastic paper, PVC pipe, rubber string made from inner part of a tyre, gabion wire, and concrete flume, etc. RDP/EPA officers as agreed with the farmers may procure foreign materials such as cement, reinforcing bar, pipe (concrete, PVC), timber, gabion wire, tools, etc. However, due consideration should still be made to substitute such foreign materials by local materials. Example is: instead of using sacks for weir, construct it with locally available materials such as wooden logs, grasses, etc.; instead of using PVC pipe for road crossing, make water corridor by flat stones; instead of rubber string, use sisal rope; instead of reinforcing iron bars, even bamboo strips can be tried.

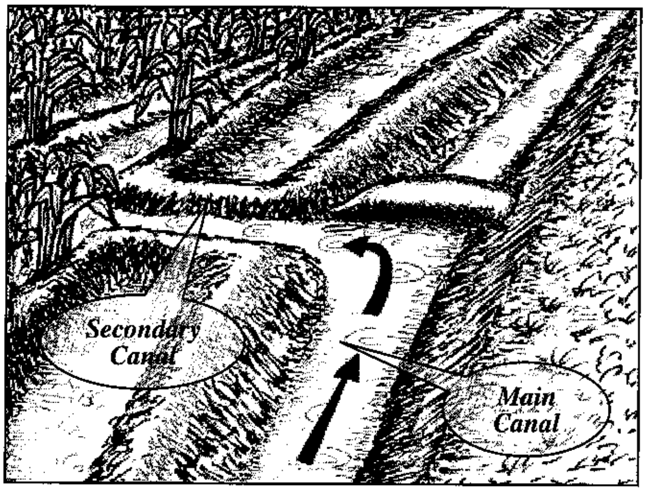
MODULE 7 OPERATION AND MAINTENANCE

7.1 Rotational Irrigation

As per water distribution, there are two different methods at the main canal level; namely, 1) proportional distribution to secondary groups, and 2) rotational distribution among the secondary groups (it is remarked that secondary group means in most of cases on-farm group so that secondary canal means on-farm feeder canal). The former, proportional distribution, entails continuous flow in the main canal and accordingly continuous inflow into secondary groups. The latter, rotational distribution, distributes irrigation water into a secondary group on basis of on-off.

For the proportional distribution, the canal flow in the main canal is diverted continuously and proportionally to the different secondary groups. Amount of the irrigation water shared to each secondary is decided on the size of irrigated area. The water sharing is done according to the opening width of a turnout structure or by adjusting the opening of the turnout with stop-log. Then, a farmer belonging to a secondary group can share the irrigation water on a rotational basis; namely, farmers in the secondary group carry out irrigation one by one based on the irrigation schedule.

As per rotational distribution among secondary groups, all the canal flow into the scheme is alternately diverted to a secondary canal, or a group of secondaries, of the service area. Rotational distribution is thus done at the secondary canal level. Thereafter, field level rotational irrigation is once again carried out among the farmers in the secondary canal. This rotational system entails equal water distribution among the secondary groups, but the size of the main canal should be the same as the intake portion all the way down to the turn-out point of the last secondary.



Which water distribution should be applied depends on the size of the irrigation scheme and also what type of turnout at the secondary canal level is used. Generally, as the irrigation system becomes bigger, proportional distribution is applied mainly because the system does not require main canal size being same to the end and also turnout at the secondary intake is constructed in such a way of controlling the flow into the secondary canal.

> <u>How many farmers per group is appropriate</u>
> To share the irrigation water properly, it is said that the number of farmers per group is 10 – 20 farmers and it may work well. This number, of course, should not be fixed and may depend on other factors such as existing organizations in the scheme and also topography of the area.

On the other hand, smaller irrigation system may prefer rotational distribution as it ensures fair water distribution among the secondary groups. Since smallholder irrigation scheme mostly falls in small-scale category, this Package recommends the rotational distribution at the secondary level.

7.2 Irrigation Schedule

To properly operate the irrigation facilities, an irrigation schedule should be prepared. Irrigation schedule shows an irrigation interval, the date and time, when the farmers may irrigate. The irrigation interval should not exceed a permissible maximum irrigation interval that is determined based on moisture holding capacity of the soil. Though the maximum irrigation interval depends on the soil characteristics, it can be said that the interval should not be over 8 days in most cases. This means every secondary group should receive irrigation water at least once out of every 8 days, or crops may start wilting.

The irrigation interval

For optimum growth, the crop will be losing water at a rate equal to Crop Water Requirement (ETc). The number of days for the crop to deplete is calculated by Readily Available Moisture (RAM) and ETc:

Irrigation interval = RAM / ETc (days)

Example:

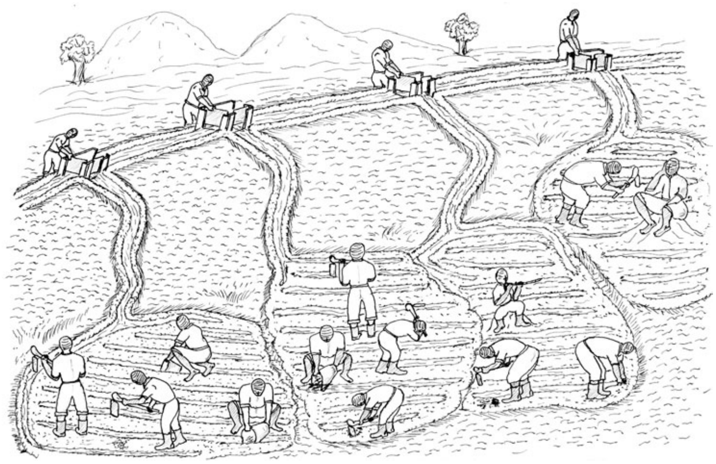
Onions
- RAM = 14 42 mm
- ETc = 4.42 mm/day
- Irrigation Interval (max.)
  =RAM/ETc=14/4.42=3.16 days=>3 days

Tomatoes
- RAM = 25.2 mm
- ETc = 5.11 mm/day
- Irrigation Interval (max.)
  =RAM/ETc=25.2/5.11=4.9days=>4 days

Neither is the interval taken too short. Too short interval needs the farmers to attend their farm very frequently throughout the season. Therefore, all the secondary canals may be groped into 8, 6, 4, or 2 in such a way that each group should have almost equal service area. The rotational distribution is therefore carried out from one secondary group to another. Then, field level rotation is further planned amongst the farmers in a secondary group. Considered in planning the field level rotational irrigation are:

Example:
- One-day irrigation hour: 12 hours
- Water application duration per farmer in a group:
  2 hrs. (1/6 of 12), 3 hrs. (1/4 of 12)
  4 hrs. (1/3 of 12), 6 hrs. (1/2 of 12)

- The minimum duration per irrigation per farmer is in the order of 2 to 3 hours,
- The maximum duration per irrigation per farmer is in the order of 10 to 12 hours, and
- The water application duration per farmer in a group should be a part of the one-day irrigation hour, e.g., 1/1, 1/2, 1/3, or 1/4 of the hour.



An example of irrigation schedule is given in the table below, on condition that there are 8 secondaries, each of which has 16 farmer members in average and irrigation is done only during daytime, 12 hours a day. It is noted that the irrigation schedule may not be fixed as the irrigation interval may change depending on the stage of crop development. For instance, at the initial stage the interval will be short while at maturity stage the interval will be longer as the roots will have fully developed. This means that the timetable will be reviewed as the season progresses:

Assumption:
Nr. of Secondaries: 8
Nr. of Farmers per Secondary: 16

Table 7.1 An Example of Irrigation Schedule

At the Main Level	Maximum Irrigation Duration		At A Secondary Level		Irrigation Hour per Group	Selection
Nr. of Sec. Groups	days	hours	Nr. of Groups	Farmers/Group		
8	1	12	8	2	1.5	
			4	4	3	O
			2	8	6	O
4	2	24	8	2	3	O
			4	4	6	O
			2	8	12	O
2	4	48	8	2	6	O
			4	4	12	O
			2	8	24	

7.3 Estimation of Scheme Irrigation Water Requirement

Net crop water requirement is normally defined as the depth or amount of water meeting the water loss through evapo-transpiration so that the crop can grow optimally. In the absence of calculated data, seasonal crop water requirement values for ordinary crops may be as follows:

Crop	Crop duration (days)	Net Crop Water Requirement (mm)	
	(days)	(mm)	(mm/day)
Cereals	120 - 140	450 - 650	3.8 - 4.6
Vegetables	90 - 120	40 - 650	4.4 - 5.0

<u>Net crop water requirement (NCWR)</u>
- NCWR is expressed in mm/day.
- NCWR for small-scale scheme roughly
  =5 mm/day

- <u>Convert the net crop water requirement (mm) to cubic meters (m^3)</u>
  *Net Seasonal Crop Water Req. (m^3/ha) = Seasonal Net Crop Water Req. (mm) *10*

- <u>Convert the net crop water requirement (m^3/ha) to (m^3/ha/day), if the crop growth period is known.</u>
  Net Crop Water Req. (m^3/ha/day)=Net Seasonal Crop Water Req. (m^3/ha)/ growth period (days)

- <u>Convert the net crop water requirement (m^3/ha/day) to (lit/s/ha)</u>
  *Net Crop Water Requirement (lit/sec/ha) = Net Crop Water Requirement (m^3/ha/day) *0.012*

- <u>Convert the net crop water requirement to gross crop water requirement</u>
  Gross Crop Water Requirement (lit/sec/ha) = Net Crop Water Requirement (m^3/ha/day)/ irrigation efficiency (depending on canal and field irrigation situations, but roughly 0.5 can be applied for smallholder irrigation schemes)

The table below shows the net and gross crop water requirements in (m^3/ha/day) and (lit/sec/ha) by most common crops:

Table 7.2 Net and Gross Crop Water Requirement

Crop	Seasonal Water Requirement		Growth Period	Net Crop Requirement		Gross Crop Requirement	
	mm depth or litre/m^2	m^3/ha	Days	m^3/ha/days	lit/s/ha	m^3/ha/days	lit/s/ha
Beans	180 – 300	1,800 – 3,000	120	15 – 25	0.2 – 0.3	30 – 50	0.4 – 0.6
Onion	300 – 400	4,000 – 5,000	90	44 – 56	0.5 – 0.7	88 – 112	1.0 – 1.4
Maize	320 – 450	3,200 – 4,500	120	27 – 38	0.3 – 0.5	54 – 76	0.6 – 1.0
Potatoes	340 – 520	3,400 – 5,200	120	28 – 43	0.3 – 0.5	56 – 86	0.6 – 1.0
Cabbage	350 – 500	3,500 – 5,000	90	39 – 56	0.5 – 0.7	78 – 112	1.0 – 1.4
Tomatoes	390 – 550	3,900 – 5,500	90	43 – 61	0.5 – 0.7	86 – 122	1.0 – 1.4
As a thumb of rule (in case of 24 hours irrigation):							**1.2**
As a thumb of rule (in case of 12 hours irrigation):							**2.4**

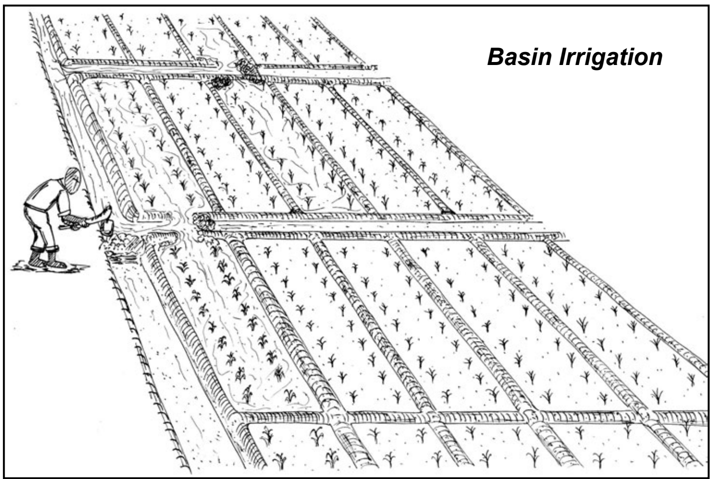
Example:
- Gross irrigation water requirement: 2.4 lit/s/ha
- Irrigated area: 10 ha
- Scheme irrigation water requirement:= 2.4x10 =**24 lit/sec**

With reference to the above gross crop requirement, it can be known how much diversion water is required to irrigate the prospective areas or visa versa; namely, based on the available flow in the stream how much acreage can be irrigated will also be known. Roughly, an amount of 2.4 lit/s/ha of gross cop water requirement can be applied for daytime irrigation while the 1.2 lit/s/ha may be used if farmers try day and night time irrigation.

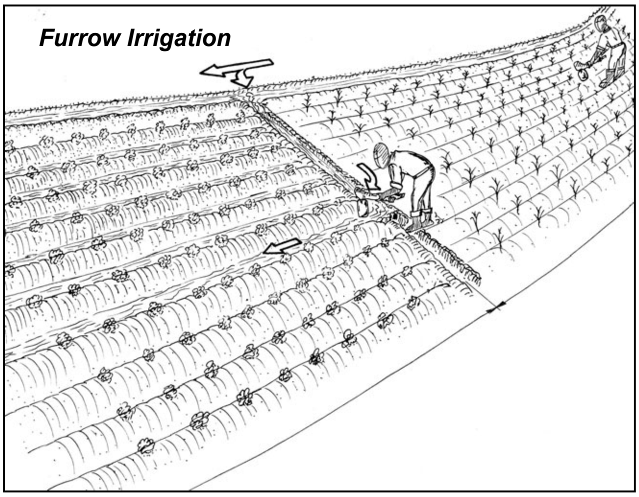
In other way, it can be roughly said that a crop area of 1 hectare needs about 1.2 l/s of gross irrigation water under 24 hours continuous application. This means 10 l/s could serve 10 hectares at maximum. However, as most farmers do daytime irrigation only, possible irrigable area could be less than half of that. Therefore, possible service area could be said to be equal acreage to the water amount in litre per second; say 10 acreages on 10 l/s, 30 acreages on 30 l/s, etc (1 acreage equals to 0.4 hector).

7.4 On-farm Irrigation

Smallholder irrigation almost exclusively adopts surface irrigation methods for on-farm. Surface irrigation system conveys water to the farmland by an overland gravity flow. This method is categorized into: 1) basin, 2) furrow and 3) border strip irrigations. Of them, border strip hardly applies to small lands, therefore the on-farm irrigation should apply the first two methods: basin irrigation and furrow irrigation.



Basin irrigation is the most common type of surface irrigation, and is now getting familiar as treadle pump is being promoted widely in Malawi. This method is suited for any kinds of crops such as row crops, orchard, wheat, alfalfa, rice, etc., as long as water logging does not last for very long (water logging should not be more than 48 hours). As per the efficiency of on-farm irrigation application, basin irrigation could achieve as high as 80% when it is properly leveled and well managed.



Furrow irrigation system looks like commonly used ridged rain-fed agriculture since it consists of furrows and ridges. The furrow irrigation is best suited to row crops such as maize, beans, onions, tomatoes, potatoes, etc. The water is led to the furrow that should be on a uniform longitudinal slope, and capillarity moves and lifts the water into the ridges. This irrigation sometimes gives a risk of localized salinization in the ridges if the soil contains salt. As per on-farm application efficiency, furrow irrigation could reach 70%, which is about 10 % less than the basin irrigation.

From the viewpoint of efficient water use, basin irrigation is recommended as this irrigation method could avail of the water for crops about 10% more than furrow irrigation. However, sloped topographic condition requires heavy land leveling work and often terracing to convert the slope into a series of cascaded basins. If a topographic condition is associated with 4% slope (1/25) or more which is very commonly found in highland areas of Malawi, the width of a terrace cannot go beyond about 2 m. This means that almost every basin would result in accompanying terracing which is very laborious work.

Therefore, on sloped lands, say more than 4% slope, furrow irrigation may be much preferred by the irrigators and in deed adaptable. The spacing of the furrow can follow the rainy season's ridging spacing; preferably 75 cm or a little less than that. Ridge height, equally to furrow depth, should be around 20 – 25 cm in order for capillary to lift the water toward ridge. Standard height of ridge adapted during rainy season is usually 30 cm, and this height is so high that capillary may not be able to wet the soil around the seed.

Furrow length can be 5 m in the shortest case and to as long as 10 meters depending on the consistency of the gradient and the length of the plot owned by the farmer. Limiting factor of furrow length may be the length of the plot since the service area is usually divided into pieces, say 0.05 – 0.1 ha each as an example, and lent to many members. Another factor of determining the length of furrow is water volume available. If the water volume is very critical, say less than 3 l/s, furrow length should not be long; preferably to be 5 m or even less, otherwise it takes too long to fill up the furrow and results in great water loss.

In case of flat lands such as dambo areas, lower parts of hilly areas and lands in Rift Valley floor, basin irrigation can be best suited. Smallest size of sunken bed could be 1.2 m x 5 m, and can be enlarged depending on the leveling and the size of the plot owned by the farmer. Water volume available may limit the size of basin; namely, if water volume is very critical, say less than 3 l/s, the size should be small such as 1.2 x 5 m or even 1.2 x 3 m taking into account the time required to fill up the basin.

Though basin irrigation is very suitable for flat land, dambo area is often associated with water logging problem especially near the stream. In this case, furrow irrigation can be applied instead of basin and drainage may also be required. Dambo area may adopt basin irrigation in its higher elevation where water logging does not take place, which is close to the main canal, and furrow irrigation in the vicinity of stream.

7.5 Maintenance

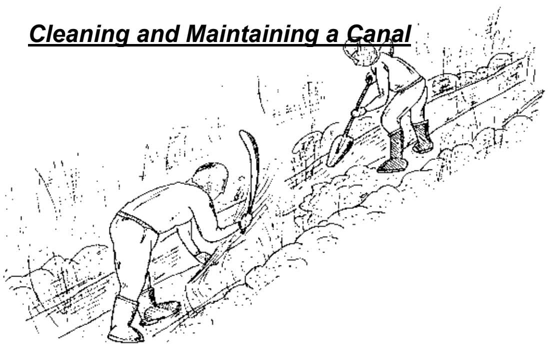
Maintenance should be done by the farmers' organization with technical advices from the AEDOs concerned. Maintenance work is required for the main facility; that is diversion weir, and canal including its ancillary facilities. The work can be categorized by nature into two: 1) regular maintenance and 2) routine maintenance. Regular maintenance includes; 1) re-shaping of the canal slope, 2) removal of silt or sediments inside the canal, and 3) removal of debris and other obstructions, and this is usually carried out just before the irrigation season starts. Routine maintenance should be done as required or at least once a month throughout irrigation season. It includes cutting of grasses at canals, particularly its inner sections, de-silting and removal of debris in the canal.

1) Weir Maintenance

As per temporally weirs such as sand bag dam and brush dam, no routine maintenance work is usually required during the season except minor repairs but replacement/renovation should be done every year sometime before they start the season's irrigation. It is advised that after they have finished the season's irrigation, the weir should be dismantled and such precious materials as logs, sacks, pegs, etc. should be kept. These materials can be again used for the next season.

2) Canal Maintenance

Cleaning and Maintaining a Canal



Stream water usually contains certain amount of suspended particulars, causing sedimentation in the canal. Eroded soil loss from field also gets into canal, resulting in the sedimentation in the canal. Maintenance work for canal should be done at least once before the irrigation season starts. Maintenance works required for the canal are; cleaning, weeding, de-silting, re-shaping, and also minor repairs as described below:

- Bushes and trees on the canal embankments should be removed. They may obstruct the water flow and their roots will open the banks and develop leakages.
- Grasses, sediments and debris in the canal should be removed. While cleaning the canal, care must be so taken that the original shape of the cross-sections is kept. For this, a wooden frame with exact dimensions of the designed cross-section can be of great help.
- Crossing sections by people and animals (livestock) along the canal should be strengthened by hard compaction or lined with stones, bricks or masonry.
- Holes/cracks in the canal should be filled with sticky clay soil, and eroded sections should be rebuilt to the original shape.

MODULE 8 APPROPRIATE FARMING IN IRRIGATED AGRICULTURE

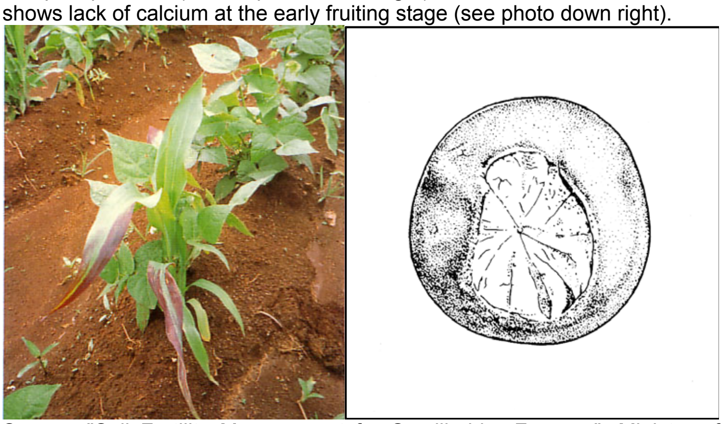
Providing irrigation water alone does not realize a significant progress in agricultural production. Integrated with appropriate farming technologies from various fields such as appropriate crop husbandry, marketing strategies, and post-harvesting technologies is also essential to gain maximum benefit from the irrigated farming.

Under the existing situation, where distribution system of farm input such as certified seed and chemical fertilizer has not been properly arranged, high-input farming system is not sustainable for smallholders who are of resource-poor stratum. Therefore, this package targets at establishing low-input farming system. This strategy, however, doesn't always deny adopting high-input farming. It is important in cases to apply best combination of high-input technologies and low-input technologies.

8.1 Identifying of the Site Conditions

Grasping an accurate site situation is the first step toward formulating appropriate farming program. Issues below will be the bases of formulating the farming program. Particularly, soil condition is an important factor that has an influence on the productivity. Soil test should be done or otherwise soil condition should be judged through the careful observation in the field in order to make an appropriate fertilization plan.

Lack of soil nutrient: Purple coloring on maize leaves shows a symptom of low phosphorous (see in photo down right). Blossom-end rot of tomato shows lack of calcium at the early fruiting stage (see photo down right).



Source: "Soil Fertility Management for Smallholder Farmers", Ministry of Agriculture, and Irrigation/International Crops Research Institute for the Semi-Arid Tropics, 2000

- Metrological condition: rainfall, temperature, humidity, sunshine, etc.
- Geographical feature: land slope, the extent of land degradation, vegetation, etc.
- Soil condition: soil type, fertility, texture, property, etc.
- Farming situation: area planted, yield, cropping pattern, cropping calendar, farm mechanization, crop protection, post-harvesting, access to farm input, etc.
- Extension service: access to AEDOs, contents of service, needs, etc.
- Marketing situation distance to market, farm-gate price, transaction volume, etc.

8.2 Proposed Crops

There are many crops currently cultivated by the smallholder sub-sector under the various conditions. Although present crops are considered adaptable to the present condition, proposed crops should be selected based on; 1) increasing food production, 2) improving nutrition, and 3) increasing cash income. Several crops suitable for smallholder irrigation schemes are recommended as below with reference to manuals prepared by MOA:

Crops for food security and improved nutrition:

- Maize: Hybrids (MH18 and NSCM51)
  Composites (UCA, CCA, CCB, CCD, ZM421, ZM621, Masika)
- Food legumes: Soybeans (Magoya), Groundnuts (CG7and JL24)
- Fruits: Orange, Tangerine, Mango and Guava
- Roots & Tubers: Sweet potato, Cassava

Crops for cash income:

- Industrial Crops: Barley Tobacco
- Vegetables: Paprika, Chills (Birds Eye)
- Legumes: Groundnuts (CG7 and JL24)
- Fruits: Orange, Tangerine, Mango and Guava
- Spices: Ginger, Turmeric

	ZM421 (Early maturing)	ZM621 (Late maturing)	Masika (Late maturing)
Growing period (days)	110-120	130-140	130-140
Prospective yield (t/ha)	5-6	7	8.5

As to seed security under the concept of low input, production of OPV maize, which can be recycled for three successive seasons, should be promoted. It contributes not only to seed security but also to commercial activities. 3 varieties of OPV are shown in the table including early and late matured varieties. Early matured varieties are necessary to cope with uncertainty of rain in rainy season cultivation, while late matured varieties, which possibly produce more cobs, can also be introduced to enhance economical effects from irrigation. It is recommendable to have both early and late mature varieties from the viewpoint of food security. In this case, however, contamination by different species possibly takes place, which reduces quality of the seeds. It requires to plant same variety in same place and to arrange the blooming seasons, which means that different variety should bloom in different timing to reduce risk of cross-pollination.

8.3 Cropping Models with Irrigation

Farmers in most cases intend to plant maize even with irrigation as the major crop from the viewpoint of supplementing their staple food. According to a base line survey carried out in year 2003 within Ntchisi, Dowa, Lilongwe East and Dedza Hills RDPs, about 70 % of 360 sample farm-households could not produce self-sufficient maize from 2002/03 rainy fed agriculture. This situation urges most of the farmers once again to produce maize even under irrigation. Following discussion, therefore, refers to maize as the major crop. There are three farming models that can be realized with irrigation as follows:

Type-1 (Double-cropping, single-plot): Type-1 copping model uses same plot for both rainy season and dry season. Though this is the most common cropping model, there are fewer choices from the viewpoint of farmers. Farmers have to plant dry season crops with irrigation as soon as he/she or landowners from whom he/she rents a piece of land finish harvesting rainy season crops. They may plant maize which requires about 4 months time to harvest if it is not too late, otherwise plant beans which require shorter growing period of about 3 months. Some farmers can try vegetables that also require shorter growing period if endowed with marketing opportunity.

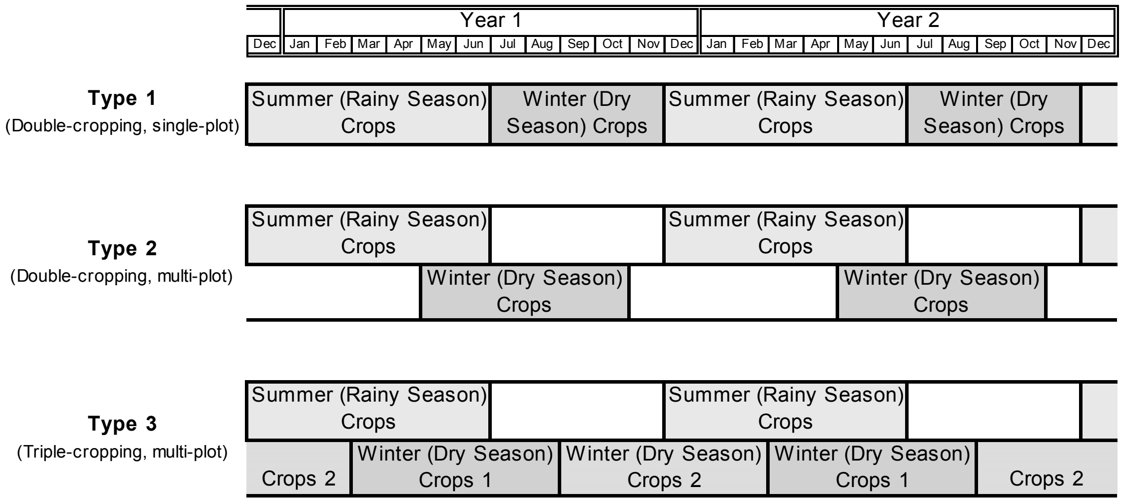


Figure 8.1 Typical Farming Patterns with Irrigation

There are often conflicts between landowners and renters in this type-1. An example is Mtsetse site in Dedza Hills for which the owners could not plant maize of 2003/04 rainy season because harvesting of maize in 2003 dry season went into as late as December. The late harvesting forced the landowners to give up the planting of 2003/04 rainy season maize. This type-1 often entails such conflicts, and recommendations are: 1) start construction of irrigation facilities even before rain-fed crops have been harvested, enabling irrigated agriculture to start earlier, 2) try to dry the rain-fed maize in homestead and not in the field, which can avail of longer time for the land, and 3) plant shorter maturity crops such as beans and vegetables if the following rainy season planting seems affected.

In addition, benefit for the land owners who lend out their lands to fellow farmers should also be considered such as, 1) allocate bigger portion of land to the land owners, 2) reasonable rental fee be considered to settle, 3) renters be advised by AEDO to well take care of the land by clearing crop residues after harvesting, making furrow for the following rain fed agriculture, applying enough amount of compost manure to improve the soil, etc., and 4) local authorities be involved in solving the problems if AEDOs cannot handle.

Type-2 (Double-cropping, multi-plot): In some cases, unused lands can be newly opened for irrigated agriculture and cultivated for dry season irrigated agriculture only. They cultivate upland plots during rainy season as they used to and now cultivate the newly opened area during dry season with irrigation. As it takes some time to get the lands opened due to such tiresome works as clearing bush, digging canal, etc., they may not have much choice when to plant at the first year. However, from 2nd year and onward, the farmers can plant the dry season crops whenever they want. They can plant the crops even before harvesting rainy season

Type 2 (double-cropping, multi-plot):
There are less conflict between the landowners and the renters under this type. Whole area of Katema and Tilime sites in Ntchisi and Dowa areas and a part of Ngoni site in Lilongwe area had been newly opened from bush. Therefore, the original landowners are very thankful to the members who had collectively opened the area. A good example is shown in Tilime site, for which the landowners are lending their lands to the members free of charge at least for the first, say, three years. As time passes by, conflict may occur between them in terms of rental fee, larger area allocation for the owners, etc. A solution may be to push this type-2 to the following type-3.

crops in order to avoid labor congestion to be incurred from harvesting of rainy season crops and planting of the dry season crops simultaneously and also to avoid shortage of water which may take place in October and November.

Consideration in terms of environmental conservation should be made whenever opening new areas. Newly opened area is prone to soil erosion, so that conservation methods such as counter ridge and hedge row, vetiver grass planting, etc. should always be incorporated. Apart from this soil conservation, this type-2 creates less problem between landowners and renters comparing to the abovementioned type-1 (see good examples in the above box). Though conflict may occur between them in terms of rental fee, larger area allocation for the owners, as time passes by, a solution may be to push this type-2 to the following type-3.

Type-3 (Triple-cropping, multi-plot): The above type-2 can move to this type-3 unless otherwise critical water shortage takes place in the later part of dry season. This type-3 enables farmers to plant crops twice in dry season plots. They may need to harvest dry season crops-1 before maize becomes dry in the field. They may need to harvest the maize as green which, however, itself is a good cash crop (farm-gate price of green maize is about MK2500/50kg while that of dry maize is MK500/50kg in Lilongwe area as at June 2004). If they need maize to be dried as staple food, they can try it for the dry season second crop.

In year 2004, a site in Ntchisi area planted maize in as early as March even before the irrigation system was made operational. This means they started the dry season crop by utilizing the out-leaving rainfall, and then wetting the crops was overtaken by irrigation in April. Under this arrangement, they can practice double croppings in a dry season, which means triple croppings in a year; called type-3.

No noticeable problem is usually expected under this type-3. A problem may be concerned with soil fertility rather than socially related ones. Since this type-3 uses same land twice a dry season, as in the case of type-1 in a year, soil fertility is in fact diminished if the soil is not well undertaken. Chemical fertilizer alone cannot deal with the improvement of the soil texture rather worsens soil in terms of physical property. Therefore, compost manure should always be applied.

Triple croppings in a single plot is possible?

There may be suggestion of establishing triple croppings in a single plot; namely one cropping with rain and two croppings with irrigation in a same plot. This is very difficult to practice under current situation; farmers plant maize as the major crop of rainy season and need them dried up as staple food. The drying up of the maize is usually done in the field, meaning that maize stays in the field for six to as long as seven months. The remaining period, say five to six months, is too short to accommodate double croppings, given the task of establishing irrigation system every time before dry season starts.

One may say drying up of maize should be done in the farmers' yard, leaving longer period to the field. With this arrangement, triple croppings in a plot throughout a year may be possible. However, one should have in mind this urges farmers to change their practice having been done since long time ago. Changing their tradition requires longer time than expected by outsiders, hence triple cropping in a single plot should not be expected or planned so easily.

8.4 Appropriate Forms of Ridge / Basin under Irrigation

Forms of ridge and basin should be decided by considering of water availability, types of crop, direction of sunshine, cropping patterns, topography, soil types, crop pest, working efficiency, economic efficiency, environmental situations, etc. Especially, forms of ridge and basin influence much on effective use of irrigation water. Inappropriate forms of ridge and basin are sometimes found under existing irrigations, and measures are given of the following:

1) Appropriate Form of Ridge

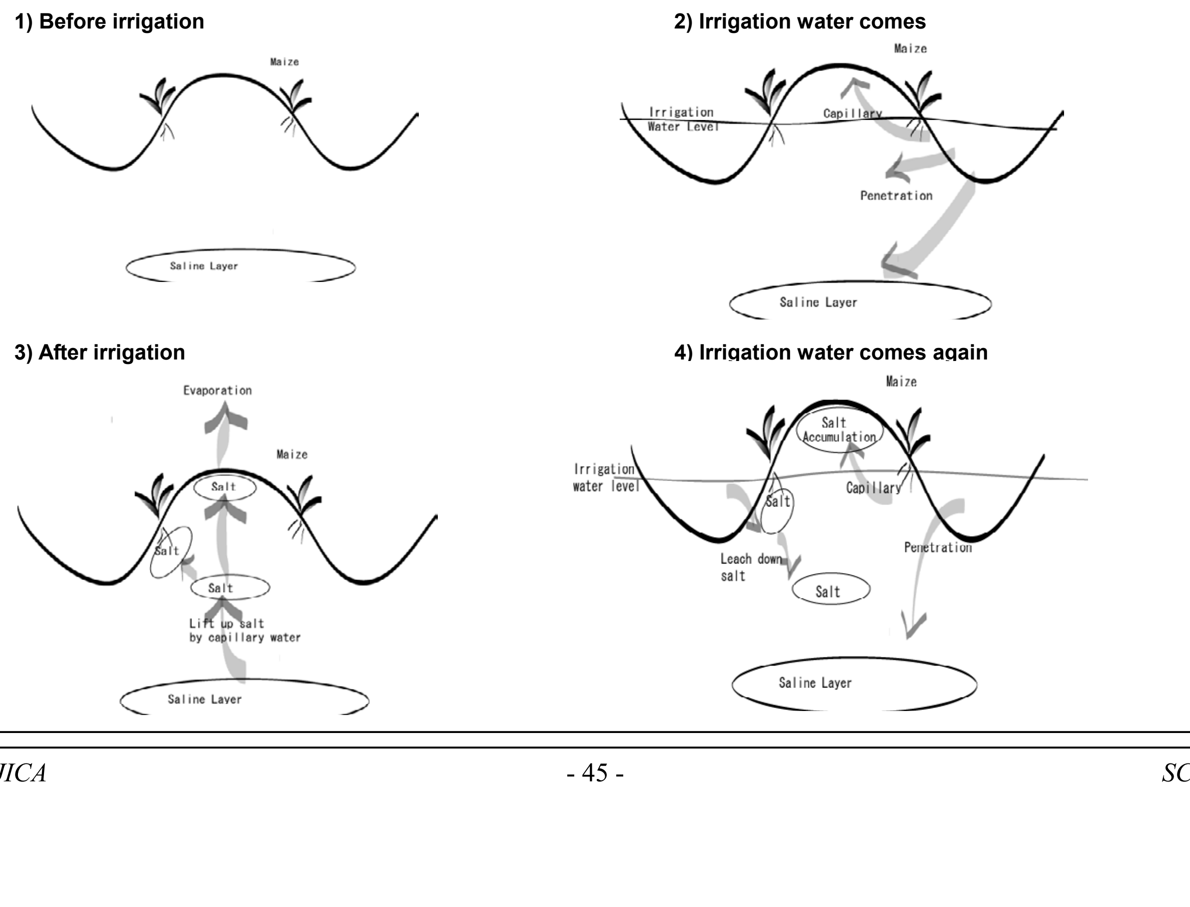
In Malawi, contour ridge method is found in many places in order to reduce erosion and to avoid excessive humidity in rainy season cultivation. This counter ridge can be utilized for furrow irrigation in dry season cultivation. In fact, since farmers can reduce construction work of farm ditches, furrows in rainy season are used as farmland irrigation canals in many cases. In some cases, excessively high ridges are found as farm irrigation canals which are 30 cm high same as rainy season agriculture. Under this condition, water scarcely takes place to the seeds planted on top of the high ridges, which as a result causes late germination and late growth in the initial stage of crops.

The purpose of contour ridging should be distinguished by season. In rainy season, the purposes are to avoid excessive humidity, and to reduce velocity of surface water on the field so as to reduce erosion, while in dry season the purpose is to provide effectively irrigation water by using the furrow. Suitable height of ridge/ depth of ditch should be about 20 cm in order to provide the irrigation water evenly and effectively.

2) Appropriate Planting against Salinity Problems

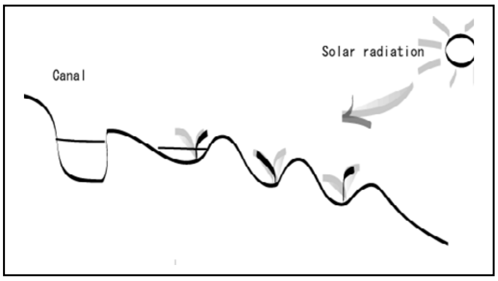
In dry season cultivation, soil salinity problem, in which salt is deposited on the surface of farmland, is sometimes found. Irrigation water may bring up salt, if the soil contains soil, to the surface areas of the ridge by capillarity, while there is no water such as rain to leach down the salt. Thus, the movement of salt is one way, which means that it just goes up and is accumulated little by little. This salt accumulation gives damage to the crop especially if the crop is planted on top of the ridge. On contrary, in cases that the crop is planted on the side

Figure 8.2 Salt Accumulation in Irrigation Farming



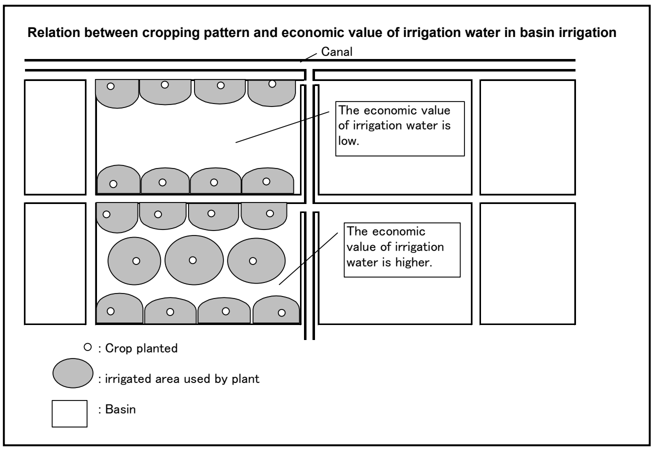
of ridges or planted in basins, the planted areas are always directly exposed to irrigation water, so that the salt is leached down and soil salinity problems hardly take place. Where salt problem is expected, side planting or basin plating should be practiced.

3) Ridge considering of Solar Radiation



If crops are planted on the side of ridges considering of the soil salinity problems as above-mentioned, amount of solar radiation, which plant can receive, is indispensably influenced by height of the ridges, planted places on the side of ridges and direction of the ridge. Inappropriate forms and planting methods possibly reduce the solar radiation and give bad influences on the plant growth in initial stage. Maize planted on almost bottom of the side of ridge in the northern side slope seldom get direct solar radiation until plant's height has become over the top of the ridge. Plants in the northern side slope should not be planted at the bottom of the ridge and also the ridge should not be high, preferably less than 20 cm.

4) Forms of Basin on Crop Type and Planting Density



In cases, just 2 lines of maize planted on both sides of 90 cm width basin are found, and there is a big space in center of the basin. The farmers say that other crops would be planted at ending stage of the maize. The dispersion of the planting timing is an effective method to reduce the risk of uncertain precipitation in rainy season. However, in irrigation agriculture, the dispersion may sometimes reduce the economic value of irrigation water since water in the center space of basin is not used for anything. In irrigation agriculture, in the view of enhancing economic value of irrigation water, it is important to use effectively irrigated space.

Mixing cultivation of maize and legume on same ridge/basin is recommendable considering of maintaining soil fertility, while, unless size of ridge/basin and planting space are considered well, competitions between maize and legume possibly happen relating to availability of water, amount of solar radiation, amount of soil nutrient, availability of space, and so on. Size of ridge/basin should be decided by number of line, type of crop, and so on.

8.5 Special Causions of Maize Cultivation in Dry Season

Since it is windy in Malawi in September and October, if maize is in the flowering stage in such windy season, the pollen might be blown away by wind resulting in no pollination. In dry season cultivation, maize in the flowering period should be irrigated more frequently than usual in order to add humidity not only around the root but also around the upper part of plant body. If the condition around flower is too dry, the pollen tube cannot extend well and as a result the fertilization is not done, even though the pollination is done. This is one of the reasons of low productivity taking place even under irrigation, therefore more frequent irrigation should be applied during flowering stage.

8.6 Soil Productivity Improvement : Organic Matter Applicatiion

Irrigated farming gives opportunity to cultivate crops during dry season, but on the other hand it exploits soil fertility due to a year-round cultivation. Continuous cropping without any measures causes serious land degradation. Some of the beneficiaries in smallholder irrigation project sites may do farming on a leased land on condition that the leased land should be returned to the owner during rainy season. If land degradation were caused by dry season cropping and left over, the landowners would no longer be willing to lend their land. In order to establish sustainable irrigated farming system, it is due required to keep and even improve the soil fertility as well as the texture.

Application of chemical fertilizers is an option to improve soil fertility. Especially, chemical fertilizer gives quick effects and provides required nutrients accurately. Although chemical fertilizer cannot improve soil physical characters and it is very expensive for smallholders, most farmers prefer applying chemical fertilizer only. Many farmers buy fertilizer and apply it to farmlands without improving the soil texture. If the soil does not contain much organic materials, most fertilizer applied may be washed away without being used by crops, since the capacity of fertility retaining is low in such a kind of soil conditions.

1) Compost Making

Promoting compost manure application is one of the extension activities by AEDOs as a low-cost option for fertilization as well as soil texture improvement. Various methods of making compost have been already introduced in Malawi such as Chimato, Pit, Chinese, etc. Of them, AEDOs are mostly promoting Chimoto since it effectively reduces evaporation and leaching losses of material fertility during the decomposing period. However, despite the effort of AEDOs, dissemination of compost making is a difficult process due mainly to:

- Comparing with chemical fertilizer, effects of compost seem to be little and appear late.
- It is a hard work to carry compost to farmland, since compost is generally made nearby farmer’s house, and generally should be applied in a large amount (water is usually available around house, and not available around field used for rainy season agriculture because these are mostly located on upland).
- There is little animal manure available, because population of cattle has been decreasing due mainly to drought, thieves, etc.
- Compost is often not available when it is necessary, because making compost takes a lot of time; for example pit-compost method requires 3 months and Chimato method needs about 2.5 months.

To cope with above-mentioned constraints, “Bocashi” compost which is a kind of quick made and quick effect compost is recommend (for the character of Bocashi, see Table 8.1). Bocashi needs only 2 to 3 weeks to be decomposed, quite shorter than other conventional composts of 2- 3 months. Why making Bocashi process is so short are to: 1) incorporate virgin soil which contain a lot of active microorganisms to facilitate the decomposition of the materials, 2) keep the temperature less than 50 centigrade in order not to kill microorganisms (periodical turning up is required in this regard), and 3) aerobic condition in the material heap accelerates microorganism's activities.

In conventional way of making compost, soil is collected from any place; including farm soil. Farm soil does not contain much active microorganisms because of UV from sunshine. Conventional composts are usually left rising of the temperature of materials, and in so doing most effective microorganisms die once. After the temperature has decreased to favorable temperature, other microorganisms come in and start to work/ decompose again, which means a lot of time to complete the decomposition process.

Bocashi has another unique process, which is to incorporate yeast. Yeast can be arranged in the farmers' locality from local beer residue (masese). During the decomposition procedure, yeast takes nitrogen from the materials, and uses it for their body growth. In this procedure, yeast is a kind of nitrogen storage. The nitrogen in their body of the yeast is mainly in amino acid form which is water-soluble and as a result plants take and utilize it easily. This means that the effect of the Bocashi appears relatively rapid[8]. Yeast's body also contains rich vitamins which accelerate plant growth.

Bocashi needs watering periodically, hence water availability is a key constraint or opportunity for making Bocashi with irrigation. Irrigation canal will give more opportunities to make it in their farmland, which simultaneously will solve transportation problems of Bocashi.

Appropriate amount of Bocashi Compost

Nutrient contents of Bocashi Compost and Compost in Japan

Type	Data from	% N	% P	% K
Bocashi (Cattle dung)	Chiteze Research Center	2.05	0.04	0.43
Compost (Cattle dung)	Japanese Average	1.6-2.1	1.5-3.5	2.0-4.0

If you would like to make P-rich compost, chicken droppings are recommendable as animal manure.

Amount of Application

- ✓ General application of chemical fertilizer for maize cultivation is;
  - 23:21:0-4s : 50 kg / ha
  - Urea : 50 kg / ha

  Reference : TIP Program
- ✓ Amount of each nutrient applied
  - N : 33 kg / ha
  - P : 10.5 kg / ha
  - K : 0 kg / ha
- ✓ If we want to add same amount of nutrients, we should add (/ha), based on N amount,
  - 33 kg / 2.05 % =1609.76 kg of Bocashi Compost
- ✓ If the weight of one heap of compost is 20kg, we need
  - 1609.76 kg /20 kg = 80.49 heaps
- ✓ About the other nutrients added
  - P : 1609.76 kg X 0.04 % = 0.64 kg
  - K :1609.76 kg X 0.43 % = 6.92 kg
- ✓ If we want to add same amount of nutrients of chemical fertilizer, we should additionally apply (/ha),
  - P : 10.5 kg – 0.64 kg = 9.86 kg
  - K : 0 kg – 6.92 kg = - 6.92 kg
- ✓ In Japan, for a reference, the amount of Compost application recommended is 5,000 kg / ha (Cattle Dung Compost)

[8] On the other hand, this means that the nitrogen in Bocashi is easier to leach out or to evaporate than the nitrogen in conventional compost. Therefore, Bocashi should be used immediately after completion, or it should be stored under cool condition avoiding sunshine.

Table 8.1 Comparison between Bocashi and Conventional Compost

Item	Bocashi Compost	Conventional Compost
Materials	• Water, Soil, Plant residues, Animal manure, Local beer residues(or fruit residues) • Collect all materials as fresh as possible.	• Water, Soil, Plant residues, Animal manure
Method to collect soil	• Collect virgin soil which seems to contain a lot of active microorganisms (decomposer). Don't collect farmland soil which exposes to the UV from sunshine which kills microorganisms. • Additionally, soil absorbs nitrogen in the materials and fixes it, which means that it reduces the nitrogen loss in the procedure of making Bocashi.	• Collect soil from wherever. • In order to add enough microorganisms, it is necessary to add large amount of soil. Compost including high percentage of soil is very heavy to carry, and again the concentration of nutrient is very low.
Methods to collect animal manure	• In order to reduce evaporation of nitrogen from fresh dung and urine, at night, middle - or large –size livestock should be tied in a house garden or in a khola covered with straw or plant residues on the ground. The dung and plant residues absorbing the urine should be collected every morning, and should be put into a pit filled with water.	• They collect whichever animal manure. The animal manure is often dried and lost most nitrogen by evaporation. Consequently, the compost has less nitrogen, but it can still improve soil physical character by developing crumb structure.
Add yeast (Local beer residues, fruit residues, etc.)	• Yeast contains rich amino acid, which is easy to be discomposed and taken into plant, vitamins, and the other growth stimulating materials. • Materials containing rich yeast are Chibuku (Local beer) residues, sweet fruit residues, a part of Bocashi which somebody has already made, etc.	• Yeast is not considered.
Nitrogen form	• Relatively water soluble and easy to be discomposed into NH^{4+} form and taken by plant.	• Most nitrogen is fixed well, which means that it is caught by soil or the other organic materials, so that it is difficult to be used by plant immediately.
Making Method	• Mix a small portion of each material together. An appropriate amount of water should be added, which means that mixed materials should have appropriate moisture and air within spaces. Mix the next portion of materials in above-mentioned method and pile it on the first portion. Repeat till finishing all materials. Don't compact the heap to keep airy condition. • Cover the heap with banana leaves, etc. in order to reduce evaporation of water. Fermentation of materials raises temperature of the heap. Keep the temperature less than 50 centigrade. If the temperature is more than 50 centigrade, break down the heap in order to decrease the temperature. When the temperature decreases to normal level, make a heap again and cover it again. • Moisture also should be checked. If it is too dry, add water.	• Pile layers of a certain portion of each material. Add water and compacting by stamping down. Generally, these actions are done in a pit or on ground. • After piling, cover the pile by plastic, banana leaves, mud, etc. in order to reduce evaporation. • 1 month later, break down the pile, and pile the layer again adding water. (This procedure is sometimes not practiced).
Time to make	• 2 or 3 weeks later, the compost, Bocashi, is ready to use. Spread all the materials and dry it under shade in order to stop the decomposition.	• 2-3 months
Moisture and air	• Keep optimum moisture and aeration for aerobic microbes.	• Since stamping down the materials reduces the water evaporation, level of moisture and aeration of materials is not controlled well. At first, much water is added to the materials (anaerobic condition). Later, in many case dry condition is left.
Temperat'e of materials	• Since high temperature of materials by fermentation heat kills microbes and stops the decomposition procedures, the temperature is checked and if the materials are very hot, it should be cooled down.	• High temperature by fermentation heat kills microorganisms once. Later, it takes time to increase population of microbes again.
Storage method	• Since nitrogen in Bocashi is not stable and Bocashi contains a lot of effective living microbes, keep Bocashi in dry and cool place evading UV from sunshine or use it immediately. Excessive moisture activates microbe activities in it, promoting further decomposition, and finally causes nitrogen loss by evaporation.	• Avoid excessive humidity. However, nitrogen remaining in the compost is already stable so that it can be kept relatively long time.
Application method	• Bocashi is used both as basal- and as additional-fertilizer, but since it is a quick effect fertilizer, it should be used rather as additional fertilizer.	• Since conventional compost is slow effect fertilizer and is a good soil physical improvement material, it is generally used as basal fertilizer.

2) Compost Extension

Although Malawian government has been promoting compost application for recent years, the rate of adapting this technology is still low. It is found that farmers, who know exactly about the benefits from application of composts/ other organic matters to farmlands, apply compost/ organic matters to soil more positively. On the other hand, farmers who do not know about the benefits and regard compost as just an alternatives of chemical fertilizer do not apply it positively and say, "Now, I don't have money so I use compost. But if I get enough money, I will use chemical fertilizer instead of compost".

The benefits of compost/ organic matter are; 1) to add fertility to soil, 2) to improve soil physical characters, and 3) cheap and made of locally available materials. Generally, the second benefit, "to improve soil physical characters", is the most important benefit, though it is not realized well by many farmers. It is considered to be effective for diffusion of compost/ organic matter application to emphasize the point about improvement of soil physical characters and to let farmers reallize again about the benefits. The following is an example to explain the benefit of improvement of soil physical characters.

One example of explanation of improvement of soil physical characters:

1. First, go to the farm, and show the soil in the farmland. Generally, the soil in farmland has some debris of the plant residues, pick up these residues and show them. And say, "Farmland has plant residues and the other organic materials, which improve the soil physical characters, for example, to increase soil absorption, to make soil soft, to add soil nutrients and so on. If we continue to cultivate in farmland, what happens? We rapidly lose these plant residues and organic materials, because the some of them are consumed by crops, some of them are washed away by rain, some of them are blown away by wind, some of them are burned out. What happens next?"
2. Go to the some place where the soil doesn't have organic materials and the surface of the soil is hard (ex. some soil in farming road). Or remove soft surface soil in farmland until we can see the hard layer. Show the soil and say; "This is the soil without plant residues and organic materials. It is too hard for plants to extend their roots."
3. Pour water to the soil. Water doesn't absorb and go away rapidly to lower place. Saying; "If we add water to soil, water flows away rapidly. No absorption."
4. Stick a small branch of trees or so to the soil, liken to maize. Saying; "This is a maize crop, Now we irrigate."
5. Pour water. Water flows away rapidly. Saying; "With this kind of soil, water goes away rapidly, and when the crop tries to drink, water has already gone."
6. Saying, "If you apply chemical fertilizer into soil", put some small stones around the crops, liken to chemical fertilizer. Saying; "Generally, chemical fertilizer is dissolved to irrigation water, and then, plant drinks dissolved chemical fertilizer in irrigated water. However in such kinds of soil, chemical fertilizer dissolved in water goes away rapidly and crop cannot drink it. Even though you add much chemical fertilizer, plant can take only a little amount of fertilizer."
7. Saying; "What should we do now? We should add some organic materials into soil."
   Make balls with toilet paper liken to compost and put them around the stick liken to maize. Saying; " This is compost. We apply the compost near maize. Now, water is absorbed into that compost and stays around maize, so now crop can drink water and also can take chemical fertilizer dissolved in the water. The compost is a kind of sponge in soil and the role is very important.

8.7 Appropriate Timing of Fertilizer Application

Maize requires more nutrient than other major crops grown in Malawi. Though heavy application of fertilizers contributes to high yield, their misapplication leads to loss of the investment. If full amount of nutrient requirement for growing maize is applied at a time of basal dressing, that will cause spindly growth leading to lodging and less photosynthetic capacity. It is, therefore, appropriate that half to two-third of required amount of fertilizers should be applied for basal dressing and one third to half for top dressing.

Even though farmers afford an appropriate amount of chemical fertilizer, if the timing of application is not appropriate, farmers cannot get planned harvest. Delay of fertilizer application is often found in maize field, which causes low productivity. When the seeds are planted, basal fertilizer should be applied next to the seed at the same time. The 2^{nd} application, top dressing, should be done when the plant reaches knee-height or leafs come out with 6 - 7 pieces of blade. If one applies the fertilizer to maize after that period, the fertilizer is used not for growth of cobs but for growth of leaves and stems, and finally the yield becomes very low, even if the plant body grows large enough. Influences from delay application of fertilizer seems to be more serious in hybrid varieties than local/ OPV varieties.

8.8 Plant Residues, Agroforestry and Green Manure

1) Plant Residues

Input of organic matter to maintain the soil productivity is not enough presently. It is often seen in mid dry season (August and September) that plant residues of the last rainy season's cultivation are burned without plan to cultivate immediately there. After the burning, the lands are often left idle so long until the coming rainy season cultivation. If they burn the residues just before cultivation, it is effective to prevent weed but no meaning in that situation.

In addition, carbon and nitrogen in plant residues, which are important to maintain soil fertility are lost by burning, and the ash of plant residues, which contains rich potassium and the other minerals, also might be brown or flown away before the rainy season cultivation. Plant residues should firstly be used as a material to improve the soil fertility as well as soil physical texture. In this sense, plant residues are not recommended to burn, and even if the farmers want to burn, the burning should be practiced just before the rainy season starts.

2) Systematic Tree Inter-planting of *Faidherbia albida*

Faidherbia albida tree left in maize field

In rural area, one can observe several legume species intensively left in the maize fields. *Faidherbia albida* is one of them recognized as a traditional soil fertilizer. This species has strong nitrogen-fixing ability, and it sheds its nutritious leaves in the beginning of rainy season, which means that the organic compound, a fallen leaf, is immediately used for maize cultivation in rainy season. Maize production under this tree's canopy is generally 50% to 250% higher than usual.

The other tree species such as *Acasia Senegal*, *Pakia biglobosa* and *Borassus aethiopum* are also planted or left intensively in the maize cultivation systems in order to enhance the soil fertility. These species shed leaves in dry season, providing a certain amount of organic matter to soil, so that crops under irrigation could make better use of those.

3) Intercropping with Legumes

Intercropping with leguminous species in maize cultivation increases soil productivity by its nitrogen-fixing ability. Maize can be intercropped with economically valuable legume crops such as soybeans, beans and cowpeas. Body of legumes contains rich nitrogen, however large amount of nitrogen does not return to soil since nitrogen-rich legume residues are easy to be decomposed and to volatilize. Therefore legume residues should be, right after harvesting, incorporated into soil in order to let the nitrogen be fixed to soil.

Distance for Intercropping

M T T M T T M ……….
30cm 30cm 30cm 30cm………
)75-90c
M T T M T T M ……….
30cm………

M: Maize seed
T : *Tephrosia* seed

Leguminous tree spices are also effective in nitrogen fixation. *Tephrosia vogelii (Katupe)* is a nitrogen-fixing shrub that can be intercropped with maize. Though the maize density becomes less than simple maize cultivation, it increases the total production especially under poor soil fertility condition. *Mucuna*, velvet bean, is also a representative species for the intercropping systems. According to an experiment at Chitedze Agricultural Research Station, *Mucuna* has ability to provide about 10,000 kg/ha of biomass containing about 5.5 % of nitrogen to soil (implying 550kg nitrogen per hector).

8.9 Non-tillage Farming

Non-tillage method, which is a farming practice without tillage or with minimum tillage, attracts considerable attention of those who are seeking appropriate technologies not only as labor extensive farming without land preparation and ridging but also as environmental-friendly farming method. Since this method requires no disturbance of the soil, physical and biological structure of the soil can be maintained. Also, plant residues are left on the ground for the purpose of supplying organic matters to the soil so that it contributes to fertilizing the soil. Especially, non-tillage farming is suitable for maize production because maize provides a lot of plant residues.

Sasakawa Global 2000 (SG2000) is now promoting non-tillage farming for maize production in Malawi. The procedure of non-tillage farming recommended by SG2000 is summarized as follows:

- Control the weed completely before planting (apply such chemicals of "Round-up" effective in plant on the ground and "Bullet" effective in seeds in the soil),
- After harvesting, cut down the plant residues and leave them on the ground,

- In the next cropping season, start cultivation without land preparation or ridging, and
- Shift the row of cropping by every season in order to prevent the soil from hardening, which has a similar effect for crop rotation.

75cm	x	x	x	x	x	x	x	x	x	1st & 4th cropping
25cm	y	y	y	y	y	y	y	y	y	2nd & 5th cropping
	z	z	z	z	z	z	z	z	z	3rd & 6th cropping
	x	x	x	x	x	x	x	x	x	1st & 4th cropping
	y	y	y	y	y	y	y	y	y	2nd & 5th cropping
	z	z	z	z	z	z	z	z	z	3rd & 6th cropping

8.10 Pest-Controling Methods

1) Botanical Pesticide

Irrigation system makes it possible for farmers to do dry season vegetable cultivation. Vegetable cultivation is very often affected by pests. However, leaf eaters can be controlled by using natural repellants which themselves are other crops in cases. An example is onion. Onion can work as a repellant, so that intercropping with, for example, cabbage, can repel leaf-eating caterpillars to an extent. Any natural plants that are already used by the local people for repelling mosquito, snake, etc. have an effect of repelling insects to some extent. Extract of such plants as garlic, tobacco and chili is also reported to be effective to control some pests. Damages by nematode in cultivation of tomato and chili cannot be disregarded. Marigold is well known as a nematicidal plant, which can be used as species for intercropping or crop rotation.


Maize attacked by stalk borer

As per maize pests, damages by stalk borer are very often found. The symptom is that young plant has "holes and windows" in the leaves and small borer can be seen at the base of the leaf. Larvae of this insect firstly eat surface of the plant tissues, and when they grow they start feeding down the inside of stalks and make a tunnel. Therefore, most of maize infected by the insect cannot be harvested. To control the insect, as they generally enter into stalks at the first growth stage of maize, application of botanical insecticides can be tried at this timing.

Tephrosia vogelii (Katupe)[9] is well known to control plant pest including the maize stalk borer. 2 kg of the fresh leaves crashed is soaked in 5-liter water for 12 hours, and then the filtrated extract is sprayed to crops. This is effective to control stem bores, aphids, leaf eaters and fleas. Crushed leaves mixed in granaries are also effective against weevils. The leaves contain rotenone, tephrosin and deguelin, which work as botanical insecticide. The half-life

9 Aside from Katupe, some farmers have been practicing such tree leaves extracts of Jerejere tree (*Sesbania sesban*), Futsa, India, Dellia, Mnadzandiyani, and also root of Dema. These extracts are actually effective to control bores, aphids, leaf eaters and fleas.

of these elements dissolved in 20 degree water is usually less than 1-day (Gilderhus et al:1982, 1991), and it is decomposed easily under sunshine (ultraviolet ray). However, it is recommended that vegetables applied with the botanical pesticides should be well washed before being eaten, and also irrigation water which contains such natural pesticides should not directory go back to the stream.

In dambo area, maize streaking mosaic virus is often found. This virus is serious, and maize which is infected in the early growth stage cannot produce cobs. Virus is expanded by sap transmission, and there are various ways of infection and its capacity of the infection is very high, for example, it is carried by aphis that sacks sap of the infected crop, and it is also transmitted by scratching uninfected and infected plants each other by wind. Generally, if infected plants are found, they should be pulled out and burned immediately. However, in many cases farmers do not pull them out, and naturally all plants become infected. The best way considered is introduction of anti-virus species of crop, including both hybrid and OPV.

Due to economical reasons and so on, farmers generally do not implement preventional pest control methods. Farmers do not apply agri-chemicals/ natural pesticides until they find certain damage by pest, and in such cases the crops will have difficulty to fully recover due to the late application of pesticides. It is necessary to emphasize the point, which is “prevention is more important than cure”.

2) Introduction of Pest Resistant Varieties

There are various pest-resistant varieties of crops/ vegetables sold in markets. Those are effective to control pests without causing environmental damage by agrochemicals. Where maize streaking virus is a common pest, it is often found that farmers cannot get any harvest due to damages by the pest if the maize is a local variety. A virus resistant OPV variety, Masika, does not have any problem. In view of food security, introduction of the virus resistant varieties may be inevitable. About tomato cultivation, the varieties which have resistance to nematodes, wilt bacteria, and so on are effective to reduce damage of pests.

3) Nematoda Control for Vegetable Cultivation

Nematoda is a kind of microorganism to form root-knot that affects plant growth. Damage by Nematoda often occurs under the condition of over-moisture in the soil and continuous cropping. Especially, Solanum family such as tomato and chill is sensitive to this disease. Damage by Nematoda can be controlled through; 1) rotating different crops in a field with an interval of more than 3 years, 2) improving drainage condition in the field, 3) intercropping with Marigold, which is well known as a nematicidal plant, and 4) combining crop rotation with Mucna, which is effective not only as a nematicidal plant but also as green manure. In case the infection occurred, it is strongly recommended to remove the infected plants from the field immediately and to stop irrigation in order to prevent the damage from expanding.

8.11 Soil Conservation : Contour Ridge and Contour Hedge Row

This method makes ridges along contour lines to reduce water speed and to stop run-off, and is already observed everywhere in Malawi. In this method, a simple farmer-made equipment called A-frame is used to measure level. Effect and durability of the contour ridge can be enhanced with contour hedge row, in which certain tree species or grass species such as *Tephrosia* and vetiver are planted along the contour lines. One thing unique associated with irrigation development is that irrigation canal can work as storm drain that traps eroded soil during rainy season. To enhance this effect, irrigation canal should always be planted vetiver grass alongside the canal.

Contour hedge of vetiver grass and contour ridging

Vetiver hedge is also recommended along lower peripheral of irrigation area. Lower peripheral is often extended to be very close to the stream side or the valley side. If irrigation area is extended to that area without taking any measures of conserving soil erosion, the peripheral might start collapsing into the stream/valley. Therefore cultivation should not be extended to as close as that area, and also vetiver hedge should be promoted along the lower peripheral adjusting to the stream/valley.

8.12 Post-Harvest Management Technologies

Maize damaged by LGB

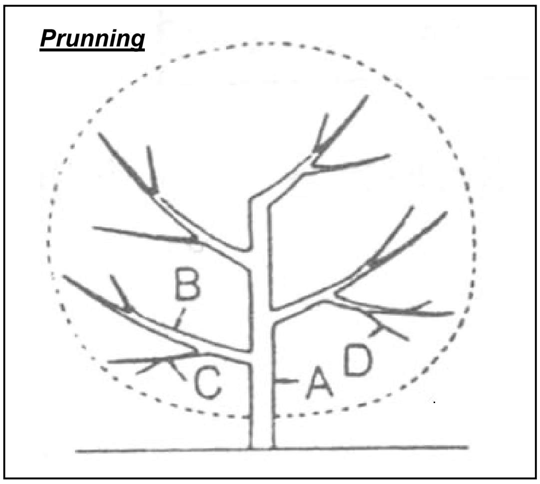
In recent years, maize loss in the post-harvest period has become very serious problem. The damage is induced by Larger Grain Borer (LGB), a species introduced from Central America about 10 years ago. In 2001/2002, the loss in the post harvesting period was reported at about 17%, 176,000 tons, which is enough to feed more than 800,000 people for a whole year. Since this insect can eat woody materials, traditional grain storage made of bamboo cannot prevent the insect. Thus, appropriate post-harvest management technologies should be introduced.

An Improved Granary made of locally available material

Improved post-harvest technologies are; 1) An improved granary totally covered with clay to prevent the damage (see photo), 2) Shelling before storing maize to remove harmful insects hiding in the pods away, and 3) Harvesting in the proper period and drying-up the product before storing to reduce rotten damages from humidity. This post-harvesting method should be promoted in line with irrigation development. Farmers will be encouraged to keep the surplus products, which come from irrigation, until the off-season comes, and they can sell the products at higher price.

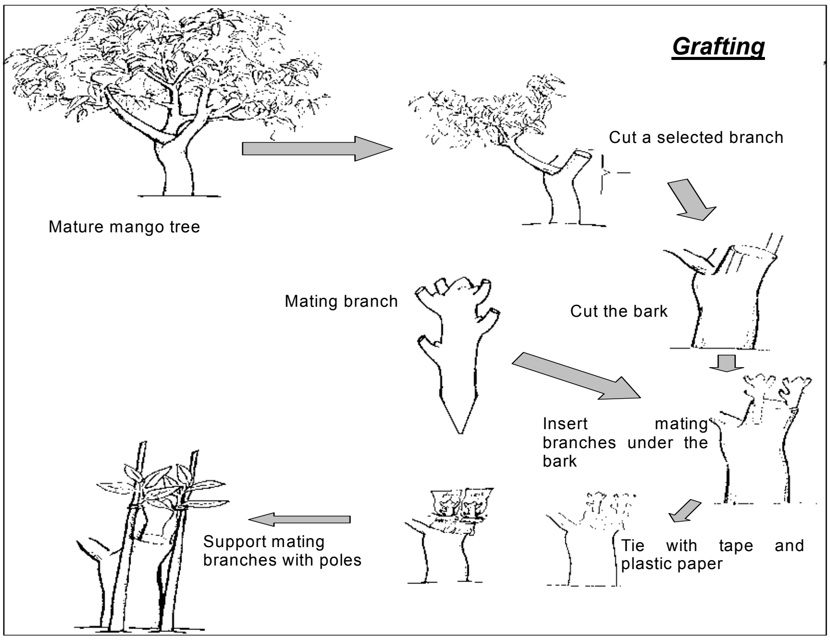
8.13 Strengthening of Fruit Production

Fruit tree provides products in various seasons, and after once it starts to produce fruits, it continuously produces without high input. Rural farmers in Malawi mostly own several kinds of indigenous and non-indigenous fruits trees such as plum, mango, citrus, guava and banana, which are important as a source of revenue in income scarce season as well as for self-consumption. That is to say, it could establish a safety net for farmers to strengthen the fruit production sector. Two low input technologies to strengthen fruits production sector are; 1) Pruning and 2) Grafting.



Tree branch arrangement, pruning fruits tree, is low input and very effective way to induce constant fruit production and to increase its production. This method shifts nutrient / energy flow within a fruit tree from leaf production to fruit production, and also changes tree form to be more convenient for harvesting. It is not difficult to master but initially requires appropriate instruction by extension workers when farmers select branches to prune. Since farmers in many cases do not want to prune tree branches, extension workers may require lots of time to explain the benefits of the method.

Grafting techniques object to enhance marketing value of fruit by shifting the harvesting season and by producing high quality fruits. For example, the price of imported grafting mango is generally 3-5 times higher than local mango. Some grafting species, which can produce fruits in the off-season, are supposed to generate higher income.



MODULE 9 PARTICIPATORY MONITORING AND EVALUATION

9.1 Monitoring and Evaluation

Since the owners of the self-help type irrigation schemes are farmers from the beginning, the main actors of monitoring and evaluation should also be the farmers. Therefore, monitoring and evaluation (M & E) in this Package does not mean observation and evaluation by outsiders or a third party but a key element of the capacity building; a learning process. Self-evaluation, self-education and self-improvement from lessons learned are the main activities of monitoring and evaluation in this Package.

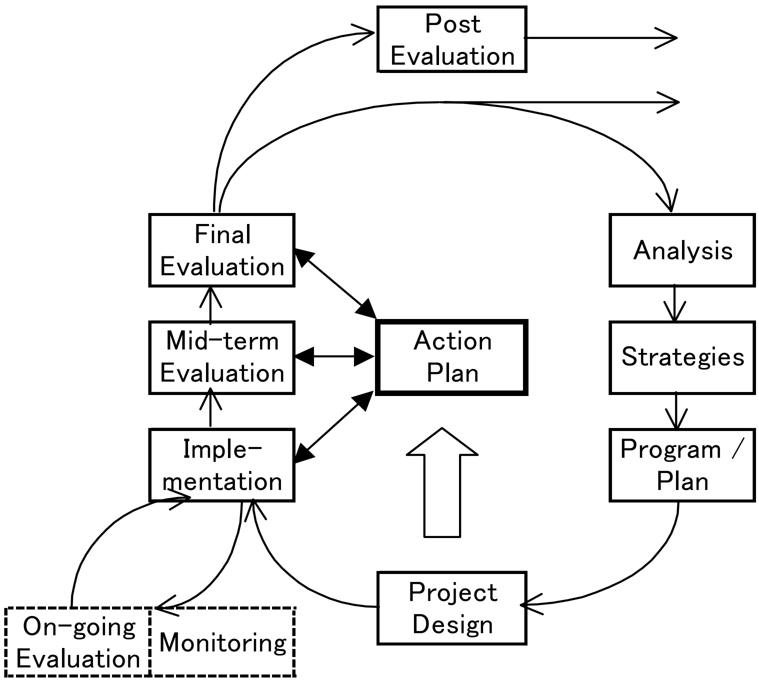


Figure 9.1 Project Cycle and M & E

The project cycle and monitoring and evaluation process are shown in the Figure 9.1. Monitoring and on-going activities are basically daily and weekly, mid-term evaluation at the middle of the project implementation, final evaluation at the end of the project implementation, post evaluation sometime after the project completion. One or two mid-term evaluation workshops and a final evaluation workshop for the project are expected to be held at the concerned village.

On the other hand, post evaluation workshops will be held at RDP, ADD and national level once a year. These workshops are also expected to work as the venue for conventional third party evaluation and the simplified project design matrix for smallholder irrigation schemes will be reviewed as in the table below. During the workshop, following year's action program with the target should also be made.

Table 9.1 Summary of Projects at RDP, ADD and National Level

	Indicator	Unit
Overall Goal	Poverty Alleviation	Number of households under poverty line
Project Purpose	Amount of Maize Available in Dry Season	Kg of Maize per person
Output 1.	Irrigated Land Area, Beneficiaries	ha, persons
Output 2.	Amount of Green Manuare Used	kg, kg / ha
Output 3.	Amount of Maize Seed Produced	kg, kg / HH
Output 4.	Amount of Produce Sold	MK, MK / HH
Output 5.	Amount of Soft Loan / Village Development Fund Available	MK, MK / HH
Output 6.	Amount of Produce Damaged	kg, %
Output 7.	Extension Works	Number of visits

9.2 Capacity Building

Monitoring and evaluation for capacity building of the stakeholders/actors and organizations could be evaluated in time series based on Toolkits: A Practical Guide to Assessment, Monitoring, Review and Evaluation, Development Manual 5, by Save the Children or self-evaluation method (FAO, People's Participation Program) conducted by Uphoff. Followings are the examples of evaluation criteria. By monitoring the rates scored in each period, the process of how capacity building has been done can be traced.

Example (8 criteria): SPIDER DIAGRAM OF INSTITUTIONAL MATURITY

1. Leadership
2. Organizational management
3. Funding performance
4. Accountability
5. Degree of autonomy
6. Learning and evaluation mechanism
7. Linkage and negotiating levels
8. Technical Operation and Management

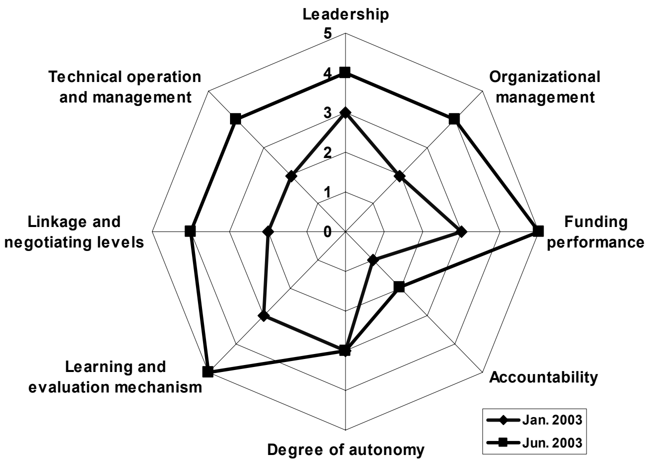


Figure 9.2 An Example of Spider Diagram

Example of rating

0 = Undesirable level: drastic improvement required

1 = Poor situation: much room for improvement

3 = Good situation: some room for improvement

5 = Ideal situation: little room for improvement

MODULE 10 PROVIDING SUSTAINABLE SYSTEM

10.1 Public Equity in Irrigation Development

Irrigation development can be implemented in water available areas only, and it promises stable agricultural productivity, and possibly increases production yield generally to 150% and to as much as 200% under good condition. On the other hand, however, it is true to actually increase economic disparity between the direct beneficiaries and non-beneficiaries even in a village.

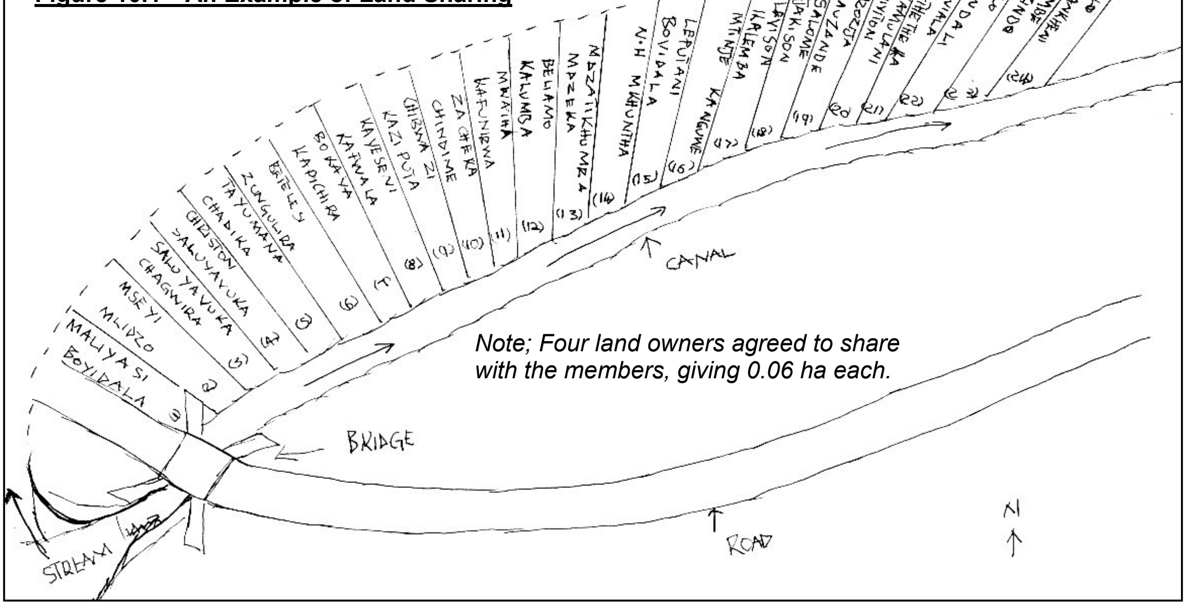
Simply because of some lands being outside the service area, irrigation obviously cannot serve all the villagers. Combined with the limited irrigation water that most potential sites confront, often observed is such situation that only less than one tenth of whole villagers have lands within the potential service area. This situation creates gap between the villagers in the services area and outside. That gap may create jealousy to the Haves; that is landowner in the service area.

This Package therefore proposes measures contributing to public equity through the operation of irrigation project. The measures are: 1) sharing of the service area, 2) staple food storage at village level (in some case, group village level), and 3) establishment of field of open pollinated variety (OPV) seed production. These public contributions should be well discussed among all the villagers including non-beneficiaries for the irrigation system. Government officers should facilitate the concerned villagers from the viewpoint of public equity as well as securing village level food security.

1) Sharing of Service Area

Sharing of the service area is to divide the service area into blocks and lend out to the Have-nots, that are the farmers who do not have any land in the service area, either free or with a minimal rental fee during dry season. This measure can be observed in many smallholder irrigation sites already. Given the strong leadership of village headman together with facilitation from AEDO, the landowners in a service area could agree to divide the lands into pieces and lend out to the Have-nots during dry season free of charge or with minimal charge.

Figure 10.1 An Example of Land Sharing

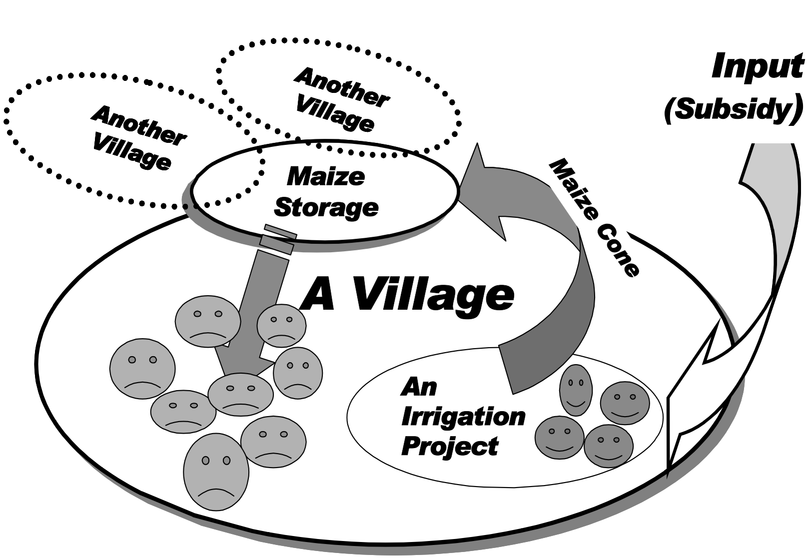


2) Food Storage

Food storage proposes such saving for the purpose of public equity as several percentage of the benefit from a smallholder irrigation project; for example, in case that one’s total yield of maize is 10 sacks, half a sack of maize is saved in the storage that is to be used for the purpose of public equity. This idea can be well combined with winter Targeted Input Program. Given TIP seed and fertilizer free of charge, he/she is asked to share a part of benefit with non-irrigators. Smallholder irrigation schemes are in most cases implemented in village level, so that it may be better that the storage be established in the village level.

It means that direct beneficiaries pay a part of the profit from the smallholder irrigation project to the storage, which in turn provides the stored maize to the people who do not

Figure 10.2 Food Storage at Village



directly receive the benefit. Maize collected in the storage, for instance, can be provided for Food for Work in public construction work including village road, emergency food during natural calamity and also as seeds for next season's planting inclusive of non-irrigators. Consequently, it contributes to the public benefit/equity over a wider area beyond just the direct beneficiaries.

3) OPV Seed Production Field

Establishment of OPV seed production field aims at improving the seed security at the village level or at the group village level. As most of the rural farmers face the difficulty of getting improved seed[10], they have to rely on local recycled seed that lowers maize yield.

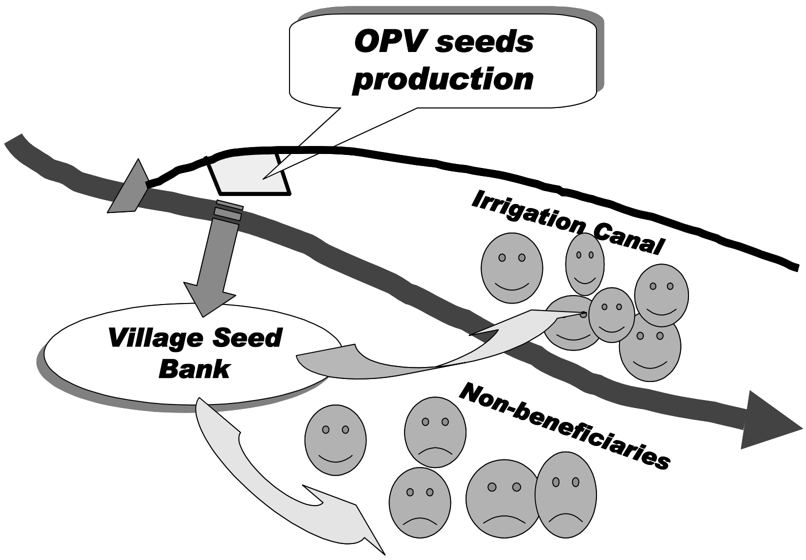


Figure 10.3 OPV Seeds Production

To improve the local situation, this Package proposes to establish a separate block, either common or individually sub-divided, in the irrigation system wherein OPV seed is produced. This block is supposed to provide OPV seeds to the villagers irrespective of if he/she is the direct beneficiary or not, though non-beneficiaries may have to purchase but with cheaper price. This system contributes to public equity and also secures improved seed at local level.

10.2 Revolving Fund in Irrigation Equipment

Cost-recovery is a crucial issue in any country's irrigation development sector. Irrigation bears benefit, which will directly fall on the beneficiaries. The beneficiaries are, therefore,

[10] As of year 2002/03, about 50 % area is nation-widely planted with local seed. Average maize yield by local seed is about 0.8 t/ha only, while the average yield by OPV is 1.2 t/ha (about 2.2 t/ha for hybrid seed) based on the nationwide production from 1990/91 to 2002/03. This is mostly under rain-fed condition, so that with irrigation the yield is expected to improve.

supposed to amortize the investment made by others than themselves partly at a cost of the benefit they have got. However, self-help type irrigation this Package undertakes pursues farmers' self-effort as much as possible while minimizing outside assistance. In this condition, cost recovery mechanism, a sophisticated amortization process, would not be required.

1) Revolving Mechanism

Instead, this Package proposes a revolving fund solely for equipment such as treadle pumps. Price of such equipment is very clear, just following market price or imported CIF cost, so that there is no argument how much they have to pay back in monetary value. Issues are the interest, installment, grace period, down payment, where to open the bank account for the revolving, measures to prevent defaulters, and reschedule of installment when hit by natural calamity.

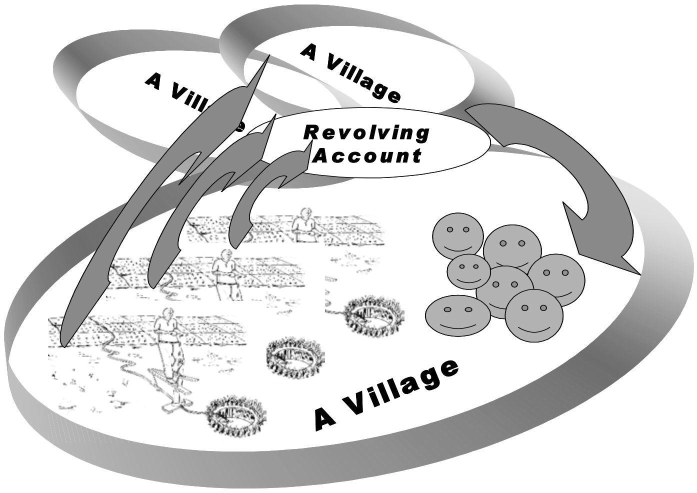


Figure 10.4 Conceptual Illustration of Revolving Fund

Following are the basic plan of setting up the revolving fund for equipment, and examples of treadle pump repayment of: 1) three year repayment with 10% interest, 2) earlier repayment under 10% interest, and 3) repayment with one-year grace period:

Table 10.1 Revolving Fund for Equipment

Items	Plan	Remarks
Account	MRFC in the concerned EPA or commercial bank according to the farmers concern.	
Down payment	Treadle pump: 10% Watering can: 30% Motorized pump: 5%	Up-front payment to make the farmer sure of the following loan repayment.
Interest	Should be not less than inflation rate (about 10% at early 2003)	Commercial bank rate is approximately 50% as of mid 2003.
Grace period	At least until the first harvesting comes.	It means first payment be done right after the first harvesting.
In vagaries	Interest rate during the vagary season is exempted.	Government officers' endorsement required.
Defaulters	Confiscation of the equipment	

Table 10.2 Sample 1: Repayment in Three Years with 10% of Interest Rate

Year	Capital (MK)	Interest (%)	Interest (MK)	Total Debt (MK)	Repayment (MK)	Balance (MK)
1	7,500	10.00	750	8,250	3,016	5,234
2	5,234	10.00	523	5,757	3,016	2,741
3	2,741	10.00	275	3,016	3,016	0
Total Repayment					**9,048**	

(Remark)

To equalize annual payment of the capital and interest, following coefficient is used:

$$\text{Coefficient: } \frac{i(1+i)^n}{(1+i)^n - 1}$$

n = Period of payment
i = Interest Rate

e.g. Loan of capital: MK7,500, Interest :10%, Repayment period: 3 years;

$$\text{Annual repayment is: } 7{,}500 \times \frac{0.1(1+0.1)^3}{(1+0.1)^3 - 1} = 7{,}500 \times 0.40211 = 3{,}016$$

Table 10.3 Sample 2: Total Loan Cost in Case of Earlier Repayment

Year	Capital (MK)	Interest (%)	Interest (MK)	Total Debt (MK)	Repayment (MK)	Balance (MK)
1	7,500	10.00	750	8,250	5,000	3,250
2	3,250	10.00	325	3,575	3,500	75
3	75	10.00	8	83	83	0
Total Repayment					**8,583**	

Table 10.4 Sample 3: Total Loan Cost in Case of One-Year Grace Period

Year	Capital (MK)	Interest (%)	Interest (MK)	Total Debt (MK)	Repayment (MK)	Balance (MK)
1	7,500	10.00	750	8,250	-	8,250
2	7,500	10.00	750	9,000	3,290	5,710
3	5,710	10.00	571	6,281	3,290	2,991
4	2,991	10.00	299	3,290	3,290	0
Total Repayment					**9,870**	

MODULE 11 GENDER AND DEVELOPMENT

11.1 Women in Development" and "Gender and Development"

Woman in development (WID) in the 1980's views women as an object of development, and aims to improve women's participation and benefits through increasing women's awareness and their productivity. Gender and Development (GAD) since the 1990's, on the other hand, aims to eliminate gender inequality and to challenge existing socio-economic structures to change unequal gender relations.

There are two complementary approaches to achieving gender equality: mainstreaming gender and promoting women's empowerment. Both are critical. Gender mainstreaming is "the process of assessing the implications for women and men of any planned action, including legislation, policies or programmes, […] making women's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes […] so that women and men benefit equally", according to a 1997 Report of Economic and Social Council (Gender Equality, Practice Note, November 2002, United Nations Development Programme).

"Gender mainstreaming" is a comprehensive strategy for promoting gender equality with

GAD as its development objective. It is to incorporate the gender perspective into all policies and projects at all levels of planning and formulation of policies and projects. This approach is based on the concept that both women and men should be allowed to participate equally in all decision-making processes. (JICA Thematic Guidelines on Gender Mainstreaming/WID, August 2002, Thematic Guidelines Team, Gender Mainstreaming Unit, Global Issues Division, Planning and Evaluation Department, Japan International Cooperation Agency)

11.2 Why Gender is a Development Issue in Malawian Rural Area?

Gender HIV/AIDS Training Manual compiled by Macadamia Smallholder Development Project, Malawi Government and African Development Bank, clearly summarizes why gender is a development issue in Malawian Rural Areas as follows:

Women in Malawi constitute 52% of the population, 70% full time farmers (who contribute 87% of the labor force). Thus, women's contribution to economic life is considerable. However, there are barriers to increasing their productivity and the benefits they receive. These include: 1) credit, 2) market, 3) land, 4) training, and 5) literacy.

1) Credit: Currently women receive 37% of the loans, so that they need increased access to credit. Group formation will assist in this. Resource-poor men and women find it difficult to save and meet minimum deposit levels in savings accounts in formal banking and lending institutions.
2) Markets: At present, women have less mobility than men due to domestic responsibilities and limited transport access. They play a role in local food markets.
3) Land: Women have limited access to land, but in MSDP (Macadamia Smallholder Development Project), through group formation, they have obtained sites from the Village Headman for nursery construction. The Malawi Government's policy is for greater access to land for women (equality of land rights)
4) Training: Men have greater contact with extension agents than women. By joining groups, with men or women only, women can obtain better access to information and training.
5) Literacy: Illiteracy rates are higher for women than for men: 37% of women are literate. This needs to be taken into account in training and extension. Methods appropriate to the level of the audience are needed in the training sessions.

Incorporating gender considerations into development planning is, therefore, a more COST-EFFECTIVE use of human, financial and other resources, which will lead to increased and sustainable development of all the people in the Country.

11.3 Gender Questions at the Initial Stage

At the initial stage including planning workshops at village level, these questions could be used to assess gender issues as well as to contribute to eliminating gender inequality by properly incorporating those issues in the design of smallholder irrigation:

1) Who will be members of the irrigation club?

- Disaggregate the potential beneficiaries by gender
- Disaggregate landowners by gender
- Avoid landowners excluding other villagers to join the club
- Identify female-headed farming households and single women

> **An Example of a Woman who was able to join an Irrigation Club:**
> A seventeen-year woman, who has not married, said "I joined the club because I worry about food problem. I do not want to suffer as I did in 2001/02. I thought hard and decided to join."

2) How is the socio-economic situation?

- Identify gender division of labor
- Identify major cash income sources by gender
- Identify social or cultural constraints on women, if any
- Determine gender inequality in education

3) Formation of an irrigation club and selection of committee members

- Advice potential male club members to include women-headed farming households and single women
- Promote both men and women become members of the club
- Advice potential club members to select at least one woman committee member
- Promote both men and women to participate construction work

4) Is there any possible negative impact?

- Where do the villagers get drinking water and cooking water?
- Are there any other water users for the same water source?
- Will irrigation farming be an alternative for their income generation (such as fetching firewood, selling charcoal, making mats/baskets, dambo farming or piecework) in dry season? Or an additional work?

> **An Example of a Woman not scarifying anything:**
> A woman of Ntchisi District said "I will continue buying fertilizer, more work and I can't be tired. I am doing irrigation farming with managing everything else such as housework, growing relish, so that I am not sacrificing anything."

5) Other tip

- Separate men and women for specific meetings and data collection

11.4 Gender Questions for Monitoring and Evaluation

At monitoring and evaluation stage, the following items need to be examined. If inequity is found, such situation can be rectified by letting concerned members to be aware of the inequity, advising the members to be equal in terms of gender, and also taking them by study tour to an irrigation club which is good example can work to instill the sense of equality:

1) Access

- Can any villagers who want to join the club be members?

- Can any villagers access to extension services and training?
- Can any villager get information which relates to farming?

An Example of Inequality relative to Landowners:
At one site in Dedza District, the membership of the second year is almost as same as the first year. However, all the members are landowners in the second year, where most of the members were renters in the first year. There is definitely an equity problem.

2) Change of membership profile

- Change of membership by gender
- Change of ratio of landowners to the membership
- Change of the number of female-headed farming households and single women

3) The change of amount of labor by gender

- Gender division of labor on irrigation farming
- Change of burden in dry season by gender
- Any other new work after introducing smallholder irrigation?

4) Income distribution

- Is there drinking problem in the village?
- How is the income from irrigation farming used? Who controls?
- Change in the expenditure on education

An Example of Unequal Control:
A member of a successful site in Dowa District said "From June, July to December, I have spent as much as MK20,000 for drinking. I want to quit drinking and that is the biggest problem for me." A member of another site in Dowa District said "I felt I would die soon if I continue drinking that way." "It was my wife who was trying hard to stop me drinking," he added.

5) Others

- Is there any change in leadership by gender?
- Any other development activities as an impact of smallholder irrigation?

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