CHAPTER 4 SMALLHOLDER IRRIGATION DEVELOP'T: PLANNING PREREQUISITE

This chapter undertakes smallholder irrigation development planning. It starts with identification of constraints and potentials for smallholder irrigation development from different areas. Some are withdrawn from workshops at officer level and village level, from past project experiences, and also based on the JICA Study Team's observation, etc. Identification of smallholder irrigation potential is to follow and then the prioritization by district in the Study provinces will be done. Based on these, planning is to start with framework setting, and to cover smallholder irrigation development, irrigated agriculture development including marketing, water management and farmer organizations, etc.

4.1 Issues Identified at Kick-off Workshop for Officers

As an entry to this Study, 1-day kick-off workshop was held on March 31, 2009, inviting as many as about 70 participants from relevant offices of the 2 provinces of Northern and Luapula (for the participants, see the table below). By the end of the workshop, the participants were, as its objectives, expected to be able to: 1) know about the Study and internalize the concept of smallholder irrigation development, 2) identify district-wise irrigation potentials in the two provinces, 3) identify and share Strengths, Weaknesses, Opportunities and Threats (SWOT) relevant to MACO, and 4) identify problems and those causes related to food security in the two provinces.

Table 4.1.1 Participants to the 1-day Kick-off Workshop by Office, held on March 31, 2009

Cadre	Northern province	Luapula province	Total
Province	12 (1F, 11M)	3 (0F, 3M)	15 (1F, 14M)
District	29 (3F, 26F)	13 (0F, 13M)	42 (3F, 39M)
Camp officers	9 (3F, 6M)	3 (0F, 3M)	12 (3F, 9M)
Total	50 (7F, 43M)	19 (0F, 19M)	69 (7F, 62M)

Source: JICA Study Team

The methodology for the workshop is of group work, presentation by group leaders, open-forum discussions, and brainstorming, etc., which are all based on participatory approach. The programme of the workshop is given of the following table, composed of mainly 4 sessions, e.g. study overview (presentation by the Team), a simplified situation analysis identifying irrigation potential by district, stakeholder analysis by simplified SWOT and problem analysis in a tree structure as related to the workshop objectives aforementioned:

Table 4.1.2 Programme of the Kick-off Workshop (1-day Kick-off with 4 Sessions)

Date	Time	Activity
March 31, 2009	08:00 – 08:30	Workshop Registration
	08:30 – 09:00	Introduction and Welcoming Remarks
	09:00 – 10:00	Study Overview (presentation by the JICA Team Leader)
	10:00 – 10:15	Tea Break
	10:15 – 12:30	Situation Analysis (Identification of Irrigation Potential)
	12:30 – 14:00	Lunch Break
	14:00 – 15:00	Stakeholders Analysis (Simplified SWOT)
	15:00 – 16:45	Problem Analysis (Identification of Problems in a Tree Structure)
	16:45 – 17:00	Closing
April 1,2009	07:00 – 09:00	Departure of Participants

4.1.1 SWOTs Identified in the Kick-off Workshop

A simplified SWOT analysis, a strategic planning method, was carried out during the kick-off workshop to analyze Strengths and Weakness of MACO and Opportunities and Threats that MACO faces. First, a facilitator made an explanation of the method in the plenary session. Then, participants were divided into two groups by the level of office they work for; district or upper level staff such as PACO, DACO, and SAO and camp level staff namely frontline extension officers.

As of the group of district level officers, it was further divided into two groups simply for a better facilitation. To identify MACO's internal and external factors for promotion of smallholder irrigated agriculture, active discussions were conducted. After the discussion, each group made a short presentation on their own result of the analysis to other groups, which was also followed by an additional discussion.

Table 4.1.3 Results of the SWOT Analysis at District/Provincial Level (Left) and Camp Level (Right)

At District and Provicnial Level			At Camp Level (frontline level for extension)	
Strengths: ✓ Knowledgeable/ qualified person power ✓ Well established organizational structure ✓ Trainable staff ✓ NIP in place ✓ Agricultural policy in place	**Opportunities:** ✓ Water availability ✓ Fertile land ✓ Available arable land ✓ Locally available materials ✓ Existing community groups ✓ Good road network ✓ Existing of infrastructure ✓ Ready market ✓ Cooperating partners ✓ Donor support ✓ National stability ✓ Political will		**Strengths:** ✓ Trained technical staff	Opportunities: ✓ Perennial streams ✓ Water bodies ✓ Favourable water condition ✓ Local resources for construction ✓ Abundant arable land ✓ Irrigation furrows (canals) already exisiting ✓ Skilled labour ✓ Ready market ✓ Grants ✓ Supporting programmes ✓ Communication network
Weaknesses: ✓ Shortage of staff ✓ Inadequate transport ✓ Transfer of staff ✓ Poor extension linkages ✓ No standard extension approach ✓ Top down approach ✓ Inadequate survey equipment ✓ Erratic Financial support ✓ Poor GRZ funding	**Threats:** ✓ Natural calamities ✓ Poor infrastructures ✓ Land tenure ✓ Low adoption rate ✓ Migration among villagers ✓ Lack of willingness of farmers ✓ Sudden withdrawal of support ✓ Unsustainable projects ✓ Death of staff ✓ Cross cutting issues (HIV/AIDS) ✓ Economic crisis ✓ Policy changes		**Weaknesses:** ✓ Inadequate technical staff ✓ Inadequate logistical support ✓ Lack of opportunities for capacity building	**Threats:** ✓ Drought ✓ Floods ✓ Bad road conditions ✓ Bad road network ✓ Land tenure ✓ Expensive farming input prices ✓ Pests and diseases ✓ Death of staff ✓ HIV/AIDS ✓ Deforestation ✓ Political interference ✓ Pests and diseases

Source: JICA Study Team, summerized from the work result by officers who participated in the Kick-off WS, March 31, 2009

From the table above, following are identified as their Strengths, Weaknesses, Opportunities and Threats, which are underlined in the above table and to be well considered in the planning of the smallholder irrigation development:

1) Strengths are not many, but identified at both levels is related to human resource, e.g. 'qualified/ knowledgeable and trained staff'. Another strength identified at district/provincial level is 'well established organizational structure.' This strength refers to the DOA's structure starting at the headquarters, and then down to the frontline camp level close to villagers through provincial and district office. In fact, except for the Ministry of Education and Ministry of Health[1], no ministry assigns their staff up to camp level. These two strengths can be an essential driver to extend smallholder irrigation to a large extent.

2) On the other hand, among major weaknesses identified are; 'shortage of staff' and 'inadequate logistic support' especially relating to 'transport'. Referring to an example of Northern and Luapula provinces, one camp extension officer has to cover a square of about 22km x 22km, which is quite extended. Some of them, especially most of the BEOs, are provided with motorbike; however the issue is still the provision of fuel. According to an interview, a block

[1] Teachers belong to the Ministry of Education and rural health centers under the Ministry of Health where nurses are stationed are placed up to rural areas. However, apart from them, no government officers, but Block and Camp Extension Officers, are stationed at the levels lower than district centre.

extension officer is entitled to receive 20 litter of petrol every 3 months but it is very often delayed or not provided even for half a year, hindering their extension activities.

3) Camp officers identified ‘lack of opportunities for capacity building’ as one of their weaknesses. In fact, without donor’s support, very little opportunities are available for any kind of training courses especially for lower cadre of government officers, who are camp extension officers. For example, there is an training opportunity for Luapula officers thanks to a donor funded project, PLARD; however in Northern province after ASP, a Swedish governed funded project, phased out in 2008, no training has been carried out in 2009.

4) Looking at opportunities, one may sense the area is very much blessed with natural resources, water and land, as is expected. These are essential factors to develop smallholder irrigation schemes. In addition, locally available materials and local resources for construction were also identified as an opportunity, which enable the construction of simple (temporary) diversion weir irrigation schemes.

5) Threats identified, among others, are natural calamities such as drought and flood, poor infrastructure especially poor road condition and its network, land tenure, low adoption rate (for new technologies) by farmers, migration among villagers (due to shifting cultivation still widely practiced), expensive farm input, etc. Note that there is flood as calamity due to heavy rainfall. It was also learnt at village level workshops that crop damage has been caused by heavy rainfall more often than drought.

6) Low adoption ratio (for new agriculture technologies), one of the threats, is related to thrush and burn agricultural practice still prevalent in Study area. This associates with ‘migration among villagers’ identified as another threat. Rural farmers cut bushes, trees, twigs, soon after rainy season ends, and leave them in the field and set them on fire for the preparation of rain-fed agriculture at the end of dry season. Under this system they sift farmlands every couple to several of years, and this situation makes the government officers difficult to disseminate modern agricultural technologies, resulting in low adoption ratio.

7) As per ‘land tenure’ as one of the threats, most of the lands belong to traditional authority in Zambia. Therefore when the government plans to open up an area for, say, irrigation purpose, they have to acquire consent from the traditional chief concerned, and in cases with compensation. This procedure may affect the development of land; this is what the participants thought as one of the threats for irrigation development especially in case of developing settlement schemes.

4.1.2 Problems Identified in the Kick-off Workshop

The last activity of the kick-off workshop was a problem analysis. In this activity, major problems related to agricultural livelihood in the two provinces were analyzed. After an explanation of basic principles of the problem analysis, all the participants were divided into two groups. The groups were divided by province rather than type of posted stations as agricultural problems are mostly attributed to physical condition of the area. Originally, core problem was prepared by the JICA Study Team; “food security is not guaranteed.” However, participants suggested that deciding the core problem by each group may have different view better reflecting on the situation. The group of Luapula province set the core problem as “low production” and Northern province, “food insecurity.”

After setting the core problem, participants started discussing what the direct causes of the core problem are. For example, Luapula group suggested ‘low productivity,’ ‘dependency on rain-fed crops’ and ‘inadequate land under production’ as major direct causes of low production. Direct causes for Northern group were ‘low production’, ‘unstable production’, and ‘inadequate land under production’.

As like, causes of these problems were further analyzed. After the analysis, each group made a presentation of their result for the entire participants so that officers from both provinces could share their findings and understanding on the current situation. The result of problem analysis in Northern and Luapula provinces are shown in Figure 4.1.1 and Figure 4.1.2, and following were identified;

1) In Northern province, irrigation related problem was identified as a cause of 'over-dependency on rain-fed agriculture'; that was 'inadequate function of irrigation infrastructure'. Reasons further causing this problem are; 1) lack of technical skill of farmers, 2) low investment levels and 3) vandalism. When going further down the line of 'lack of technical skills of farmers' we come across the 'inadequate logistics support for extension officers', which was also identified in SWOT analysis as a typical weakness pertaining to them.

2) 'Poor water management', another irrigation related issue, was identified as one of the causes of 'inadequate water supply source', leading to 'unstable production'. As such 'inadequate function of irrigation infrastructure', Northern group more or less concentrated on existing irrigation schemes. This implies though lots of potential exist to develop new sites in the Study area, there is still an approach of improving agricultural production by way of rehabilitation and improvement of existing schemes.

3) For Luapula group, 'inadequate irrigation facilities' was identified as the cause of 'dependency on rain-fed crops', further causing the core problem of 'low production'. New irrigation schemes may be more required in Luapula province while in Northern province improvement of existing facilities may have higher priority according to the result of the problem analysis.

4) With regard to 'low production', both groups identified soil related issues, e.g. 'low soil fertility' caused by 'land degradation' for Northern group and 'high level of soil degradation' caused by 'acidity problem soil' for Luapula group. Going further down along the line of Luapula group, we can see 'inadequate extension services' caused by such 3 problems as 'less staff employed', 'inadequate logistical support', and 'wide coverage area'. To pursue effective extension, logistical support could be a critical issue taking into account their wide coverage area.

5) In addition, Northern group identified input issue as one of the causes of 'low production'. In fact, chemical fertilizer price is extremely high in Zambia nowadays. Without subsidy provided by the government, most of the farmers cannot have access to it.

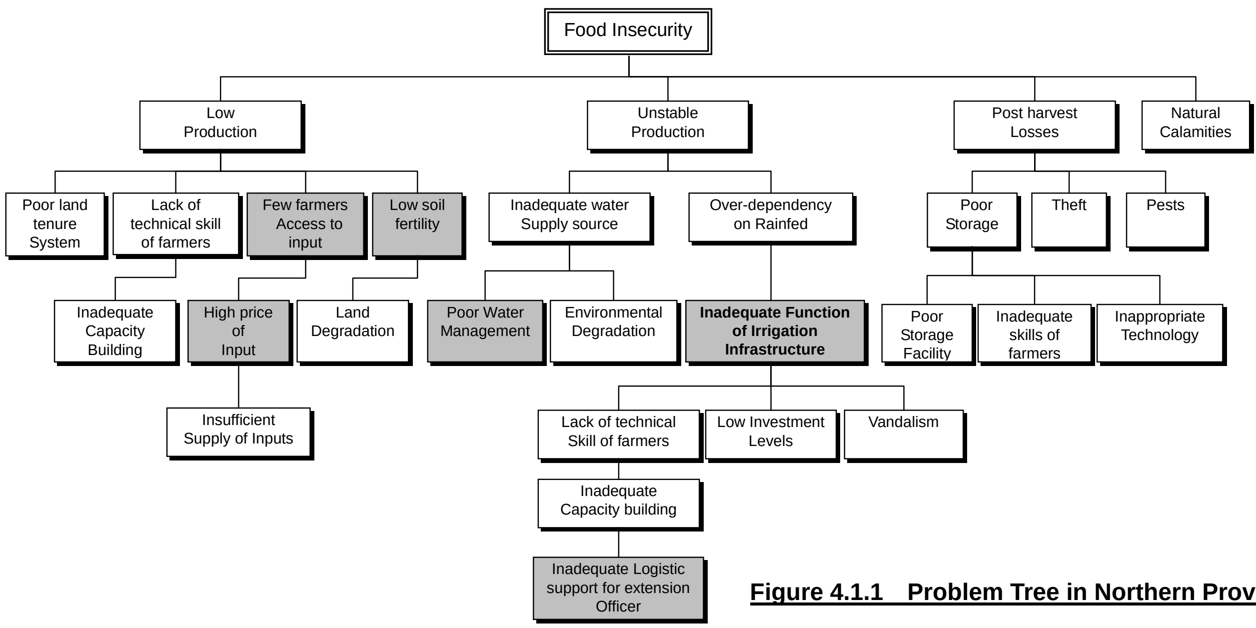


Figure 4.1.1 Problem Tree in Northern Province

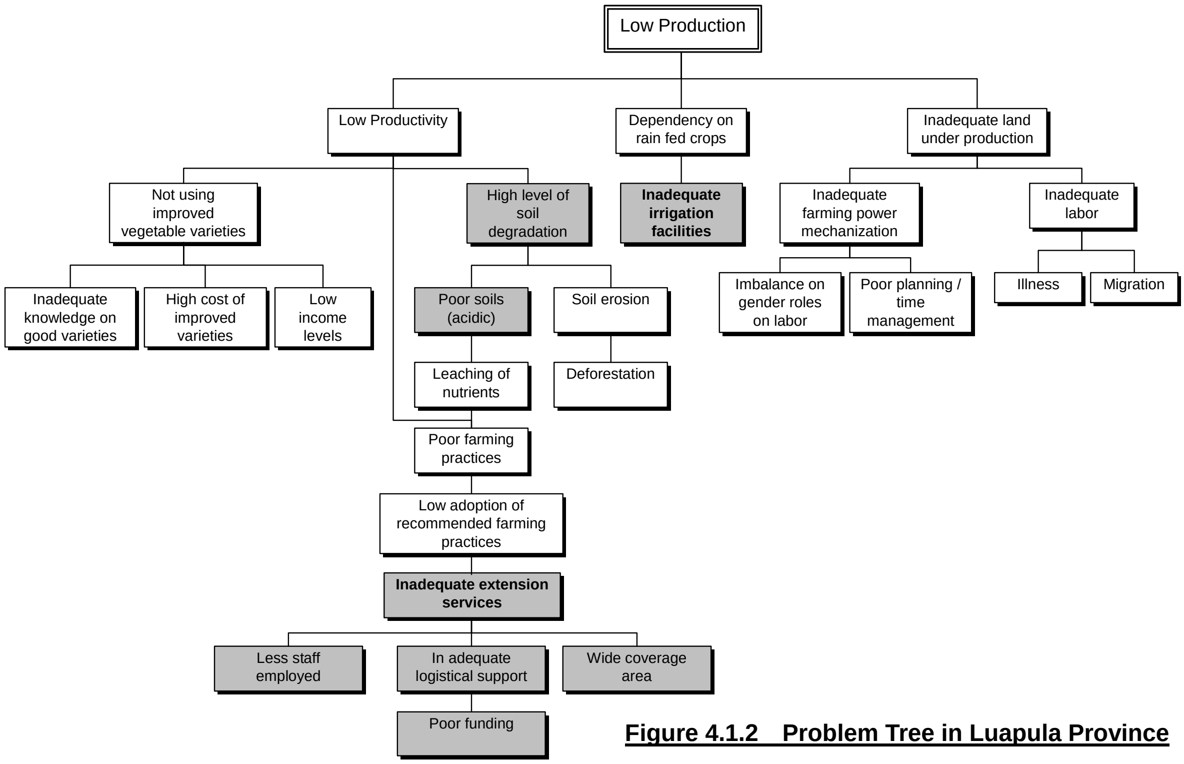


Figure 4.1.2 Problem Tree in Luapula Province

4.2 Issues Identified at Village Level Workshop

During phase 1 survey in 2009, the JICA Study Team, together with counterparts, has carried out a series of village level workshop at six villages where we employed several tools to identify problems they are facing and also to know how irrigation development could improve their livelihood. One of the tools employed was PCM problem analysis, identifying causes and effects of the problems facing the villagers. Core problem used in the workshop was “life is not easy in ‘XXX village”. With this sort of broad core problem, they identified several issues facing them, and thereby we could find to what extent smallholder irrigation could contribute to.

Table 4.2.1 summarizes the problems identified in the six villages, and also Figure 4.2.1 – Figure 4.2.6 show the cause-effect relationship of the problems they are facing, with priority issues marked with No.1, No.2, and No.3. From this table and figures, following are found:

1) Out of six villages, three villages were identified ‘no community canal’, ‘not enough water for agriculture’, or ‘cannot cultivate in dry season (due to no-existence of canal)’ as the top problem they are facing, leading to the core problem of ‘life is not easy’. Though the rest of three villages did not identified irrigation related issue(s) as one of top three problems, one can find out it when going down to the tree structures either under ‘low crop production’, ‘cannot cultivate in dry season’, or else (see Figures 4.2.1 – 4.2.6).

2) In fact, looking at frequency of the problems across villages (see the middle and bottom rows of Table 4.2.1), all the six villages identified ‘no community canal/furrow’ as one of their problems, at least occupying a position in the problem trees. Likewise, ‘not enough water for agriculture’ and ‘no crops in dry season’ were identified in two villages each (refer to lower middle rows of the Table 4.2.1), which are also related to no-existence of irrigation facilities in their villages.

3) The villagers might have been shaped by the introduction that the JICA Study Team made, saying we came here to explore a possibility of promoting smallholder irrigation development. The Team

had to state why we were in their villages clearly otherwise ambitious request could have come. However, above identification could tell us that there was at least a driving factor in the villages to promote smallholder irrigation development. All the villages found irrigation related issues as one of their problems or a cause of bearing broader issues like low crop production, hunger, not-enough food, etc. Therefore, from this point of view, we can say that smallholder irrigation development can meet one of what they need, so-called felt-need.

4) Two villages, Lunda and Molwani, identified ‘chemical fertilizer issue’ as one of top three problems. In addition, from the frequencies shown below the three top problems, we can know all the villages identified ‘input’, that is chemical fertilizer, as one of their problems. In fact, high price of chemical fertilizer has been almost always highlighted when the JICA Study Team interviewed rural farmers. Without subsidy, it is true for ordinary farmers not be able to access the fertilizer costing them as high as ZMK 250,000 per 50 kg bag (about US$50 per 50kg bag vs. 1/4 of the cost under subsidy as of 2008/09 rainy season).

5) Low soil fertility was identified in 5 villages, though it was not included in the top 3 prioritized problems. As it is well known, acid soils extend over Northern and Luapula provinces where they face difficulty of boosting crop production without measures of neutralizing the soil acidity. *Chitemene*, slash and burn cultivation, is still widely practiced in these areas, which can replenish ash into the soil thereby mitigating the acidity. This cultivation, however, gives certain negative impact on natural environment and also Saise village identified it is becoming difficult of continuing *Chitemene* due to population increase.

6) Market related issue was identified as the 3rd top problem by Molwani village and also another 3 villages found it as one of their problems. There are villages to which middle men/ traders come to fetch their products, but in that case at a discounted price. Most of the villagers have to ferry their products far up to a market available at towns. Most of the transportation they use is bicycle. It is quite common, according to interviews, to take over 2 hours to ferry their products to the market, spending over 4 hours per day for the round trip. Population density is quite low in the Study area and in Zambia at large. This situation works negatively from the view point of marketing their products.

7) Other problems identified by as many as 4 villages are; seeds, low crop production, hunger/not-enough food, livestock, and clinic/health center far away. Since most of the villages are located deep in rural areas, they have difficulty of accessing quality seeds unless they come to a township area where they can find agriculture shop. ‘Low crop production’ was the top problem for Chipapa and Saise villages. Including ‘hunger/not-enough food’ is associated with low soil fertility, high price of chemical fertilizer, and drought and flood. Note that in these areas flood can be a very natural calamity, resulting in no-crop production, rather than drought. Livestock issue was related to poultry and pig rearing; not enough feed, many diseases, etc. ‘Clinic is far away’ was the 3rd priority problem for the 2 villages of Lunda and Saise.

8) Problems listed by 3 villages are; weeding, population increase, no hummer mill nearby, and thefts. Theft was once identified in the kick-off workshop for officers as one of post-harvest losses. Problems recognized by 2 villages are; ‘not enough water for agriculture’ and ‘no crops in dry season’ as aforementioned, ‘limited farm land’, ‘not diversified crop’, ‘late cultivation’, ‘not much knowledge (on land), ‘no oxen’, ‘low income’, ‘poor road’, ‘no electricity’, and ‘schools are far’. ‘Limited farm land’ does not mean their lands are psychically very small, but it is rendered in the fact that due to lack of chemical fertilizer they cannot expand their cultivation and also it means that the land available for *Chitemene* cultivation, which requires extensive area, is limited.

Table 4.2.1 Problems Identified at Six Villages in Northern Province

Village	Lunda	Molwani	Kalemba Chiti	Chipapa	Saise	Mayanga
District	**Kasama**	**Kasama**	**Mungwi**	**Mungwi**	**Mbala**	**Mbala**
No.1 Problem	**No community canal.**	**Not enough water for agriculture.**	Maize production is low.	Crop production is low.	Crop yield is low.	**Cannot cultivate in dry season.**
No.2 Problem	Cannot buy fertilizer.	Cannot buy fertilizer.	Difficult to transport prod'ts.	Livestock production is low.	No. of livestock is decreased.	Farm mg't is poor.
No.3 Problem	Clinic is far away.	Cannot sell produce at high price.	Pig rearing is decreased.	Cannot get enough crop.	Clinic is far away.	Do not have work oxen.
Frequencies						
Input (fertilizer)	X	X	X	X	X	X
No community canal/furrow	X	X	X	X	X	X
Low soil fertility	X		X	X	X	X
Seeds			X	X	X	X
Market	X	X		X		X
Low crop production			X	X	X	X
Hunger/ not enough food	X		X		X	X
Livestock		X	X	X	X	
Clinic/H.C. far	X	X			X	X
Weeding			X	X		X
Population increased		X		X	X	
No grinding mill	X	X	X			
Many thefts	X		X	X		
Not enough water for agr.		X	X			
No crops in dry season					X	X
Limited Farm lands			X		X	
Not diversified crops		X			X	
Late cultivation				X	X	
Not much knowledge	X			X		
No oxen		X				X
Low income			X			X
Poor roads			X			X
No electricity	X					X
Schools far	X	X				

Source: JICA Study Team, based on village level workshop held in April-June 2009

A village workshop, now carrying out problem analysis (about 130 villagers participated)

After a group work, representatives of the group are sharing their work results with the participants.

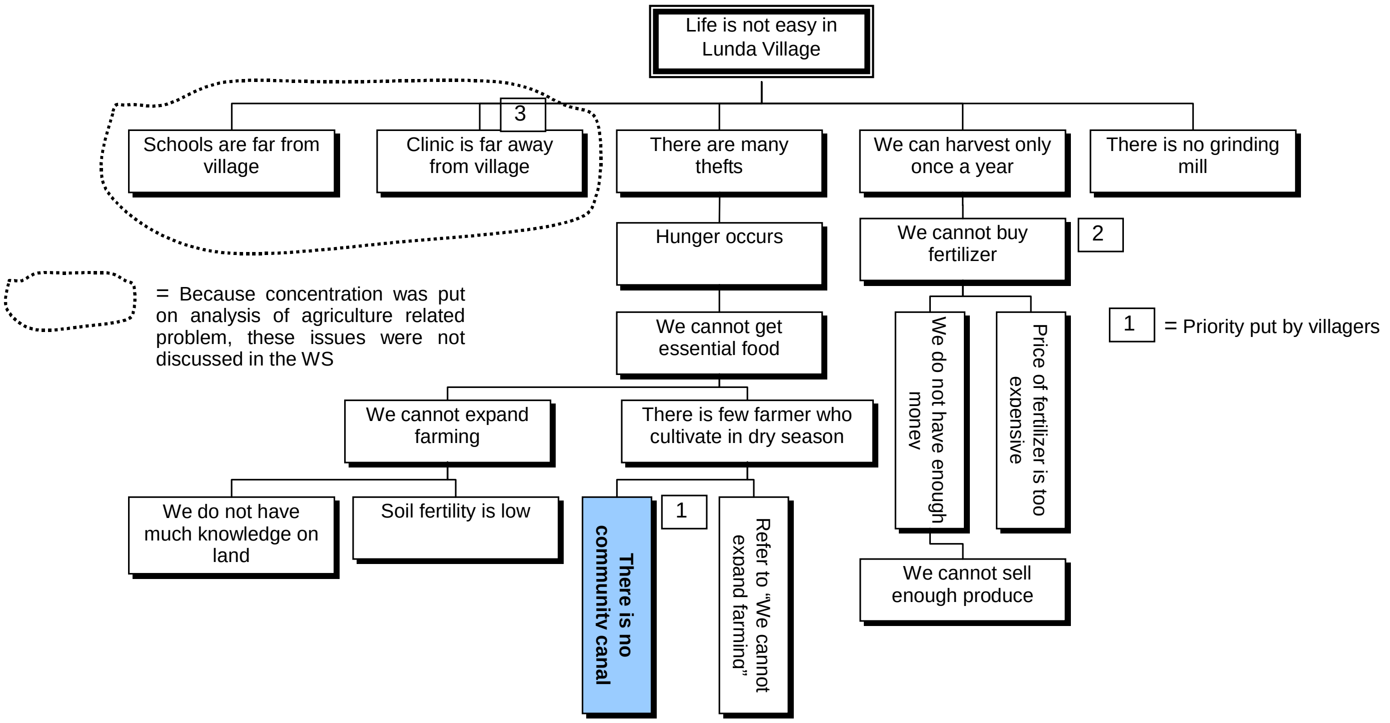


Figure 4.2.1 Problems Analysis Carried out in Lunda Village, Kasama D. Northern P.

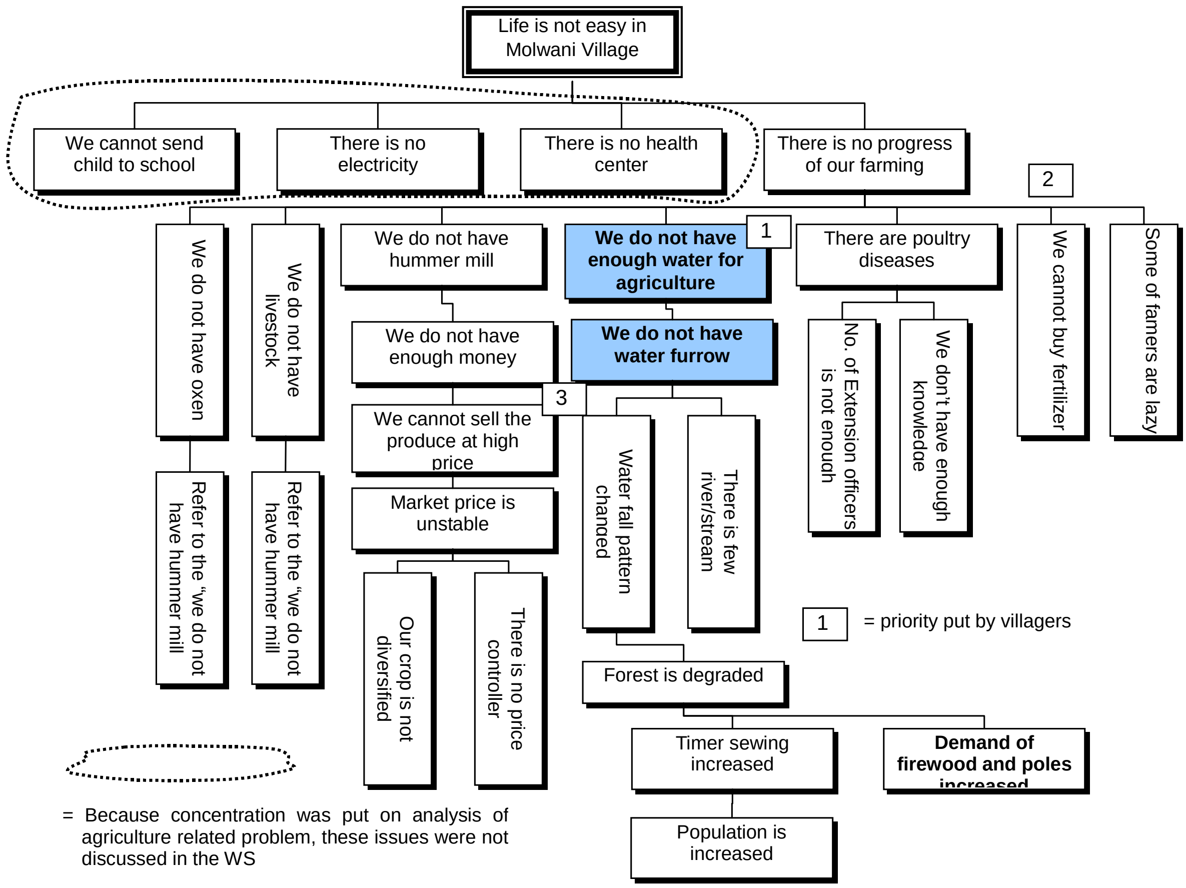


Figure 4.2.2 Problems Analysis Carried out in Molwani Village, Kasama D. Northern P.

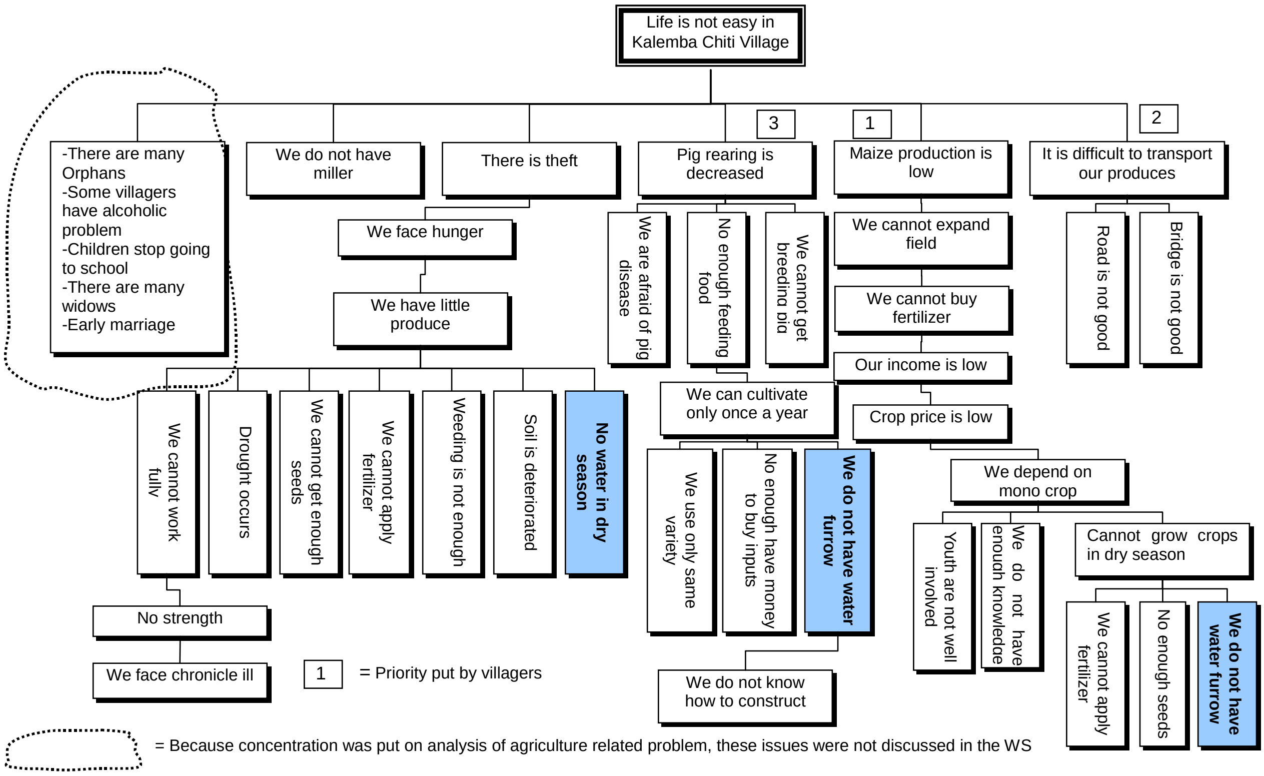


Figure 4.2.3 Problems Analysis Carried out in Kalemba Chiti Village, Mungwi D. Northern P.

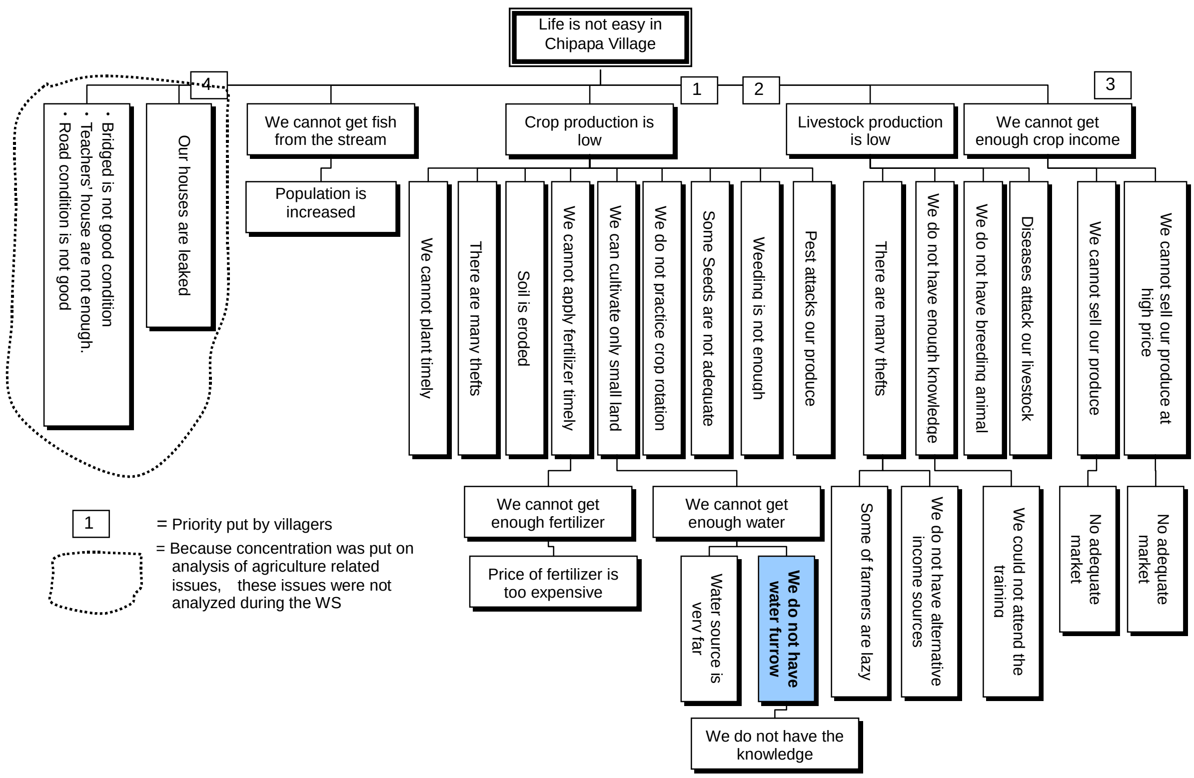


Figure 4.2.4 Problems Analysis Carried out in Chipapa Village, Mungwi D. Northern P.

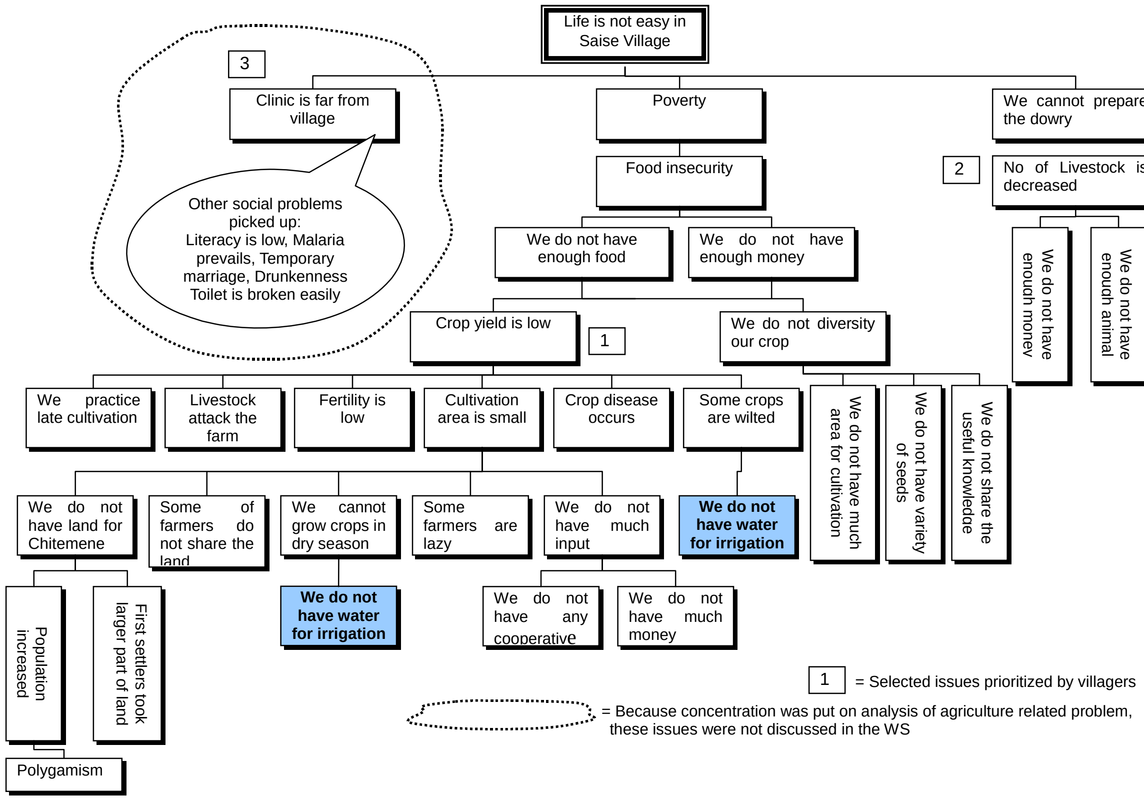


Figure 4.2.5 Problems Analysis Carried out in Saise Village, Mbala D. Northern P.

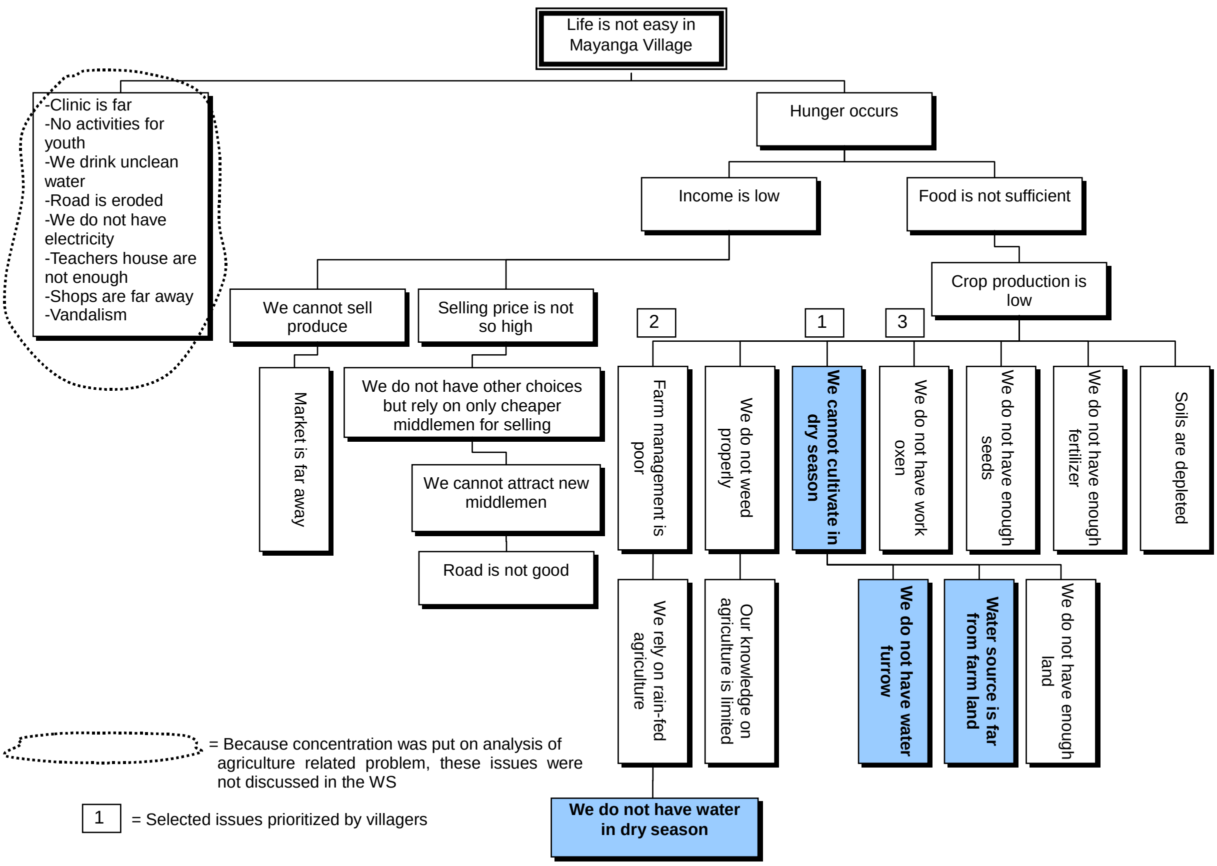


Figure 4.2.6 Problems Analysis Carried out in Mauanga Village, Mbala D. Northern P.

4.3 Development Constraints

In this sub-chapter, development constrains are to be examined, which should be referred to in planning the smallholder irrigation development as well as to present measures of how to tackle them. The constraints elaborated below are, for example, large area coverage in agriculture extension, shortage of technical staff in irrigation development, high cost of input (fertilizer), and subsistence allowance vs. mobility.

4.3.1 Large Area Coverage in Agriculture Extension

In agricultural extension activities, the biggest challenge is outreach. As shown in Table 4.3.1, a total of 230 CEOs are assigned in Northern province as of mid 2009: 19 CEOs per district on average. In Luapula province, on the other hand, a total of 136, 19 CEOs per district are assigned. Excluding those who are stationed in the district office (number shown in parenthesis in the table), occupancy rate of camps is 93% in Northern and 81% in Luapula provinces with the overall rate of the 2 provinces being 88%.

As a matter of fact, after having reached the HIPC completion point in 2004, the government, MACO, started recruiting extension officers. An example can be seen in the participants who came to kick-off trainings for pilot project implementation held in year 2009 and year 2010. The year of service was less than or equal to 5 years for almost or more than half of the participants (49% in 2009 and 62% in 2010 respectively). This suggests that many extension officers were recruited recently. Thus the number of CEOs has far increased recently, however they are still somewhat junior in their experiences. Also noted is that number of BEOs, who should be senior than CEOs, is still at a low level especially in Northern province. In those areas where no BEO is assigned, an active or senior CEO has to operate as the acting BEO.

Table 4.3.1 Number of BEOs and CEOs Per District (as at June 2009)

District	No. of Blocks	BEO	Ratio	No. of Camps	CEO (at District)		Ratio	BEO+CEO	Motor-bikes
Chilubi	3	1	33%	9	9	(1)	89%	10	3
Chinsali	5	(4)	(80%)	32	30		94%	30	0
Isoka	5	0	0%	24	24		100%	24	12
Kaputa	2	1	50%	10	10		100%	11	0
Kasama	4	0	0%	26	26		100%	26	13
Luwingu	5	(5)	(100%)	16	11		69%	11	3
Mbala	4	4	100%	18	18		100%	22	6
Mpika	6	1	17%	34	38	(4)	100%	39	24
Mporokoso	4	4	100%	26	24		92%	28	4
Mpulungu	3	0	0%	15	9		60%	9	2
Mungwi	4	2	50%	22	21		95%	23	10
Nakonde	3	(3)	(100%)	10	10		100%	10	0
Northern Total	48	13	**48%**	242	230	(5)	93%	243	77 (32%)
Chienge	4	(4)	100%	11	9		82%	9	3
Kawambwa	7	7	100%	37	16		43%	23	3
Mansa	7	7	100%	43	37		86%	44	12
Milenge	0	0	N/A	13	13		100%	13	3/5 bikes
Mwense	5	5	100%	24	24		100%	29	0/3
Nchelenge	3	3	100%	15	12		80%	15	0/2
Samfya	0	0	N/A	25	25		100%	25	5/10 bikes
Luapula Total	26	22	85%	168	136	(0)	81%	158	26 (16%)
Grand Total	**74**	**35**	**47%**	**410**	**366**	**(5)**	**88%**	**401**	**103 (26%)**

Source: TSB at each district

Note/ Parenthesis in the column of BEO indicate the number of CEOs who take care of the block instead of BEOs.

Ratio of number of CEO to number of camps excludes the ones who are stationed in district office.

Number of motorbike does not include the ones that are not functional at all.

The mode of transport for BEOs and CEOs is supposed to be motorbike taking into account the wide coverage of area, but it is not always the case. Donor supporting projects, e.g. ASP and PaViDIA, have so far provided motorbike to the participating extension officers, and the government is also procuring motorbikes at a national level[1]. However, as of mid 2009, there are total 103 motorbikes as against total number of 401 BEOs/CEOs (see the most right column of Table 4.3.1). This means one out of four extension officers is narrowly provided with motorbike, otherwise the rest has to operate by borrowing it from colleagues, or on foot or by bicycle.

Table 4.3.2 explores how many rural household CEOs have to deal with and how much extended area they have to cover. Average numbers of rural households that a CEO has to take care of are estimated at as many as 1,301 households and 1,398 households in Northern and Luapula provinces respectively. Though not all the rural households are engaged in farming, one may see it is practically impossible for CEOs to take care of all their clientele farmers.

As such, area that has to be covered by a CEO is also extended very much. Coverage area of one CEO is estimated at around 657 km^2 (or 611 km^2 per camp) in Northern province and 372 km^2 (or 301 km^2 per camp) in Luapula province, arriving at an average coverage area of 550 km^2 per CEO (or 484 km^2 per camp) for the 2 provinces. These coverage areas are geographically equivalent to 26 km square (25 km square per camp) and 19 km square (17 km square per camp) respectively, arriving at an overall coverage area of 23 km square (22 km square per camp).

Table 4.3.2 Rural Population and Household to be Covered by CEO as at June 2009

District	No. of CEOs*	Rural Population 2009	Rural Household 2009	Land Area (km^2)	Per CEO			
					Rural Pop.	Rural HH	Land Area, km^2	Square (km)
Chilubi	8	90,155	19,490	4,648	11,269	2,436	581	24
Chinsali	30	162,446	31,914	15,395	5,415	1,064	513	23
Isoka	24	104,044	20,137	9,225	4,335	839	384	20
Kaputa	10	131,680	27,956	13,004	13,168	2,796	1,300	36
Kasama	26	127,260	26,073	10,788	4,895	1,003	415	20
Luwingu	11	83,157	17,378	8,892	7,560	1,580	808	28
Mbala	18	173,141	35,390	8,343	9,619	1,966	464	22
Mpika	34	140,055	28,766	40,935	4,119	846	1,204	35
Mporokoso	24	92,572	18,654	12,043	3,857	777	502	22
Mpulungu	9	87,808	18,791	9,865	9,756	2,088	1,096	33
Mungwi	21	154,952	33,398	9,766	7,379	1,590	465	22
Nakonde	10	95,292	19,411	4,621	9,529	1,941	462	21
Northern Total	225	1,423,621	292,808	147,826	6,327	1,301	657	26
Chiengi	9	140,421	31,294	3,965	15,602	3,477	441	21
Kawambwa	16	100,156	20,960	9,303	6,260	1,310	581	24
Mansa	37	182,546	37,204	9,900	4,934	1,006	268	16
Milengi	13	39,926	7,991	6,261	3,071	615	482	22
Mwense	24	122,908	26,434	6,718	5,121	1,101	280	17
Nchelenge	12	132,061	28,962	4,090	11,005	2,414	341	18
Samfya	25	192,151	41,219	10,329	7,686	1,649	413	20
Luapula Total	136	895,154	190,193	50,567	6,582	1,398	372	19
Grand Total	**361**	**2,318,775**	**483,001**	**198,393**	**6,423**	**1,338**	**550**	**23**

Note: * Exclusive of the ones assigned in district office
Rural household is estimated based on the estimated population (2009, refer to Table 3.2.1) and number of members per household in 2000 (National Census 2000).

Considering the fact that villages and individual households are scattered in the rural area, it is absolutely challenging for the CEOs to interact with farmers in the every corner of the camp. What makes it more difficult is the lack of, or delay of, funding for the transportation arrangement. On

[1] As an example, Northern province has received total 4 motorbikes in 2009 for the extension work of BEOs/CEOs.

average one out of every four extension officers has now motorcycle as aforementioned, meaning that the majority of CEOs yet to have such devise. Although specific data are not available, the majority of CEOs are equipped only with bicycle or just no means of transportation. To deal with this situation, CEOs often borrow motorcycle from their colleagues within the district.

Furthermore, outreach is not an easily task even for those who have motorcycle. BEOs/CEOs are often given a very limited, if not at all, funding for fuel or spare parts. Therefore, their extension activities repeatedly get stuck or they have to bear the cost by themselves unless they are given special funding from the donors as ASP had provided as much as 20 litters per month for each CEO.

By 2008, budget for CEOs' activities was treated as a part of whole budget of the district. In this system, DACO had a full authority and responsibility in the allocation of the district budget. Therefore, if CEOs' activities were not given higher priority among other items, or if there were other necessary expenditures in the district, DACO would not allocate enough funding for BEOs/CEOs' fuel cost. Therefore, lack or delay of budget had been a chronic constraint for the extension work of BEOs/CEOs.

Fortunately, the funding mechanism at the district level was amended in early 2009 and the budget became to be earmarked as "activity-based budget." Now, CEOs are supposed to receive full entitlements they bear. In fact, this system has been in place since before but the budget allocated to this item was so much limited and thus this budget was not practically recognized as a real activity budget. However, it became significant in 2009. For example, in Northern province, average budget for pure extension operation, exclusive of infrastructural arrangement, was ZMK 96,000/month/peson in 2008; it increased to ZMK 1,126,000/month/person. Although not full amount of budget is usually disbursed, this change of official budget is quite in favor of the activities of CEOs and BEOs[2].

4.3.2 Difficulty for BEOs/CEOs to Meet at Plenary

In principle, BEOs/CEOs are supposed to meet quarterly. However, in reality, it is often once a year for CEOs to meet as plenary unless they have special occasions. Although BEOs are, reportedly, meeting as planned, the lack of meeting opportunity makes them difficult to communicate each other and to exchange up-dated information. As a result, it is rarely possible to organize peer-to-peer training opportunity. For example, a BEO did not see one CEO out of seven in his block in Mbala district for a year. He met another CEO only two times in a year 2008, that is, he has only four to five CEOs meeting on regular basis. On top of that, CEOs are supposed to submit a monthly report to the BEO in person or by consignment; however, there are some CEOs who do not regularly submit his/her report.

Beside, the capacity building of BEOs/CEOs themselves is also a handful task. In general, CEOs are given supervision from SAO and technical support from the subject matter officers in each technical branch of the district or the province, including TSB officer in charge of irrigation. However, it is only once a year that BEOs and CEOs have an assemble meeting with technical officers, implying a very limited number of opportunity wherein they can share what they are doing and learning what others are doing. Even during the pilot project implementation under this Study, training of CEOs through peer-to-peer training has not worked fast as it was hoped; on average, a CEO could train only three fellows and 2 fellows per TOT in 2009 season and in 2010 season respectively.

The findings suggest that CEOs can organize Training of Trainers (TOT) only to neighboring officers by inviting them to his/her own site. As shown in Table 4.3.3, on average 2.9 officers per one time of TOT were actually trained by fellow BEOs/CEOs during the pilot project of year 2009 and 2.0 fellows

[2] Yet, they still face a lot case of delays: some complained that they have not received any Kwacha since the beginning of the second quarters of year 2009 by July 2009. Still, some CEOs need to make advancement on the disbursement of fuel cost and are worried about the future.

only in 2010. In Mungwi and Mporokoso, specifically, TOTs were organized at district level in 2009 when they had an opportunity of quarterly meeting. However, for other districts, CEOs were able to train only around two fellows in one time, implying the limitation of TOT as a modality of capacity development.

Table 4.3.3 Number of TOTs held during the Pilot Project Implementation in 2009 and 2010

District	In 2009 Pilot Project			In 2010 Pilot Project		
	No. of TOT	No. of CEO/BEO Participated	Participants Per TOT	No. of TOT	No. of CEO/BEO Participated	Participants Per TOT
Kasama	2	2	1.0	13	17	1.3
Mbala	10	13	1.3	4	33	8.3
Mpika	6	10	1.7	8	13	1.6
Mporokoso	3	25	8.3	9	10	1.1
Mungwi	6	36	6.0	7	19	2.7
Luwingu	3	7	2.3	6	6	1.0
Nakonde	NA	NA	NA	2	18	9.0
Isoka	NA	NA	NA	4	11	2.8
Sub-total	30	93	3.1	53	127	2.4
Mansa	15	36	2.4	10	11	1.1
Kawambwa	0	0	-	10	11	1.1
Milenge	NA	NA	NA	5	9	1.8
Nchelenge	NA	NA	NA	3	9	3.0
Mwense	NA	NA	NA	7	13	1.9
Sub-total	15	36	2.4	35	53	1.5
Grand Total	45	129	2.9	88	180	2.0

Source: JICA Study Team (2009). Based on the report from each district during pilot project implantation.

4.3.3 Shortage of Technical Staff in Irrigation Development

Acute shortage of technical staff in irrigation sector is one of critical constraints in pursuing smallholder irrigation development. In fact, dominant present practice in promoting smallholder irrigation is a sort of 'direct force account' whereby TSB is in charge of all the technical services starting from survey of the area, then designing of the required structures, aligning of the canal/pipes, preparation and procurement of foreign construction materials such as cement and iron bars, and also supervision of the construction work.

Almost all the construction works in smallholder irrigation development do not engage civil contractor, rather are carried out by direct force account participated by the beneficiary farmers. Beneficiary farmers are required to provide whatever available in and around the construction site, e.g. sand and gravels/cobbles for concrete work. As for labour force, skilled labors such as masonries and carpenters are recruited in and around the village and paid according to the prevalent wage rate while unskilled labour forces are to come from the beneficiary farmers voluntarily.

In some cases, however, unskilled labours are paid with a minimum level of payment, in most cases equivalent to the government official minimum wage (ZMK9,400 as of mid 2009) or alike. This case where participating farmers are paid often takes place in a site which requires a long construction period, say more than 1 month like earth dam construction. Typical example for it is an earth dam constructed within Mansa Resettlement Scheme. Approximately 100 farmers had been paid official minimum wage during the construction period that needed as long as 7 months. Otherwise, payment for pre-agreed days would sometimes apply, say days for 1 – 2 week are to be paid, meant for providing startup capital for irrigated agriculture.

Though organizing and mobilizing of the relevant farmers are the task of CEOs, in any case of above examples TSB officers should play the major role in technical matters including the supervision of the construction. This implies even if there are a lot of potential sites to develop a permanent structure, one technical officer may be able to manage only one to maximum two sites per season. So-called engineering preparatory work alone, e.g. identification of the specific diversion site, topographic survey, and designing and billing of quantities, shall need at least more than two months though it very much depends on the size of the irrigation scheme envisaged. Including the period of construction would easily stretch out to the end of the dry season, though again dependent on the size of the scheme.

Table 4.3.3 below summarizes the TSB officers at different cadres. Looking at the above part of the table, one may see there are 63 staff in the irrigation section of the TSB in total. In fact, there are as many as 72 district offices aside from 9 provincial ones over Zambia. Though some of the districts may not need to develop irrigation, this comparison simply indicates that not all the districts countrywide can be allocated with TSB staff in irrigation. In addition, such cadres from chief irrigation engineer to principal technical officer are degree holders specialized in irrigation or agricultural engineering. They are however only 22 over the Country.

Table 4.3.4 Approved Staffing for Irrigation Engineering Section under TSB

Order	Title of the Cadre	Posted	Remarks
1	Chief Irrigation Engineer	1	as of June 2007
2	Senior Irrigation Engineer	3	ditto
3	Irrigation engineer	15	ditto
4	Chief Technical Officer	1	ditto
5	Principal Technical Officer	2	Total 22 for above, ditto
6	Senior Technical Officer	7	ditto
7	Technical Officer	17	ditto
8	Junior Technical Officer	17	ditto
Total in the Country		63	ditto
Place	**Offices**		
1	Headquarters	2	Excluding the deputy director of TSB
2	TSB at Northern province	6 (1), 1/	Including Land Husbandry & FPM
3	TSB Luapula province	6 (1), 1/	Including Land Husbandry & FPM
4	TSB at districts in Northern province	2.8	Average/ district
5	TSB at district in Luapula province	2.0	Average/ district

Source: For the staff numbers by title of the cadre, paper presented to JICA Preparatory Team, June 2007. For the number of staff at different levels of offices, directly interviewed as of July 2009.
1/; Although there are six officers at each of the two provinces, officer with the educational background of irrigation/ agricultural engineering is only one each, and others are in general agriculture.

Staffing by office, as shown in the lower part of the table, indicates there are only 2 irrigation officers at the TSB headquarters as of July 2009, and six each in the two provinces of Northern and Luapula. In fact, officer specialized in irrigation at the provincial level is only one each, and others either fall in the different sections of the TSB such as land husbandry and farm power and mechanization, or otherwise they are technical/junior technical officers educated in general agriculture who work across the sections under the TSB[3]. At the district level, as far as the Study area is concerned or alike nationwide, there are only 2 – 3 TSB officers, who should undertake not only irrigation but also land husbandry as well as farm power and mechanization. Officers of district TSBs are not specialized in irrigation but in most cases in general agriculture.

If they intend to put up simple diversion structures instead of permanent one, they may develop more than 10 sites per district in a season provided that the CEOs are well engaged in the development with the district and provincial officers as back-stopper. However, taking above staffing into account, if the intended irrigation structure is of permanent, a typical district can probably manage only 1 to

[3] At the headquarters, the TSB is divided into 3 sections administratively and technically as Irrigation, Land Husbandry and Farm Power and Mechanization. However, TSBs at provincial level and district level do not have administratively divided sections, not like the headquarters, but they should undertake the 3 areas of irrigation, land husbandry and farm power and mechanization.

maximum, say, 2 sites to be developed in a dry season as far as it is constructed by direct force account.

To cope with this situation, simple construction method for permanent facilities should be explored wherein even CEOs can be in the supervisory position of permanent facilities' construction, e.g. use of alternative formwork instead of timber by means of bricks, gabion walls, etc. With the CEOs undertaking major construction process, district TSB officers may manage several construction sites. However, in any case, current minimum level of staffing could definitely be one of critical elements if the government intends to develop permanent irrigation structures at an extended scale.

4.3.4 High Cost of Input

The cost of fertilizer stands as a primary constraint for smallholder farmers. It is significant for the farmers who produce hybrid maize that inherently requires an intensive application of the fertilizer. It is a common observation that farmers in the Study area cultivate as much land for maize as they can purchase the fertilizer for. In Zambia, spending on the importation of chemical fertilizer continued to increase during 1999 to 2004. As shown in Figure 4.3.1, the spending in 1999 accounted as much as ZMK 80 billion, or US$ 33 million, and it became ZMK 393 billion, or US$ 82 million, by 2004.

This trend can be partly explained by the increase in the amount of chemical fertilizer imported. As seen in Figure 4.3.2, imported quantity of urea had increased constantly from 2002 to 2004 and it once decreased in 2005-06, as corresponding to Figure 4.3.1. Although data on spending on the importation after 2005 is not available, it must have increased as the quantity of imported urea has shown a big increase in 2007. This consequence suggests that the spending on importation is a big burden for Zambia. Still, imported quantity of urea is accounted for around 160 kg/ha, which is less than recommended amount for maize under FSP/FISP: 200kg/ha of urea in addition to 200kg/ha of D compound. Considering the use of urea for other crops, urea does not seem to be enough for maize production.

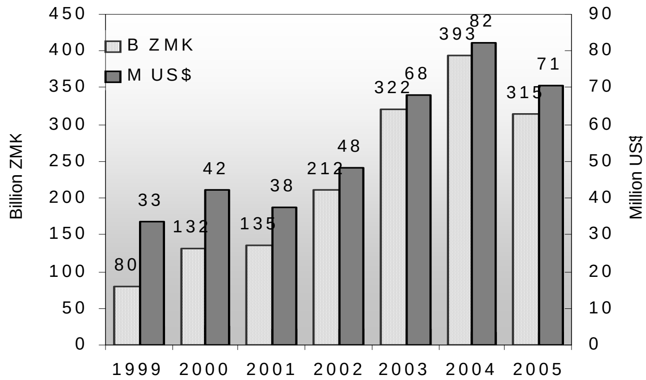


Figure 4.3.1 Spending on the Importation of Chemical Fertilizer
Source: Value; Central Statistic Office (2009)/ Exchange rate; USDA.
Note: CIF (Cost, Insurance, and Freight) value

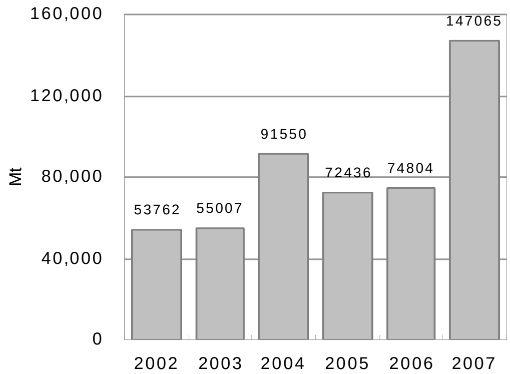


Figure 4.3.2 Urea Imported (tons)
Source: FAOSTAT (2009).

Market price of chemical fertilizer is another critical factor which influences agricultural condition of the country. In general, market price of chemical fertilizer has skyrocketed in the past several years. As shown in Figure 4.3.3 (left figure), price of D-compound, with a composition of N:P:K=10:20:10, increased from ZMK 18,000/50kg in 2001 to ZMK 250,000/50kg in 2009; it became more than 13 times during the 8 years. In fact, looking at the inflation adjusted price of the same commodity that is equivalent to the 2001 value (right figure), price actually remained almost the same from 2001 until 2006. Then, it was doubled in 2007 and also tripled for the years of 2008 and 2009. This sudden and big increase may have originated in the significant increase in the world oil price. As a consequence, Zambian farmers, as a whole, are now facing the most difficult time they have ever experienced.

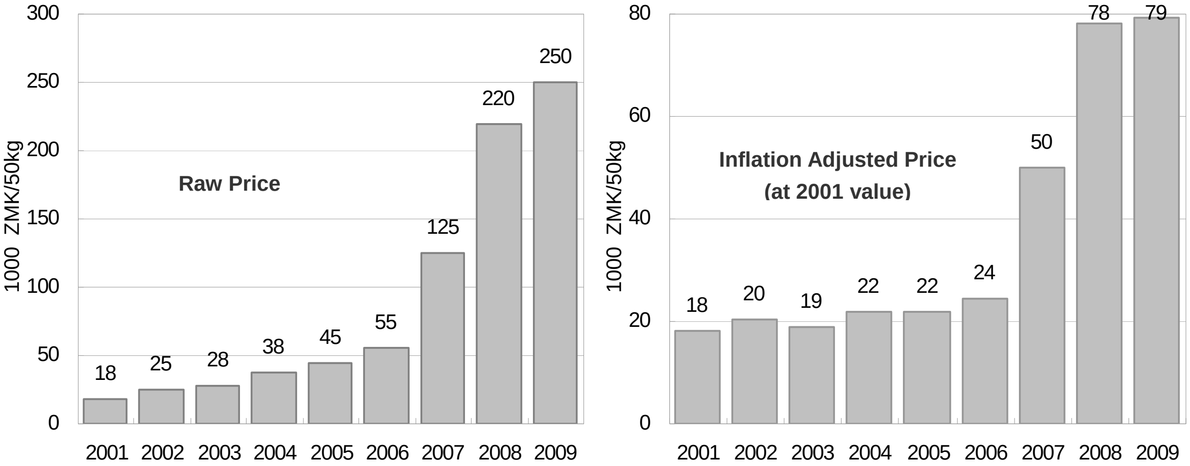


Figure 4.3.3 Market Price of Chemical Fertilizer (D-compound) in Kasama

Source: Agricultural commodity shop in Kasama town. Price of D-compound (N:P:K=10:20:10).

Table 4.3.5 explores an example of how the farmers nowadays suffer from the magnitude of the fertilizer's price hike. In 2006 when the fertilizer price stayed at ZMK 55,000 per 50kg bag, the ratio of fertilizer cost over gross income from the maize production, where 4 ton/ha is assumed as the yield, consisted of only 14.5 %. On the other hand, the share became as high as 38.5% in 2009 when the fertilizer price increased to ZMK 250,000 per 50kg bag.

Table 4.3.5 Ratio of Fertilizer Cost against Gross Income of Maize per Hector

Item		2006		2009	
		Commercial	FSP/FISP (60%)	Commercial	FSP/FISP (75%)
Fertilizer					
Unit price	ZMK/bag	55,000	22,000	250,000	62,500
Quantity	Bags (50kg)	8	8	8	8
Total	ZMK	440,000	176,000	2,000,000	500,000
Income					
Unit price	ZMK/bag	38,000		65,000	
Quantity	Bags (50kg)	80		80	
Total	ZMK	3,040,000		5,200,000	
Ratio (Fertilizer/Income)		14.5%	5.8%	38.5%	9.6%

Source:
Fertilizer Price: Interview at a commodity shop in Kasama (2009). Quantity of fertilizer: recommended by FSP/FISP.
Selling price of maize: FRA buying price in each year
Percentage of the subsidies in FSP/FISP: FSP Implementation Manual (2008/09).

Under FSP/FISP arrangement, however, quite different view comes up. Under the programme, farmers can access heavily subsidized fertilizer, as 60% subsidized and 74% subsidized in 2006 and 2009 respectively. With this arrangement, the shares of the chemical fertilizer cost against gross income from the maize sold arrive at 5.8% and 9.6% respectively, suggesting large share in net profit. However, expected beneficiaries of FSP/FISP account for about 40% of total rural households as of 2010, notwithstanding nearly 40% of MACO's budget is infused into this programme. When the program was shifted from the FSP to the FISP, the number of bags per a unit of package was reduced from 8 bags/ha/pack to 4 bags/0.5ha/pack so that more farmers could benefit out of same amount of budget.

Given the situation above, Zambian farmers are facing the most difficult time they have ever experienced. Chemical fertilizer would not spare what is valued if they produce conventional food crops only with irrigation. Irrigated agriculture should therefore focus on high valued cash crops which can compensate the high price of chemical fertilizer, or otherwise they would rather stay with rain-fed agriculture. Marketing opportunities should always be examined in this regard.

4.3.5 Subsistence Allowance vs. Incentive

There is a collective agreement between the union of agriculture technical and professional staff and the Government, made on April 2, 2007 with regard to salaries, wages and allowances. As per meal allowance and subsistence allowance for overnight stay, the agreement states as:

1) Meal allowance shall continue to be paid at the rate of ZMK 50,000 per day, and
2) The rates of subsistence allowance shall be paid as follows; ZMK 280,000 for married and ZMK 275,000 for single in case of division III officers wherein most of the BEOs/CEOs fall.

Based on this agreement, not only the frontline officers but also all the cadres' officers claim the meal allowance whenever they go out of their station whereby they miss a lunch at their home. There may be 2 issues pertaining to the meal allowance; namely, 1) there is no definition as to how many hours working in the field can entitle the officers for meal allowance, and 2) the level of the amount itself.

An officer may say that as long as BEOs/CEOs work in their jurisdictional areas they are not entitled for meal allowance regardless that they miss or skip lunch or not. On the other hand, BEOs/CEOs with almost no exception claim lunch allowance whenever they miss lunch. In fact, when we think of an effective extension activity, it may be a bit difficult for the officers as well as for the farmers to finish a session by noon, and may extend to till afternoon, e.g. till 14:00 or even 15:00 hours. In this case, farmers may take late lunch or otherwise skip it by expecting heavy supper. Extension officers, on the other hand, may start claiming the allowance.

Another issue is how much a lunch meal costs them if they take it outside their home. In the capital of Zambia, Lusaka, it may cost us ZMK 50,000 per lunch or even more. However, those who work at fields can hardly find such a restaurant where we have to pay as much as ZMK 50,000 per lunch meal. Restaurants at district centers would not be able to provide lunch more than ZMK 20,000 in most occasions and neither in rural areas.

In essence, meal allowance is an allowance, which should merely substitute lunch, costing us not more than ZMK 20,000 in most cases. Given above situation, however, meal allowance has become an incentive for those officers to work or to discharge their duty. Especially, those officers who work under a project involving donor tend to claim the allowance more as incentive. Such statements were raised during follow up trainings held on November 4 and 5, 2009 and November 16 to 18, 2010 under the pilot project implementation of this Study.

Forty-nine (49) officers and as many as 73 officers participated in the trainings held in 2009 and 2010 respectively. They reported their achievement, difficulties, lessons, etc. from the pilot project implementation in the dry seasons of year 2009 and year 2010. Top most difficulty was always 'logistics' across all the districts engaged. Of the logistics, what came first was 'transportation' as expected and followed by the issue of lunch allowance. The JICA Study Team thinks that as far as they work in their jurisdictional areas like the case of simple diversion scheme development, lunch allowance could be avoided. However, this contradicted what the participants stated.

They in fact developed as many as 94 sites for new simple diversion scheme and improved as many as 100 existing simple sites in 2009 season. About 50 extension officers did this great achievement in just one dry season without, in most cases, being given lunch allowance. In 2010 season, about 80 extension officers improved about 200 existing simple diversion sites and newly constructed about another 200 simple diversion schemes. They have proved they can achieve a great output without it though this issue always hangs, and to some extent their motivation may have been affected.

4.4 Development Opportunities

This sub-chapter identifies and examines development opportunities. Taken well into consideration the development opportunities, the smallholder irrigation development plan will be so formulated that it can work more. Development opportunities, if well undertaken in the plan, would work as driving element which pushes the smallholder irrigation projects/schemes into high performance. The opportunities presented below are rich resources available in the Study area, mobile phone network, radio broadcast programmes, urbanized areas conducive to marketing, and development fund from Poverty Reduction Programme (PRP).

4.4.1 Rich Water Resources

As it is well known, the Study area is blessed with much water resources, e.g., rainfall, streams, lakes and wetlands (*dambos*). As Figure 4.4.1 shows, the precipitation in the Study area is more than 1,000 mm per year and in many places it records more than 1,200 mm. In fact, Kasama station has not recorded any annual precipitation less than 800mm over the last 75 years, and the minimum annual rainfall was still 902 mm recorded in 1952/53. Mansa station in Luapula province shows almost same records as those of Kasama station, and no record of annual precipitation less than 800 mm is found over the last 48 years either. This rich rainfall is contributed from North-east monsoons, North-west rain-bearing winds and also South-east Trades Winds depending on the season.

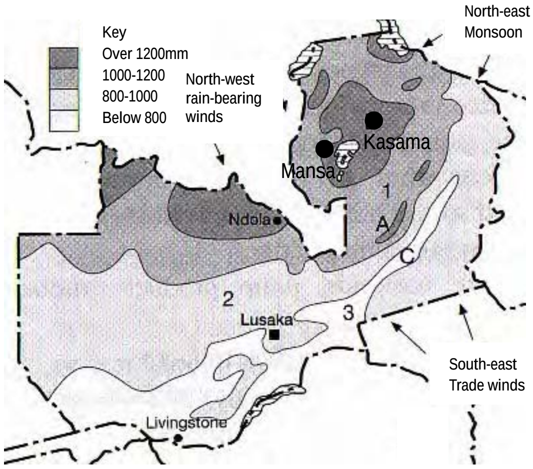


Figure 4.4.1 Rainfall in Zambia
Source: Geography for Zambia, TM Bwalya, MR Naidoo

Given such rich rainfall, the Study area has developed many streams and wetlands. Figure 4.4.2 shows the development of streams in the Study area, originating in upper hilly areas and also in mountainous areas at some places like Mbala and Isoka which are situated in north and north-eastern areas of the Study area. Though the density of the streams cannot be compared with other pars of Zambia, National Water Resources Master Plan (1995, JICA) identified that Luapula province carries the highest surface water resources in terms of cum per day per sq.km. It is 520 cum per day per sq.km and 357 cum per day per sq.km for average year and 10-year drought year, as against the national average of 316 cum per day per sq.km and 181 cum per day per sq.km. Northern province was ranked at 3rd after Luapula province and Lusaka province for average year and 2nd for drought year after Luapula. Northern province still carries 458 cum/day/sq.km and 304 cum/day/sq.km respectively, both of which are much more than those of national averages.

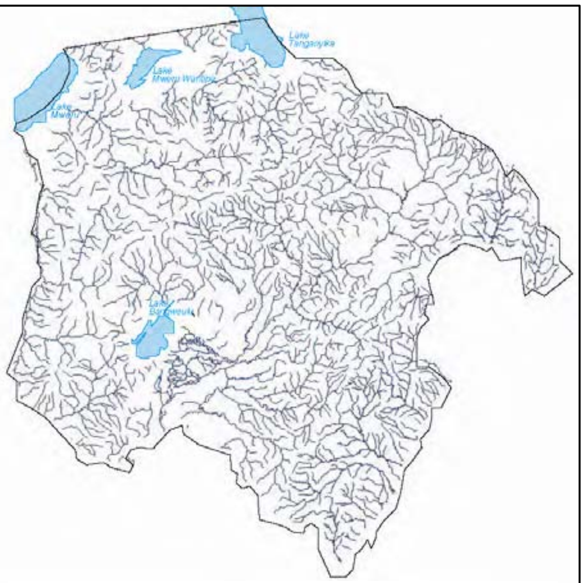


Figure 4.4.2 Rivers Developed in the Study Area
Source: 1:250,000 Map, LANDSAT Images

There are 2 major rivers in the Study area; Chambeshi and Luapula. Though these rivers are too big to divert water for smallholder irrigation development, there are lots of tributaries replenishing the big rivers. In fact, Figure 4.4.2 shows such tributaries only identified from 1:250,000 map and LANDSAT images, and therefore small streams, which could be ideal for smallholder irrigation development, are hardly shown. Field observations recognized that there were a great number of streams to be developed ideal for diverting water for smallholder irrigation purposes. The existence of the well developed streams which are replenished by rich rainfall is the essential development opportunity for smallholder irrigation development.

4.4.2 Mobile Phone Network and Text Messaging in Agriculture Extension

Information and Communication Technology (ICT) is seen as a potential medium in development. In the recent past, radio broadcasting has played and still plays an important role in the dissemination of agriculture-related information to be mentioned in the following session, which includes farming technology, market information, and announcement from the government. When the timing meets, farmers are able to obtain useful information at the marginal cost zero. And today, mobile phone appeared to be a promising technology for the peer-to-peer communication even in the developing countries.

In fact, Africa has been ranked as "the fastest growing mobile phone market in the world with mobile penetration in the region ranging from 30% to 100%[1]" and Zambia is not an exception with a yearly growth rate of 72.5% from the first quarter of 2006 to the first quarter of 2007 (African Mobile Factbook 2008). In effect, all the participants in the kick-off trainings for smallholder irrigation development in 2009 and 2010 were identified as mobile phone user. In addition, surprisingly, a baseline survey carried out by the JICA Study Team in 2009 and 2010 identified that total 166 rural households out of 370 sampled households were mobile phone users, which consists of 44% roughly equivalent to one out of every 2 households being accessible to mobile network.

Based on the observation throughout the phase I study, TSB officers, BEOs/CEOs, and even farmers often communicate one to another through text messaging rather than calling so as to save unnecessary expenses. They use text messaging to arrange an engagement with farmers, request some information, and claim the fuel for their mobility. Now, the text messaging has come to be an essential tool for communication in their daily life.

Accordingly, it is recommended for them to fully utilize the fruit of this technology in agricultural development activities. First of all, as a large number of government officers, though data is not available it can be said nearly about 100% of the officers, seem to have mobile phones, text messaging can be incorporated into the basic and legitimate communication channel for the smallholder irrigation development. This is really one of development opportunities we can relay on in disseminating not only smallholder irrigation but also agricultural extension.

The benefit of using mobile phone as a communication tool can be maximized in Zambia because Zambia, including Northern and Luapula provinces, is one of the countries that maintain the least population density in Sub-Sahara Africa. As one CEO usually covers an area of about 20km square or more, it is rarely available for them to have a face-to-face communication with their fellows. In this circumstance, CEOs tend to work alone and have fewer opportunities to learn from the others or be encouraged by the fellows. Therefore, overcoming a remote communication should be a primary target in the sub-sector of the agricultural extension system.

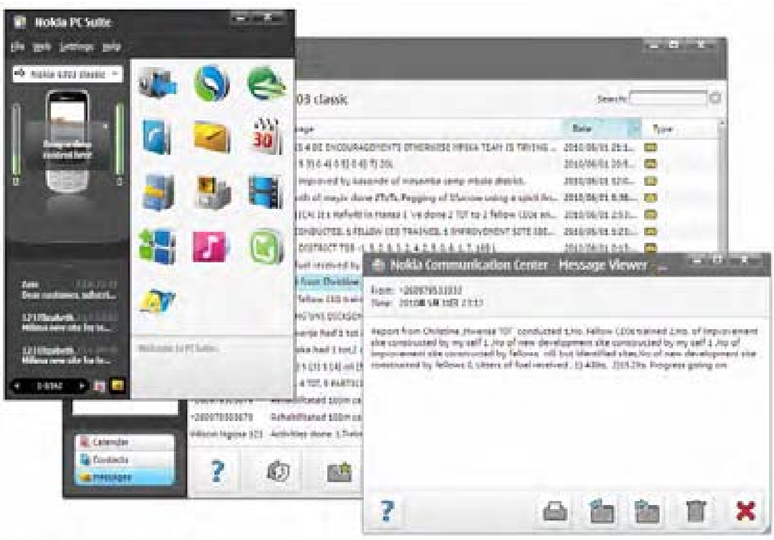
Expected effects of using mobile phone can be summarized as follows:

[1] African Mobile Factbook 2008, available online at http://www.web4dev.org/images/8/8d/Africa_Mobile_Fact_Book_2008.pdf

1) Recipients of the message can see the message anytime when available (different from radio because timing of sending message does not matter);
2) By updating the progress of extension activities, i.e., promotion of smallholder irrigation, of each CEO in the area, competitive consciousness can be stimulated and CEOs can be motivated; and
3) CEOs can receive real-time feedback or advice from supervisors whom they actually know.

Possible constraints are also summarized below:

1) Remote area is often an out of coverage, though receiving of text messaging can become available when they move into the coverage area since the message is stored in the server until it is to reach;
2) Long sentence or complicated description may not be suited as the present Short Message Service (SMS) limits a message with a total of 160 characters per SMS (if there are more than 160 characters, it is charged by how many times of the 160 characters), and also the display of mobile phones are usually not so large to accommodate lots of characters; and
3) CEOs may not be always willing to bear the “airtime” or may fail refilling the “airtime” for a certain period of time.



A software provided by a mobile phone manufacture. The left up interface is the main operation screen and the back one is the incoming and outgoing SMSs, and the left down shows a SMS to be sent to receivers (if the text is over 160 characters, it is double charges according to how many times of the characters to 160.

Fortunately, at present, SMS that enables sending messages to a large number of mobile phone users at once is already in hand in Zambia. There are basically 2 systems for such service; 1) from ordinal mobile phone which however should be connected to a PC and operated from the PC, and 2) through internet service operated again from a PC.

The former service is available for almost all the phones provided that the phone can be connected with PC. A typical software is shown in the picture right (this case shows a software provided by Nokia), with which an operator can send bulk messages from a PC which connects the mobile phone equipped with SMS function. In this case, the charge is same as the unit charge per SMS multiplied with how many receivers are. For example as at November 2010, a SMS within 160 characters costs us ZMK 285. There are about 400 BEOs/CEOs altogether in the 2 provinces as at 2010. If all of them are to receive a SMS once per week during the dry season of year, say 7 months, total SMSs will arrive at 12,000 messages. This incurs about ZMK 3.4 million (equivalent to about US$ 728 with an exchange rate of 4,700 as at early November 2010).

The latter service is shown in the picture below. It is operated on a PC from which bulk message is sent through internet server (it means the system does not need a mobile phone which sends message but requires a PC and internet service). As shown in the picture, operator can send text message by logging in a website and, like sending a web mail, message can be sent to a large number of recipients who are registered in the list. The cost of establishing and operating the system is as follows as at August 2010:

Establishment: US$ 900 with 5,000 SMSs

Purchase of additional SMSs:

5,000 messages x $.065 = $ 325
10,000 messages x $.060 = $ 600
25,000 messages x $.050 = $ 1,250
50,000 messages x $.045 = $ 2,250

If the operator is to send a total of 12,000 messages for a period of 7 months to about 400 BEOs/CEOs, the operating organ is to pay US$ 1,320 (=$900 + $0.06 x 7,000) at the first year, and from the second year onwards it is US$ 600 (=0.05 x 12,000). This cost may not be so expensive by considering the fact that all the BEOs/CEOs in the 2 provinces are bound together through SMS. However, there is a shortfall with this latter service system; it cannot receive any SMS from the receivers but only can send out the SMS (one way communication only).

An example of bulk SMS provided by an internet provider: you can easily send a text message to a large number of mobile phone users at once.

In any case, it is encouraged for MACO to introduce such bulk SMS system to its tail-end officers for more efficient and effective extension. Which system is better may depend on how many receivers are targeted. In case that a great number of receivers are targeted e.g. more than 50,000 messages are planned, it may be better to introduce the latter system otherwise the former system can be recommended, which just utilizes mobile phone system with a PC.

Furthermore, it is anticipated that, in near future, sending electronic money may become available. For instance, it is already in place in the Philippines as of 2009, not just Japan as industrialized one, wherein mobile phone users can send "units (same as airtime in Zamia)" to the other users or even purchase goods by paying a part of the "unit" on the phone. Thus, information and communication technology is a fast-evolving and wide spreading technology.

Even for now, exchanging "airtime" is popular amongst the users in Zambia. They send the code number of scratch card through SMS; air time itself is now like a virtual currency. Moreover, a credit swapping service is already offered and is popular in Mozambique as of 2009. If those services become available in Zambia, the disbursement of ear-tagged budget for particular officers, for example the disbursement of fuel cost to a CEOs, can also be easily managed and monitored at a fewer expense.

4.4.3 Radio Broadcast Programmes

There are four radio programmes which broadcast topics on agriculture and rural livelihood improvement; Radio Farm Forum, Farmers Note Book, Rural Note Book, and Farm Magazine (see Table 4.4.1. below). National Broadcasting Cooperation (ZNBC), Radio 2, which is owned by the Government, broadcasts these programmes. For example, Rural Note Book comes on air every day morning except Sunday at exactly 06:45 hours, and on Sunday another programme that is Farm Magazine is aired. These two programmes are broadcasted in English, and for the sake of the rural farmers, there are another two programmes broadcasted in major seven vernaculars. Each of the local vernacular programmes is broadcasted once in every week.

Table 4.4.1 Agricultural Radio Programmes Time Table

Language	Radio Farm Forum (30 minutes)	Farmers Note Book (15 minutes)	Rural Note Book (15 minutes)	Farm Magazine (30 minutes)
Bemba	**Monday 15:30**	**Sunday 8:15**		
Nyanja	Monday 13:30	Thursday 20:15		
Tonga	Wednesday 16:30	Saturday 20:15		
Lozi	Tuesday 16:30	Friday 17:00		
Lunda	Thursday 16:30	Wednesday 19:45		
Luvale	Tuesday 10:45	Wednesday 19:45		
Kaonde	Monday 16:30	Tuesday 20:15		
English			**Everyday ex. Sun. 06:45**	**Sunday 09:00**

Source: National Agricultural Information Services

The vernacular broadcasting includes Bemba, which is the most popular language in the Study area as shown in Table 4.4.2. In fact, there are people who communicate in other languages in the Study area, e.g. Namwanga, Manbwe, Bisa, Ushi, Ng'umbo, etc. However, these people on the vernaculars can also communicate in Bemba in most cases. Therefore, it can be said most of the people in the Study area understand the radio programmes broadcasted in Bemba or otherwise in English.

Table 4.4.2 Predominant Language of Communication, %

Language	Zambia	Northern	Luapula
Bemba	30.1	**59.6**	**61.3**
Nyanja	10.7	0.2	0.1
Tonga	10.6	0.1	-
Lozi	5.7	0.1	-
Chewa	4.9	-	-
Namwanga	1.3	8.8	-
Mambwe	1.2	8.5	0.1
Bisa	1.0	6.6	0.1
Lungu	0.6	4.6	-
Ushi	-	0.1	16.0
Ng'umbo	-	-	5.6

Source: National Census 2000

National Agricultural and Information Services (NAIS) under MACO is the key player in the production of the programme as well as sponsoring. In the programmes, a lot of agriculture problems are solved for example when they talk about vegetable cultivation, what the farmers are supposed to do are discussed, meaning farmers listening to the programme in very deep rural areas will gain knowledge equivalent to the one who in the urban areas. Then also when they talk of marketing and management of the crop production to build capacity, equally a farmer will acquire knowledge on how to make profits out of the losses having been made in the previous years.

Issue is how many rural households have radio, and of whom how many listen to the radio programme(s). In 2009 and 2010, this Study carried out a baseline survey covering 12 villages in Northern and Luapula provinces. Figure 4.2.3 shows the percentage of the households who possess radios, and also how many of the sampled 30 households per village listen to such agriculture radio programme(s) almost every week. It is learned, from the baseline survey, that about 60% to as much as over 90% of the surveyed households have radio with an overall average of 72%, and most of them in fact listen to the radio programme(s) almost every week though it varies from village to village.

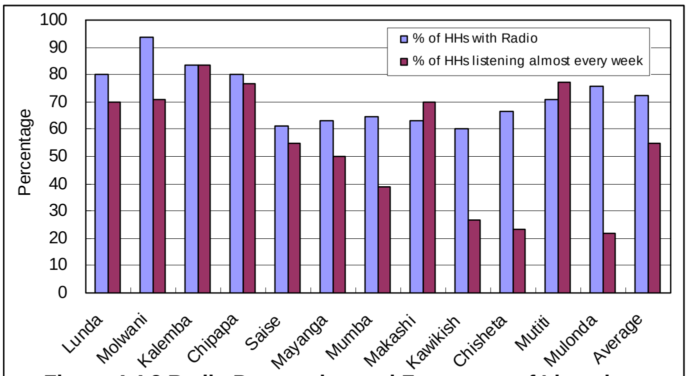


Figure 4.4.3 Radio Possession and Frequency of Listening,
JICA baseline survey, 2009/2010

National Agricultural Information Service in MACO has successfully managed to broadcast these programmes for so many years now. Rural Note Book, for example, started back in 1970s. Much rural population listens to the programmes, and as a matter of fact some participants to the construction of simple diversion weir under the pilot project talked about a programme which aired irrigation and its benefit. The aired programme motivated them to establish their own community irrigation schemes with simple diversion weir (example of Kalemba Chiti village, Mungwi district, Northern Province). These radio programmes can be a good opportunity of promoting smallholder irrigation scheme to a wider extent.

4.4.4 Aspects Conducive to Marketing

1) Urbanized Areas accessible from the Study Area

Marketing is a challengeable aspect of agriculture as an economic activity especially in such areas where population density is low and thus market place is relatively far. In the Study area, a number of farmers are often observed who are pushing their bicycles, carrying a large piece of their produces along the main road to the market. It takes hours from their farm to the market and another hours going back home. It surely is a big burden for them, although it is still a preferable situation as compared to such farmers who can not even access to the big market.

Although the Study area seems to stand little chance of agricultural marketing, there are a couple of best practices: inter-district or inter-provincial marketing. While Zambia in general is low in the population density, population is actually concentrated in some particular areas such as small and medium towns along the rail road and some big cities like Lusaka and Copperbelt. In such urbanized areas, there is a huge demand for food. One may think that the Study area is too far from those areas, there are actually a number of small cases that smallholder farmers carry their produces to other district or other province like Copperbelt, by hiring transportation by themselves. There are two cases:

Case One: Shipping from Mbala Northern Province to Copperbelt

According to Mr. Derick Chisulo, a farmer in Mbala district, Northern province, onion is one of the most preferable crops for his family, earning considerable amount of incomes. With irrigation, he produces onion during the dry season, May to July. In his 1.5 limas of land (0.375 ha), he can expect as much as 60 bags of 90kg bag, equivalent to 14,400 kg/ha. He sells his produce mostly to Kitwe district in Copperbelt province, approximately 900 km away from his village. Based on a rough estimation, as far as he describes, he can anticipate as much as a net ZMK 18 million from his 1.5 limas of farm land.

One of the possible contributors is the way of marketing he practices; he brings produce by himself and can expect twice as much unit price as the one in Mbala town. An average selling price of ZMK 200,000 per bag (90kg) in Mbala skyrockets to ZMK 400,000[2] per bag in Copperbelt, where a lot of demand exists. Even after deducting transportation cost, income is far better than selling in town. Another possible contributor is the fact that he sells by himself. Generally, it is well known that middlemen can obtain considerable level of margin and thus farmers can expect only a limited profit from his produce. In his case, he can keep everything he sold; that is why unit profit can be beyond our expectation.

Case two: Shipping from Chambeshi region (Mungwi district) to Kasama market

Chambeshi river basin in Mungwi and Isoka districts is well known as a large production area of paddy rice. Different from many other places in the Study area, farmers in this area focus on rice production. Without applying any fertilizers, they can produce about 2 bags of 60 liters bag from 1 lima (1/4 ha) paddy field. In the area, middlemen play a role in buying

[2] In fact, he has to pay an additional ZMK 60,000 per bag to ferry to Kitwe district centre, and another ZMK 5,000 per bag for storage use. Subtracting the sum of ZMK 65,000 per bag, he earns a net of ZMK 335,000 per bag which is still much higher than the ZMK 200,000 at Mbala.

the paddy from the farmers. Middlemen set up a temporary "camp" where they buy paddy from a number of farmers until they fill up enough amounts of bags to transport. Farmers can fetch around a gross profit of ZMK 140,000 per lima by selling the paddy to the middlemen, and by subtracting production cost of ZMK 50,500[3] per lima, a net profit of ZMK 89,500 can remain in their hand.

On the other hand, some villagers bring their paddy to Chambeshi Market in Kasama town by hiring a transport service. Fortunately, in this particular area, transporters are active. During the harvesting season, they shuttle trucks two to four times a day between the area and Kasama town. Some farmers use this service by paying a fee of ZMK 5,000 per bag (60 liters). With the service, they bring the paddy to the market and mill it at a miller because they can sell only milled white rice at the market. The milled rice which came from one lima paddy field can fetch about ZMK 234,000 at the market. Subtracting the transport, milling and production cost, which are 2 bags x ZMK 5,000, 2 bags x ZMK 4,250, and ZMK 50,500 per lima respectively, the net profit arrives at ZMK 165,000. As compared with the above farm-gate price of ZMK 89,500 in net, here they can fetch as much as ZMK 165,000 in net out of one lima paddy field, increased by 184%.

Both cases clearly illustrate the marketing potential in the urbanized area in the nearby district or in the other provinces. What should be noted is that some smallholder farmers are already transporting their produces to those areas and gaining a good amount of profit; those areas are actually accessible today. The key factor in those areas is the means of transportation. In both cases, there are service providers of transportation from the production area to the market. It implies that by connecting producers to those transporters, marketing opportunity can be capitalized.

2) Nearby Schools and Hospitals

Long distance transportations would not be an option for most of the farmers. Some, or most, of farmers may not afford hiring transportation even if they can expect higher profit from that arrangement. Some may face a lack of fund and the other may not be confident. For those farmers, nearby markets are the only options. In addition to conventional markets in the communities, there are also some potential customers: boarding schools and district hospitals.

During the Study, there were a few smallholder farmers who responded that they are selling their produces to the nearby schools or hospitals. As those institutions maintain a good number of clients, there should be a certain demand of food. Although the number of those institutions per district is limited, once farmers are linked, they can expect stable market. Specifically, boarding school at secondary and tertiary, regardless of governmental and private, is the type of school that provides food for student.

However, it should be noted that a procedure is required for farmers to deal with the government entities, not private institutions. In general, to sell their produces to the governmental institutions like schools and hospitals, farmers are required to obtain a registration paper from the government, particularly from the tender board committee of the office of the permanent secretary in each province. By registered as a food supplier, farmers are then able to sell their produce. In many cases, however, farmers do not know this procedure and miss their opportunity to sell their produce.

Another constraint reported is that, for some reason like a lack of funding, it sometimes takes months to get paid from those institutions. A farmer once experienced that he waited nearly eight months of time to get paid. As noted, to be a potential market destination, some issues have to be solved. To this

[3] Production cost is around ZMK 50,500 composed of ploughing, harvesting, but not including weeding. They do not do weeding in this area, hence resulting in very low yield, e.g. only 2 bags of 60 liters out of one lima paddy field.

end, extension workers including CEOs and BEOs can help link farmers to those potential institutions, support farmers to be registered, and ensure farmers about the attendant risk. The potential in the long run is however preferable. Since 2003, the government is running a free primary education, raising the enrollment rate in primary school nationwide. It can be a general perception that higher enrollment rate in primary school naturally leads to the higher enrollment rate of secondary and tertiary schools, which have boarding facilities. Therefore, expected demand from the schools in the future can be positive.

4.4.5 Debt Relief and Development Fund Available from PRP

Zambia reached the Decision Point under the Enhanced HIPC Initiative in December 2000, and became eligible for debt relief in the amount of US$ 2.5 billion in 1999 net present value term. Full delivery of this assistance was meant to lower the ratio of Zambia's NPV of external public debt to exports to the enhanced HIPC Initiative's threshold of 150% based on end-1999 parameters and debt stocks[4].

In 2004, Zambia has met all but three of the completion point conditions which were specified and agreed upon in the decision point document. The three conditions were; privatization of the electricity utility (ZESCO), implementation of an integrated financial management and information system reforms and strengthened public expenditure management system (IFMIS), and privatization of Zambia National Commercial Bank (ZNCB), though progresses had been made partially.

Since Zambia had made substantial progress in the fulfillment of the completion point triggers set out in the Decision Point documents, it was agreed by the World Bank that Zambia has reached Completion Point under the Enhanced HIPC Initiative, and the debt relief on debt owed to IDA by Zambia became available in 2005. Likewise, financing assistances for the provision of debt relief to Zambia have been obtained from creditors in Paris Club representing about 97% of total debt relief in NPV terms.

In line with the debt relief assistances under the Enhanced HIPC Initiatives, a sort of basket fund became available since 2005, which was linked with MTEF and the PRSP. It is a general budget support, though it cannot be disbursed to government recurrent operations, e.g. salary payment and utility settlement. As of 2010, nine cooperating partners are participating in the Fund, called Poverty Reduction Budget Support (PRBS) that, together with government fund, implements Poverty Reduction Program (PRP). The value of this budget support was the equivalent of US$ 143.6 million in 2008 and US$ 226.3 million in 2009.

Combined with the debt relief, the PRBS contributes greatly to improving the financial performance of the government of Zambia. For example, Table 4.4.3 summarizes the actually released budget, categorized in three items, to MACO in 2007, 2008 and 2009. Though great share of the budget, say as much as two-thirds of the total, went to FSP/FISP and Food Reserve Agency (FRA), there is still considerable budget actually released to identified investment programmes, including irrigation development. The budget actually released for identified investment programmes were about US$ 24 million, about US$ 19 million and US$ 44 million in 2007, 2008 and 2009 respectively.

[4] Memorandum and Recommendation of the President of the IDA to the Executive Directors on Assistance to the Republic of Zambia under the Enhanced HIPC Debt Initiative, March 23, 2005, The World Bank

Table 4.4.3 Budget Actually Released to MACO by Major Category

Year	2007		2008		2009 (projection)	
Items	Billion ZMK	MUS$	Billion ZMK	MUS$	Billion ZMK	MUS$
Identified investment Programme	**96.5 (14%)**	**24.2**	**68.6 (9%)**	**18.8**	**229.5 (20%)**	**43.6**
FSP/FISP and FRA	409.7 (59%)	102.8	549.3 (70%)	150.2	763.4 (66%)	144.9
Others including MACO operation	193.9 (28%)	48.7	164.1 (21%)	44.9	156.6 (14%)	29.7
Total	700.1 (100%)	175.7	782.0 (100%)	213.8	1,149.5 (100%)	218.2
US$ Rate		3,985		3,657		5,269

Source: Ministry of Finance and National Planning, Planning and Economic Management Division

With the budget released under the above identified investment programmes, some irrigation projects in Northern and Luapula provinces were funded. Table 4.4.4 summarizes the projects and released funds (the figures are not the budgeted ones but actually disbursed amounts). From the table, it is learnt that one to three projects per year per province have been implemented over last several years, and released annual budget ranges from about US$ 7,000 to as much as over US$ 400,000.

Table 4.4.4 Projects Actually Funded in Northern and Luapula Provinces under PRP

Year	Northern Province			Luapula Province		
2005	Chinenke Irrigaiton Project Chilubula Irrigation Project	K 11 M K 23 M	$2,465 $5,177	Mansa Resettlement	K 600 M	$134,439
2006	Kasama Farmer Training Ins.	K 123 M	$33,763	-		
2007	Chinenke Irrigation Project Lukulu North Project	K 244 M K 205 M	$61,230 $51,443	Kapako irrigation	K 150 M	$41,175
2008	Chinenke Irrigation Project Lukulu North Project Ngulula Irrigation Project	K 249 M K 166 M K 135 M	$68,089 $45,392 $36,916	-	-	-
2009	Lukulu North Irrigation Chinenke Irrigation	K 1.90 B K 250 M	$360,600 $47,447	Kapako Irrigation (rehab.) Mulunbi Irrigation (plan)	K 100 M K 250 M	$18,979 $47,447

Source: TSBs of Northern and Luapula Provinces, Note: However no irrigation projects in the two provinces are budgeted in 2010 Yellow Book.

Debt relief and Poverty Reduction Budget Support (PRBS) have thus contributed in implementing irrigation projects, not to the least of improving overall financial situation of the Government. The budget now available is a part of the government allocation in that the government has the initiative to disburse. This financial situation works as an opportunity in developing irrigation projects.

4.5 Prioritization of Irrigation Potential

This section tries to identify the potential of smallholder irrigation development in the Study area. Here two practices are undertaken; one is prioritization by government officers concerned, and the other one is by reading available data including LANDSAT image. Based on these practices, irrigation potential in terms of hectorage and also ranking of districts by irrigation potential are presented.

4.5.1 Ranking of District Irrigation Potential by Government Officers

As aforementioned, the kick-off workshop was held on March 31, 2009, inviting as many as about 70 participants from relevant offices of the 2 provinces. Taking advantage of this gathering from all the districts in the 2 provinces, potential for smallholder irrigation development in each district was analyzed based on comparative advantages of the districts. Major steps of this activity, so-called “situation analysis,” is as follows:

1) Identification of attributes that may explain the potential of the district,
2) Comparison and ranking of the districts on each attribute,
3) Comprehensive evaluation of the potential districts, and
4) Ranking of the significance of the attributes in determining the potential for smallholder irrigated

agriculture

1) Identification of Attributes that may Explain the Potential of the District

Possible attributes for the situation analysis were discussed among all the participants of two provinces in a plenary session. The suggested attributes are as follows:

- Production/ Season
- Availability of local labor
- Topography
- Soil type and fertility
- Current irrigation scheme used
- Road infrastructure
- Current area under irrigation
- Perennial water bodies and streams
  Availability of water
- Local leadership influence
- Potential market/ distance to it
- Less Livestock Interference
- No. of farmers already practice irrigation
- Availability of local materials
- Total Ranking Crop Pests and Diseases
- Community Initiative
- Weather climatic condition
- Land ownership

2) Comparison and Ranking of the Districts on Each Attribute

Participants were divided into two groups by province. On each attribute, DACO, SAO and CEOs representing each district discussed the comparative advantages of all the districts in the two provinces of Northern and Luapula. Based entirely upon their individual experience and knowledge about the districts, districts were ranked in a two-step process. First, six and four districts for Northern and Luapula provinces respectively were selected as high potential districts in the attribute. Then, three and two districts respectively were further selected among them as the highest potential districts (see Table 4.5.1).

In the discussion, some attributes were omitted because the participants considered them unsuited for the ranking or simply due to lack of time for the discussion. The omitted items in Northern province were: 1) community initiative, 2) local leadership influence, 3) perennial water body, 4) availability of water, 5) production, 6) crop pests and disease, 7) no. of farmers practicing irrigation, 8) availability of local material, 9) soil fertility, 10) livestock interfering, 11) water rights, 12) culture influence, 13) land ownership, and those in Luapula province were; 1) crop pests and diseases, 2) community initiative, 3) weather climatic condition, and 4) local ownership.

Table 4.5.1 Process of the Prioritization by 3 groups

Step 1

District	Attribute
A	
B	○
C	
D	○
E	
F	○
G	○

→

Step 2

District	Attribute
A	
B	⊙
C	
D	○
E	
F	⊙
G	○

Step 1: Select four high potential districts for the attribute such as availability of water and circle them

Step 2: Select two highest potential districts among the four and double-circle them.

3) Ranking of the Significance of the Attributes

In the case of Luapula province, participants made a ranking of attributes themselves so that the significance or the importance of attributes can be identified. The ranking of the attributes is shown below:

1) Availability of water
2) Soil type and fertility
3) Potential market/ distance to it
4) Production/ Season
5) Road infrastructure
6) No. of farmers already practice irrigation
7) Topography
8) Availability of local labor
9) Availability of local materials
10) Current irrigation scheme used
11) Local leadership influence

Current area under irrigation
Perennial water bodies and streams
Less Livestock Interference

Note: some items were not ranked

4) Comprehensive Evaluation of the Potential Districts

After a series of discussion and ranking exercise on all the attributes, participants made a comprehensive ranking of the districts for the potential of smallholder irrigated agriculture. The result of the situation analysis is shown in Table 4.5.2 and Table 4.5.3 for Northern province and Luapula province respectively, and the outcomes are:

i) In Northern province, top 4 potential districts for smallholder irrigation development are Mbala, Mpika, Mungwi, and Kasama where we can see undulating topographic condition. There are streams draining into Chambeshi river. Then, followed are Mporokoso, Luwingu, Isoka, Nakonde, etc. Districts where there seems least irrigation potential are Chilbi, Chinsali, Mplungu, Kaputa. For those least potential districts, the topography is almost flat and in fact Chilbi, Mplungu and Kaputa districts are located adjacent to lake, and thereby there is a difficulty of developing gravity irrigation scheme.

ii) As per Luapula province, top 3 high potential districts are Kawambwa, Mansa, and Mwense where we can see again gentle rolling hill like topography. Streams in these districts drain into Luapula river in most cases. Subsequent districts in terms of irrigation development potential are Milenge and Nchelenge, and the lest potential districts are Chieneg and Samfya. Chienge is located along lakeside of Mweru while Samfya is along Lake Bangwelu where the topography is very flat, showing difficulty of developing gravity scheme.

Table 4.5.2 Result of the Situation Analysis in Northern Province

Districts/ Attributes	Current irrigation scheme used	Perennial shallow stream	Potential market	Road infrastructure (feeder road)	Topography	Total Ranking
Mbala	⊙	⊙	⊙	⊙	⊙	1
Mpika		⊙	⊙	⊙		2
Mungwi	⊙	○	⊙	⊙	⊙	3
Kasama	⊙	○	⊙	○	⊙	4
Mporokoso	○	⊙	○		⊙	5
Luwingu	○	⊙			○	6
Isoka	⊙	○	○	○	○	7
Nakonde	○		○	⊙	○	8
Chilubi		○				9
Chinsali	○			○		10
Mplungu				○		11
Kaputa			○		○	12

Source: JICA Study Team, from kick-off WS held on March 31, 2009

Table 4.5.3 Result of the Situation Analysis in Luapula Province

Significance of the attributes	1	2	3	4	5	6	7	8	9	10	11	-	-	-	Total Ranking
Districts/ Attributes	Availability of water	Soil type and fertility	Potential market/ distance to it	Production/ Season	Road infrastructure	No. of farmers already practice irrigation	Topography	Availability of local labor	Availability of local materials	Current irrigation scheme used	Local leadership influence	Current area under irrigation	Perennial water bodies and streams	Less Livestock Interference	
Kawambwa	⊙	⊙	⊙	○	⊙	○	⊙	○	⊙	○	⊙	○	⊙	○	1
Mansa	⊙	○	⊙	⊙	⊙	⊙	○	⊙	○	⊙	○	⊙			2
Mwense	○			⊙	○	⊙	⊙	⊙	○	⊙	○	⊙	⊙	○	3
Milenge	○	⊙	○			○			⊙		⊙	○	○	⊙	4
Nchelenge			○	○	○		○	○		○					5
Chienge		○											○		6
Samfya														⊙	7

Source: JICA Study Team, from kick-off WS held on March 31, 2009

4.5.2 Identification of Irrigation Potential by Inventory Survey

An inventory survey was carried out in 2009, which requested district TSBs to report potential sites for small scale irrigation development aside from the inventory of existing permanent and temporary schemes (for these existing ones, refer to '3.6.2 Existing Irrigation Schemes in the Study Area'). The potential site here means extension from either present permanent or temporary ones or otherwise completely new sites. Table 4.5.4 summarizes the irrigation potential together with the existing irrigated area once presented in '3.6.2', from which following are identified:

1) At present, there are 104 permanent schemes in the 2 provinces which altogether irrigate 441 ha. This area, given some rehabilitation and/or upgrading, could be enlarged to cover as much as 3,536 ha. The average irrigation area per site is only 4.2 ha at present, and it is expected to extend to 8.8 ha per site.
2) There are 1,024 existing temporary sites as of mid 2009, altogether irrigating 1,772 ha. These temporary schemes have a potential of irrigating as much as 4,922 ha given some improvement. Improvement can be done by strengthening current temporary facilities, by introducing permanent weir, etc.
3) Aside from the existing permanent and temporary schemes, the provincial and district TSB offices have some plan or identified sites for new development. As at July 2009, they have altogether identified 129 new sites. These 129 new sites are planned to irrigate a total farmland of 1,333 ha. Expected irrigable area per site is estimated at 10.3 ha.
4) Summing up the above 3 categories of areas arrives at 9,792 ha divided into 8,480 ha and 1,311 ha for Northern and Luapula provinces respectively. Since all these areas have been confirmed on the field, it can be said that this '9,792 ha' is the confirmed irrigation potential for the 2 provinces. Of the 9,792ha, 2,213ha is already under irrigation, so the additional potential area is 7,579ha.
5) In estimating above potential irrigable areas, all facilities were expected to be permanent ones. However, as pilot project has proved, even temporary irrigation facilities can open a new irrigable area to some extent. Sites, which can be developed by temporary facilities, could be estimated as the sum of existing temporary sites and new sites; namely, total 1,153 sites (1,024 + 129). As per the command area, since a typical temporary site can irrigate 2.5 ha as average according to the experiences from the pilot project implementation, total irrigable area with temporary facilities may reach about 2,900 ha (1,153 x 2.5ha).

Table 4.5.4 Confirmed Irrigation Potential in the 2 Provinces

Particulars	No. of Existing Sites		No. of Potential New Sites	Existing Irrigated Area (ha)			Potential Irrigable Area (ha), inclusive of existing irrigated area			
	Permanent site	Temporary site		Permanent site	Temporary site	Total	Permanent site	Temporary site	Planned Site	Total
Northern	**67**	**850**	**86**	**361**	**1,565**	**1,926**	**3,169**	**4,322**	**990**	**8,480**
Chilubi	-	0	-	-	0	0	-	0	-	0
Chinsali	6	35	8	20	55	74	239	313	106	659
Isoka	12	21	9	32	52	84	154	93	75	322
Kaputa	1	5	2	1	3	4	35	4	3	41
Kasama	9	57	10	19	122	141	369	455	79	902
Luwingu	3	97	10	4	313	317	56	589	254	898
Mbala	3	186	15	125	125	250	1,780	789	178	2,746
Mpika	4	18	7	8	37	45	37	63	74	173
Mporokoso	6	162	7	6	435	441	91	641	49	781
Mpulungu	-	16	-	-	6	6	-	100	-	100
Mungwi	14	229	6	124	293	417	281	1133	48	1,461
Nakonde	9	24	12	23	123	146	127	144	126	397
Luapula	**37**	**174**	**43**	**80**	**208**	**288**	**367**	**601**	**343**	**1,311**
Chienge	1	9	4	1	35	36	5	101	26	132
Kawambwa	18	32	13	46	14	60	275	111	68	454
Mansa	7	103	2	8	121	129	32	274	9	315
Milenge	1	5	3	2	5	7	10	26	14	50
Mwense	1	20	9	2	22	24	5	63	137	205
Nchelenge	1	1	5	5	3	8	5	6	48	59
Samfya	8	4	7	17	8	25	35	20	42	97
Total	**104**	**1,024**	**129**	**441**	**1,772**	**2,213**	**3,536**	**4,922**	**1,333**	**9,792 ***
Area per site				**4.2**	**1.7**		**8.0**	**2.8**	**10.3**	

Source: Inventory Survey, carried out in 2009, JICA Study Team, Note: * due to round-off after decimal, it may not be equal to simple summation of the 3,536 ha, 4,922 ha and 1,333 ha.

4.5.3 Identification of Irrigation Potential by LANDSAT Image

By downloading the LANDSAT 7 ETM data, land use map was prepared. A total of 12 scenes of LANDSAT images were needed to cover the whole Study area, and following scenes whose cloud coverages were the least among available scenes were selected. Then, software called Erdas Imagine was employed in the analysis, based on which a trial of identifying irrigation potential area was made.

Table 4.5.5 LANDSAT Images Used in Establishing Land Use Map

No.	LANDSAT Scene Identifier	Date Acquired	WRS Path	WRS Row	Cloud Cover
1	LE71690672003131ASN00	2003/5/11	169	67	7.43
2	LE71700662002055SGS00	2002/2/24	170	66	7.3
3	LE71700672002231SGS01	2002/8/19	170	67	0
4	LE71700682002135SGS01	2002/5/15	170	68	0
5	LE71700692002071SGS00	2002/3/12	170	69	0.52
6	LE71710662003145ASN00	2003/5/25	171	66	0.12
7	LE71710672003145ASN00	2003/5/25	171	67	0.01
8	LE71710682003145ASN00	2003/5/25	171	68	0.02
9	LE71710692003113ASN00	2003/4/23	171	69	0.12
10	LE71720662002133SGS00	2002/5/13	172	66	0
11	LE71720672002133SGS01	2002/5/13	172	67	0
12	LE71720682002133SGS00	2002/5/13	172	68	0

Source: LANDSAT 7 ETM

After importing the LANDSAT images to Erdas Imagine, the images were adjusted with GCP (Ground Contour Point) based on current topographic map (1:250,000), SRTM (Shuttle Radar Topography Mission), DEM (Digital Elevation Model). The adjusted LANDSAT images were transported into Mosaic images. Upon the Mosaic images completed, pre-land use map was prepared. The pre-map was verified in the field and finally land use map was prepared demarcating the area by paddy field, upland, water body, river, urban area, forest area, bush land, grassland, bare land as in Figure 4.5.1.

Of the land use areas established, wet lands and river/stream peripheral areas were further demarcated (see Figure 4.5.2). Within the areas, the current paddy area and upland area can be set as maximum probable irrigation area. Of course, not all the area can be irrigated due to high elevation gap between the stream and the farms, unfavorable soil condition for farming, etc. In fact, LANDSAT image does not read the elevation gap between points, which means even if there are a lot of potential areas along streams, it may not be feasible to pump up stream water to those high lands from the financial point of view. Therefore the maximum 'probable' irrigation area does not automatically entail the feasibility of the area. At first, feasibility study should be carried out in advance of the development.

The demarcated wetlands and the peripheral areas shown in Figure 4.5.2 together make up a total 32,386.8 km^2 which shares 16.3% of the whole Study area (198,393 km^2). Of the 32,386.8 km^2, paddy field occupies 66.3 km^2 (0.2%), upland does 1,427.2 km^2 (4.4%), forest does 1,165.3 km^2 (3.6%), bush-land does 508.1 km^2 (1.6%), grass-land shares 24,582 km^2 (75.9%), urban areas do 5.1 km^2 (0.02%), and bare-land shares 4,632.3 km^2 (14.3%). The paddy and upland areas together arrive at 1,494.0 km^2 (4.6%), 149,400 ha. This area can be taken as the maximum probable irrigation potential in the 2 provinces. This maximum probable irrigation potential area of 149,400 ha shares 4.6 % of wetlands and peripheral areas, and does only 0.75% of whole the Study area (198,393 km^2).

Table 4.5.6 Estimation of Maximum Probable Irrigation Area in the Study Area, Unit: km^2

Province	Paddy	Upland	Paddy+ Upland	Share,%	Forest	Bush-land	Grass-land	Urban	Bare-land	Total Area
Northern	**56.9**	**1,038.4**	**1,095.3**	**73.3**	**894.7**	**279.5**	**17,435.1**	**2.2**	**3,327.5**	**23,034.2**
Chilubi	7.3	263.2	270.5	18.1	185.8	17.3	3,270.0	0.7	504.1	4,248.4
Chinsali	3.6	69.1	72.7	4.9	95.0	36.9	1,987.1	0.0	348.3	2,540.0
Isoka	3.2	12.2	15.4	1.0	19.3	0.1	330.3	0.0	162.9	528.0
Kaputa	7.1	126.7	133.8	9.0	43.8	29.3	738.3	0.2	304.8	1,250.2
Kasama	11.1	58.1	69.2	4.6	97.7	5.2	1,019.4	0.1	136.5	1,328.0
Luwingu	4.1	26.7	30.8	2.1	9.7	3.6	785.5	0.0	103.2	932.9
Mbala	0.6	19.9	20.5	1.4	65.8	29.1	557.9	0.1	52.5	725.9
Mpika	0.9	340.3	341.2	22.8	254.4	121.9	4,068.0	0.6	950.5	5,736.6
Mporokoso	2.2	20.1	22.4	1.5	80.1	10.8	391.8	0.0	27.1	532.1
Mpulungu	2.2	8.0	10.2	0.7	21.0	1.3	283.4	0.0	72.4	388.4
Mungwi	12.0	83.2	95.3	6.4	7.1	12.0	2,952.0	0.4	444.7	3,511.5
Nakonde	2.5	10.7	13.3	0.9	15.0	11.8	1,051.4	0.1	220.6	1,312.2
Luapula	**9.4**	**389.3**	**398.7**	**26.7**	**270.6**	**228.7**	**7,146.9**	**2.9**	**1,304.9**	**9,352.6**
Chiengi	0.6	8.9	9.5	0.6	20.8	0.2	107.7	0.2	21.4	159.7
Kawambwa	0.8	66.6	67.4	4.5	12.1	19.5	863.3	0.5	127.2	1,090.0
Mansa	1.4	51.9	53.3	3.6	24.8	12.4	279.7	0.0	30.0	400.1
Milenge	1.4	38.4	39.8	2.7	182.9	11.3	298.9	0.0	9.8	542.6
Mwense	1.0	48.9	50.0	3.3	25.6	12.2	436.3	0.9	114.3	639.2
Nchelenge	1.5	32.1	33.6	2.2	2.6	1.0	575.7	1.1	79.1	693.1
Samfya	2.7	142.5	145.2	9.7	1.8	172.2	4,585.5	0.2	923.0	5,827.9
Total, km^2	**66.3**	**1,427.7**	**1,494.0**	**100.0**	**1,165.3**	**508.1**	**24,582.0**	**5.1**	**4,632.3**	**32,386.8**
Share, %	**0.2**	**4.4**	**4.6**	**-**	**3.6**	**1.6**	**75.9**	**0.0**	**14.3**	**100.0**

Source: JICA Study Team, LANDSAT image analysis, Note: MPIA means maximum probable irrigation area.

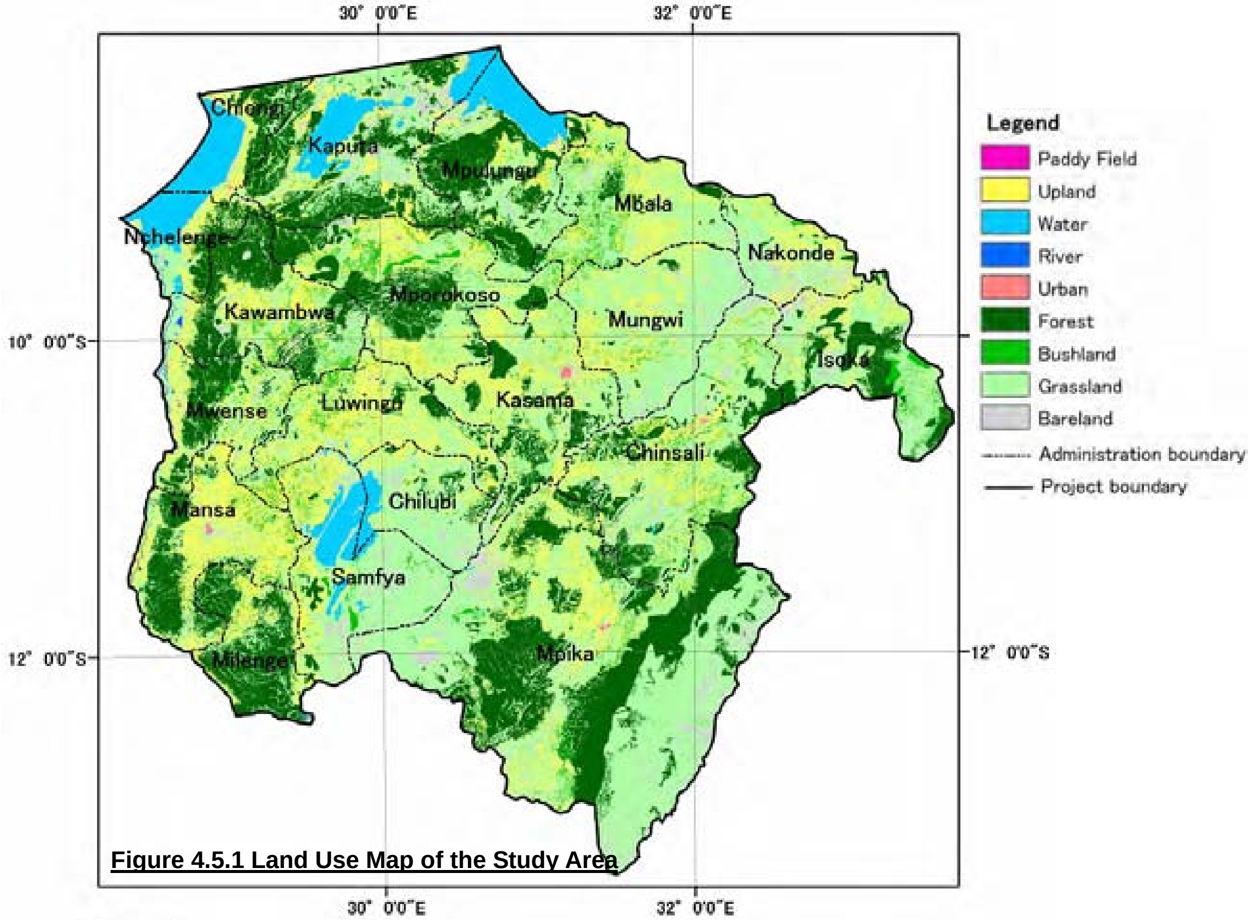


Figure 4.5.1 Land Use Map of the Study Area

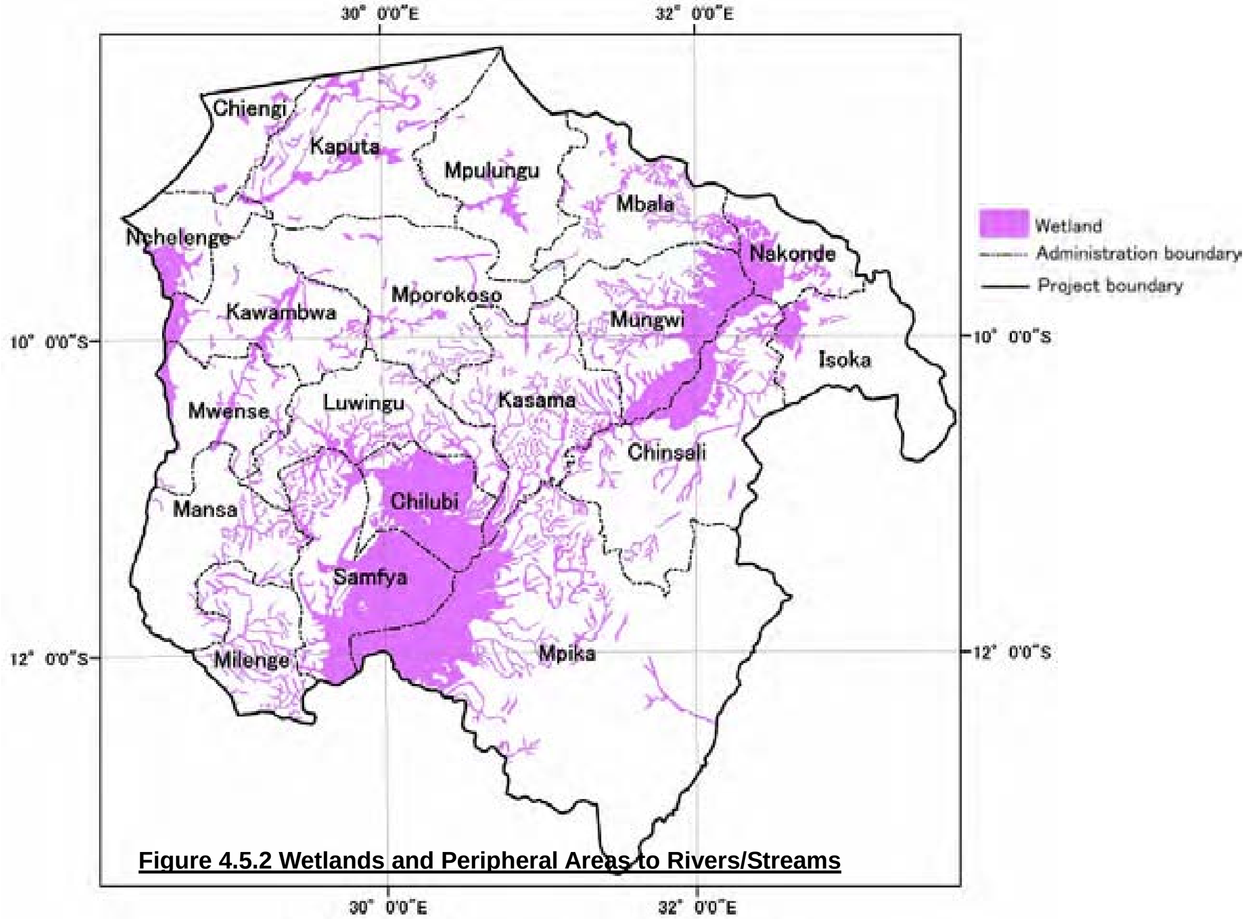


Figure 4.5.2 Wetlands and Peripheral Areas to Rivers/Streams

4.5.4 Smallholder Irrigation Potential and Its Prioritization by District

Above discussion indicates the following:

1) An area of 9,792 ha has been identified as 'confirmed irrigation potential' in the 2 provinces. Of them, 2,213 ha is already under irrigation, so that the confirmed potential area additional is 7,579 ha. This has been confirmed by inventory survey which involved provincial and district TSBs.

2) An area of 149,400 ha could be counted as 'maximum probable irrigation potential' in the 2 provinces as identified by LANDSAT image reading. Since this identification does not automatically entail the feasibility, it must be taken as an indicative figure from the viewpoint of farmland availability around water.

Upon the identification of irrigation potential, this session tries to prioritize districts. Taking into account here are not only identified irrigation potentials but also other critical parameters e.g. stream density which is the essential parameter for smallholder irrigation development, road density which can facilitate marketing, and existence of smallholder irrigation schemes both permanent and temporary ones and the potential irrigation area proposed by each district TSB, aside from LANDSAT image reading. From Table 4.5.7, this Study recommends the following prioritization by 3 groups as:

1) Group A (High potential districts); Mbala, Mungwi, Luwingu and Kasama districts in Northern province, and Kawambwa and Mansa districts in Luapula province.

2) Group B (middle potential districts): Nakonde, Isoka, Mpika, Mporokoso, and Chinsali districts in Northern province, and Mwense and Milenge districts in Luapula province.

3) Group C (low potential districts): Kaputa, Mpulungu, and Chilubi districts in Northern province, and Nchelenge, Chienge, and Samfya districts in Luapula province.

Table 4.5.7 Overall Prioritization of the Districts by Three Groups

Particulars	Pop. Density, 2000	Order by Officers	Rank	Stream Density, m/km^2	Road density, m/km^2	Nr. of Existing Sites	Area developed, ha	Confirmed Potential, ha	Maximum Potential, km^2
Northern	8.5			132	46	1,003	1,926	8,480	1,095
Mbala	17.9	**1**	**A**	157	85	204	250	2,746	20
Mungwi	11.6	**3**	**A**	114	68	249	417	1,461	95
Luwingu	9.1	**6**	**A**	113	69	110	317	898	31
Kasama	15.8	**4**	**A**	156	60	76	141	902	69
Nakonde	16.3	**8**	**B**	156	76	45	146	397	13
Isoka	10.8	**7**	**B**	142	56	42	84	322	15
Mpika	3.6	**2**	**B**	145	24	29	45	173	341
Mporokoso	6.1	**5**	**B**	133	43	175	441	781	22
Chinsali	8.4	**10**	**B**	131	55	49	74	659	73
Kaputa	6.7	**12**	**C**	88	38	8	4	41	134
Mpulungu	6.9	**11**	**C**	121	25	16	6	100	10
Chilubi	14.3	**9**	**C**	96	34	-	0	0	271
Luapula	15.3			115	53	254	288	1,311	399
Kawambwa	11.0	**1**	**A**	109	50	63	60	454	67
Mansa	18.2	**2**	**A**	114	79	112	129	315	53
Mwense	15.7	**3**	**B**	126	81	30	24	205	50
Milenge	4.6	**4**	**B**	149	35	9	7	50	40
Nchelenge	27.2	**5**	**C**	63	30	7	8	59	34
Chienge	21.1	**6**	**C**	84	29	14	36	132	10
Samfya	15.8	**7**	**C**	127	40	19	25	97	145

Source: JICA Study Team

CHAPTER 5 SMALLHOLDER IRRIGATION DEVELOPMENT: ACTION PLAN

This chapter, based on what were discussed in the previous chapters, elaborates smallholder irrigation development; that is the main part of the planning. From this planning, an action plan for smallholder irrigation development is to be proposed. The action plan is a sort of guide with which the GRZ can take concrete actions towards development of smallholder irrigation schemes in the Study area. The action plan starts with strategy and framework setting, and is composed of; 1) irrigation development, 2) irrigated agriculture, 3) O&M of the smallholder irrigation schemes, 4) institutional development. The plan also incorporates programme cost as well as implementation arrangement.

5.1 Development Strategy and Framework

5.1.1 Positioning and Limitation of the Smallholder Irrigation Schemes

This Study undertakes smallholder irrigation schemes as stated in the Scope of Work of the Study. It refers to the category of ‘Smallholder Irrigation’ in the National Irrigation Plan (NIP), 2005 as indicated in the left column of Table 5.1.1 below. In fact, the NIP categorizes irrigation schemes only by type of beneficiary farmers whereby if an irrigation scheme is operated and maintained by small scale farmers, it is categorized as ‘Smallholder Irrigation’.

As a matter of fact, scale of the smallholder irrigation scheme varies widely, from a temporary scheme to certain scale of permanent facilities equipped with reservoir plus pumping station. For example, AfDB undertakes Nega Nega irrigation scheme which command area is about 600ha, and it is still categorized as small-scale irrigation scheme. Though the AfDB funded project does not refer to the term of ‘smallholder’ irrigation, it is yet to belong to other than the ‘smallholder irrigation’ in the NIP. In fact, the government refers to the term of ‘smallholder irrigation’ by those irrigation schemes whose operation and maintenance is solely carried out by smallholder farmers irrespective of whether it is constructed by farmer themselves or by contractor (by the government).

Given such situation, Table 5.1.1 and Table 5.1.2 try to elaborate the ‘Smallholder Irrigation’ by mode of scheme and by mode of planning/designing, construction and O&M respectively. As Table 5.1.1 briefs, ‘smallholder irrigation’ in fact covers all the mode of scheme from temporary one to permanent one including reservoir, pump facilities, etc. Of them, ‘smallholder irrigation’ undertaken by this Study excludes the permanent irrigation scheme more than 50 ha, requiring full level of EIA, and hardly support reservoir system and engine/motor pump system which entail difficulties in the O&M in many cases. It simply means that the ‘smallholder irrigation’ undertaken by this Study focuses on gravity system, which is also gender/ age sensitive measure.

Table 5.1.1 Irrigation Schemes in Zambia by Mode of System

NIP category	Gravity Distribution			Reservoir	Pump		Remarks
	Temporary	Permanent			Manual e.g. treadle	Engine/ motor	
		< 50ha	50 ha =<				
Peri-urban		○	○	○		○	
Out-grower		○	○	○	○	○	
Smallholder	○	○	○	○	○	○	
(This Study)	○	○		△	○	△	
Large scale commercial			○	○		○	
Other private		○	○	○		○	

Source: JICA Study Team

In fact, if a planned irrigation scheme goes beyond 50 ha, it requires feasibility study together with full

EIA, like AfDB funded Small Scale Irrigation Project. Though this scale of irrigation schemes can fall in the category of smallholder irrigation under the NIP, it cannot be implemented as ‘programme’, collective mode of many small projects in other word, but only by conventional project type approach which goes through feasibility study, EIA, detail design, costing and billing of quantity, contracting to a civil contractor, construction and supervision, etc. Thus, the latter approach needs a separate arrangement ‘by project’, like AfDB approach, and therefore this Study excludes such category from the smallholder irrigation.

Table 5.1.2 shows that all the modes of planning/designing, construction and O&M can be seen under the category of ‘smallholder irrigation’ by NIP. However, this Study concerns such smallholder irrigation schemes as; 1) planning is done by the government officers in consultation with the beneficiaries, 2) construction should be managed by the beneficiary farmers given technical assistances by the government, and 3) full O&M by the beneficiaries. Though construction may incorporate skilled labors, no civil contractor is expected to engage in the construction. It means that simple (temporary) smallholder irrigation schemes are to be constructed by farmers and even permanent structure by themselves under a direct force account by the government.

Table 5.1.2 Irrigation Schemes in Zambia by Mode of Planning/Designing, Construction and O&M

NIP category	Planning/ Designing		Construction			O & M	
	Personal	Government	Self (organization)	w/ Gvt technical assistance	Contractor	Self (organization)	Entrusted[1]
Peri-urban		○		○	○	○	○
Out-grower		○	○	○	○	○	○
Smallholder	○	○	○	○	○	○	○
(This Study)		○	○	○	Skilled labor only	○	
Large scale commercial	○	○	○	○	○	○	○
Other private	○	○	○	○	○	○	○

Source: JICA Study Team

In sum, getting the beneficiary farmers’ own efforts, the smallholder irrigation facilities under this Study should be constructed, operated and maintained by themselves with the government as partner on one side. The irrigable area for simple (temporary) schemes ranges 1 to 3 ha in most cases according to the experiences under the pilot project implementation and even permanent structures could hardly go beyond 10ha. Most of the permanent schemes undertaken in this Study may be in a range of 3 – 10 ha since they are to be constructed by farmers themselves not engaging civil contractors. Following Table 5.1.3 summarizes the discussions above as compared to conventional medium to large scale irrigation schemes:

Table 5.1.3 Measure by Irrigation Type

Item	Smallholder Irrigation		*Medium to Large Scale Irrigation (Not the target of the Study)*
	Simple Weir	**Permanent Weir**	
Intake work	Temporary (constructed by locally available materials)	Permanent (wet-masonry made of cement mortar and concrete with reinforcing bars)	*Permanent (cement, reinforcing bar, metal gates, etc)*
Irrigation period	Dry season (diversion weir is to be removed upon the onset of rainy season)	Throughout the year (In rainy season, mainly for supplementing water especially during the onset of rainy season)	*Throughout the year*

[1] This is to engage a third entity responsible for operation and maintenance of the irrigation scheme. This arrangement is designed in Nega Nega irrigation scheme as of mid 2010, funded by AfDB. In this scheme, a group composed of specialists is to be employed by the scheme committee organized of representative beneficiary farmers, and be responsible for the scheme O&M.

Beneficiary	A group in a village	Can cover more than half of the villagers of a village or even some villages	*Some villages (In some cases more than 10 villages)*
Construction	All the material and labors by farmers	Materials[2] and skilled labors by outsiders (Government, donor, etc.) Unskilled labors by farmers	*Contractor*
Operation	Farmers	Farmers	*Main facility by government and terminal facility by farmer, or entrusted to a private entity e.g. Nga Nga irrigation scheme.*
Maintenance	Farmers	Farmers	*Main facility by government and terminal facility by farmer, or entrusted to a private entity e.g. Nga Nga irrigation scheme.*
Irrigated area	Less than 10ha, mainly 1 to 3ha	Some could be more than 10ha and the rest less than 10ha. In any case, it does not go over 50ha which requires full EIA.	*More than 10ha, and upper limit depends on the amount of water resources*

Source: JICA Study Team

5.1.2 Objectives of Smallholder Irrigation Development (SHID)

Through the implementation of smallholder irrigation development, such outputs are expected; 1) institutional capacity development for the concerned government officers, 2) establishment of farmer organization responsible for the construction and O&M, 3) establishment of irrigation schemes either simple or permanent, and 4) establishment of irrigation during dry season as well as during onset of rainy season as supplemental irrigation.

With the above outputs, farmers' livelihood is to be improved which itself can be the programme purpose of smallholder irrigation development. In particular, the livelihood improvement will be realized mainly through 2 ways of; 1) fulfilling food shortage taking place between rainy seasons, and 2) diversifying crops thereby promoting cash crops such as vegetables.

Food shortage between the seasons was reported in 4 villages out of 6 villages where village level analytical workshop was carried out in 2009. For these villages, dry season agriculture can contributes to increasing the food security. Though not all the food shortages were attributed to drought but rather to heavy rains, dry season agriculture promoted under smallholder irrigation development would contribute to improving the food security, thereby their livelihood is to be improved.

On top of the food security, dry season irrigated agriculture can provide a big opportunity to cultivating cash crops, e.g. vegetables, green maize, etc. As a matter of fact, the Sturdy area is a kind of granary in this country; implying at least staple food production could meet what the people consume as a whole. Of course, if we look into by village, there are often food shortages as reported by the village workshop. However, if we examine staple food production in the 2 provinces as a whole, it is more than the self-sufficient for the population.

This fact is also correlated with the calorie level they intake according to the baseline survey carried out in 2009/2010. A typical Zambia rural population requires 2,750 kcal per head per day according to LCMS report 2006, and baseline survey revealed the sampled people are in-taking more or less almost same level of the calories[3]. This fact strongly recommends that the beneficiary farmers would go for cash crops with irrigation rather than staple food which can be produced under rain-fed agriculture.

Then, the accomplishment of the purpose, 'farmers' livelihood is to be improved', leads them to an

[2] If materials are available in the beneficiaries' locality e.g. sand and cobbles, the beneficiaries are supposed to provide by themselves voluntary.
[3] According to the result of the baseline survey, the average calorie consumed by sampled households was 2,411 kcal corresponding to about 88% of the 2,750 kcal.

overall goal that is poverty alleviation, which the Country advocates in nowadays context. Including the overall goal, these objectives relevant to the smallholder irrigation development (SHID) are broken down into three levels as repeated below;

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

SHID Purpose: Livelihood for smallholder farmers is improved through promoting irrigated agriculture with an emphasis on dry season cultivation that fulfills the foot shortage between the seasons as well as that can enable cash crop production.

SHID Outputs:

1) Institutional capacity such as facilitation and technical knowledge and skills relative to smallholder irrigation development is built among government officers,
2) Farmer organizations responsible for constructing, operating and maintaining smallholder irrigation schemes are established with facilitation from the extension officers concerned,
3) Simple schemes are established out of locally available materials by farmer themselves with the government technical assistance, and permanent structures are also constructed by the farmers given technical as well as foreign material assistances by the government/ donors, and
4) Dry season irrigation and supplemental irrigation during lean rainy season are established in the smallholder irrigation sites with appropriate agriculture extension services from the extension officers.

5.1.3 Assembling of Development Constraints and Opportunities

Through workshops for government officers and farmers, interviews, field observations and available data reading, development constraints and opportunities were identified as elaborated in Chapter 4 ‘Smallholder Irrigation Development: Planning’. In detail, sub-chapters 4.1 and 4.2 withdrew the opinions and thoughts of the government officers and also sampled villagers while sub-chapters 4.3 and 4.4 were explored by the JICA Study Team itself. Planning should show a concrete way of how to tackle the constraints and how to utilize the opportunities, whereby the smallholder irrigation development plan becomes more workable.

Table 5.1.4 summarizes them in that major development opportunities and constraints are listed with the measures of how to incorporate them or how to cope with them for the smallholder irrigation development. From the table, one may see the overall direction of pursuing smallholder irrigation development as:

1) Large extent of engagement of BEOs/CEOs in smallholder irrigation development, in particular for simple diversion schemes,
2) Extensive involvement of beneficiary farmers not only in simple scheme development but also for permanent scheme construction, and
3) Utilization of information technologies available nowadays such as mobile-phone, radio programme, etc. to widely disseminate smallholder irrigation development and also motivate farmers.

In fact, irrigation development is not a limited task only for those officers specialized in irrigation engineering. If an irrigation scheme goes over 50ha, it may be for those specialized personnel but as far as the scale is of community based one, extension officers can easily promote such irrigation as a part of their recurrent activities. Beneficiaries should undertake the maximum role in developing smallholder irrigation schemes from the viewpoint of not only project sustainability but also taking into account the limited budgetary allocation by the government.

Table 5.1.4 Major Development Opportunities and Constraints Assembled in Planning

Opportunities/Strengths	Measures to Utilize/ Cope with
1. Trained technical staff available	In particular, permanent irrigation schemes should be constructed by direct force account rather than employing civil contractor. This enables irrigation schemes to be established at lower cost.
2. Well established organizational structure	By mode of irrigation scheme, different cadres of government offices should be in charge. For example, temporary irrigation schemes should be promoted by BEOs and CEOs with support by district TSBs while permanent schemes should be promoted by district TSBs back-stopped by provincial TSBs.
3. Rich water resources (many perennial streams)	Small streams can be developed for temporary irrigation schemes while mid streams for permanent schemes. Also, frontline extension officers, e.g. BEOs and CEOs can have opportunities of developing temporary irrigation schemes in their areas as well.
4. Abundant/available arable land	It is expected to develop irrigation schemes without much difficulties of land tenancy. Once local authorities agree, CEOs/BEOs can facilitate farmers concerned to develop irrigation schemes.
5. Local resources for construction	The plan should utilize locally available materials as much as possible, whereby temporary diversion schemes can be established without any cash cost and also sand and stones locally available can reduces the cost of construction of permanent structures.
6. Mobile-phone network	The project unit to be established in implementing smallholder irrigation programme should use 'bulk text message service' in order to keep up all the concerned officers on board. This service facilitates them to update project progress, peers' achievement whereby they can be motivated. Also the BEOs/CEOs should use mobile phone as has been done to make an arrangement for meeting, construction, and agriculture extension with the farmers (nowadays, no village is found without any mobile phone so that extension officers can communicate with farmers through mobile phone).
7. Radio broadcast programmes	In the implementation stage, radio programme should air smallholder irrigation development activities whereby farmers listening to the programme will be so motivated that they can embark on smallholder irrigation by themselves and the facilitation by BEOs/CEOs can easily get them on board of irrigation.
8. Conducive to market	Since there are potentials of market, the beneficiaries can grow cash crops e.g. vegetables, green maize, etc. In general, Zambia is rather urbanized country, so that demand for relish is more than what the farmers can supply. Therefore, at this moment, beneficiary farmers would be able to market their cash crops without much difficulty.
9. Budget available from PRP	Should utilize to arrange foreign materials such as cement, iron bars, and in cases sand and gravels, with which permanent smallholder irrigation schemes can be more established.
Constraints/Weaknesses	
1. Shortage of technical staff in irrigation	Technical staff with an educational background of irrigation are in fact very few. Therefore simple structures, which do not require sophisticated irrigation technologies e.g. temporary irrigation schemes, should be promoted by engaging BEOs/CEOs. Also even permanent ones should be of simple structure like wet-masonry structure, relatively simple in design and construction. Concrete structure can be tried but it should be implemented upon endorsement by provincial irrigation engineer with irrigation educational background.
2. Large area coverage (per CEO)	About 1/4 of extension officers are given motor bike as of end 2009; mostly they are BEOs. Therefore, the plan should undertake BEOs being the core of disseminating temporary irrigation schemes with fuel provision and CEOs as subordinates to the BEOs. Though the government is to provide motor bike only, it may have to consider to provide bicycle as well since CEOs can cover a certain range of area even with bicycle.
3. Inadequate transport	
4. Difficulty for BEOs/CEOs to Meet at Plenary	
5. Land tenure	Land tenure entails 2 issues; 1) tenure acquisition from local authorities, and 2) tenure claimed by existing landowners. For the local authorities, since area to be developed under smallholder irrigation is quite small, BEO/CEO can easily get them agreed provided that advance notification and requirement be made. For the latter case, land sharing only during dry season can be an option with in cases minimal charge (in most cases it can be

	arranged in kind, say, one sack of produce out of 1 lima to the original landowner, etc.).
6. Poor infrastructure (e.g. road)	BEOs/CEOs should promote perishable produces to minimum extent and instead probably green maize more, which is not perishable. Transport condition should be always considered in promoting irrigated crops.
7. Input (fertilizer) expensive	Should introduce compost manure. Conventional compost manure is not much effective in fertilization, so that *Bokashi* incorporating yeasts should be promoted. Also, to utilize chemical fertilizer's effect as much as possible, compost should be applied together with chemical fertilizer. Chemical fertilizer can be well retained in the compost so that farmers can avoid chemical fertilizer from being eroded away.

Source: JICA Study Team

5.2 Smallholder Irrigation Development

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 with the farmer's self-effort, should be examined as the first step. Including the confirmation of the potential as well as the feasibility, what the next steps are for developing smallholder irrigation schemes are given of the following:

5.2.1 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 an end the flow starts retarding. Throughout the dry season, almost all the streams continue reducing the flow and in some cases dry up. Discharge record is not available for those relatively small streams undertaken in this Study. Given this situation, following can be given as an idea on 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".

Try to measure the stream flow. There are two methods as elaborated in PART II "Process Description Manuals, 12. Discharge Measurement". They are 1) float measurement and 2) V-notch or rectangular notch 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. Critical issue is on 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, which inevitably causes abandoning of part of the irrigation service area toward the end of dry season.

With this above in mind, 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 the potential area.

Under above arrangement, some farmer members may claim that they cannot be benefited in the first year. However, with land sharing to be introduced, this claim can be ameliorated. Most of the irrigable land may belong to only handful number of land owners, so that almost all the schemes are encouraged to introduce land sharing arrangement, by which each and every member is given say half lima, and upon the harvest, the land is returned to the original owners for rainy season agriculture. In case that the land is virgin and newly opened for irrigation purpose, the village headman concerned is expected to discharge the leading role of distributing the land to members as equally as possible.

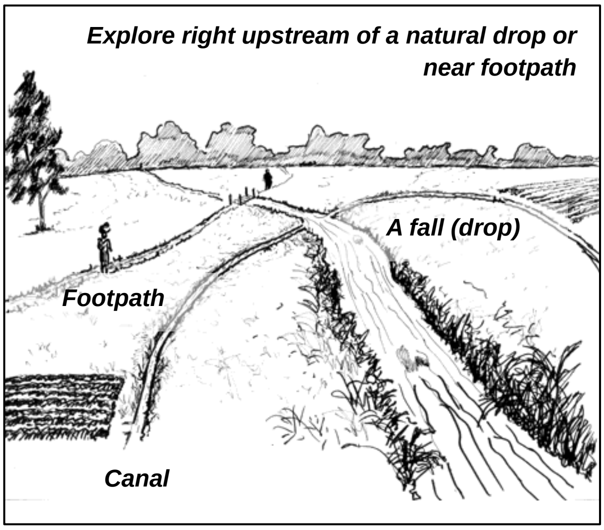
This Study deals with both simple (temporary) and permanent structures, and does recommend step-wise development. The step-wise development from simple scheme to permanent scheme can avoid over-investment in putting up expensive concrete and/or wet-masonry structure. Under this arrangement, farmers are firstly supposed to put up simple scheme and sometime after they have practiced irrigation with the simple structure they are to improve the structure to permanent one.

It means during the irrigation practice with the simple scheme, they and the extension officers, BEOs/CEOs, can know how much the maximum irrigable area can be with the stream even by the low flow taking place at the end of dry season. From this viewpoint, this Study maintains the step-wise development whereby over-designing of permanent structure and also over-investment can be avoided.

5.2.2 Diversion Site for Gravity Irrigation

Gravity irrigation scheme starts with diversion weir. Potential diversion sites being blessed with perennial flow, the depth should not be very deep; preferably limited to 2m 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).

Footpath usually traverses streams at a shallower 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.



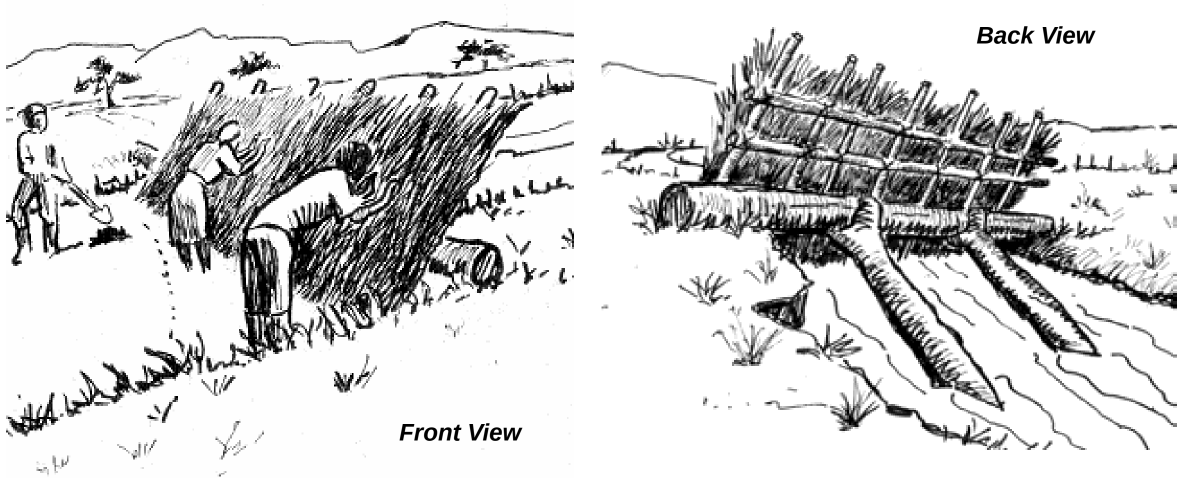
5.2.3 Development of Simple Diversion Structures

As for simple diversion structures made out of locally available materials, this Study presents following 4 types of diversion structure (for detail, refer to the Part II Process Description Manuals). In the field, however, it is not limited to just four types depending upon farmers' and extension officers' innovative ideas. In any cases, important point is to believe that diversion weirs can be constructed by using such locally available materials as wooden log, bamboo, grasses, soils, etc., and can raise the water level across even over a 20 meter width stream and as high as 1.5 meter depth.

- ✓ Inclined type diversion weir
- ✓ Single-line diversion weir
- ✓ Double-line diversion weir
- ✓ Trigonal prop supported diversion weir

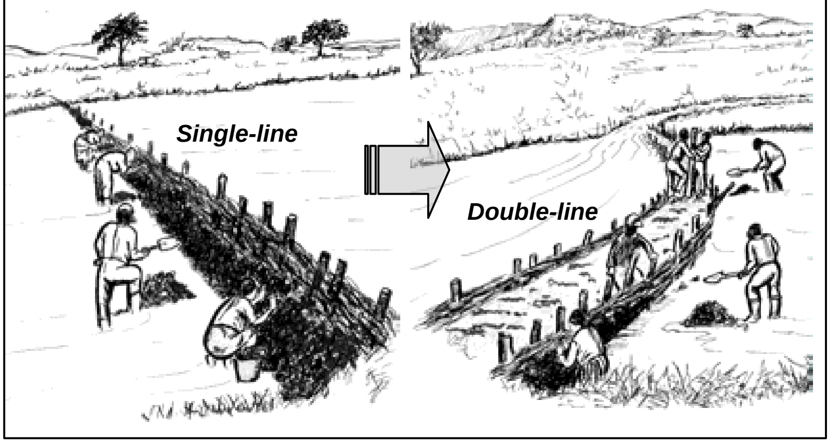
In case of narrow stream, constructing diversion weir is very easy: namely, 1) put a horizontal member astride the both banks preferably supported by a wooden prop from behind, 2) place vertical members, on the horizontal member, of bamboos, twigs, and reed inclined to the downstream, 3) put grasses on the vertical members and then clay soil thereon. This process can be the simplest way of putting up temporary diversion weir for irrigation purpose. In fact, it takes only half a day to maximum 2 days to complete such diversion weir depending upon the width and the depth of the stream.

Diversion Weir in a Narrow Stream

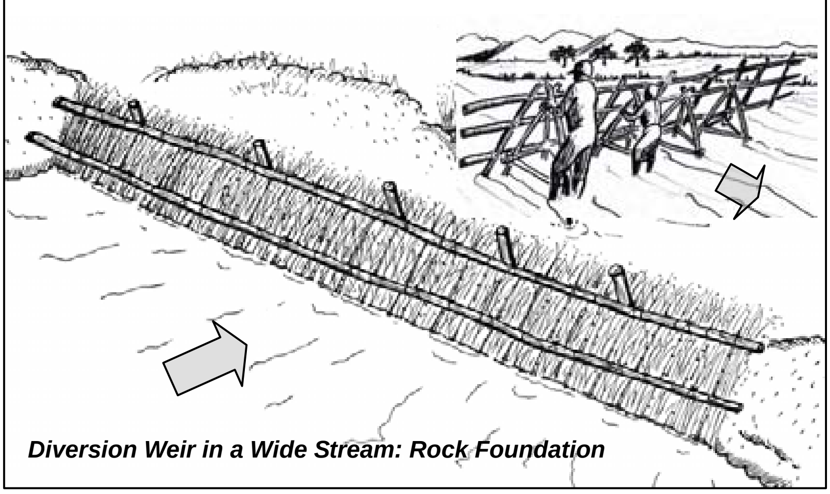


In case of wide stream, there are mainly two ways of constructing a diversion weir depending on the foundation condition: i.e. soil or rock. At soil foundation, we should; 1) drive wooden logs into the foundation across the stream preferably 30 – 50 cm interval, 2) put grasses alternately through the logs like weaving the logs, and then 3) patch clay soils upstream on the woven wall. This is called single-line weir, which is very simple and can fit in *dambo* areas. For the construction, on condition that all the necessary materials have been well prepared in advance, it takes only half a day to maximum 2 days.

Diversion Weir in a Wide Stream: Soil Foundation



If leakage through the weir body needs to be minimized, one may make another line just downstream from the first line preferably 70 cm to 150 cm apart. Then clay soil is placed in between the two lines and compacted by footing/treadling. This double-line weir can also work as footpath for villagers. In some cases, beneficiaries may wish to use the simple double-line weir as permanent one. If the width of the weir is more than 1.0 m, there is high possibility that most parts of the weir body can remain over a rainy season. In fact, some parts would be washed away by flood. Every year, they have to mend the flushed parts or otherwise spillway structure may be introduced.



Diversion Weir in a Wide Stream: Rock Foundation

At rock foundation, wooden

poles cannot be driven into the foundation. There should be some self-stand structures, which can support the weir body against water pressure. An idea is to put up trigonal props across the stream where the weir is to be established. By step we should; 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, and 4) put grasses and then clay soils thereon.

5.2.4 Development of Permanent Diversion Structures

Permanent structure can hardly be constructed in deep *dambo* areas. In *dambo* areas, there is always a thick organic sedimentation accumulated, most of which are not consolidated yet. The foundation would therefore start sinking by the weight of the structure as exampled in the photo right. The example shows as much as about 20cm settlement, opening a way for leakage in the beneath of the weir.

Blocks of the weir body slided down at contraction joints due to settlement of the foundation.

In fact, as the contraction joint between the concrete blocks slided down, much leakage underneath the weir body did not take place. Otherwise leakage underneath the weir body could have stopped the weir from functioning. Therefore, this Study recommends NOT to construct permanent structure in deep *dambo* areas, and recommends to construct permanent structures on a relatively hard foundation, preferably on rock foundation.

1) Type of the Permanent Diversion Structure

This Study presents total 3 types of permanent diversion structures; namely, 1) wet-masonry wall type weir supported by buttresses, 2) concrete wall type weir supported by buttresses, and 3) wet-masonry gravity type weir. To minimize the cement volume, the first 2 structures are designed by having buttress, prop type supports. With the buttress, the body itself can stand as vertical wall-like one thereby reducing cement volume. As the height of the wall becomes taller, wall-type weir would have difficulty of standing against water pressure. Also sliding along the contact between the foundation and the weir body might take place. In such case, more stable structure should be introduced, e.g. gravity type wet-masonry weir. Following are the standard recommendation of the types in accordance with the height:

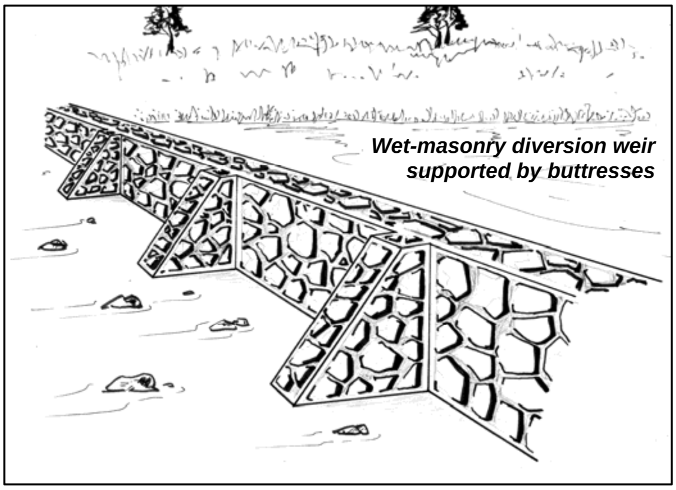
Table 5.2.1 Recommended Type of Permanent Weir with Relevant Height

Height (Max.)	Type to be Selected	Remarks
H =< 1.5 m	Wet-masonry wall type	
1.5 < H =< 2.0 m	Wet-masonry/Concrete wall type	According to the site condition either type be applied.
2.0 < H =< 3.0 m	Concrete wall type	No more than 3.0m height shall be tried.
2.0 < H =< 5.0 m	Wet-masonry gravity type	1) No more than 5 m height shall be tried under direct force account construction. 2) Between 2 – 3 m of height, either type be applied according to the site condition, e.g. in case that there are lots of cobbles, this type can be applied.

Note: the height (H) in the table shall not include the height of basement. Source: JICA Study Team

1.1) Wet-masonry Wall Type Weir

Wet masonry weir is made of stones/ rocks with cement mortar. Wet-masonry weir is not much familiar in Zambia but it can apply to upland streams where stable foundation, e.g. rock foundation,



can be found. Cement mortar is applied in this structure, but farmers may try clay-mortar as the first step constructing simple weir. Thereafter, they may move to the cement mortar wet-masonry weir, which is permanent.

In applying this permanent weir, meandering of the stream should be well observed. Under any possibility for the stream to meander, no this kind of permanent weir should be constructed. From this point of view as well, farmers can try simple weir made out of stones/rocks with clay-mortar where possible. Sometime after they have observed the diversion situation, they may move to the permanent one. No more than 2 m height shall be tried for this type of masonry wall type structure, and preferably the height shall be limited less than 1.5m (excluding the thickness of foundation basement).

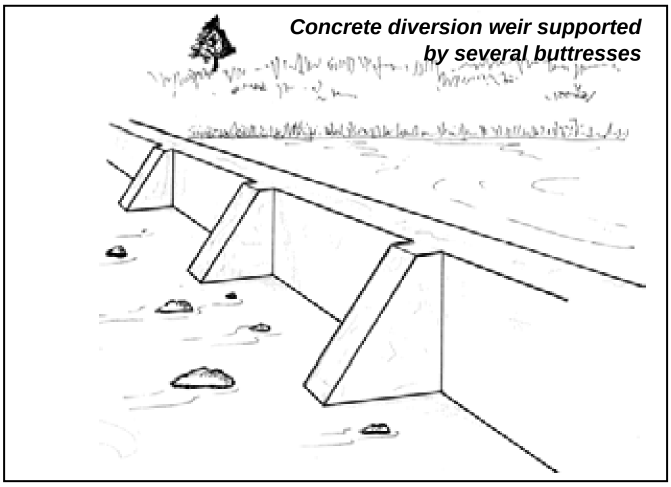
1.2) Concrete Wall Type Weir

Concrete made weir functions almost the same way as those of cement-mortar masonry weir. This, however, is much higher in construction cost and needs skilled labor or at least qualified technical assistance in mixing, placing and curing concrete. Placing concrete requires formwork, which also needs skilled carpenters. Therefore this Study recommends this type of weir only in sites where wet-masonry weir can hardly be constructed.

If a diversion weir requires more than 1.5m - 2m height, it is considered that wet-masonry type weir becomes difficult to stand against water pressure unless otherwise well supported by continuous buttress from the behind (in this case, the cross section of the weir becomes gravity self-standing type weir against water pressure). With this situation, following are recommended:

Weir height;

Less than 1.5 – 2.0 m:	Wet-masonry weir supported by several buttresses,
More than 1.5 – 2.0 m:	Concrete wall weir supported by several buttresses (however the height not more than 3.0m in any case)

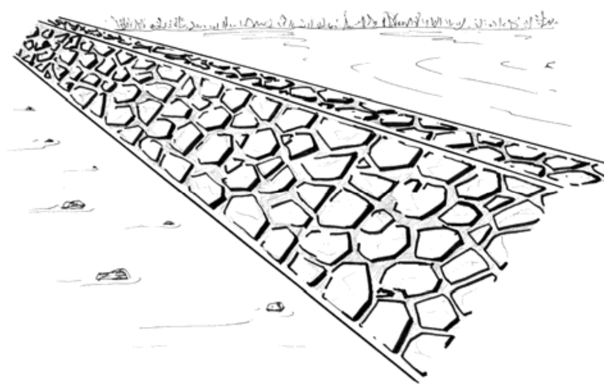


In case that the height is between 1.5 m and 2.0 m, the type can be selected according to the site condition; namely, where there are lots of stones and cobbles available and also where there is a solid foundation, wet-masonry weir may be selected otherwise concrete weir should be selected. It is also remarked that without irrigation/civil engineer at site, no weir more than 1.5 m above the ground level should be constructed due to high risk of accident.

1.3) Wet-masonry Gravity Type Weir

In case height of wall becomes more than 3.0 m, there could be a difficulty for wall type weir to stand water pressure even if the body is constructed with concrete. Even if the wall itself can put up with the pressure, the foundation may not be able to stand to seal the water because contact line between the wall base and the foundation is not long due to the nature of the wall type structure. Therefore, this Study does not recommend to construct wall type weir in case of the height being more than 3.0m, and in such case gravity type weir should be introduced instead.

Since gravity type weir requires mass volume of stuff in the body, wet-masonry structure should firstly be considered. Wet-masonry structure can be cheaper than that of concrete made ones. Likewise, if there are lots of stones at the site, this gravity type wet-masonry weir can be tried instead of concrete wall type even in case that the wall height is less than 3.0 m.



Wet-masonry gravity type weir

Since the construction modality proposed under smallholder irrigation is of direct force account, no civil contractor is to be engaged in the construction. It means all the construction works are to be undertaken by hired skilled labors who are supervised by district TSB/provincial TSB and unskilled labors who are the beneficiary farmers. In this arrangement of construction, there could be a high risk of accidents in putting up a diversion structure more than 5m height even if it is a gravity type wall. Therefore, this Study recommends that no diversion structure whose height is more than 5m should be tried.

2) Design of the Permanent Diversion Structure

To design a diversion structure, forces on the wall shall be examined and well undertaken[4]. The forces on the wall may be a combination of hydraulic and the body weight of the structure as well as resistance force. The magnitude of hydraulic force depends on the density and the depth of the retained materials (mostly it is water). The force will act at the centre of gravity of the pressure distribution diagram. The pressure is zero at the water surface and will increase linearly as the depth of water increases.

The weight of the structure should be sufficient to counteract the tensile stress caused by total lateral load of the water. The weight of the wall depends on the materials used for construction. The force due to its weight passes through the centre of gravity for the structure. This centre depends on its shape. The resisting force due to sliding depends on the weight of the structure and the type of the soil of which foundation is build. The product of the 2 factors will give a resisting force.

2.1) Stability of the Structure

Diversion structure should be stable against all the expected forces above-mentioned. The horizontal pressure of the water is the most consideration when dealing with water diversion structure. The higher the structure is, the higher the hydraulic force is. This pressure distribution diagram is in a triangular shape and therefore the centre of gravity is at one-third its height, thus 1/3 of height.

The middle-third law is usually employed to check the stability. This middle-third law rule may be simplified as; for a diversion structure to be stable against tension, the resultant force on the wall as a result of stored water should fall within the middle third of the base. One may consider a horizontal thrust force P through the centre of gravity of the structure. The weight W also acts through the centre

[4] Referred to a guideline employed in Zambia, e.g. Design of Water retaining Walls

of gravity to the ground. The resultant of these 2 forces is R directed to the base as well. For a stable structure, R should pass through middle third of the width of the base of the structure.

In addition to the middle-third law to be obeyed, the total active horizontal force should not exceed the total horizontal resistance in order for the structure not to slide. The factor obtained in dividing the total horizontal resistance by the total horizontal active force should be at least two. However, there may be a difficulty of estimating the resistance since it depends on the contact condition between the base and the foundation. In case that the foundation is formed of soil rock, there is no problem in this sliding. However, should the foundation be formed of soft soil, at first such soil shall be removed out and then basement of the structure shall be buried in enough depth, so that the sliding would not take place.

2.2) Foundation

Foundation is the lowest part of the structure. The purpose of the foundation is to support the weight of the structure, and transmitting the weight of the structure, both live and dead weight to the sub-soil. The depth of foundation of the weir is very important, and it should ensure safer transfer of weight of the weir into the foundation thereby ensuring its stability.

The depth should be determined upon examination of the sub-soil condition. Therefore, inspection pits should be dug or otherwise auger boring should be done every 3 – 5 meter along the weir axis. We should always check for stable base preferably rock. Hard sub-surface soil can also be accepted. The depth of the stable foundation determines the excavation depth for the core trench part of weir. If no proper foundation exists, a change in the design for the basement of weir would be necessary. In this case, foundation on soft soil may have to be designed with a concrete apron.

2.3) Construction

Materials for the diversion structure can be burnt bricks, stones and concrete. Clay burnt bricks may be used for the construction of the diversion structure. However it should be built of sufficient wall width. In using the burnt bricks, we should always ensure recommended thickness of the structure to avoid internal wall failure. It is also assumed that no super-imposed loads are carried. On the other hand, stone masonry and concrete are the most preferred materials for the construction of diversion weirs.

As for the wet-masonry structure, the recommended mortar ratio should never be weaker than 1:4 (cement to sand). The actual quantities of materials are best estimated in situ. Ruble-stone masonry is the most common type of masonry for diversion weir. This includes stones shaped roughly or properly selected in order to easy construction. Care should be taken to fill air voids in the body. For the sake of estimation, this type of masonry is 35% mortar and 65% stone of the volume of the structure (mixing ratio for mortar is 1:4). In case bricks are used instead of stones, it can be estimated that the total volume of brick masonry is approximately 25% mortar and 75% bricks.

Materials for concrete weirs are mainly stones, aggregates, water, cement and sand. Though concrete mixing ratio depends on the type of structure to be established, a suitable mix of concrete is 1 part cement by volume to 2 parts sand and 4 parts stones (1:2:4=cement: sand: aggregates[5]). Thus the quantities required per cubic meter of concrete are 5 pockets of 50kg cement, 0.36 m^3 sand 0.73 m^3 stones. Concrete should not be allowed to dry out quickly since this causes shrinkage, cracking and thus loss of strength. It should be cured for at least 1 week thus kept moisture by covering with wet-sack, wet grasses, etc.

[5] In case of concrete used in gravity type diversion structure, a weaker mixing ration can be applied, e.g. 1 part cement: 3 parts of sand and 6 parts of aggregates by volume (Source: Design of Water Retaining Walls).

3) Typical BOQ and Construction Cost of the Permanent Diversion Structure

Taking into account aforementioned discussions, following are the typical designs of diversion structure, and those BOQs (bill of quantities) and the construction cost; Table 5.2.2 shows those of wet-masonry wall type weir, Table 5.2.3 is for concrete wall type weir and the Table 5.2.4 is for wet-masonry gravity type:

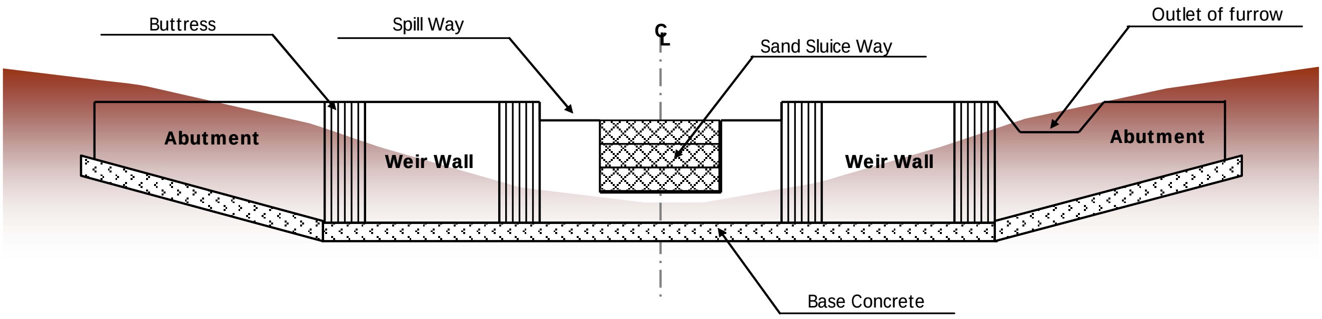
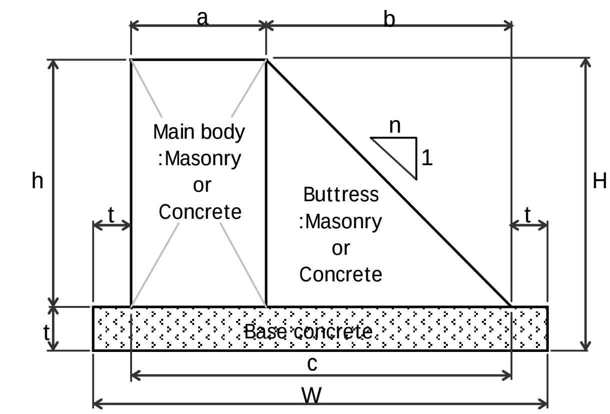


Figure 5.2.1 Typical Longitudinal Section of Diversion Weirs (applied regardless of the 3 types)



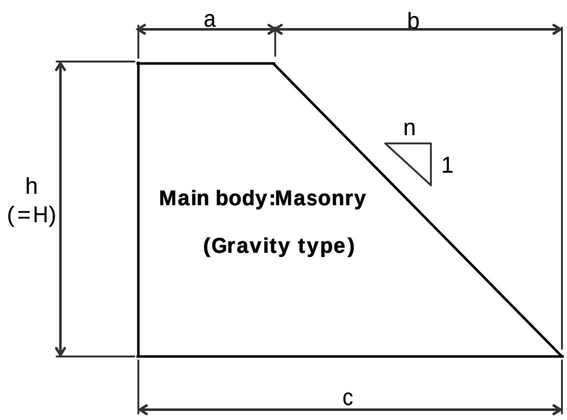
Dimensions of Wet-masonry Wall Type Weir

h	a	b	c	n	t	W	H
m	m	m	m	1:n	m	m	m
1.0	0.5	1.0	1.5	1.0	0.5	2.5	1.5
1.5	0.5	1.5	2.0	1.0	0.5	3.0	2.0
2.0	0.5	2.0	2.5	1.0	0.5	3.5	2.5

Dimensions of Concrete Wall Type Weir

h	a	b	c	n	t	W	H
m	m	m	m	1:n	m	m	m
1.5	0.40	1.5	1.9	1.0	0.40	2.7	1.9
2.0	0.45	2.0	2.5	1.0	0.45	3.4	2.5
2.5	0.50	2.5	3.0	1.0	0.50	4.0	3.0
3.0	0.60	3.0	3.6	1.0	0.60	4.8	3.6

Figure 5.2.2 Typical Cross Section of Wall Type Weir



Dimensions of Wet-masonry Gravity Type Weir

h (=H)	a	b	c	n	t	W	H
m	m	m	m	1:n	m	m	m
2.0	0.40	1.4	1.8	0.7	-	-	-
2.5	0.45	1.8	2.3	0.7	-	-	-
3.0	0.60	2.1	2.7	0.7	-	-	-
3.5	0.70	2.5	3.2	0.7	-	-	-
4.0	0.80	2.8	3.6	0.7	-	-	-
4.5	0.90	3.2	4.1	0.7	-	-	-
5.0	1.00	3.6	4.6	0.7	-	-	-

Figure 5.2.3 Typical Cross Section of Gravity Type Weir

Table 5.2.2 Typical BOQ and Construction Cost of Wet-masonry Wall Type Weir

Dimension		Volume of Masonry and Concrete			Construction Cost			
Height m	Length m	Masonry m^3	Concrete m^3	Total m^3	Materials MZK	Labor MZK	Engineering Services K	Total MZK
1.0	5.0	2.5	6.3	8.8	7,594,000	884,000	6,980,000	15,458,000
1.0	10.0	5.0	12.5	17.5	13,770,000	1,760,000	9,032,000	24,562,000
1.0	15.0	7.5	18.8	26.3	20,198,000	2,644,000	11,084,000	33,926,000
1.0	20.0	10.0	25.0	35.0	26,633,000	3,500,000	12,908,000	43,041,000
1.0	25.0	12.9	31.3	44.2	33,690,000	4,436,000	15,772,000	53,898,000
1.0	30.0	15.4	37.5	52.9	39,816,000	5,300,000	17,596,000	62,712,000
1.0	35.0	17.9	43.8	61.7	46,548,000	6,176,000	19,648,000	72,372,000
1.0	40.0	20.4	50.0	70.4	53,306,000	7,060,000	22,284,000	82,650,000
1.0	45.0	22.9	56.3	79.2	59,744,000	7,936,000	24,336,000	92,016,000
1.0	50.0	25.4	62.5	87.9	66,337,000	8,800,000	26,160,000	101,297,000
1.5	5.0	4.1	7.5	11.6	9,419,000	1,168,000	7,664,000	18,251,000
1.5	10.0	8.1	15.0	23.1	17,513,000	2,336,000	10,400,000	30,249,000
1.5	15.0	12.2	22.5	34.7	25,846,000	3,476,000	12,908,000	42,230,000
1.5	20.0	16.3	30.0	46.3	33,939,000	4,644,000	15,644,000	54,227,000
1.5	25.0	21.3	37.5	58.8	43,161,000	5,884,000	18,964,000	68,009,000
1.5	30.0	25.3	45.0	70.3	51,964,000	7,052,000	21,700,000	80,716,000
1.5	35.0	29.4	52.5	81.9	59,508,000	8,192,000	24,208,000	91,908,000
1.5	40.0	33.4	60.0	93.4	68,473,000	9,360,000	27,528,000	105,361,000
1.5	45.0	37.5	67.5	105.0	76,722,000	10,500,000	30,036,000	117,258,000
1.5	50.0	41.6	75.0	116.6	85,076,000	11,668,000	32,772,000	129,516,000
2.0	5.0	5.8	8.8	14.6	11,210,000	1,468,000	8,348,000	21,026,000
2.0	10.0	11.7	17.5	29.2	21,243,000	2,936,000	11,768,000	35,947,000
2.0	15.0	17.5	26.3	43.8	31,480,000	4,384,000	14,960,000	50,824,000
2.0	20.0	23.3	35.0	58.3	41,486,000	5,852,000	18,380,000	65,718,000
2.0	25.0	30.8	43.8	74.6	52,980,000	7,468,000	22,612,000	83,060,000
2.0	30.0	36.7	52.5	89.2	63,288,000	8,936,000	26,032,000	98,256,000
2.0	35.0	42.5	61.3	103.8	73,864,000	10,384,000	29,224,000	113,472,000
2.0	40.0	48.3	70.0	118.3	84,343,000	11,852,000	33,228,000	129,423,000
2.0	45.0	54.2	78.8	132.9	95,062,000	13,300,000	36,420,000	144,782,000
2.0	50.0	60.0	87.5	147.5	105,556,000	14,760,000	39,840,000	160,156,000

Source: JICA Study Team

Table 5.2.3 Typical BOQ and Construction Cost of Concrete Wall Type Weir

Dimension		Volume of Concrete m^3			Construction Cost			
Height m	Length m	Wall and Buttress	Foundat'n	Total	Materials MZK	Labor MZK	Engineering Services K	Total MZK
1.5	5.0	3.3	5.4	8.7	12,432,000	2,672,000	8,120,000	23,224,000
1.5	10.0	6.5	10.8	17.3	23,280,000	5,316,000	11,312,000	39,908,000
1.5	15.0	9.8	16.2	26.0	34,697,000	7,960,000	14,504,000	57,161,000
1.5	20.0	13.0	21.6	34.6	45,702,000	10,632,000	17,468,000	73,802,000
1.5	25.0	17.0	27.0	44.0	58,725,000	13,496,000	21,472,000	93,693,000
1.5	30.0	20.3	32.4	52.7	70,303,000	16,160,000	24,664,000	111,127,000
1.5	35.0	23.5	37.8	61.3	81,666,000	18,812,000	27,856,000	128,334,000
1.5	40.0	26.8	43.2	70.0	93,403,000	21,456,000	31,632,000	146,491,000
1.5	45.0	30.0	48.6	78.6	105,115,000	24,120,000	34,596,000	163,831,000
1.5	50.0	33.3	54.0	87.3	116,528,000	26,772,000	37,788,000	181,088,000
2.0	5.0	5.3	7.5	12.8	17,226,000	3,936,000	9,716,000	30,878,000
2.0	10.0	10.5	15.1	25.6	33,055,000	7,864,000	14,276,000	55,195,000
2.0	15.0	15.8	22.6	38.4	49,069,000	11,772,000	18,836,000	79,677,000
2.0	20.0	21.0	30.2	51.2	65,324,000	15,700,000	23,624,000	104,648,000
2.0	25.0	27.8	37.7	65.4	84,757,000	20,076,000	29,224,000	134,057,000
2.0	30.0	33.0	45.2	78.2	101,347,000	24,004,000	34,012,000	159,363,000
2.0	35.0	38.3	52.8	91.0	117,905,000	27,932,000	38,572,000	184,409,000
2.0	40.0	43.5	60.3	103.8	135,160,000	31,840,000	43,716,000	210,716,000
2.0	45.0	48.8	67.8	116.6	151,853,000	35,776,000	48,504,000	236,133,000
2.0	50.0	54.0	75.4	129.4	169,118,000	39,684,000	53,064,000	261,866,000

Dimension		Volume of Concrete m^3			Construction Cost			
Height m	Length m	Wall and Buttress	Foundat'n	Total	Materials MZK	Labor MZK	Engineering Services K	Total MZK
2.5	5.0	7.8	10.0	17.8	22,857,000	5,472,000	11,540,000	39,869,000
2.5	10.0	15.6	20.0	35.6	44,568,000	10,944,000	17,924,000	73,436,000
2.5	15.0	23.4	30.0	53.4	66,541,000	16,396,000	24,308,000	107,245,000
2.5	20.0	31.3	40.0	71.3	88,668,000	21,860,000	30,920,000	141,448,000
2.5	25.0	41.7	50.0	91.7	116,180,000	28,128,000	38,800,000	183,108,000
2.5	30.0	49.5	60.0	109.5	139,038,000	33,580,000	45,184,000	217,802,000
2.5	35.0	57.3	70.0	127.3	162,338,000	39,052,000	51,796,000	253,186,000
2.5	40.0	65.1	80.0	145.1	185,542,000	44,516,000	58,764,000	288,822,000
2.5	45.0	72.9	90.0	162.9	209,321,000	49,968,000	65,148,000	324,437,000
2.5	50.0	80.7	100.0	180.7	233,273,000	55,440,000	71,532,000	360,245,000
3.0	5.0	12.0	14.4	26.4	31,466,000	8,100,000	14,504,000	54,070,000
3.0	10.0	24.0	28.8	52.8	61,847,000	16,200,000	24,080,000	102,127,000
3.0	15.0	36.0	43.2	79.2	92,980,000	24,300,000	33,656,000	150,936,000
3.0	20.0	48.0	57.6	105.6	124,657,000	32,400,000	43,232,000	200,289,000
3.0	25.0	64.5	72.0	136.5	164,295,000	41,860,000	54,988,000	261,143,000
3.0	30.0	76.5	86.4	162.9	197,255,000	49,960,000	64,564,000	311,779,000
3.0	35.0	88.5	100.8	189.3	230,675,000	58,060,000	74,140,000	362,875,000
3.0	40.0	100.5	115.2	215.7	264,896,000	66,160,000	84,300,000	415,356,000
3.0	45.0	112.5	129.6	242.1	299,564,000	74,260,000	93,876,000	467,700,000
3.0	50.0	124.5	144.0	268.5	335,125,000	82,340,000	103,452,000	520,917,000

Source: JICA Study Team

Table 5.2.4 Typical BOQ and Construction Cost of Wet Masonry Gravity Type Weir

Dimension		Volume of Masonry			Construction Cost			
Height m	Length m	Masonry m3	Concrete m3	Total m3	Materials MZK	Labor MZK	Engineering Services K	Total MZK
2.0	5.0	11.1	-	11.1	5,660,000	1,128,000	7,664,000	14,452,000
2.0	10.0	22.2	-	22.2	10,098,000	2,236,000	10,172,000	22,506,000
2.0	15.0	33.3	-	33.3	14,554,000	3,344,000	12,680,000	30,578,000
2.0	20.0	44.4	-	44.4	19,029,000	4,452,000	15,188,000	38,669,000
2.0	25.0	55.5	-	55.5	24,145,000	5,560,000	18,280,000	47,985,000
2.0	30.0	66.6	-	66.6	28,657,000	6,668,000	20,788,000	56,113,000
2.0	35.0	77.7	-	77.7	33,188,000	7,776,000	23,296,000	64,260,000
2.0	40.0	88.8	-	88.8	37,938,000	8,884,000	26,388,000	73,210,000
2.0	45.0	99.9	-	99.9	42,855,000	9,992,000	28,896,000	81,743,000
2.0	50.0	111.0	-	111.0	47,441,000	11,100,000	31,404,000	89,945,000
2.5	5.0	17.3		17.3	8,182,000	1,752,000	9,032,000	18,966,000
2.5	10.0	34.7	-	34.7	15,092,000	3,476,000	12,908,000	31,476,000
2.5	15.0	52.0	-	52.0	22,535,000	5,228,000	17,012,000	44,775,000
2.5	20.0	69.4	-	69.4	29,536,000	6,952,000	20,888,000	57,376,000
2.5	25.0	86.7	-	86.7	36,855,000	8,684,000	25,348,000	70,887,000
2.5	30.0	104.1	-	104.1	44,426,000	10,428,000	29,452,000	84,306,000
2.5	35.0	121.4	-	121.4	51,561,000	12,160,000	33,328,000	97,049,000
2.5	40.0	138.8	-	138.8	59,371,000	13,884,000	37,788,000	111,043,000
2.5	45.0	156.1	-	156.1	66,821,000	15,628,000	41,892,000	124,341,000
2.5	50.0	173.4	-	173.4	74,092,000	17,360,000	45,768,000	137,220,000
3.0	5.0	25.0	-	25.0	11,095,000	2,500,000	10,628,000	24,223,000
3.0	10.0	50.0	-	50.0	21,516,000	5,000,000	16,328,000	42,844,000
3.0	15.0	74.9	-	74.9	31,694,000	7,500,000	22,028,000	61,222,000
3.0	20.0	99.9	-	99.9	42,301,000	9,992,000	27,728,000	80,021,000
3.0	25.0	124.9	-	124.9	52,944,000	12,492,000	34,012,000	99,448,000
3.0	30.0	149.9	-	149.9	63,742,000	14,992,000	39,712,000	118,446,000
3.0	35.0	174.8	-	174.8	74,282,000	17,492,000	45,412,000	137,186,000
3.0	40.0	199.8	-	199.8	85,565,000	19,984,000	51,696,000	157,245,000
3.0	45.0	224.8	-	224.8	96,296,000	22,484,000	57,396,000	176,176,000
3.0	50.0	249.8	-	249.8	107,482,000	24,984,000	63,096,000	195,562,000
3.5	5.0	34.0	-	34.0	14,754,000	3,400,000	12,808,000	30,962,000

Dimension		Volume of Masonry			Construction Cost			
Height m	Length m	Masonry m3	Concrete m3	Total m3	Materials MZK	Labor MZK	Engineering Services K	Total MZK
3.5	10.0	68.0	-	68.0	28,851,000	6,800,000	20,560,000	56,211,000
3.5	15.0	102.0	-	102.0	43,198,000	10,200,000	28,312,000	81,710,000
3.5	20.0	136.0	-	136.0	57,291,000	13,600,000	36,064,000	106,955,000
3.5	25.0	170.0	-	170.0	72,255,000	17,000,000	44,400,000	133,655,000
3.5	30.0	204.0	-	204.0	87,047,000	20,400,000	52,152,000	159,599,000
3.5	35.0	238.0	-	238.0	102,092,000	23,800,000	59,904,000	185,796,000
3.5	40.0	272.0	-	272.0	117,172,000	27,200,000	68,240,000	212,612,000
3.5	45.0	305.9	-	305.9	132,473,000	30,600,000	75,992,000	239,065,000
3.5	50.0	339.9	-	339.9	148,043,000	34,000,000	83,744,000	265,787,000
4.0	5.0	44.4	-	44.4	19,029,000	4,452,000	15,316,000	38,797,000
4.0	10.0	88.8	-	88.8	37,385,000	8,884,000	25,348,000	71,617,000
4.0	15.0	133.2	-	133.2	56,255,000	13,336,000	35,608,000	105,199,000
4.0	20.0	177.6	-	177.6	75,201,000	17,768,000	45,640,000	138,609,000
4.0	25.0	222.0	-	222.0	94,801,000	22,200,000	56,256,000	173,257,000
4.0	30.0	266.4	-	266.4	114,491,000	26,652,000	66,516,000	207,659,000
4.0	35.0	310.8	-	310.8	134,402,000	31,084,000	76,548,000	242,034,000
4.0	40.0	355.2	-	355.2	154,967,000	35,536,000	87,392,000	277,895,000
4.0	45.0	399.6	-	399.6	175,472,000	39,968,000	97,424,000	312,864,000
4.0	50.0	444.0	-	444.0	196,187,000	44,400,000	107,456,000	348,043,000
4.5	5.0	56.2	-	56.2	24,213,000	5,636,000	18,052,000	47,901,000
4.5	10.0	112.4	-	112.4	47,581,000	11,252,000	30,820,000	89,653,000
4.5	15.0	168.6	-	168.6	71,423,000	16,868,000	43,588,000	131,879,000
4.5	20.0	224.8	-	224.8	95,722,000	22,484,000	56,356,000	174,562,000
4.5	25.0	281.0	-	281.0	121,147,000	28,100,000	69,708,000	218,955,000
4.5	30.0	337.2	-	337.2	146,650,000	33,736,000	82,704,000	263,090,000
4.5	35.0	393.4	-	393.4	172,376,000	39,352,000	95,472,000	307,200,000
4.5	40.0	449.6	-	449.6	198,890,000	44,968,000	108,824,000	352,682,000
4.5	45.0	505.7	-	505.7	225,576,000	50,584,000	121,592,000	397,752,000
4.5	50.0	561.9	-	561.9	253,087,000	56,200,000	134,360,000	443,647,000
5.0	5.0	69.4	-	69.4	29,536,000	6,952,000	21,016,000	57,504,000
5.0	10.0	138.8	-	138.8	58,811,000	13,884,000	36,748,000	109,443,000
5.0	15.0	208.1	-	208.1	88,683,000	20,836,000	52,708,000	162,227,000
5.0	20.0	277.5	-	277.5	119,413,000	27,760,000	68,440,000	215,613,000
5.0	25.0	346.9	-	346.9	150,874,000	34,692,000	84,756,000	270,322,000
5.0	30.0	416.3	-	416.3	183,196,000	41,644,000	100,716,000	325,556,000
5.0	35.0	485.6	-	485.6	215,826,000	48,576,000	116,448,000	380,850,000
5.0	40.0	555.0	-	555.0	249,735,000	55,500,000	132,764,000	437,999,000
5.0	45.0	624.4	-	624.4	283,974,000	62,452,000	148,724,000	495,150,000
5.0	50.0	693.8	-	693.8	319,020,000	69,384,000	164,456,000	552,860,000

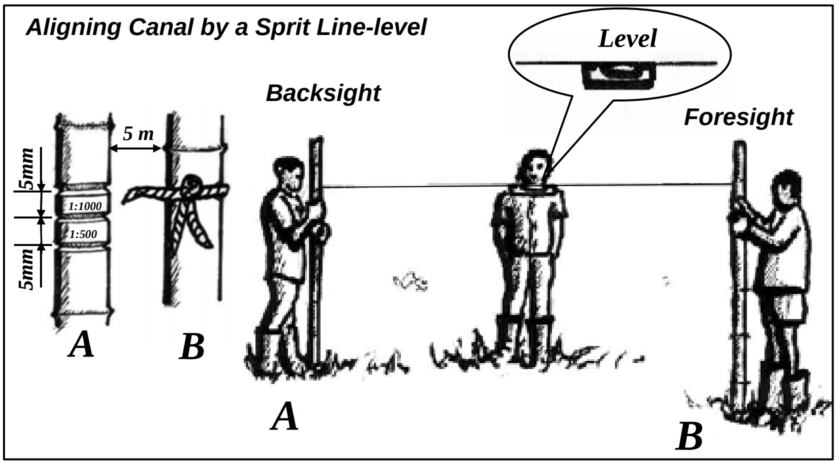
Source: JICA Study Team

5.2.5 Designing of Canal

Canal (called furrow in Zambia) 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. For the stretch where sandy soil prevails, sealing may be required with clay soil, brick-lining, wet-masonry lining, or concrete lining.

1) Aligning of Canal

A tool called sprit line level can be used in aligning canal with a designed longitudinal slope. In fact, sprit line level is used in aligning counter in the field of land conservation. Example is that a series of counter lines are identified with the sprit line level along which *Vetivar* grasses are planted to prevent soils from being eroded by rainfall. This is the conventional way of using the line level, and in aligning canal; a suitable longitudinal gradient shall be placed on the expected canal stretch.



To introduce the line level in ailing canal, 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 over the 5 m distance (this is the point different from the conventional way of using). Pole with higher tied point should always be placed foreside, not like conventional alternate placing. 0.5 cm difference over 5 meters gives 1:1,000 gradient suitable for gentle topography like *dambo*, and 1 cm difference over the same 5 meters distance gives 1:500 gradient adaptable for sloped topography (for detail explanation, refer to Part II Process Description Manuals 10. Canal Alignment with Sprit Line Level).

In some areas, topography is too gentle to align canal with sprit line level. An example is that the foreside of the line-leveling cannot find out any point 0.5 – 1.0 cm lower than the backside in a straight way. Faced with this situation, line-leveling usually starts staggering the way. In such cases, distance of the 2 poles should be extended to 10m or even to 15m in cases, double – triple distance of the standard 5.0 m. With this 10 – 15 m distance, 1.0 – 1.5 cm (double – triple difference of 0.5cm) difference can give 1:1,000 longitudinal gradient and 2.0 – 3.0 cm difference (double – triple difference of 1.0cm) can provide with 1:500 longitudinal gradient. In such case where topography is too gentle, 1:1,000 longitudinal gradient is usually recommended rather than 1:500 gradient.

Then, if still there is a difficulty to align canal with the sprit line level, it is the time of bringing dumpy level. As most BEOs/CEOs can hardly operate dumpy level, district TSB officers should be in charge of aligning canal by using the dumpy level. Dumpy level may be required in places where the topographic condition is too flat or there are obstacles on the planed canal line higher than that of the sprit level whereby sprit level cannot be operated.

2) Design of Canal

Canal is categorized into two; either non-lining or lined. Lining is made of clay soil often tried by farmer themselves over a stretch showing leakage, and also of artificial materials e.g. stone lining, brick lining and wet-masonry lining. Concrete lining is sometimes seen but the cost goes beyond farmers' affordability, and therefore this Study does not support this option under the smallholder irrigation schemes.

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 smallholder farmers. 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.

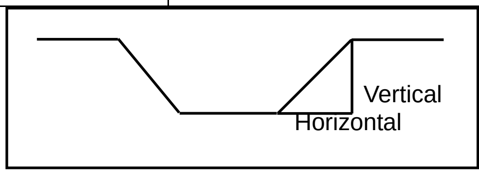
Lining can be done with stone, brick or masonry. These canals reduce the canal conveyance loss and also minimize maintenance works as compared to earthen canal. In particular, reducing the canal conveyance loss becomes very important when diversion water is not enough to cover all the potential service 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 stone lining. Farmers in rural area make bricks by themselves. Therefore, brick lining is cheaper than wet-masonry lining, 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 tried in this regard.

For earthen canals, standard trapezoidal shape is commonly used but in some 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 can become vertical if the soil is hard and very cohesive. Recommendable side slopes for different soils are given in Table 5.2.5:

Table 5.2.5 Recommendable Side Slope of Canal

Type of Soils	Vertical : Horizontal
Clay	2 : 1 - 1: 0(vertical)
All other soils	1: 0(vertical) - 1 : 1
Sand	1 : 1 - 0.5: 1



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.

This Study recommends the minimum allowable velocity should be in a range of 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. On the other hand, maximum allowable velocity is presented in Table 5.2.6 depending on the canal material.

Table 5.2.6 Maximum Allowable Velocity

Canal Material	Allowable Velocity, (m/s)
Sandy soil	0.4 - 0.6
Sand-loam	0.5 - 0.7
Clay-loam	0.6 - 0.9
Clay	0.9 - 1.5
Rock	1.0 - 2.0
Thin concrete	1.5 - 2.5
Wet masonry	2.50

Source: Canal, Design Manual, MAFF, Japan, 1987

Steep longitudinal slope creates erosion due to its high flow velocity though it can reduce the canal section. On the other hand, too gentle longitudinal slope causes heavy silting in the canal and also enlarges canal section to accommodate the required flow. Taking into account the two factors, Table 5.2.7 on the right hand shows the recommended canal longitudinal slope. In sum, this Study recommends 1:1,000 longitudinal slope in relatively flat lands e.g. dambo areas and 1:500 longitudinal slope in a relatively sloped topography.

Table 5.2.7 Maximum Minimum Slope of Canal

Design Flow, liter/s	Minimum	Maximum
5	1:2000	1:100
10	1:2000	1:100
15	1:2000	1:100
30	1:2000	1:200
50	1:2000	1:300
100	1:2000	1:400

Source: Canal, Design Manual, MAFF, Japan, 1987

5.2.6 Construction of Smallholder Irrigation Schemes

The irrigation facilities range from primitive but cheap one to modern but costly one. In this Study, primitive one is of simple diversion schemes while modern ones are either wet-masonry structure or concrete structure. All the materials for simple schemes should be provided by farmers themselves while foreign materials required for permanent structures can be provided by the government, donors, or other stakeholders e.g. NGO, religious organizations, etc.

As for construction, considering the financial affordability of the farmers, the principle for the construction should center on intensive labor manual work by the farmers themselves. Construction, therefore, will not employ any heavy equipment nor engage local contractor in principle. In this regard, even the construction of permanent structures does not employ civil contractor in principle and therefore should be carried out under direct force account by the government. Under this system, provincial/district TSB procures necessary foreign materials such as cement, iron bars, and timbers for formwork and farmers undertake the work under the technical supervision of the TSB.

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, spade, 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, spade and wheel barrow, may be arranged by concerned provincial and district TSBs and rented out to the farmers upon the request.

As a matter of fact, construction of permanent structures may need to engage skilled labors such as masonry and carpentry. In this case, BEOs/CEOs and the farmers should learn the technique at the beginning stage of the construction so that the employment can be minimized. BEOs/CEOs are also expected to furnish the technique they have acquired to other areas. The payment to the skilled labors is undertaken by the concerned district TSB under the direct force account system.

However, this direct force account system can hardly deal with more than 2 permanent construction sites per season per district as the technical staff in district TSB is very much limited, say 2 – 3 staff only including not only irrigation but also land husbandry and farm power mechanization. Therefore, provided that there is a sum of budget for promoting permanent irrigation structures arranged by either the government or donors, this Study does not exclude the option of engaging civil contractors in the construction.

The point, still in the above arrangement, is that the contractor should not undertake whole part of the construction work, and rather the farmer beneficiaries should undertake most of the construction work. This arrangement can save contract price as well as increase the scheme's sustainability based on the nurturing of ownership. Therefore, the contract with civil contractors should be of procurement by nature as much as possible. Under this concept, the contractors procure necessary materials and ferry them to the sites and provide some technical assistances with concerned district TSB, BEOs/CEOs. Then, beneficiary farmers carry out the construction.

5.3 Operation and Maintenance of Smallholder Irrigation Schemes

Operation and maintenance is very much crucial in sustaining irrigation schemes, and this session elaborates such O&M. First, operation should be carried out in so doing as securing equal water distribution as much as possible amongst the scheme members. In gravity irrigation scheme, there is a thumb of role; that is the more upstream the more advantage in terms of water allocation since water by gravity runs from upstream to downstream. A mean to ensure equitable water distribution is the introduction of rotational irrigation.

Second, maintenance should be carried out all by farmer beneficiaries under smallholder irrigation scheme arrangement. Government may provide advices or otherwise facilitation of organizing member farmers in carrying out maintenance work. However, physical assistances from the government should no be considered. As for simple irrigation schemes, farmers would definitely carry out required maintenance work because they have constructed the scheme by themselves, which must be much harder work than the maintenance. Permanent structure usually requires minimal level of maintenance for diversion weir, as it is permanent. They may, however, require government physical assistance in carrying out major rehabilitation work in that they need cement, iron bars, etc.

5.3.1 Equitable Water Distribution: Rotational Irrigation

As per water distribution, there are two different methods at the main canal level; namely, 1) proportional distribution to secondary groups under continuous flow, and 2) rotational distribution among the secondary groups[6]. 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 based on on-off distribution.

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. 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 within the group based on the on-farm 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 on the secondary canal is used. Generally, as irrigation scheme becomes bigger, proportional distribution is applied mainly because the system does not require main canal size being same up to the end and also turnout at the secondary intake is constructed in such a way of properly controlling the flow into the secondary canal.

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

5.3.2 Local Water Governance

On the matter of local water governance systems, two different scales of systems should be considered: physical water allocation within an irrigation system and water right coordination among multiple water users along a stream or spring. On the part of efficient water allocation within a system, a set of rotational irrigation systems are recommended.

For effective local water governance among different systems, on the other hand, it is important to focus on “water right” rather than physical allocation of water. In general, prior right is given to those who started using the water first.

Therefore, it is extremely important for late comers to see if there are any other people who are currently using the water along the stream. To be sure, it should be prohibited by a rule to construct intake structures within the range of couple kilometers from existing intake that someone is using. For this type of arrangement, extension officers’ involvement and instruction on site selection is essential to avoid unnecessary conflict between the two parties in the future.

In addition, for those who are the first comer to the area, it is also recommended to secure the water right. Even if a group of farmers started using water prior to the other group, their water right is still at

[6] It is remarked that secondary group means in most of cases on-farm group so that secondary canal here in smallholder irrigation scheme means on-farm feeder canal.

a risk to be violated just because their water right is yet to be legally confirmed. In the regulation, it is stipulated that water users need to apply to Ministry of Energy and Water Development for water right. Once water right is secured, this group of farmers is entitled to the water use for long period of time over other groups who come later.

In practice, securing the water right has been also practiced in the pilot project with a great deal of support by extension officers. In the evaluation workshops held at the end of pilot project, several extension officers reported that she or he helped farmers apply water right. Therefore, it is expected that water right in the smallholder irrigation sites will be, or have to be, secured in the future and thus, in most of places, local water governance system can be better administered.

5.3.3 Irrigation Schedule

To properly operate an irrigation scheme, irrigation schedule should be prepared. Irrigation schedule shows an irrigation interval, the date and time, when the farmers should 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 and also crop type, it can be said that the interval should not be over 8 days in most cases. In fact, it may extend up to 2 weeks interval under cool weather while it may limit to only 5 days under very hot and dry weather. In general, this Study recommends that every secondary group should receive irrigation water at least once out of every 8 days, or we may face that crops start wilting.

All the secondary canals may be grouped 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 the other. Then, on-farm level rotation is further planned amongst the farmers in a secondary group. Following should be considered in planning the field level rotational irrigation from the viewpoint of workability:

> 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)

1) The minimum duration per irrigation per farmer is in the order of 2 to 3 hours,
2) The maximum duration per irrigation per farmer is in the order of 10 to 12 hours, and
3) 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 below, on condition that there are 8 secondaries, each of which has 4 farmer members in average and irrigation is done only during daytime, 12 hours a day.

Table 5.3.1 An Example of Irrigation Schedule

Condition: Total number of secondary canals = 8, Nr. of farmer per secondary = 4

At main canal	Maximum irrigation duration per group		At a secondary level		Irrigation hour/ group	Selection
Nr. of 2nd groups	days	hours	Nr. of on-farm groups	Farmers/ on-farm group		
8	1	12	4	1	3	○
			2	2	6	○
			1	4	12	○
4	2	24	4	1	6	○
			2	2	12	○
			1	4	24	
2	4	48	4	1	12	○
			2	2	24	
			1	4	48	

Note: irrigation is planed at least once not more than 8 days.

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 shorter while at maturity stage the interval can be longer as the roots have fully developed. This means that the timetable will be reviewed as the season progresses.

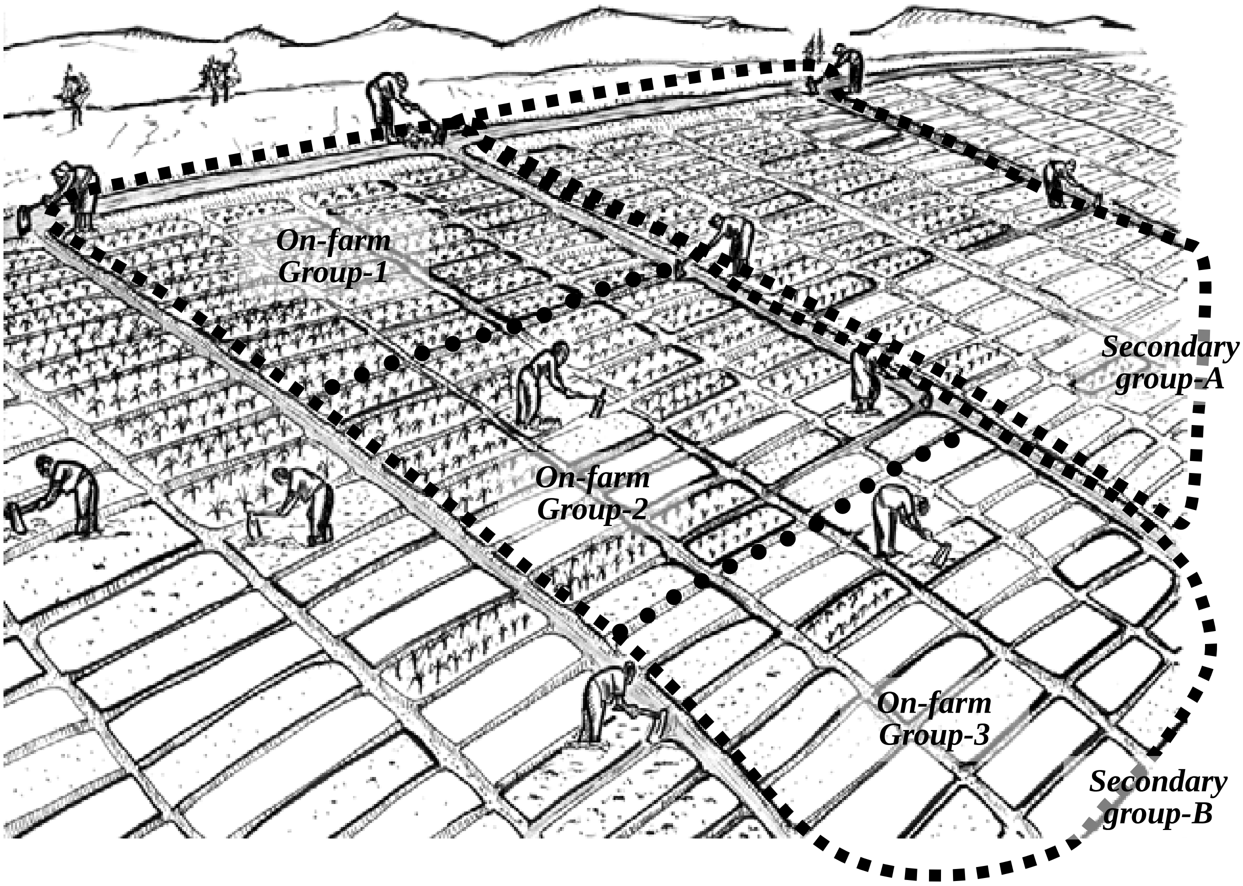


Figure 5.3.1 An Example of Rotational Irrigation Block

5.3.4 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 experimental data, seasonal crop water requirement values for ordinary crops may be as follows, taking into account of overall irrigation efficiency of 0.5 (ratio of what is provided by the irrigation scheme over what is consumed by crop).

Table 5.3.2 Net and Gross Crop Water Requirement

Crop	Seasonal Water Requirement		Growth Period	Net Crop Water Requirement		Gross Crop Water Requirement (NCWR/0.5)	
	mm depth or litter/m^2	m^3/ha	Days	m^3/ha/ day	liter/s/ha	m^3/ha/days	liter/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**

Source: FAO Irrigation and Drainage Paper No.45, FAO 1989

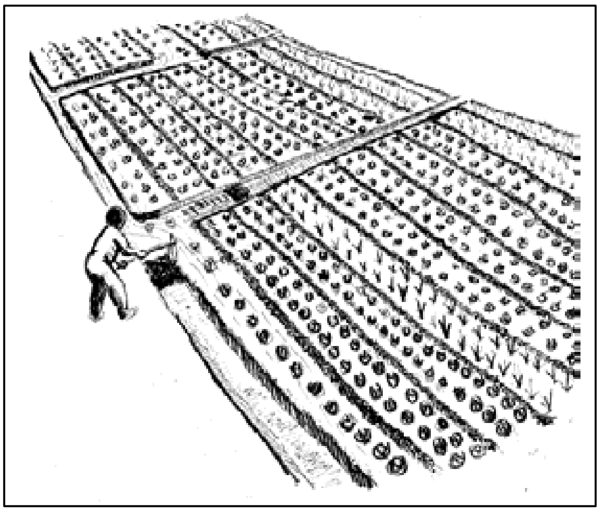
With reference to the above gross crop water requirement, it can be known how much diversion water is required to irrigate the prospective areas or visa versa; namely, based on the available flow in the stream how much acreage can be irrigated will also be known. Roughly, an amount of 2.4 liter/s/ha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

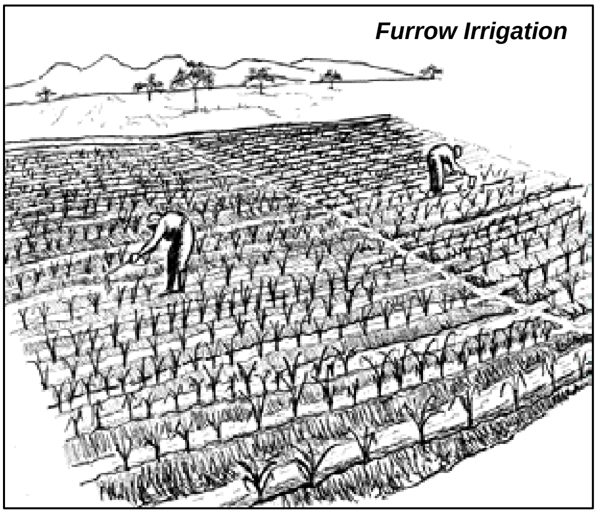
In other way, it can be roughly said that a crop area of 1 hectare needs about 1.2 liter per second of gross irrigation water under 24 hours continuous application. This means a flow of 10 liter per second could serve 10 hectares at maximum (mathematically, it is 8.3 ha and rounded to 10 ha). However, 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 liter per second; say 10 acreages on 10 liter/s, 30 acreages on 30 liter/s, etc (1 acreage equals to 0.4 hector).

5.3.5 On-farm Irrigation

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

Sunken-bed irrigation is the most common type of surface irrigation. 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, this surface irrigation could achieve as high as 80% when it is properly leveled and well managed.





Furrow irrigation scheme 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 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%, about 10 % less than the sunken-bed irrigation.

From the viewpoint of efficient water use, sunken-bed 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 beds. If a topographic condition is associated with 4% slope (1/25) or more, the width of a terrace cannot go beyond about 2 m. This means that almost every bed would result in accompanying terracing which requires too much laborious work.

Therefore, on sloped lands, say more than 4% slope, furrow irrigation may be much preferred by the farmers and in deed adaptable. The spacing of the furrow can follow the rainy season's ridging spacing; preferably 70 – 90cm. Ridge height, equally to furrow depth, should be around 20 – 25 cm in order for capillary to soak the water toward ridge. Standard height of ridges 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 3 m in the shortest case and can be extend 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 0.1 – 0.2 ha each as an example, and cultivated by many members. Another factor of determining the length of furrow is water volume available. If the water volume is very critical, say less than 2 liter/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 and lower parts of hilly areas, sunken-bed irrigation can be best suited. Smallest size of sunken bed could be 1.2 m x 3 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 bed; namely, if water volume is very critical, say less than 2 liter/s, the size should be small such as 1.2 x 3 m taking into account the time required to fill up the basin.

Though sunken-bed 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 sunken-bed and drainage may also be required. *Dambo* areas may adopt sunken-bed 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.

5.3.6 Maintenance

Maintenance should be done by the farmers' organization with technical advices from the BEOs/CEOs concerned. Maintenance work is required for the main facility; that is diversion weir, and canal including its ancillary facilities. The work can be categorized 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 simple weirs such as brush dams, no routine maintenance work is usually required during the season except minor repairs. However, 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 material as big logs, sacks, pegs, etc. should be kept besides the site or in their village. These materials can be again used for the next season.

For the permanent weirs, no routine maintenance work is required. However, physical observation shall be made once in every 2 – 3 days to check whether the weir is functioning as designed or not. Especially, crack on the weir, deformation of the weir, and settlement of a part of weir shall always be paid attention. If the cracks are small, so-called hair crack, they are not harmful. However, should noticeable settlement, and thereby cracks on the concrete be found, those cracks should be filled with cement mortar. To place cement mortar, the cracked part should be at first chipped into V-shape and the V part should be filled with cement mortar.

2) Canal Maintenance

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:

i) 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.

ii) 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.

iii) Crossing sections by people and animals (livestock) along the canal should be strengthened by hard compaction or lined with stones, bricks or wet-masonry.

iv) Holes/cracks in the canal should be filled with sticky clay soil, and eroded sections should be rebuilt to the original shape.

5.4 Irrigated Agriculture Development

Farming scheme and marketing are as important as irrigation development itself; indeed, irrigation development and irrigated agriculture development are two wheels of one cart that runs toward better livelihood improvement. In practice, farmers may not be able to gain any kwacha unless they can produce enough amount of quality harvest that the market demands.

In reality, it was found that as much as 85% of what were produced under irrigated agriculture was sold either within the village or outside market. Also, major concerns often claimed by the farmers were means of transportation and negotiation power, but not a low market demand, suggesting a high fundamental demand in the market. Thus, there is enough reason to believe that the irrigated agriculture in the Study area should be more market oriented, rather than self-sufficiency of staple food crops. This chapter, therefore, aims to propose plans for market-oriented agriculture development together with soil management plan, and cropping calendar to be recommended.

5.4.1 Market-Oriented Agriculture Development Plan

Market is ever changing. Consumer demand shifts from one commodity to the other. Producers react with different strategies. As a result, no one can predict the market dynamics accurately. In this regard, there is no point to set a concrete plan of crop production or farming scheme suitable to the market demand. Rather, specific decisions have to be made by the each and single stakeholder on a case-by-case basis. In this concern, this section intends to provide a plan with which farmers can make better decisions applicable to the market dynamics.

1) Issues to be concerned for Decision Making

Farmers are required to make a decision on whatever they can choose. For some, choices are quite limited or sometimes there is no choice, while difficult decisions are required for those who have many choices. In any cases, decisions should be made by considering best available information that farmers can access to. Here listed are typical issues for profitable agricultural production.

1.1) Expected Profitability

Simple and typical approach to choosing appropriate crops is to consider expected profitability of crops. Profitability differs in accordance with the types of crops, although it is affected by the location, season, and quality of the produces. Expected level of profitability, therefore, should be first of all taken into account in deciding what crops to produce. For instance, result of harvest survey carried out by the JICA Study Team provides an overall picture of profitable crops in the area. As shown in Table 5.4.1, the most profitable crop in the sampled villages in six districts was onion at ZMK 3.6 million per lima for the net income, which was followed by cabbage at ZMK 3.3 million per lima. Although profitability should be carefully assessed in each case because the selling price may vary greatly, it can be a first step to consider the options of best crops.

1.2) Level of Investment Required

Required investment level of production is also an important factor. Even if profitability is preferable, it is sometimes difficult for such farmers who have limited access to funding to go for that crop. For instance, required level of investment for cabbage is approximately ZMK 1.9 million per lima, while it is only ZMK 0.15 million per lima for groundnuts; namely, required cost of input are totally different. It should be clearly understood that, as agriculture always involves some levels of risk, crops should be selected with concern to the required cost and availability of funding of farmer household.

One important fact which should be clearly understood is that farmer should not expect the same amount of harvest that neighbor farmers get unless he/she put the same amount of input as the neighbor put. Unfortunately, it was revealed that the production of green maize in the existing irrigated schemes was quite depressed, only ZMK 1,173,000 per lima net, even though some particular cases suggest the potential net profit of green maize up to ZMK 9.9 million per lima. According to some follow-up interviews, this low level of net profit was mostly caused by significantly low level of fertilizer application.

Same as rain-fed maize production, standard cropping scheme suggests farmers to apply 50 kg/lima of D-compound fertilizer and another 50kg/lima of urea, totaling 100kg of chemical fertilizer per lima (equivalent to 400 kg per hector). However, there are many cases that farmers do not apply that much. For instance, according to the harvest survey, number of farmers who applied 50kg/lima or more of D-compound was 97 out of 194, only 50% of all the samples. Instead, 62 farmers, 31% of the samples, applied less than 30 kg/lima (see Table 5.4.1). It implies that the many farmers are having difficulty to purchase the amount of fertilizer that is dully required for good harvest.

For those farmers who are facing such challenges, it is recommendable to consider other type of crops, e.g. groundnut, that require relatively low input cost, which could sometimes result in better net profit.

Table 5.4.1 Number of Farmers by Amount of Fertilizer to Green Maize

Amount of Fertilizer Applied per lima	D-compound	Ratio	Urea	Ratio
50kg or more	97	50%	91	47%
40 - 50kg	15	8%	17	9%
30 - 40kg	20	10%	17	9%
0 - 30kg	46	23%	52	27%
0kg	16	8%	17	9%
Total No. of Samples	194	100%	194	100%

Source: Harvest Survey by JICA Study Team 2010-11

1.3) Technical Difficulty

In addition to the economical aspect of crop production, level of technical difficulty or, in other word, farmers' experience also is an essential factor. There should not be much problem if farmer have some experience of growing that crops in the past. However, if it is completely a new crop for the one, it should be confirmed if he or she is familiar with the cropping practice from A to Z. In this doing, it is a key factor if he or she can get a technical support from extension officers or if there are some neighbor farmers who have enough experience in that crop. In other word, it is an important task for extension officers to provide farmers with technical support especially on new crops in the area.

1.4) Labors Required

For many farmers in the area, irrigated agriculture is on small-scale basis. As shown in Table 5.4.2, typical size of land irrigated only by family labor resulted in an average of 0.57 lima per household, while it was 1.00 lima/ household with labor.. It can be said that the area with labor is roughly 1.8 times larger than what is managed without labor. Yet, if farmer aims to expand his/her cultivating land, availability of labor becomes crucial. Although an opportunity cost in general is quite low in the rural area as there are only a few major income generating activities other than agriculture, labor becomes scarce in a particular timing of the year.

Table 5.4.2 Area Irrigated per Household (with & without labors)

Item	Area Irrigated (lima/households)		
	Without Labor	With Labor	Average
Average	**0.57**	**1.00**	**0.87**
Max	3.53	8.33	8.33
Min	0.01	0.03	0.02
No. of Samples	318	229	471

Source: Harvest Survey by JICA Study Team 2010-2011
Note: Average is inclusive of both plots cultivated with and without labor.

For instance, November to December is the beginning for preparation of rain-fed maize production. Farmers start land preparation and there appears to be so much demand in labor. In this case, if the harvest of irrigated crops gets into this season, it may conflict with the preparation of rain-fed maize over the limited labor force including family labor. Therefore, when planning the type of crops to be planted, timing and required amount of labor should be carefully considered. If it is anticipated that enough labor cannot be secured, timing or cultivated area may have to be adjusted or simply the type of crop may better be changed.

1.5) Growing Period

Farmers should not disregard the growing period required for the crop production. Different crops require different periods of times for growing. Leaf vegetables usually require shorter period of time, while the fruit vegetables require longer. For instance, as Table 5.4.3 shows, rape requires about 2 months from sowing to starting harvest, while onion requires 6 months. Required time simply means the time farmers have to bear without income. Cash flow of smallholder farmers is generally constrained and thus they often need immediate cash. In this context, farmer in such situation better choose rape and Chinese cabbage rather than going for onion, even if onion promises higher profit.

Table 5.4.3 Growing Period of Major Crops

Crop	Required Time (days)			
	Nursery	Growing	Harvest	Total (standard)
Rape	20	30-35	90-120	140
Chinese Cabbage	30-40	120-150	15	165
Beans	-	60-90	30	120
Green maize	-	90	30	120
Tomato	30	90	60	180
Irish Potato	-	105	30	135
Cabbage	30-40	120-150	30	180
Groundnuts	-	60-120	30	120
Onion	60	120-180	30	210

Source: TSB Northern Province (2010)

In other word, needs of immediate cash accounts when choosing the combination of crops to be planted. There is some seasonal fluctuation in the significance of household expenditure. For instance, for those who have school children, they have to clear the school fee, including PTA fee and other related fee, at the beginning of each semester, January, May and September in this country. Also, certain amounts of cash are required for other agricultural activities: rain-fed maize, *Chitemene* shifting cultivation, and *Fundikila* composting. Typically, farmers tend to hire labors for the land preparation for rain-fed maize from November to December. During this time, certain amount of cash is particularly needed.

For *Chitemene*, as another instance, farmers often ask other farmers to help cut the branches during May to July. So, for those who also manage *Chitemene* agriculture, conflict between *Chitemene* and irrigated agriculture over the investment cost becomes critical. Same story is applied to *Fundikila*, which is usually practiced in March to April. As such, profitability of a crop should not be only a factor to decide what to grow. If farmers need immediate cash, short maturity crops should be incorporated into the cropping scheme.

1.6) Price Trend

Consequence of market dynamics appears to be as a form of price trend. For instance, price of tomato was found fluctuating from ZMK 50,000 per bucket to ZMK 100,000 per basket in Kawambwa district, Luapula province. And, price of onion was ranging from ZMK 20,000 per 5kg to ZMK 40,000 per 5kg. The highest price was twice as much as the lowest price in both cases.

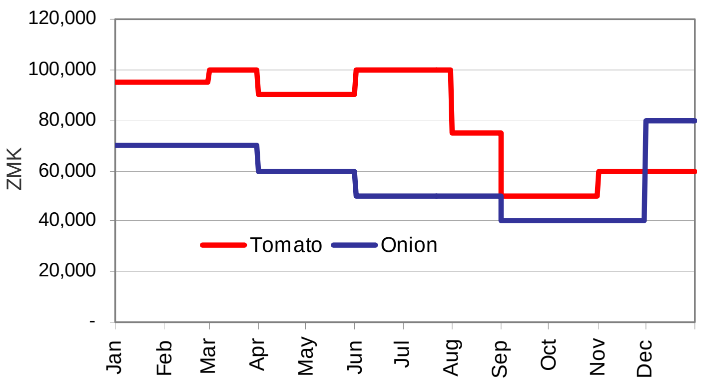


Figure 5.4.1 Price Trend of Tomato and Onion

Note: Tomato (per basket), onion (per 10kg)
Source: Interview to Farmers in Kawambwa (2010)

Price is one of the most important explanatory variables of the profitability. Although it is far difficult for farmers to double the yield, they can get same effect by changing the timing of the planting time.

1.7) Quality of Produces

As the price is an important explanatory variable of the profitability, it also depends on the quality of produces. Needless to say, the better the quality is, the higher the price should be. Furthermore, here is a vital implication on the effect of quality to the price. In a course of the Study, it has been observed that the price of green maize was set as discrete figure. For instance, small size was sold at ZMK 500 per cob, while the big one was at ZMK 1,000 per cob. There were only two prices. In this case, depending on how the size of cob is regarded, what the farmer can get changes significantly. As such, the practical effect of quality control is much bigger than what it implies.

1.8) Market Linkage

Market linkage is the last and biggest issue of market-oriented agriculture. Even getting plenty of water through irrigation development, and producing an amount of quality produces, farmers cannot get satisfied until they sell their produces at fair price. In order to get involved in better market linkage, there are three major approaches which are manageable to smallholder farmers: 1) quality control of the produces; 2) adjusting cropping season according to price trend; 3) matching buyers and produces.

As discussed, producing quality produces and catching the price trend are fundamental practices for market oriented agriculture. In addition, farmers have to make significant effort to link themselves with a better market. Fortunately, there are a number of best practices in this matter. For example, a farmer in Mbala district sold onion in Copperbelt province at the price twice higher than the price in Mbala. For another example, a group of farmers in Mpika district established a new linkage with a middleman from the DRC who was on the way to Nakonde district to buy onion. Then, they agreed to have a deal of onion periodically—it is a win-win situation in which farmers can sell a bulk of onion at higher price and the trader can minimize the transportation cost.

To obtain market linkages, there are many factors to be considered: distance from the market, means of transportation, physical condition of the access road, and existence of marketers. Farmers in each location have to consider the strengths of what they have. For instance, if the village is close to bigger market, it can be a good option for them to carry their produces by their own. On contrary, even if the village is located quite far from big market, if it is located by trunk road, villagers can put a signboard along the board.

Furthermore, schools, hospitals and other public institutions can be also a good marketing channel accessible in the rural context. By assessing the needs of those institutions through discussion (what crops, how much quantities and when), farmers possibly get new market linkage. In case farmers are not capable to produce required amount, it is a good time to consider joint shipping with other farmers.

Considering the marketing, getting in touch with middlemen is also recommended especially in the local settings. According to the harvest survey, it was found that relatively little percentage of farmers had access to middlemen; only 16% of the sampled farmers were selling to middlemen. Although it implies a limited linkage to the middlemen currently in the area, it also suggests the necessity to make more effort to cultivate good linkages between farmers and middlemen. To this end, it is an extension officers' task to match producers and middlemen. Once the relationship is established, they can keep their communication through mobile phone network already available in most of the villages.

1.9) Recommendation to Extension Officers

As discussed above, there can hardly be definitive plan for market-oriented agriculture development.

Decisions should not be made as a holistic plan of the government. Instead, specific decisions should be made on a case-by-case basis at farmers' own risk. For field extension officers who work directly with farmers to support them in this decision making, here are some recommendations.

First, farmers are always challenged by imperfect information. They do not always know market trend, whereby they often sell their produces at disadvantageous price. Second, they are not confident enough to encourage themselves to do whatever they have never tried. Therefore, the main task of extension officers would be to provide farmers with the latest information related to crop production and marketing.

For instance, general profitability of major crops should be presented. Generally, farmers know well about the market price of crops in the area. However, they do not necessarily know the profitability of that crop. In fact, they were often surprised at the profit of their farming when the JICA Study Team computed it. Support in getting market linkage is also a potential activity of extension officers, as they usually have better access to market oriented information including market prices in different locations and existence of buyers from those places. What they can do may be limited but that could make a difference.

5.4.2 Recommended Cropping Schemes

When planning the cropping schemes suited to the Study area, agro-ecological condition, profitability of crops, and technical and financial applicability lies as central issues. Conditions of those factors differ from place to place, time to time, and farmer to farmer. Thus, it is rather inappropriate or sometimes risky to set a concrete plan that is oriented to the entire area of two provinces.

1) Benefit of Intercropping

Here, therefore, recommended is a typical strategy harmless but having a positive effect applicable to various circumstances: intercropping. Intercropping is a way of diversifying the farming scheme by which crop production can be more stabilized at lower risks. Specifically, there are several advantageous aspects in this mechanism. First, by mixing two or more types of crops, it can dramatically increase the production per land area. Second, by enriching the diversity in the farming scheme, stability generally increases with reduced risk of pest and disease.

In addition, with the use of crops with different root schemes, shape plants, and growing characteristics, water, nutrient and sunlight can be used more efficiently, leading to higher production level comparing to aggregated production of individual crops. Furthermore, increased leaf cover in intercropping helps reduce weed populations once the crops are established.

2) Type of Crop Arrangement

There are three typical types of crop arrangements: strip/ row cropping, mixed cropping, and relay cropping. In strip cropping scheme, two or more crops are planted in a row separately. If the each row is determinately wide, it is called strip. On the other hand, in mixed cropping, two or more crops are planted randomly with no specific row arrangement. In the Study Area, it is sometimes observed that small number of pumpkin is planted in a groundnuts field; this is a kind of mixed cropping. Lastly, relay cropping is associated with a sequence of planting timing. In this scheme, one crop, for example maize, is planted preliminarily. Thereafter, second crop, for example climbing bean, is planted before the harvest of the first crop. The benefit of relay cropping includes the less competition between/among the combined crops. In the case of maize and climbing bean combination, bean can climb maize stakes.

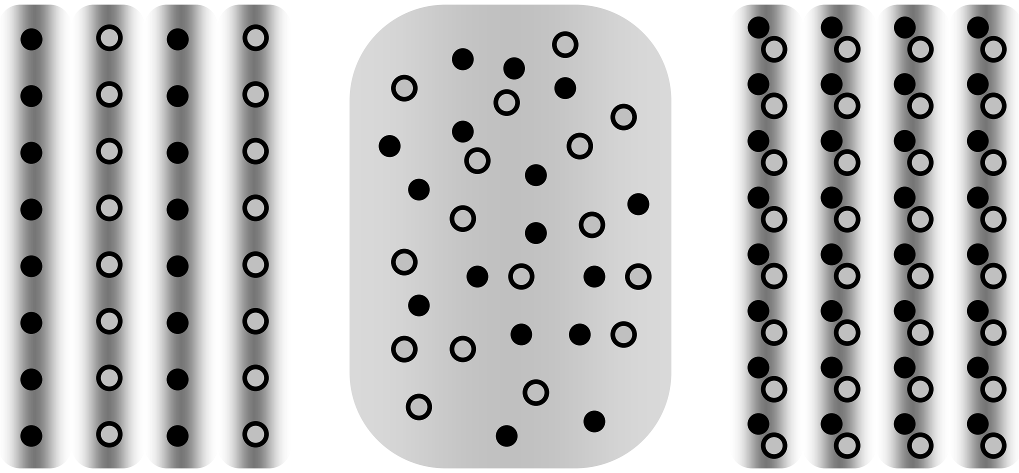


Figure 5.4.2 Three Types of Crop Arrangement For Intercropping

Note: One type of crop in the relay cropping is planted significantly later after another crop.
Reference: Intercropping of Annual Foodcrops AGROMISA (http://www.allindiary.org/resource/435)

3) Recommendable Combinations

Recommendable combinations of crops for intercropping are summarized in Table 5.4.4. Concerning the generally depleted and thus low fertile soil in this area, it is recommendable to mix legume crops with other crops. By incorporating legume crops in the scheme, nitrogen fixation can be facilitated depending on the existence of appropriate bacteria in the soil, whereby soil fertility is to be improved and maintained. Furthermore, legume crops are generally rich in protein and can be a good source for nutrition management of the rural population. Another good aspect of intercropping is that when incorporating deep rooting crops, such as pigeon pea, physical characteristics of soil can be improved deeper.

Table 5.4.4 Recommendable Combination of Intercropping

Crop	Particulars
Maize-climbing bean (Relay-cropping)	Maize is sown in row at 75cm between rows and 20cm between each plant in a row. After at least 4 weeks after sowing maize, but before the harvest, plant climbing bean so that the bean can use maize stalks as stakes. Climbing beans can produce 3-4 times more yield than bush beans.
Maize-Legume (2 by 2 scheme)	Instead of establishing the rows of maize with 90cm of uniform intervals, establish two rows close (50cm) and create wider gap (100cm or more) with next two rows. And in the wide gap, plant legume crops in two rows. This is why it is called 2 by 2 scheme. Common bean, Soybean, green gram, and groundnuts can be used in this scheme. By creating a wide space, legume crops can receive more sunlight and thus a total production can be increased.
Maize-Pigeon pea	Maize and Pigeon pea are sown at the same time in rows. When using long duration variety, Pigeon pea takes 5-11 months to grow. Therefore, harvest of pigeon pea can be done after expected after the harvest of maize. Pigeon pea is a deep-rooting crop and thus effect of improving soil fertility is good. Pigeon pea is relatively resilient to drought and is suited to such irrigation scheme where water volume becomes significantly low during the peak of dry season.
Maize-Sweet potato (Leaves) (mixed cropping)	Maize is sown in row and after the first weeding, and fertilization if applicable, sweet potato tubers are planted in between the maize. Sweet potato plants cover the surface of the soil by which damage of weeds can be reduced. Farmers can harvest sweet potato leaves according to their preference.
Maize-Cowpea (Relay-cropping)	Maize is sown first and after approximately 45 days, cowpea is sown. Maize serves as support for cowpea. After harvesting both crops, they are to be left on the soil or incorporated in the soil as green manure.
Cabbage-Tomato	Tomato acts as a physical barrier against insects like Diamondback moth and it also has a characteristic to reduce the population of insect with its repellent odor. Tomato is first transplanted. Two weeks later, cabbage is planted in alternate rows.
Cabbage-onion	Onion is famous with its repellant effect against common insects including aphids. Therefore, onion is a useful intercrop for many crops. One of recommended combination is with cabbage and carrot. However, combination of onion with pea is not recommended Because it is reported that pea can be a host for some kind of bacterium that cause disease specifically to onion.

Source: JICA Study Team

4) Cropping Calendar

There is no solid cropping calendar exclusively recommendable over the others. Here recommended is, therefore, a sample model under irrigated agriculture for smallholder farmers. As shown in Table 5.4.5, it is assumed that smallholder farmers can maintain 0.25 limas of farmland for irrigated agriculture in addition to other fields for rain-fed agriculture in rainy season. Accordingly, the dry season agriculture starts with the preparation of irrigation in and around April when the dry season is expected to begin. It may take a few days to repair the weir originally constructed in previous season, or take a few weeks to rehabilitate or clean the whole length of canal; in this model, a one-month period is shared for that activity in April.

After irrigation scheme becomes to be an ideal setting, next step is to prepare *Bokashi* compost. By using water from the canal and mixed with other materials necessary for the compost, *Bokashi* compost can be ready to use in a two-to-three weeks period. Therefore, mid or late May is an expected time for the actual planting of dry season crops. The benefit of planting in early stage of the season is that farmers can share the workforce to maize harvest after they prepared the dry season crops.

Table 5.4.5 Recommended Cropping Calendar under Irrigation (Dry Season)

Area	Apr – Oct (Apr, May, Jun, Jul, Aug, Sep, Oct)	Expected Profit
Other Activities	Weir & Canal (Apr); Bokashi Compost (May); Conventional Compost (Aug–Sep)	ZMK per 1.00 lima ZMK per 0.87 lima ZMK per 0.25 lima
Pattern 1 G-maize & beans (0.25 lima)	Green Maize; Relay planting; Climbing Beans	2,772,000 2.412,000 693,000
Pattern 2 Tomato (0.25 lima)	Tomato; Tomato; Tomato	1,764,000 1,535,000 441,000
Pattern 3 Groundnuts & Year 1 (0.25 lima)	Groundnuts	1,466,000 1,275,000 367,000
Cabbage Year 2 (0.25 lima)	Cabbage	2,664,000 2,318,000 666,000
Pattern 4 Tomato and Cabbage Intercropping (0.25 lima)	Tomato; Cabbage	2,214,000 1,926,000 554,000
Pattern 5 Cabbage and Onion Intercropping (0.25 lima)	Cabbage; Onion	3,154,000 2,744,000 789,000
Pattern 6 Rape and Green maize (0.25 lima)	Vegetable e.g. Rape; Green Maize To be harvested in rainy season	2,731,000 2,376,000 683,000

Source; JICA Study Team

The table provides six patterns of cropping calendar. First pattern is, as discussed previously, a mixed or relay planting of green maize and climbing beans. Green maize is planted in May and, and sometime after it, climbing beans are planted underneath the maize plants so that beans can use the maize as stakes. They can enjoy the residual stands of the maize even after the harvest of maize cobs. Note that if the climbing beans are planted too early, it may disturb maize's growth. Therefore, at least four weeks should be kept before sowing bean seeds.

Next pattern is just a production of single crop represented by tomato in this particular table. The point here is to plant these crops in a different timing little by little. First of all, in this method, farmers can disperse the labor force for planting. Then, risk of damage by the change of natural condition can be averted. Also, produce can be harvested and marketed little by little for a longer period of time. As marketing modality is quite primitive in the area, carrying on the head or using bicycle, it can avoid unnecessary loss of harvest. Finally, farmers can hedge the risk of price change, if at all.

The third pattern is a model of rotation cropping. There are some farmers who may not be able to purchase fertilizer, or would not like to purchase for whatever reasons. For such farmers, incorporation of legume in the scheme is highly recommended. In addition to intercropping, rotation is highly recommendable. Cultivate groundnuts for the first year and cabbage in the following year, for example. It helps improve soil fertility to some extent. However, it should be noted that use of legume crop does not simply mean no chemical fertilizer is necessary.

Pattern 4 and pattern 5 are based on the same concept; combination with crops that have repelling effect. For instance, tomato is well known having a repelling effect against Diamondback moth and so is onion against aphid. Therefore, combination of tomato and cabbage, as well as onion and cabbage, make the cropping scheme more stable.

The last pattern is a double cropping of leafy vegetable, for example rape in this case, and green maize. There already are farmers who manage double cropping in the area, although the harvest of second crop may be in the beginning to even mid of rainy season. If the planting of the second crop is delayed, the second one could better be maize. Maize starts growing with irrigation and then it can be taken over by rainfall and harvested before pure rain-fed maize is marketed. It means maize which can be harvested before that time of harvest of rain-fed maize can fetch very high price; more than 2 times in many places. Therefore, double cropping of leafy vegetables followed by maize can be one of the options for high profitability.

5) Crop Rotation

Basic way to cope with undesirable soil condition is by crop rotation—it is quite manageable even for the resource-poor farmers. In other word, continuous cropping of single crop will deteriorate the soil condition. The most important principle is not to continue a single type of crop. By cultivating same type of crop, particular type of soil element necessary for that crop will be reduced, by which that type of crop will suffer from the lack of the elements. Also the particular type of pathogenic bacteria or nematode can easily increase its population.

Continued planting of crops in the same family should also be avoided. For instance, rape, cabbage, and Chinese cabbage should not be planted one after another because they are in the same brassica family. Similarly, continued planting of tomato, eggplant, and Irish potato should also be avoided as they are in the same Solanaceae family. Table 5.4.6 shows major crops by the type of family which are prone to disease under continued cultivation. On the other hand, sweet potato, pumpkin, carrot, onion, and garlic are relatively tolerant to continued cultivation.

Table 5.4.6 Crops in the Same Family Prone to Disease under Continued Cultivation

Family	Crop Prone to Disease under Continued Cultivation
Brassica	Rape, Cabbage, and Chinese cabbage
Solanaceae	Tomato, eggplant, Irish Potato, Chili Pepper, Paprika, Tobacco,
Cucurbitaceae	Cucumber, Watermelon, Melon
Fabaceae	Soybean, Groundnuts, Cowpea, Pigeon pea, Common beans

Source: Agronomic aspects of irrigated crop production, FAO (2002)

The level of pathogenic effect by the continuous cropping is also a dependent on soil condition. If the soil is rich in organic materials with a large population of microorganisms, risk of disease can be kept relatively low. However, if the organic matters are poor in the soil, population of pathogenic bacteria can easily increase. There are some farmers in Japan who continued eggplant production for years through application of organic fertilizer, for instance.

When planning the crop rotation, furthermore, frequency of cultivating same kind of crop should be carefully considered. Some kinds of crops should be kept away from the same plot for years, while some can be planted more often. Recommended frequency to be kept is shown in Table 5.4.7. As shown in the table, eggplant should be planted at least four years of absent from the first planting in the plot, while it can be just two years for beans, cabbage, and groundnuts.

Table 5.4.7 Crop Rotation Frequency

Frequency	Crop
4 Years	Eggplant, Okra, Pepper, Irish Potato, Sunflower, Tobacco, and Tomato
2 Years	Beans, Cabbage, Carrot, Groundnuts, Rape, Soybean, Wheat

Source: Agronomic aspects of irrigated crop production, FAO (2002)

Considering all those issues discussed above, here is a set of recommendable crop rotations. As shown in Table 5.4.8, several different crops of different families should be rotated year by year. If the farm plot of irrigated agriculture and rain-fed agriculture are different, plot is better kept under fallow (not cultivating anything) during the rainy season. For instance (case 1), tomato, Chinese cabbage, green maize and cabbage can be rotated each year. In addition, continued usage of the farm plot during the rainy season is also applicable.

For another instance (case 4), a rotation of soybean- sunflower- tomato- maize- groundnuts- maize- soybean can be managed under non-tillage practice or conservation agriculture wherein crop residues are used as soil cover and eventually to be incorporated in the soil (for more detail, refer to Technical Manuals, Part II, 'Conservation Agriculture'). Lastly, double cropping of two different crops in a single dry season is also recommendable considering the increased income opportunities and high price of vegetables at the beginning of rainy season. For double cropping, however, it is highly recommended to incorporate legume crops in the rotation as soil fertility is to be easily depleted through intensive usage of the land.

Table 5.4.8 Example of Crop Rotation

No	Dry 1	Wet 1	Dry 2	Wet 2	Dry 3	Wet 3	Dry 4
1	Tomato	-	C cabbage	-	Green Maize	-	Cabbage
2	Green Maize	-	Tomato	-	Onion	-	Carrot
3	Cabbage	-	Soybean	-	Tomato	-	Onion
4	Soybean	Sunflower	Tomato	Maize	Groundnuts	Maize	Soybean
5	Rape, G Maize	-	Soybean	-	Onion	-	Groundnuts
6	Groundnuts, Cabbage	-	Green Maize	-	Soybean, Tomato	-	Onion
7	Eggplant (continuous harvest)			-	Groundnuts	-	Rape

Note: This model assume that rain-fed maize is managed in different plots except No.4 (conservation agriculture).

5.4.3 Conservation Agriculture under Irrigation

As briefly mentioned in the "crop rotation," conservation agriculture can be incorporated in the smallholder irrigation schemes. Smallholder farmers are by and large associated with low productivity caused by reduced retention of organic matters in the soil. As irrigated agriculture provides farmers with an opportunity to do agriculture more intensively in the same plot, maintenance of soil fertility becomes to be a central issue.

To sustain the farmland, conservation agriculture can be considered one of the effective measures; it helps protecting the farmland from erosion and also improving the soil condition. In fact, as mentioned in Chapter 2.5.5, conservation agriculture is being widely promoted in Zambia in cooperation with MACO, FAO, and EU, focusing in rain-fed season.

Conservation agriculture is a set of practices, in which, 1) crop residues are to be retained on the soil surface as soil cover; 2) crops with different characteristics, including legumes, are to be rotated, and 3) soil disturbance (tillage) is to be reduced. By applying this method, soil erosion by water and wind can be minimized and heat from direct sunshine can be lowered, and organic materials can be incorporated, resulting in more sustainable agricultural production.

Tomato is planted on the soil entirely covered by the plant residue from previous season (Nakonde).

Although the conservation agriculture promoted by FAO is focused mainly on the rain-fed season, it is also applicable to the irrigated agriculture during the dry season. Especially, for smallholder farmers who cultivate relatively smaller size of farmland, it is due manageable. In fact, during the pilot project in the 2010 dry season, it was already tried by a local farmer in Nakonde (see picture). In his plot, soil was thoroughly covered by the plant residue from the previous season, by which soil erosion is being avoided. One may think that the plant residue should block the water way for irrigation. However, the empirical evidence suggests that the on-farm irrigation can be managed as usual even with plant residue on the soil. In short, conservation agriculture should be incorporated into the farming practice in smallholder irrigation scheme.

5.5 Institutional Development for Smallholder Irrigation Schemes

With regard to smallholder irrigation development, an important issue is to understand who the project owners are. The owner is obviously the farmers themselves and the government officers, e.g. district TSB officers, BEOs and CEOs are the facilitators. Under this pre-requisite, who should participate to whose project is very much clear. The ones who should participate are the government officers and not the farmers. This entails a very important operation principal; that is if farmers are not interested in irrigation development, just move to next potential areas rather than sticking onto them. With this mind, following elaborate the organizing process of irrigators' association/club and also the internal set up thereof.

5.5.1 Organizing Process

The process of implementing a smallholder irrigation scheme starts with participatory entry workshop (or meeting in a simple way). Following the entry workshop, planning workshop (meeting) should be held during which feasibility for diverting water should firstly be examined. 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 villagers 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 making the organization. This Study proposes the latter approach (see Figure 5.5.1, 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 voluntary labor work, arranging the local materials such as wooden poles, twigs, grasses, clay soils, sand, stones, cobbles, 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 sense through on-the-job-training.

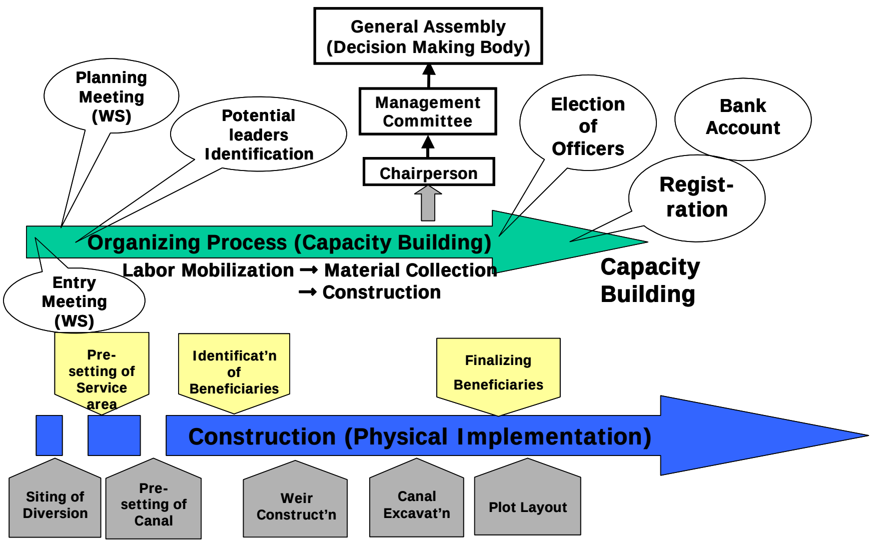


Figure 5.5.1 Organizing Process & Project Implementation

Important point is to realize that people or organizations become strong and/or capable of doing harder things through the process of project implementation. In this sense, the project is defined as merely a tool or an opportunity for capacity development. 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 farm income”, and through the implementation of the project, people will be empowered. The ones who empower the farmers are not the outsiders like BEOs/CEOs but the farmer themselves. This process itself is called capacity development or social development. Capacity development of people and organizations can and should be pursued with the irrigation project as a tool. This concept comes up with the idea of “learning by implementing, and building capacity by learning”.

On concerning important matters, 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 a village level existing organization, e.g. cooperative, 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 shall be the process, which the extension officers should intervene properly.

At 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 can 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 at the Registrar of Societies. In the case of handling certain amount of cash, the registered organization opens the joint bank account under the names of the chairperson, vice-chairperson and treasurer. This registered organization should apply the acquisition of Water Right at Water Board under the Ministry of Energy and Water Development. Application should be supported by concerned BEOs/CEOs.

5.5.2 Organization Internal Set-up

To make an organization well operational, role and authority on planning, decision-making and implementation should be clearly defined. For example, when a farmer organization thinks about the following dry season crop, they go through a process of: 1) planning of water use and allocation, 2) decision-making of the plan, and 3) execution of the approved plan. Authority for these three aspects must be independent. It means the authorities of these 3 aspects should be lodged to different sub-organs under the organization.

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 while Representatives Committee is formed from member representatives who are from, for example, such irrigation blocks as upstream, mid-upstream, and down-stream, etc. If an irrigation scheme is very small like being formed with less than 50 members, the Representative Committee may be avoided or superseded by the General Assembly. Then, according to the decision made, the plan is now implemented. The plan is implemented by the members and in this regard there should be an organ being in charge of supervision of the implementation, or day-to-day management of the implementation.

1) Irrigation Club with More Than 50 Members

If an irrigation club is relatively big, say formed with more than 50 members, this Study recommends an organization set up shown in Figure 5.5.2. The structure starts with the General Assembly as the apex organ, composed of all the membership. Important issues shall be discussed and decided at this level. However, there may be a difficulty of convening all those many members. Taking into account this difficulty, the structure puts up another decision making body that is the Representative Committee, which as aforementioned is composed of representative members, preferably 10 – 20 though depending on how much big the irrigation club is. Both organs are in charge of 'decision making' and according to the significance of the issue[1] either the general assembly or the representative committee does the decision-making.

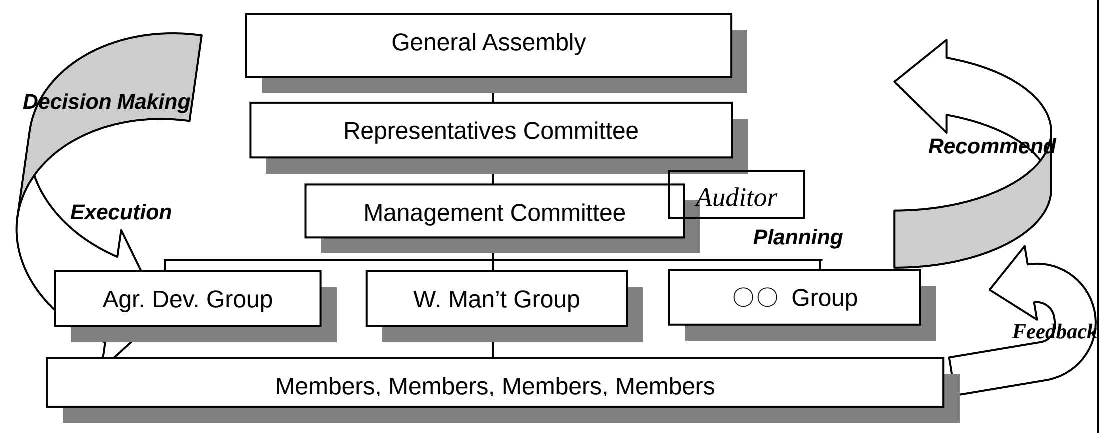


Figure 5.5.2 Internal Organization Setting-up (preferably over 50 members)

Under the Representatives Committee, Management Committee is formed consisting of the chairperson, vice chairperson, secretary, treasurer, and auditor[2]. 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. The point is the Management Committee headed by the chairperson is not in charge of decision-making but in charge of execution. It means even the chairperson has got only one vote in terms of decision making, but in terms of implementation, s/he is the chief executive officer (CEO).

Under the Management Committee, there should be groups in charge of planning. There can be agriculture development group, water management group, financial management group, etc. according to the irrigation club's needs. One committee may be composed of say 3 – 5 members by volunteers from the members, and preferably should have one of the Management Committee members as their leaders. Example is that the leader of the water management group can be the vice chairperson of the Management Committee, the agriculture development group can be headed by the secretary of the Management Committee, and the financial management committee can be headed by the treasurer of the Management Committee, and alike. In any case, they cannot be in charge of decision-making but only in charge of planning. The plan is forwarded to either General Assembly or the Representative Committee for its decision.

[1] 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.
[2] Auditor can be a member of the management committee in this kind of small scale irrigation scheme because such group does not undertake much amount of money. However, in case that they are involved in money transaction, e.g. bulk purchase of chemical fertilizer, there should be an independent auditor apart from the management committee. Such role can be undertaken by the CEO in the area in charge.

Then, the plan upon its decision has to be now implemented. If the plan is very important, e.g. decision of irrigation service fee, the decision shall usually be decided by the General Assembly, which is composed of all the membership. Now who are the ones to implement the plan ? Those who implement the plan are the members of the irrigation club and at the same time members who constituted the General Assembly to decide. Since the plan has been decided by the General Assembly composed of all the membership, the members shall now implement the plan collectively under the supervision or the leadership of the Management Committee.

2) Irrigation Club with Less Than 50 Members

In case the irrigation scheme is very small, say membership is less than 50, the Representatives Committee composed of only several members can act as the Management Committee or simply saying the Representative Committee itself is taken away from the structure (see Figure 5.5.3). In fact, this may be most of the cases in smallholder irrigation schemes in the Study area. The structure shown in Figure 5.5.3 puts up the general assembly as the supreme organ, which is composed of all the membership. Out of the general assembly, the members of the management committee are selected, e.g. chairperson, vice-chairperson, secretary, treasurer, auditor[3] and some committee members if needed. They are also members of the general assembly wherein they exercise decision making as one of the general assembly members.

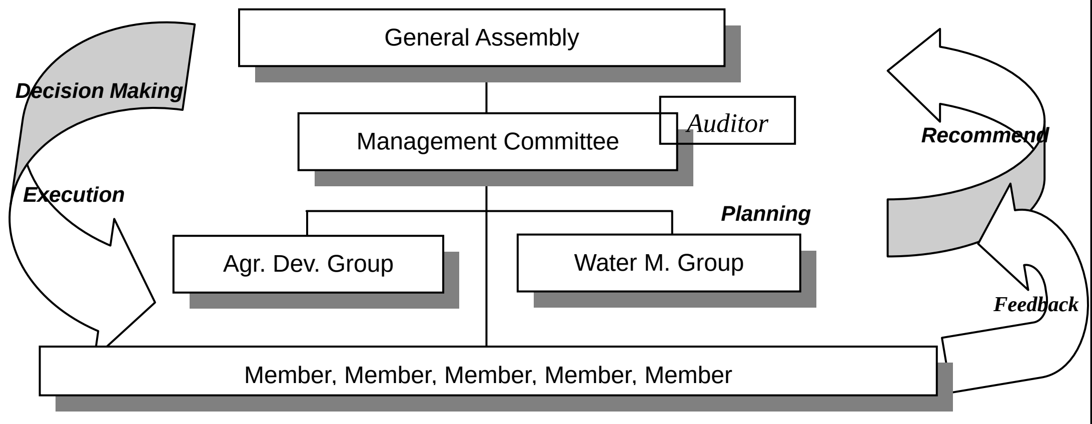


Figure 5.5.3 Internal Organization Setting-up (preferably less than 50 members)

There may be some groups established in charge of planning just same as the structure for big irrigation clubs as shown in Figure 5.5.2. However, since this irrigation club is small in scale, the Management Committee can undertake the role of planning with some specific members who are knowledgeable in its issues. For, example, when they need to prepare a crop calendar under irrigation, the Management Committee discusses what crops should be incorporated including particular members who know, e.g. cultivation method, market condition of the harvest, etc. Then, the plan is forwarded to the General Assembly for the plenary discussion and then the decision.

Although the chairperson of the Management Committee is the chief executive officer, s/he has only one vote in decision-making in the General Assembly as well. This discipline applies to all the committee members as well; meaning whoever s/he is the person can exercise only one vote in terms of decision making. Sometimes the authority and duty of the chairperson are mixed up. To prevent the authorities from being abused and promote transparency of the organization, such idea of decentralized organizational setting-up should be extended to all the membership. This principle

[3] As in the case of Irrigation Club with more than 50 members, the auditor can be a member of the management committee. In case that they are involved in money transaction, there should be an independent auditor apart from the management committee.

should of course apply to the irrigation club shown in Figure 5.5.2 as well.

3) Collective Leadership: Interplay between Democracy and Centralism

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 the 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 irrigation 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 irrigation 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:

i) 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,

ii) 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,

iii) 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.

iv) The whole Irrigation Club is subordinate to the general membership. This means that all decisions 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.

5.6 Feasibility Examination in Economic and Financial Terms per Scheme

How much profit can be born with a prescribed investment is a primary concern in any of development projects, or up to how much project cost can be justified in developing certain area is in other way round issue. Here in this sub-chapter, feasibility examination in economic and financial terms is explored. With these practices, we can know how much economic and financial impacts can be born with smallholder irrigation development. Also, we can have an indication how much irrigation areas should at least be developed given a certain investment.

5.6.1 Pre-condition in Economic and Financial Analysis

In the feasibility examination in economic and financial terms, general methodology of the economic analysis is employed; namely, the analysis includes estimation of internal rate of return (IRR), cost benefit ratio (B/C), and net present value (NPV) using financial and economic prices primarily for permanent schemes and also as a reference for simple (temporary) diversion scheme respectively. Following are the assumptions for the analysis:

With respect to economic analysis:

1) Opportunity cost of capital is determined at 12%, which was used as criterion of project selection by the World Bank for irrigation development sub-project in this Country. This 12% is also employed as the discount ratio to estimate NPV as well as B/C ratio in economic term.
2) Current Price as of July 2010 is used, and Standard Conversion Factor (SCF) of 0.9 is applied for converting financial price (market price) of tradable goods to economic price, which is also used by the World Bank. On the other hand, economic price of non-tradable goods is made equal to those financial prices.
3) All the unskilled labors are to be provided by beneficiary farmers, and the economic cost is counted as 50% of the prevalent financial cost (wage payment). 50% discount is based on concealed (potential) unemployment in rural areas.
4) The family labor cost is estimated by data from a harvest survey carried out under this Study, and counted as 50% of the labors actually spent in the field, taking into account the concealed (potential) unemployment in rural areas.
5) All the government services, which are required for survey, designing, supervision, including their salaries etc., are counted as economic cost based on the prevalent payment as of July 2010. In addition, trainings to the government officers are also counted as economic cost with reference to the practices administered under the pilot project implementation in this Study.
6) Taxes and duties are excluded from economic cost streams.

With respect to financial analysis:

1) Discount rate in estimating NPV and B/C ratio in financial term is determined at 20%, which refers to a Zambian commercial bank prime-lending rate, 19.06% as of July 2010.
2) In project cost and cost for producing crops, current financial prices (market prices) as of July 2010 are used, regardless it is either tradable good or non-tradable good.

3) All the unskilled labors are to be provided by beneficiary farmers voluntarily, and hence no unskilled cost is included in the financial analysis. Neither does the family labor cost in producing crops with irrigation.

4) As for the government services, only meal allowance and fuel during the survey, design, and construction are counted as financial cost, which are supposed to be born by the beneficiary farmers in this financial analysis. Their salaries and training costs for them are therefore excluded.

5.6.2 Economic and Financial Analysis for Permanent Scheme

1) Project Cost

Irrigation schemes undertaken in this Study are in fact small in scale. Since the projects undertaken in this Study are basically to be constructed by direct force account, not engaging any civil contractor, the project cost per site in most cases ranges from as low as US$ 5,000 to probably US$ 300,000 at maximum. To deal with this range of cost, specific case study makes little sense and therefore model case shall be prepared for the government officers especially from the view point of judging investment whether justified or not.

Model cases employed in the analysis is summarized in the Table 5.6.1, project cost of which ranges from US$ 5,000 to US$ 300,000 including canal construction. The project cost here includes all the costs including government services not only for meal allowance, fuel and also for their salaries, voluntary unskilled labors provided by beneficiary farmers which are costed according to the prevalent rural wage payment, etc. The structure is basically of concrete wall type diversion weir, and the typical dimension of length and height are indicated in the table. Some of the necessary materials for concrete such as sand and stones may be found at site and thereby practically nil cost. However, in this model analysis, all the materials are costed as purchased good according to the prevalent prices during the pilot project implementation in 2010 dry season.

Table 5.6.1 Model Project Cost in Economic and Financial Analysis

Total Cost	Economic Cost, US$	Financial Cost, US$	Diversion Weir			Canal		Gvt Services US$	Construction Period
			Cost, US$	Typical Dimension, m		Cost, US$	Length, m		
US$5,000	4,602	3,063	1,857	H:1.0	L:5.5	1,012	L:500	1,733	1 year
US$10,000	9,096	6,607	4,255	H:1.5	L:8.5	2,002	L:1,000	2,839	1 year
US$20,000	17,219	13,842	8,815	H:1.5	L:18.0	4,360	L:2,000	4,949	1 year
US$30,000	27,173	21,019	12,984	H:2.0	L:18.5	7,052	L:3,000	7,137	2 years
US$50,000	45,403	35,759	20,776	H:2.0	L:29.0	13,237	L:5,000	11,390	2 years
US$100,000	91,007	72,057	38,931	H:3.0	L:27.0	29,734	L:10,000	22,342	3 years
US$300,000	295,711	214,725	130,908	H:3.0	L:55.0	91,413	L:20,000	73,390	5 years

Source; JICA Study Team

In case of big investment, construction may not finish in one year. In this analysis, with reference to experiences from the past construction works, construction less than US$ 20,000 requires 1 year, construction for US$ 30,000 and US$ 50,000 does 2 years, construction for US$ 100,000 requires 3 years to complete, and construction for US$ 300,000 requires as long as 5 years to complete. In addition to the project cost above, O&M (Operation and Maintenance) cost should be considered. The O&M cost here is assumed at 2% of the total project cost per annum, and this O&M cost is incurred over the project life period, which is 30 years assumed in this economic and financial analysis.

2) Project Benefit

Benefit accrues on crops produced with irrigation agriculture. Benefit here in this Study refers to actual results from the fields rendered for the pilot project implementation. A harvest survey was carried out in 2010 and 2011 for the sites developed/ improved in 2009 and 2010. From the survey, an overall average financial benefit is at US$ 1,483 per ha while economic benefit is at US$ 1,322 per ha.

The benefit may take some time to accrue, and in the model analysis, it is assumed to take 3 years to reach the full benefit, e.g. 50% of the benefit at 2nd year, 75% at 3rd year and 100% full benefit at 4th year with the first year generating no benefit but construction only. In fact, on condition that the permanent structure is constructed as upgrading from simple (temporary) scheme, the benefit can accrue even during the construction stage, which is the first year, by providing the irrigation water through detour channel into the already existing irrigation furrow constructed with the simple scheme. However, this model analysis assumes that the first year is devoted for construction only, and the benefit accrues from the 2nd year as an assumption. The estimated incremental benefit per lima and per hector is summarized in the following table:

Table 5.6.2 Estimated Profit per lima and per ha by Irrigated Crops

Year	Incremental Benefit per Lima (ZMK, Year)		Incremental Benefit per ha (ZMK, Year)		Incremental Benefit per Lima (USD/Year)		Incremental Benefit per ha (USD/Year)	
	F. Price	E. Price	F. Price	E. Price	F. Price	E. Price	F. Price	E. Price
1	Construction only							
2	891,000	794,655	3,564,000	3,178,620	185	165	741	661
3	1,336,500	1,191,982	5,346,000	4,767,928	278	248	1,112	992
4	1,782,000	1,589,309	7,128,000	6,357,236	371	331	1,483	1,322

Note; conversion from ZMK to US$ is at @4,808 for this model analysis, recorded as at March 2011.
Source; JICA Study Team

3) Result of Economic Analysis for Permanent Scheme

Table 5.6.3 summarizes EIRR, NPV, and B/C ratio by different project cost and according to different irrigated area. The NPV and B/C ratio were estimated at the discount ratio of 12%, which is the opportunity cost of capital in Zambia. Also, Figure 5.6.1 shows the EIRR with solid lines by different project cost and different irrigated area on the X-axis in mathematical scale while Figure 5.6.2 shows the same but on legalistic scale X-axis. From the table and figures, following are observed:

i) EIRR changes in a wide range, and in order to keep an EIRR more than 12% for a smallholder irrigation project, approximately the unit investment per 1.0 hector of irrigated area should be maintained within US$ 10,000. For example, the EIRR based on US$ 10,000 investment with 1 ha of irrigated area is given 10.9%, which is a bit lower than that of the opportunity cost of 12%. In case of US$ 20,000 investment with 2 ha of irrigated area, it is the same 10.9%.

ii) There is a trend that the bigger the investment is, the less the EIRR becomes under same unit of irrigated area. For example, the EIRR based on US$ 100,000 investment with 10 ha of irrigated area is only 9.4%. Likewise, the EIRR under US$ 300,000 investment with 30 ha of irrigated area is given only 7.2%. This is because the bigger the project it, the longer the construction period is, delaying the emergence of benefit, leading to lower EIRR. Therefore, in relatively bigger smallholder irrigation projects, which require longer period of construction more than 1 year, the unit investment cost should be maintained well under US$ 10,000 per 1 ha of irrigated area.

iii) NPV ranges widely and B/C ratio does the same accordingly. Since the discount ratio in this economic analysis was set at 12%, the NPV is given positive and B/C ratio more than 1.0 in case of EIRR being more than 12%. In an actual case, given the investment cost according to the BOQs and unit prevalent cost and also the area of the to-be-irrigated farms, the EIRR together with the NPV and the B/C ratio can be estimated, and thereby the government can judge if the investment should be made or declined.

Table 5.6.3 Summary of Economic Analysis (Permanent Scheme)

	Model	1ha	2ha	3ha	5ha	10ha	15ha	20ha	25ha	30ha	40ha	50ha	60ha	70ha	80ha	90ha	100ha
EIRR, %	US$5,000	22.9	43.7	62.5	97.3												
	US$10,000	10.9	23.2	34	53.8	98.2											
	US$20,000	2.7	10.9	17.4	28.8	54	76.9	98.6									
	US$30,000		5.4	10.1	17.4	31.6	43.1	53.1	62.1	70.3	85.1	98.2					
	US$50,000			4.2	10	20.5	29	36.4	43	49.2	60.3	70.2	79.3	87.7	95.6		
	US$100,000				2.1	9.4	14.5	18.9	22.5	25.9	32	37.2	42	46.3	50.3	54	57.5
	US$300,000						0.7	3.4	5.5	7.2	10.2	12.6	14.7	16.6	18.3	19.9	21.4
NPV, US$	US$5,000	4,918	13,624	22,331	39,743												
	US$10,000	1,261	9,968	18,674	36,087	79,619											
	US$20,000	-6,003	2,703	11,410	28,823	72,355	115,887	159,419									
	US$30,000		-5,735	2,000	17,468	56,139	94,810	133,481	172,152	210,822	288,164	365,506					
	US$50,000			-12,476	2,993	41,664	80,334	119,005	156,676	196,347	273,689	351,031	428,373	505,714	583,056		
	US$100,000				-34,814	-483	33,847	68,178	102,508	136,839	205,500	274,161	348,823	411,484	480,145	548,806	617,467
	US$300,000						-125,301	-98,306	-71,310	-44,315	9,675	63,666	117,657	171,647	225,638	279,628	333,619
B/C Ratio	US$5,000	2.30	4.60	6.89	11.49												
	US$10,000	1.17	2.34	3.51	5.85	11.69											
	US$20,000	0.59	1.18	1.78	2.96	5.92	8.88	11.84									
	US$30,000		0.73	1.09	1.82	3.65	5.47	7.30	9.12	10.94	14.59	18.24					
	US$50,000			0.65	1.08	2.17	3.25	4.34	5.42	6.50	8.67	10.84	13.01	15.17	17.34		
	US$100,000				0.50	0.99	1.49	1.99	2.48	2.98	3.97	4.97	5.96	6.95	7.94	8.94	9.93
	US$300,000						0.39	0.52	0.65	0.79	1.05	1.31	1.57	1.83	2.09	2.36	2.62

Sauce: JICA Study Team

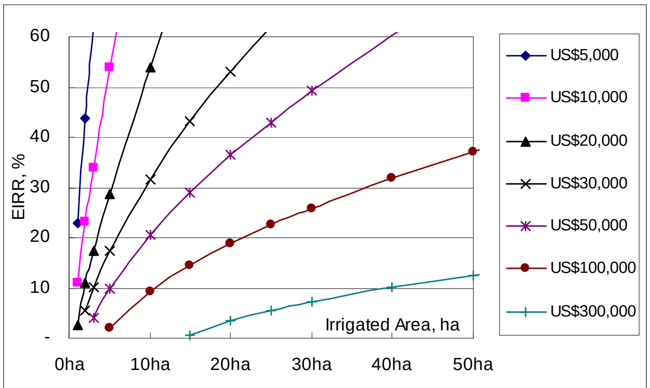


Figure 5.6.1 EIRRs with Irrigated Area (Normal X-axis)

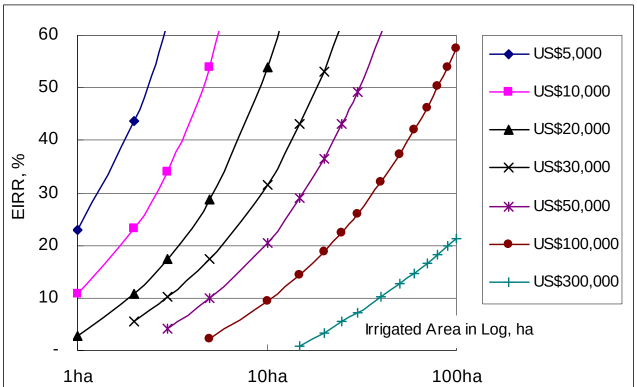


Figure 5.6.2 EIRRs with Irrigated Area (Log X-axis)

4) Result of Financial Analysis for Permanent Scheme

Table 5.6.4 summarizes FIRR, NPV, and B/C ratio by different project cost and according to different irrigated area. The NPV and B/C ratio were estimated at the discount ratio of 20%, which is equivalent to a commercial prime lending rate in Zambia. Also, Figure 5.6.3 shows the FIRR with solid lines by different project cost and different irrigated area on the X-axis in mathematical scale while Figure 5.6.4 shows the same but on legalistic scale X-axis. From the table and figures, following are observed:

i) FIRR is given bigger ratio as compared to economic IRRs. This is because the project financial cost is lower than economic cost; e.g. unskilled labors are provided by beneficiary farmers thereby no cost was considered and the government services like salary was dropped either. For the benefit side, cost for family labor was also excluded. Though the FIRR shows bigger rate than EIRR, this time the milestone value for FIRR should be 20%, equal to the commercial prime lending rate. In order to keep an FIRR more than 20% for a smallholder irrigation project, approximately the unit investment per 1.0 hector of irrigated area should be maintained within two-thirds of the US$ 10,000 indicated in the financial analysis.

ii) It is noted that theoretically a smallholder irrigation project with FIRR of 20% can be balanced even if the beneficiaries borrow loan with that 20% of lending rate from a commercial bank in order to construct and operate the project on their own (with the profit from irrigation agriculture, they can pay back the loan with the prescribed interest of 20%). However, this case does not leave any profit at the hands of the beneficiary farmers, and they can just pay back the loan by using all the profit from the irrigated agriculture. Therefore, in this financial analysis, B/C ratio rather than FIRR should be referred to know if a smallholder irrigation project can be not only variable but also profitable for the beneficiaries even if the scheme were put up with loan by the beneficiary farmers. An indication is to select cases which show B/C ratio of more than 2.0, e.g. if a project costs the beneficiaries US$ 20,000, at least 5 ha of irrigated land should be developed (see Table 5.6.4 where B/C ratio 2.14 is given).

Table 5.6.4 Summary of Financial Analysis (Permanent Scheme)

Model		1ha	2ha	3ha	5ha	10ha	15ha	20ha	25ha	30ha	40ha	50ha	60ha	70ha	80ha	90ha	100ha
FIRR, %	US$5,000	37.4	69.2	98.2													
	US$10,000	17.9	34.9	50.3	78.6												
	US$20,000	7.0	17.0	25.5	41.0	75.5	107.1										
	US$30,000	1.8	9.0	14.1	22.0	36.5	47.5	56.5	64.3	71.2	83.2	93.5	102.5				
	US$50,000		3.4	7.6	13.8	25.0	33.5	40.7	46.9	52.4	62.1	70.4	77.8	84.5	90.6	96.2	101.5
	US$100,000			0.5	5.6	13.7	19.8	24.8	29.3	33.3	40.5	46.7	52.2	57.2	61.8	66.1	70.1
	US$300,000					1.0	4.8	7.5	9.8	11.8	15.1	17.9	20.3	22.5	24.5	26.3	28.0
NPV, US$	US$5,000	2,612	8,030	13,449													
	US$10,000	-635	4,784	10,202	21,039												
	US$20,000	-7,264	-1,846	3,573	14,410	41,502	68,594										
	US$30,000	-12,902	-9,149	-5,396	2,111	20,877	39,643	58,410	77,176	95,942	133,475	171,008	208,540				
	US$50,000		-20,829	-17,076	-9,569	9,197	27,963	46,730	65,496	84,262	121,795	159,328	196,860	234,393	271,925	309,458	346,991
	US$100,000			-45,838	-38,332	-19,566	-799	17,967	36,733	55,500	93,032	130,565	168,098	205,630	243,163	280,695	318,228
	US$300,000					-126,392	-113,407	-100,423	-87,439	-74,454	-48,485	-22,516	3,453	29,421	55,390	81,359	107,328
B/C Ratio	US$5,000	1.93	3.86	5.79													
	US$10,000	0.90	1.79	2.69	4.48												
	US$20,000	0.43	0.85	1.28	2.14	4.27	6.41										
	US$30,000	0.23	0.45	0.68	1.13	2.25	3.38	4.51	5.63	6.76	9.01	11.27	13.52				
	US$50,000		0.26	0.40	0.66	1.32	1.99	2.65	3.31	3.97	5.30	6.62	7.95	9.27	10.60	111.92	13.25
	US$100,000			0.20	0.33	0.66	0.99	1.31	1.64	1.97	2.63	3.29	3.94	4.60	5.26	5.92	6.57
	US$300,000					0.17	0.26	0.34	0.43	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70

Sauce: JICA Study Team

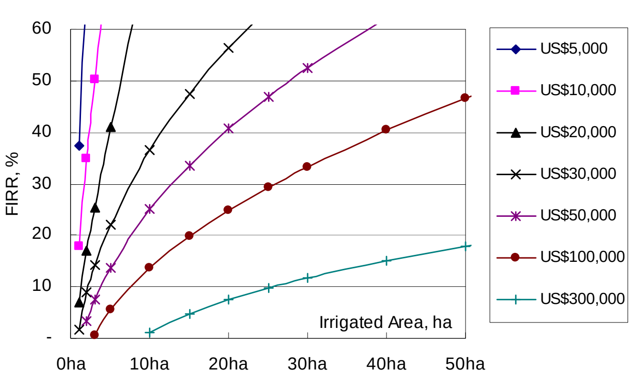


Figure 5.6.3 FIRRs with Irrigated Area (Normal X-axis)

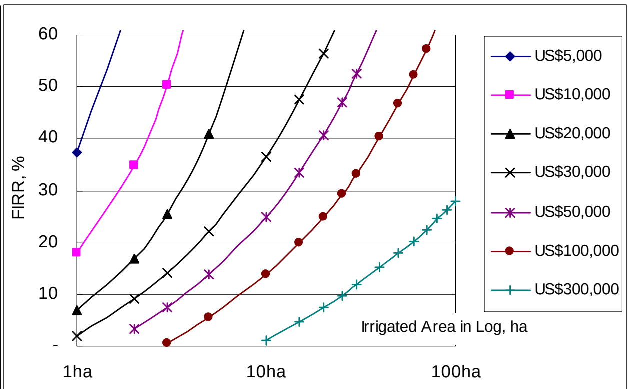


Figure 5.6.4 FIRRs with Irrigated Area (Log X-axis)

5.6.3 Economic and Financial Analysis for Simple Scheme

This session presents economic and financial analysis results for simple scheme. In fact, since cost whether it is economic or financial is very small, the economic and financial impact is expected to be very large. In carrying out the analysis, some conditions are, in addition to the pre-condition aforementioned, set as follows:

1) The first year's construction cost includes training cost for the extension officers in addition to their salary, meal allowance and fuel in economic analysis. However, a trained CEO can promote couple to several number of temporary schemes in a season. Therefore, assuming that a CEO can deal with 4 sites in a season, either improved one or newly developed one, one-forth the training cost is taken as per site in the cost. In financial analysis, training cost and salary are not considered since these are taken as a part of government services. Likewise in financial analysis, meal allowance and fuel are considered to be born by the beneficiary farmers.

2) In 2nd year's construction and onwards, at which simple diversion weir is constructed every year, the meal allowance and fuel for the government officers are considered as per site, however relevant training cost for them is not counted.

3) O&M for canal is counted at 2% of the construction cost of canal, and this is entered from 2nd year and onwards.

4) Beneficiaries' participation, as unskilled labor, is counted at 50% of the prevalence wage payment in rural area in economic analysis taking into account concealed employment while in financial analysis, it is not counted.

5) Though simple diversion structures can be constructed within one to a maximum of several days, it takes many days in digging canal, opening bush land in case of verging lands, etc. In fact, about one-third of the newly established sites under year 2009 pilot project implementation had failed to start irrigated agriculture in the same year. Given this situation, the benefit is assumed to take place from the 2nd year as is elaborated in the aforementioned Table 5.6.2. It means the first year is devoted only for the construction of the simple scheme in this model analysis (in fact, in case that the benefit accrues from the first year, the IRR can not be calculated since the first year's benefit is larger than the construction cost in the same year).

Figure 5.6.5 shows the EIRR and FIRR according to the area irrigated from 1.0 to 10.0 ha for simple diversion scheme and Table 5.6.5 summarizes the IRR, NPV, and B/C ratio for both economic and financial analysis. As aforementioned, to estimate NPV and B/C ratio, 12 % and 20 % discount ratios were employed in economic analysis and financial analysis respectively. From the table, following are observed and it is recommended that as long as simple scheme can be built, it should go with it since the simple systems are highly viable, much more viable than permanent ones:

1) The result shows highly viable in both economic and financial terms, e.g. 26.5 % for EIRR even with 1.0 ha of irrigated area of land. If a simple scheme can irrigate 2 ha, the EIRR is increased to as much as 54.2%, likewise to 79.2 % with 3 ha of irrigated land.

2) FIRR shows even bigger return as 53.9% with just 1.0 ha of irrigated area, and 102.2 % with 2.0 ha of irrigated area.

3) NPV shows positive value even from 1.0 ha of irrigated land, e.g. about US$ 4,900 and US$ 3,300 for economic and financial cases respectively, and likewise B/C ratio gives more than 2 even with 1.0 ha of irrigated area in both economic and financial terms.

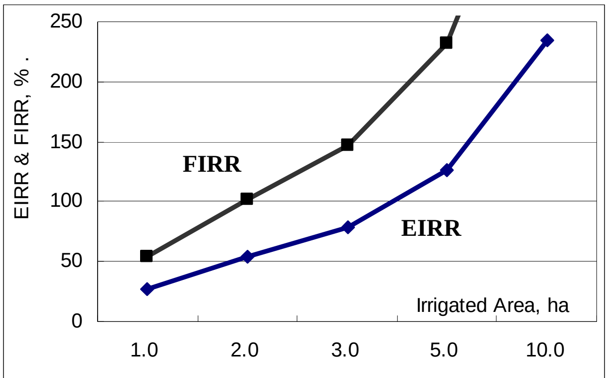


Figure 5.6.5 EIRR & FIRR for Simple Scheme

Table 5.6.5 Economic and Financial Analysis Results for Temporary Scheme

Case	Irrigation Area: ha	1	2	3	5	10	Remarks
Economic analysis	EIRR: %	26.5	54.2	79.2	125.8	234.2	
	NPV: US$	4,913	13,619	22,326	39,739	83,271	12% discounted
	B/C Ratio	2.3	4.59	6.89	11.48	22.95	do
Financial analysis	FIRR: %	53.9	102.2	146.9	232.1	437.6	
	NPV: US$	3,289	8,707	14,126	24,963	52,055	20% discounted
	B/C Ratio	2.54	5.09	7.63	12.72	25.44	do

Source: JICA Study Team

5.7 Technical Package

This chapter describes "Smallholder Irrigation Development Technical Package", which is a set of dissemination materials. The package consists of "comprehensive guideline" and "technical manual", which together composes of one volume, and incorporates a leaflet and posters. The posters work as a kind of picture stories which tell farmers the step of, for example, how to establish a simple weir. The package was once drafted prior to the commencement of the pilot project and through the implementation it was modified and refined. The package is presented separately from this Main Report, and therefore only brief explanation is made below:

5.7.1 Cascading of the Package

Since different cadres of offices are engaged in irrigation development, the technical package should be cascaded according to the users. Offices engaged in the smallholder irrigation development are provincial TSB, district TSB, Block area and then the tail end area that is Camp, aside from the TSB headquarters at Lusaka. Not only these official line of offices but also other organizations may wish to engage in smallholder irrigation development. An example could be Japanese Oversea's Cooperation Volunteers (JOCVs) and also Peace Coups[4].

The technical package prepared under this Study is as shown in Table 5.7.1. The comprehensive guideline is mainly for provincial and district TSB officers as the primary users and for BEOs and CEOs as the secondary users. Technical manual is meant for district TSB officers and also the frontline extension officers, BEOs and CEOs. Since the comprehensive guideline constitutes of the entry part to the technical manual, these two were merged into one volume, called 'Technical Manual'.

Table 5.7.1 Cascaded Dissemination Materials

Material	Primary Users	Secondary Users	Remarks
1. Technical Manual:			
1.1 Comprehensive Guideline	Provincial and District TSBs	BEOs/CEOs	Part I
1.2 Technical Manual	District TSBs, BEOs/CEOs		Part II
2. Leaflet	BEOs/CEOs	District TSBs, NGOs	
3. Posters (Picture Stories)	BEOs/CEOs	NGOs, Farmers	

Source: prepared by JICA Study Team

To widely disseminate smallholder irrigation development, especially simple irrigation schemes, another two materials were prepared; 1) leaflets and 2) posters which can also work as picture stories. These are designed to be used by the frontline extension officers, BEOs and CEOs, as the primary users and also district TSB officers and other organization including NGOs as secondary users. Posters, when used as picture stories during an entry meeting with potential farmers, can be a good attraction, aiming at getting the farmers interested in embarking on the smallholder irrigation development.

5.7.2 Comprehensive Guideline (Part I of the Technical Manual)

This guideline comes first for the cascaded dissemination materials. It deals with broad framework of smallholder irrigation development, general implementation arrangement and procedural flow, participatory planning, organizing process of farmer irrigators club and the organizational internal set-up, overall irrigation facilities & construction, monitoring and evaluation, and appropriate agriculture technologies that have to be incorporated in the irrigation development. This guideline gives an overall direction to pursue smallholder irrigation development and facilitates comprehensive understandings for the users, which therefore consists of the entry part to the technical manual.

The comprehensive guideline is firstly drafted during the Phase I study in 2009 through the

[4] In fact, during the operation of the pilot project in Mungwi district, Northern province, a Peace Coup's activity incorporated 'furrow alignment by using sprit line level' for fishponds as supported by the JICA Study Team.

implementation of the pilot project. This draft has been used and refined through the pilot project implementation in 2010 dry season, and finalized together with the Final Report of this Study. The comprehensive guideline covers following issues:

CHAPTER 1 DEVELOPMENT OBJECTIVES, STRATEGY AND PROCEDURES

CHAPTER 2 PARTICIPATORY PLANNING

CHAPTER 3 DESIGNING OF THE IRRIGATION SCHEMES
- 3.1 Irrigation Type
- 3.2 Stream Flow
- 3.3 Diversion Site
- 3.4 Development in a Stream
- 3.5 Construction of Temporary Diversion Structures
- 3.6 Construction of Permanent Diversion Structures
- 3.7 Design of Canal

CHAPTER 4 CONSTRUCTION ARRANGEMENT

CHAPTER 5 ORGANIZING FARMER IRRIGATION CLUB

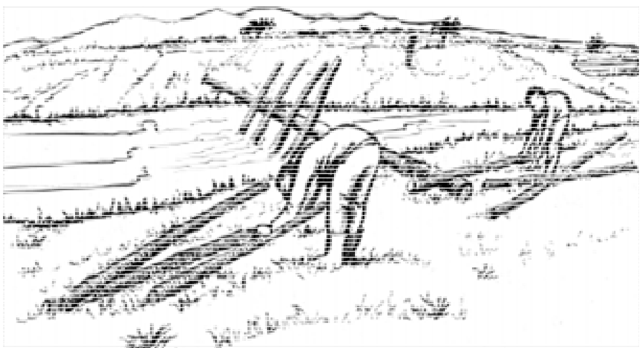
CHAPTER 6 OPERATION AND MAINTENANCE

CHAPTER 7 IRRIGATED AGRICULTURE

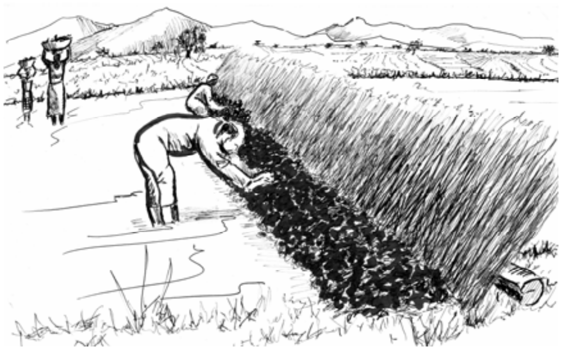
5.7.3 Technical Manual (Part II of the Technical Manual)

The technical manual shows how to construct different types of weirs including permanent weirs, together with necessary materials and tools, align canal, construct ancillary facilities such as canal bridge, irrigation methods, etc., and in most cases is referred to by district TSB officers and BEOs/ CEOs. This manual also incorporates agriculture components such as compost manure making, intercropping which can contributes to improving soil fertility, etc. Process Description (PD) method[5] developed in IFIC, JICA is employed in producing this manual, with which a step-wise detailed explanation is made together with illustrations following what to do step by step to, for example as shown below, construct an inclined standard simple weir:

Table 5.7.2 An Example of Technical Manual: Construction of Inclined Weir

Process	Description
	Put a horizontal supporting log at the diversion point across the stream. It is advisable that the horizontal log is put on a place where there are tree stump/rock for support of a log. If there are no objects for support, put something such as stone to keep the log from moving by water pressure. Also buttress vertical logs from the behind are recommended to firmly support the horizontal log.

[5] The word of “PD method” comes from “Process Description method”. This is a JICA technology transfer method of producing both an operation manual and (audio) visual aids using photos or illustrations, which are portrayed by superposing on the photos, of a series of actual activities of a work. This method is applicable not only for describing operation processes but also explaining all the field operation activities for a specific work. The process description is made by: 1) taking a series of photos of a work, and 2) describing the activities in the photos by step. It this step is undertake by counterparts, the counterpart will acquire the skill and knowledge necessary for the work and also the manual will be produced simultaneously. Source: Hideyuki KANAMORI (1994): Effective Technology Transfer by PD Method (in Japanese), Journal of the Japanese Society of Irrigation, Drainage and Reclamation Engineering, Vol.62, No.12, pp.7-12

	The vertical members composed of bamboo/twigs are put in front of the horizontal supporting log. To put grasses and soil easily, the vertical members should be put as closely as possible. These vertical members are placed into the foundation which is replaced by clay soil at the bottom and again connected to horizontal support log at the top using string.
	Grasses are placed or fixed in front of the vertical members. Grasses are at first piled horizontally, and then vertical standing grasses should be placed in the front. To prevent the grasses from swelling out, the grasses are bound by horizontal members such as bamboo and tied together with the vertical members.
	The clay soil is patched on the grasses to prevent seepage from the brush weir. The clay soil is collected from around the weir. To prevent water leakage, the clay soil is patched tightly on the grasses. The clay soil is put not only on grasses as a part of dam but also on the stream banks in contact with the weir to prevent seepage going around the weir.

The manual is prepared through the experiences of the pilot projects in 2009 centering on simple weirs and also in 2010 including permanent weirs. The manual is one of the major materials used during the kick-off trainings held in April 2009 and May 2010. Through the pilot implementation and given comments from the users, e.g. BEOs/CEOs, the manual has been finalized and presented with the Final Report of this Study. The manual covers the following topics:

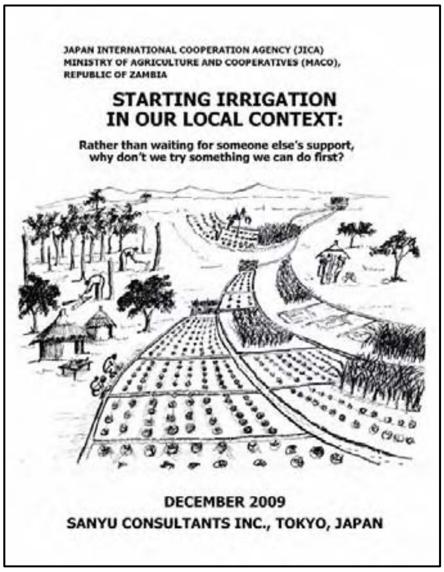
1. CONSTRUCTION OF A TEMPORARY WEIR: INCLINED WALL TYPE
2. CONSTRUCTION OF A TEMPORARY WEIR: SINGLE-LINE WALL TYPE
3. CONSTRUCTION OF A TEMPORARY WEIR: DOUBLE-LINE WALL TYPE
4. CONSTRUCTION OF A TEMPORARY WEIR: TRIGONAL SUPPORTED WALL TYPE
5. CONSTRUCTION OF A PERMANENT WEIR: WET MASONRY WALL TYPE
6. CONSTRUCTION OF A PERMANENT WEIR: CONCRETE WALL TYPE
7. CONSTRUCTION OF A SPILLWAY: SHOOT TYPE
8. CONSTRUCTION OF A SPILLWAY: SIDE-INFLOW TYPE
9. CANAL ALIGNMENT WITH SPRIT LINE LEVEL
10. CANAL DESIGN AND CONSTRUCTION
11. ON-FARM IRRIGATION METHOD (SECTION 1; FURROW IRRIGATION, SECTION 2;

SUNKEN-BED IRRIGATION)

12. DISCHARGE MEASUREMENT (SECTION 1; FLOAT METHOD, SECTION 2; V-NOTCH METHOD)
13. BOKASHI, A QUICK MAKING COMPOST MANURE
14. BOKASHI-SEED (SECTION 1; POWDER TYPE, SECTION 2; LIQUID TYPE)

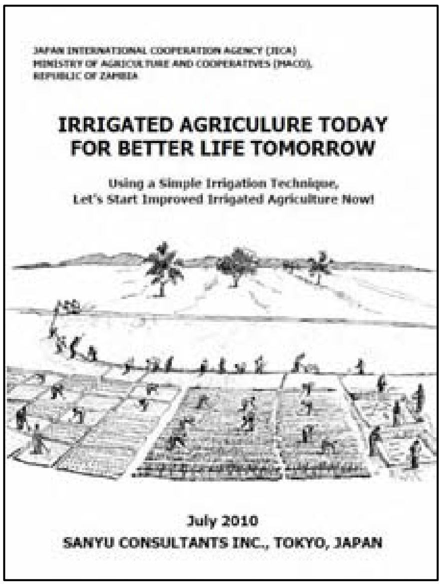
5.7.4 Leaflet (Simple Schemes and Agriculture Components)

Leaflet is meant to serve wide range of dissemination and to be used by frontline extension officers. Leaflet was prepared in 2 volumes centering on; 1) construction of simple irrigation scheme and 2) promotion of irrigated agriculture. The former leaflet briefly shows all the steps to develop smallholder irrigation for simple schemes together with illustrations. The first version was produced in April 2009, and distributed to all the participants to the kick-off training held early April 2009. Through the pilot implementation in year 2010, it was refined and finalized. The cover, which shows how rural life with irrigation looks nice is shown in the right illustration, and contents of the leaflet are as follows:



1. Attitude to promote irrigation culture
2. Identify potential diversion site
3. Construct diversion structure
4. Align canal and start digging
5. Layout the plot and do the irrigation
6. Issues and concerns

In addition to the above leaflet, another one was prepared focusing on improved irrigated agriculture. To fascinate and motivate clientele farmers, this leaflet was titled as "Irrigated Agriculture Today for Better Life Tomorrow (see right illustration)." Indeed, irrigation development alone cannot guarantee any positive outputs. Without good agricultural practice and marketing, farmers may not be able to enjoy the benefit of smallholder irrigation development. Therefore, this leaflet was prepared as a separate volume specifically for irrigated agriculture. To show the essence of irrigated agriculture, three major components are addressed in addition to an introductory part as follows:



1. Initiation of Irrigation Development
2. BOKASHI Compost (A Quick-Compost)
3. Intercropping
4. Cropping Calendar

Ambitiously, in the component of "cropping calendar," expected profits per quarter lima of recommended cropping systems were also indicated as a reference and also to motivate the readers to be more serious about the profit out of the irrigated agriculture.

5.7.5 Posters (also work as a Picture Story)

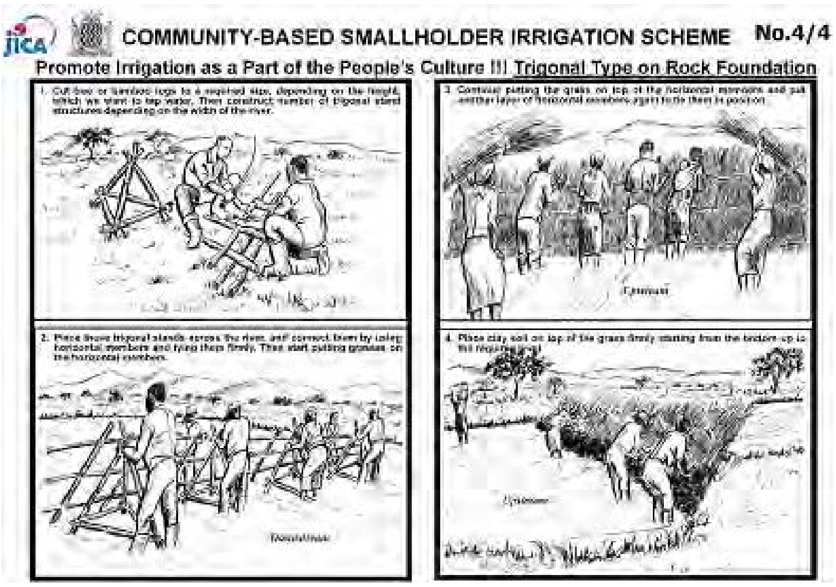
To disseminate smallholder irrigation development further widely, posters have been produced. The posters are made on A-3 sized sheets. In year 2009 during Phase I study, 4 types of A-3 posters were produced which showed the step of how to construct the basic 4 types of diversion weirs. Then, in 2010 during Phase II study, another 2 A-3 sized posters were produced incorporating a health issue; that is how to cope with malnutrition.

1) Posters for Simple Diversion Weir Construction

All the 4 posters produced in 2009 show the major steps of constructing a simple weir, meaning that major steps were excerpted from the PD manual. Poster No.1/4 shows the steps of constructing an inclined simple weir, No.2/4 illustrates the steps of constructing single-line weir which can apply to wider stream, No.3/4 is for double-line simple weir which can minimize water leakage and the last one No.4/4 shows the steps of trigonal prop weir which can be put up even on rock foundation. The headings for the 4 posters are as follows:

Promote Irrigation as a Part of the People's Culture !!!, *followed by*

- No.1/4 Inclined Type where Stream is Narrow
- No.2/4 Single-Line Type Where Stream is Wide
- No.3/4 Double-Line Type to Minimize Leakage
- No.4/4 Trigonal Type on Rock Foundation



These posters, as a good advantage, can be used as picture stories as they show how to construct weirs by 4 steps (see an example on the right illustration which shows 4 steps of constructing trigonal prop simple weir). If an extension officer needs to know detail construction procedure, s/he should refer to the technical annual prepared with PD method. However, if the extension officer needs to show farmers how easily a simple weir can be constructed within their locality, the extension officer can, while explaining, show the posters to the farmers. The posters will be of great help for the extension officers to let the farmers well understand and get them motivated especially during entry meeting.

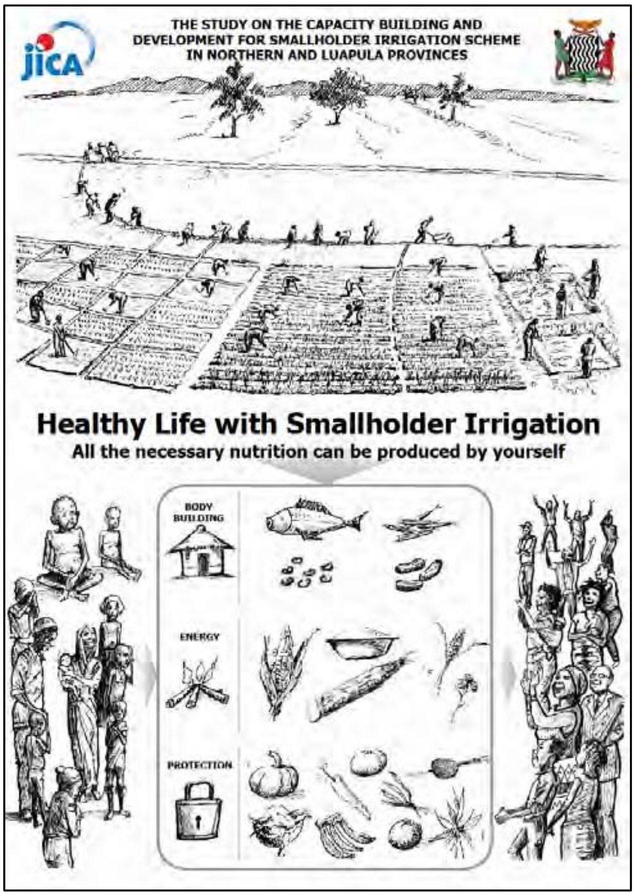
2) Posters Promoting Protein with Irrigation Development

Unfortunately, we can see a so-call pot belly child in the Study area (as an example, see the photo right). When a child is nursing, it receives certain amino acids vital to growth from its mother's milk. When the child is weaned, if the diet that replaces the milk is high in starches and carbohydrates, and deficient in protein (as it is common in parts of the world where

An example of so-called Pot Belly very often found out in the Study Area the bulk of the diet consists of starchy vegetables, or where famine has struck), the child may develop kwashiorkor. Symptoms of kwashiorkor include a swollen abdomen known as a pot belly, as well as alternating bands of pale and dark hair (flag sign) and weight loss. Common skin symptoms include dermatitis and depigmented skin[6].

The swollen abdomen is generally attributed to two causes: first, the appearance of ascites due to increased capillary permeability from the increased production of cysteinyl leukotrienes (LTC4 and LTE4) as a result of generalized intracellular deficiency of glutathione. It is also thought to be attributed to the effect of malnutrition on reducing plasma proteins, resulting in a reduced oncotic pressure and therefore increased osmotic flux through the capillary wall. A second cause may be due to a grossly enlarged liver due to fatty liver. This fatty change occurs because of the lack of apolipoproteins which transport lipids from the liver to tissues throughout the body.

Generally, the disease can be treated by adding food energy and protein to the diet. The irrigation schemes that the Study promotes can contribute to improving the situation by cultivating protein rich products. The protein rich products are beans and pulses and also fishes. In fact, there are already lots of fish ponds developed with irrigation schemes in the target 2 provinces. To facilitate this issue, 2 A-3 sized posters were prepared during the Phase II study. The first page is shown in the right and the 2nd page shows simplified steps of constructing such temporary weirs as; 1) inclined type weir and 2) single and double line weirs (simplified from those prepared in 2009).



Poster produced aiming at improving nutrition with the irrigation.

Accoding to the first page of the poster, production with irrigation is categorized into 3; 1) for body building, 2) for energy, and 3) for protection of human bodies. The first one can be supported by fish, and beans and pulses, which are the top priority in the mulnutrition issue. Energy can be obtained from carbohydrate which is the major substance of maize, cassava, millet, sorghum, etc., so-called staple food. To protect human bodies, it is recommended to uptake vegetables, which are the sources of vitamins.

All these agricultural produces including fish can be produced with irrigation as shown on the top part of the illustration. In fact, the sorce of carbohydrate can be produced under rain-fed agriculture too while the rest can be much better produced with irrigation during dry season. People shown on the left side of the square showing the 3 categories look very weak, and after going through the 3 categories they have now become quite healthy as shown in the right side of the poster. This is the main message of the poster, promoting irrigation linked up with health issue.

[6] Source(s): http://en.wikipedia.org/wiki/Kwashiorkor

CHAPTER 6 IMPLEMENTATION ARRANGEMENT OF THE PROJECT

This chapter discusses how to put the action plan into practice; so called implementation arrangement. It starts with conceptual implementation framework, followed by implementation mechanism, cost estimation, and implementation disciplines. Conceptual implementation briefly shows how to develop both simple and permanent irrigation schemes, centering on gravity irrigation scheme, in a phasing manner. Implementation mechanism refers to the implementation modality of simple and permanent schemes. Cost estimation provides an indication of cost by irrigation scheme and also as a programme, and implementation disciplines are based on the lessons gained through the pilot implementation.

6.1 Conceptual Development Framework

6.1.1 Development Modalities by Irrigation Scheme

Simple weir development scheme complements the current modality of smallholder irrigation development which stems from permanent weir construction. As shown below, combination of increased investment in permanent weir development and simple (temporary) weir development best facilitates the development process of smallholder irrigation schemes. This strategy can be pursued through a combination of construction modality for permanent scheme and extension modality for simple (temporary) diversion weir scheme.

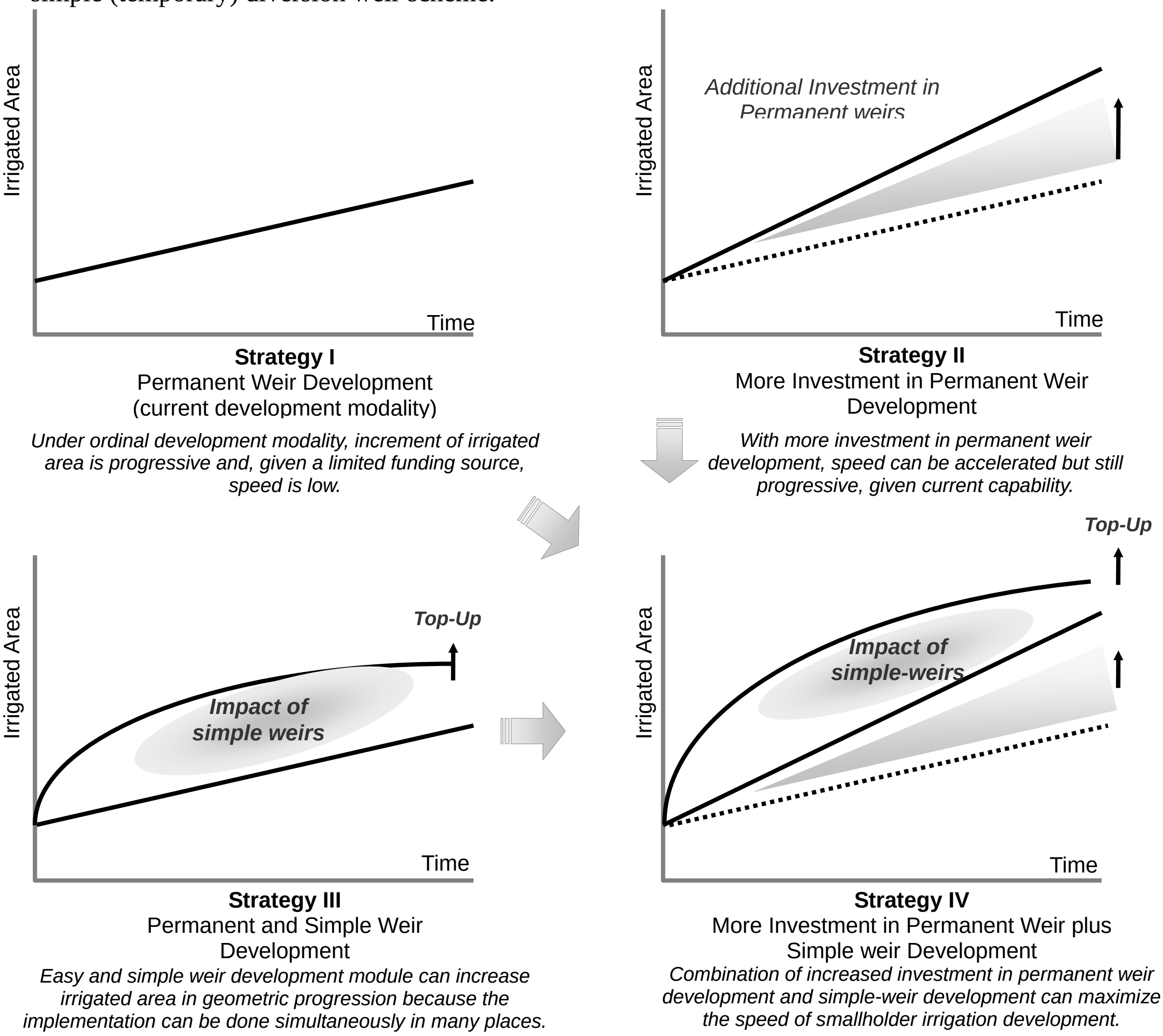


Figure 6.1.1 Conceptual Development Modality

Taking into account the present available budget for irrigation development and also human resource capacity of TSBs, 1 to maximum 2 permanent schemes can only be developed per year per distirct. This assumption does not refer to the technical capacity of district TSB officers but refers mainly to the number of staff. In fact, at district level only 2 – maximum 3 TSBs staff are available and not all of them are specialized in irrigation but in land husbandry and farm mechanization. The current implementation modality centering on permanent irrigation scheme is illustrated in the top-left of above figure, Strategy I. As time passes by, irrigated area is thereby increased bit by bit. In fact, under current situation one district is undertaking only 1 site at maximum or in cases a specific site is implemented over years (e.g. Lukulu North Irrigation Scheme[1] has been under rehabilitation since year 2007 to 2010).

As against the Strategy I, provided that there is more investment in irrigation development in Northern and Luapula provinces, there could be an accelerated development of permanent schemes and thereby accelerated increase in irrigated area. In a shorter period of time, targeted irrigated area could be achieved than that of Strategy I. This scenario is illustrated in top-right of the above figure as the Strategy II. Note is that as the investment alone can hardly assure the implementation capability of TSBs, there may be a need of engaging contractor in constructing permanent irrigation schemes. Current implementation modality is of direct force account method, which cannot undertake more number of permanent irrigation schemes per year per district. Should this situation prevail, more investment can hardly result in the implementation of many permanent sites within a single budget year.

Above discussion refers only to permanent irrigation schemes, which cannot be implemented by extension officers only. Construction of permanent irrigation schemes definitely requires district TSB and in most cases provincial TSB officers, who are knowledgeable in civil work. Also district and in cases provincial accounting sections should be engaged in procuring foreign materials e.g. cement and reinforcing bars. Contrary to this, simple irrigation schemes can be promoted by BEOs/CEOs as demonstrated throughout the 2-year pilot project implementation. For example, Strategy III in the bottom-left of the above figure shows a sort of toped up irrigated area by simple schemes on the irrigated area by permanent schemes.

Strategy III in the bottom-left of the above figures shows a combination of irrigated areas by both permanent and simple irrigation schemes. The former is developed mainly by TSBs while the latter can be development by BEOs/CEOs. It means these two implementation modalities can co-exist. Of course, simple schemes are supposed to reconstruct almost every year or at least mending is required, so that the irrigable area by simple scheme may not be counted same as those of permanent ones. However very advantage point associated with simple weirs is that simple schemes can be constructed by farmers only, not hiring skilled labors, with technical assistances from BEOs/CEOs. BEOs/CEOs are many in terms of number, e.g. over 400 extension officers in the 2 provinces while only about 50 staff in the entire district TSBs.

Above advantage indicates that aggregated irrigated area by simple schemes can increase very easily. In fact, simple schemes can be characterized by ‘quick’, ‘simple’ and ‘cheap or almost nil cost’, entailing quick implementation modality especially at an early period of implementation time frame. However the speed of increasing of the irrigated area by simple schemes would be slower as time passes by. This is because there will not be so many ideal sites for the construction of simple schemes. As the development moves forward, the rest of the potential sites for constructing simple sites would be less. Therefore the ratio of the increase of irrigated area by simple schemes would become less and

[1] Lukulu North Irrigation Scheme was firstly established in 1980, and rehabilitation started in 2007 with a budget of ZMK 80.3 million.

less as moving forward, resulting in hyperbolic curve as illustrated in Strategy III in the bottom-left of the above figures.

Furthermore Strategy IV, as illustrated in bottom-right of the above figures, shows the combination of the increment of irrigated area by simple schemes and the irrigated area by more invested permanent schemes. This Strategy IV is the one this Study proposes as implementation modality of the smallholder irrigation scheme development in the 2 target provinces. For the simple irrigation schemes, BEOs/CEOs shall fully be deployed supported by district TSB officers while the district TSBs shall undertake the permanent irrigation scheme development now supported by provincial TSB officers. By adapting this combination modality in implementing the smallholder irrigation development, the best accelerated achievement in terms of irrigated area can be realized.

Why these two different implementation modalities can co-exist? It stems from the difference of development mechanism as summarized in the following Table 6.1.1. Development of permanent schemes comes on basis of a sort of construction modality, or in other word, project type development modality while the development of simple schemes performs on extension modality, or in other word, programme type development modality. In sum, there are 2 different modalities; namely, construction modality vs. extension modality or project type development modality vs. programme type development modality.

Table 6.1.1 Implementation Modality for the Two Schemes

Particular	Permanent Scheme	Simple Scheme
Implementation Modality	Construction	Extension
	Project Type Implementation	Programme Type Implementation
Office in charge of Construction	TSB (province and district)	BEOs and CEOs
	Procurement Section (for foreign materials)	
Main Player in Construction	Skilled labors (Local Contractor in Cases)	Farmers (Beneficiaries)

Source: JICA Study Team

Two modalities operate on different cadres of government officers, e.g. the former modality on TSBs while the latter on BEOs/CEOs. The two modalities operate on different main players in construction; e.g. the former on skilled labors and in cases on contractors while the latter on farmers themselves. That is to say there is no overlapping in the development modality of the two schemes, which helps the government pursue the two schemes' development simultaneously. Strategy IV above is therefore proposed in smallholder irrigation development.

MACO is expected to secure investment with assistances from donors in constructing permanent schemes and also to strengthen the human resources in the provincial and district TSBs. Or otherwise engaging local contractors in constructing permanent schemes shall be an option to develop more permanent schemes than the present operation given the investment. On top of this arrangement, the MACO can disseminate simple schemes by deploying BEOs and CEOs in order to accelerate the development of irrigated areas from an earliest time as well as to maximize the benefit for the sake of beneficiary farmers.

Another benefit can be pointed out when pursuing two implementation modalities simultaneously. With the simple irrigation schemes established wherever possible, the beneficiary farmers can learn what the irrigation is, e.g. water management specifically how to carry out rotational irrigation among the members, on-farm irrigation method, marketing of dry season crops, etc. Through these activities, they can be united and strengthened as organization to which organizing and sensitizing process for putting up permanent weir can be easier.

In other way around, it can be said there could be high possibility for the permanent schemes to be successful. They have at least experienced irrigated agriculture with simple schemes. With these experiences, they would have no difficulties in conducting irrigated agriculture with the permanent structure, which in this case comes as an upgrade modality from the original simple scheme. They can accumulate know-how of irrigated agriculture with simple diversion weirs, which can definitely contribute to increasing the performance of irrigated agriculture now with the upgraded scheme to permanent.

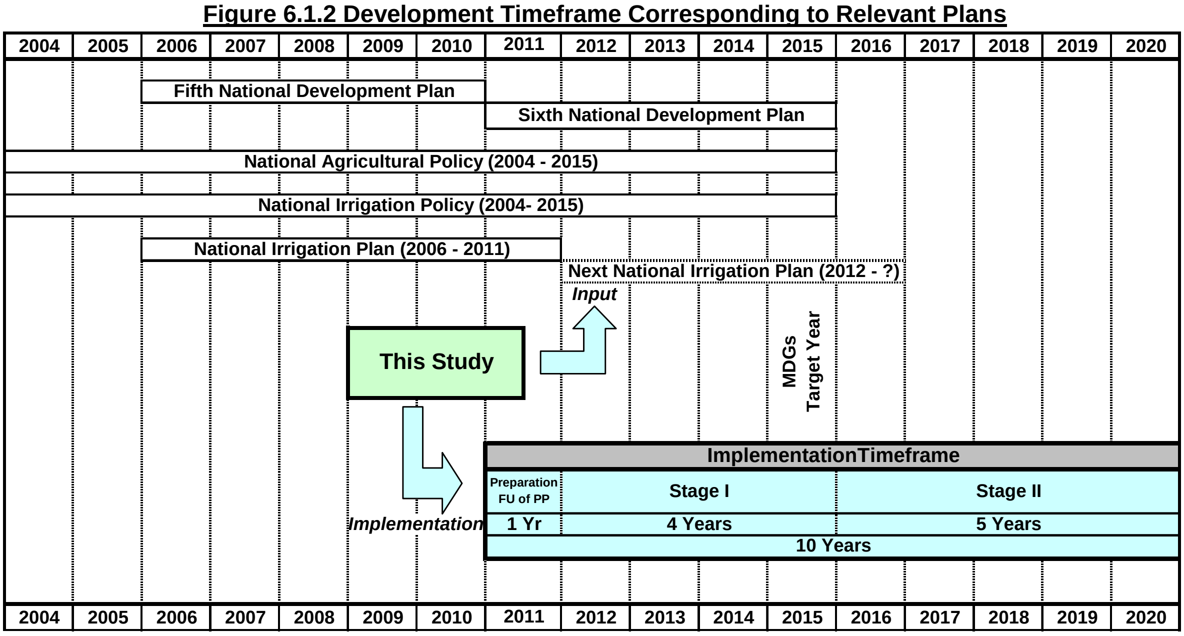
Lastly, an advantage associated with the introduction of simple schemes should also be mentioned. It takes shorter period of time to bear profit from irrigated agriculture with simple schemes than that of permanent schemes. This is simply because simple weirs can be constructed in an early date of a dry season and within the same season the beneficiary farmers can reach the harvest, getting at least some profit in the same year. On the other hand, construction of permanent structures takes obviously longer period of time, which makes farmers in many cases give up the irrigated agriculture in the same season. Present value, in economic term, would be lost in this case.

Same situation can be observed over long term of the development. As shown by the hyperbolic curve in the above illustration, benefit from simple schemes can be born much earlier than permanent schemes. The benefit from the irrigated agriculture is the additional harvest and income thereon and this benefit starts showing up since the commencement of the irrigation one by one as scheme is constructed. The aggregated impact of irrigation is correspondent to the area enclosed between the hyperbolic curve and the X (horizontal)-axis. It means that the earlier the irrigation starts, the larger the aggregated impact is. In an economic analysis based on present value, the earlier the benefit shows up, the higher the IRR is. To start irrigation earlier, we again propose to start the irrigation with simple schemes wherever possible.

6.1.2 Development Timeframe

To define development timeframe of the action plan prepared under this Study, we should refer to the existing development plans at sector level as well as national level and also broader level e.g. MDGs. Those that the Study should refer to are schematically shown in the following figure with the timeframe on which this Study operates.

Figure 6.1.2 Development Timeframe Corresponding to Relevant Plans



This Study presents the final action plan for smallholder irrigation development in mid of year 2011 with all the feedback of lessons from the pilot project implementation. Therefore, the same year, 2011, can be the preparation period for the implementation stage and also for the follow up period of the pilot project implemented under this Study. Then, Stage I implementation is programmed to cover the following 4 years ending in 2015. Year 2015 is corresponding to the final years of Sixth National Development Plan, National Agricultural Policy and National Irrigation Policy as well. Also, it is coincided with the target year of MDGs. Stage II is then set from year 2016 to year 2020, spanning over 5 years. Therefore the action plan presented under this Study is to cover a total 10 years as:

- Preparation/Follow-up of Pilot Project: Year 2011 (1 year)
- Stage I: Year 2012 – Year 2015 (4 years)
- Stage II: Year 2016 – Year 2020 (5 years), total 10 years

The current National Irrigation Plan (NIP) is to end in 2011, and next NIP is planned to start from year 2012. On the other hand, this Study completes in mid 2011 corresponding to the final year of the present NIP. It is therefore expected for this Study to feed the outputs forward to the next NIP in terms of community based smallholder irrigation development. It is recommended that development modality of smallholder irrigation schemes articulated in this Study should be referred to in the next NIP. Also manuals and guidelines and other dissemination materials, e.g. posters and leaflets, prepared under this Study can be distributed for other areas of the country.

Year 2011, one year before the year-one of the Stage I implementation, should serve for follow up the pilot projects which were carried out over the years of 2009 and 2010. The extension of the pilot project, centering on simple schemes, should also be foreseen in this year 2011, which rolls over the Stage I implementation. In the Stage I implementation, focus could be more on simple schemes especially in the earlier period. It means more BEOs and CEOs are to be trained in earlier period of time. Then, as investment becomes available and also as human resources become available not only in terms of technical capacity but also of man-power in TSB staffing, focus is shifting to permanent schemes. In this regard, no specific fund for simple scheme will be allocated in the Stage II period. BEOs and CEOs, who have already acquired necessary skills for promoting simple schemes during the Stage I period, are expected to continue as a part of their recurrent activities in the Stage II period.

6.2 Implementation Mechanism

This sub-chapter elaborates the implementation method by scheme and then implementation plan over the period afore-mentioned. The schemes undertaken in this Study are basically gravity irrigation scheme since it is the most cost-effective especially in terms of operation and maintenance. In fact, as long as the potential sites identified by relevant district and provincial TSBs under an inventory survey carried out in 2009 are concerned, the relevant officers have reported 129 potential sites which are all of gravity irrigation. Those schemes are planned to be permanent according to the TSB officers, but as the first step they may be started with simple facilities wherever site conditions allow.

As such, the first priority is attached to gravity irrigation in this planning. There may, of course, be potential sites for pumping irrigation and also reservoir (dam) irrigation scheme. However, so far such potential sites were hardly reported to the provincial offices as well as to JICA Study Team. Therefore even if there could be such potential sites as pumping irrigation and reservoir irrigation, there should be at first preliminary survey and then feasibility study, which goes beyond the scope of this Study. Since this Study deals with community based smallholder irrigation schemes only as programme (or a package), such potential sites, if any, should be kept for future potential project starting from preliminary survey and feasibility study one site by one site.

6.2.1 Organizational Arrangement

Under the provincial MACO, there are 12 and 7 district MACOs at district level in Northern province and Luapula province respectively. Besides, there are 242 camps and 168 camps in Northern and Luapula provinces respectively. Each of the province and district MACOs has Technical Service Branch offices (TSBs). For the permanent schemes, provincial and district TSBs will be responsible while for simple irrigation schemes the Camp Extension Officers (CEOs) will be the responsible implementers together with Block Extension Officers (BEOs). In sum, this Study maintains existing organizational structure in pursuing smallholder irrigation development in the target 2 provinces.

Local authorities such as traditional chiefs[2], sub-chiefs, and village headpersons at village level should also be well informed in advance of the project implementation. Though village headman is usually the contact person for government officers and for outsiders whereby such project can be automatically known to him/her, traditional chiefs may be left out unknown unless courtesy visit is arranged for that purpose. If they are well informed for the purpose of the irrigation development, they could be a good catalyst for the development as well as good mediator in case that serious conflict takes place.

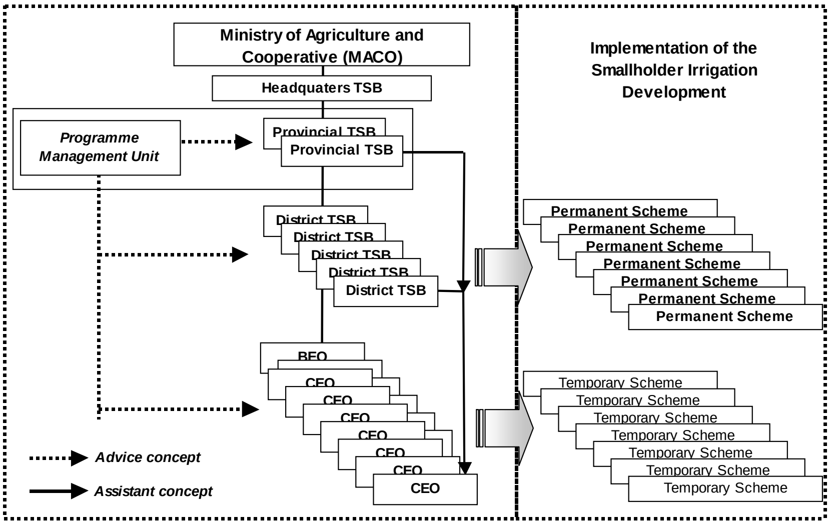


Figure 6.2.1 Organizational Arrangement in Implementation

As the Headquarters TSB is not manned with enough staff, there is difficulty of directory managing the smallholder irrigation development meant for the target 2 provinces. With the present staffing, the headquarters TSB can be in the position of overall monitoring and evaluation of the programme and also in charge of national level planning and budgeting for smallholder irrigation development. Scarce staffing prevails at provincial level as well. For example, there is only one senior irrigation engineer in each of the 2 provincial TSBs of Northern and Luapula. Under each of them, there are only 3 technical staff each in the both provincial TSBs as at 2010.

With this scarce staffing at the provincial level, there may be a need to establish the programme management unit, which is in charge of managing the smallholder irrigation development programme in the target 2 provinces. The unit may be donor-supported or otherwise the provincial TSB itself should discharge the role with some strengthened staffing. In the latter case, at least 3 technical officers under the provincial irrigation engineer should be allocated. The unit and relevant government offices should coordinate, move hand in hand and discharge their roles and responsibilities well defined at their jurisdictions:

Programme Management Unit:

Conducting of smallholder irrigation dissemination activities undertaking both simple and permanent schemes such as trainings for BEOs/CEOs, irrigation officers at district TSBs, monitoring and evaluation of smallholder irrigation development, developing of appropriate technologies and forwarding them to the Headquarters TSB, and coordinating relevant offices,

[2] In Northern and Luapula provinces, there are in most cases 3 recognized traditional chiefs in each of the districts. Under him, there are many sub-chiefs (no data available for the sub-chiefs), and there is a village headperson in each of the villages.

Headquarters TSB (central level):

Overall monitoring and evaluation of smallholder irrigation development programme, banking of appropriate smallholder irrigation technologies/experiences and these technologies dissemination to other provinces, and facilitating the exchange of the technologies amongst provincial TSBs,

Provincial Level:

Technical advises to the district TSB officers, monitoring and evaluation at provincial level, facilitating the exchange of smallholder irrigation experiences amongst districts, and budgeting for the smallholder irrigation development programme,

District Level:

In charge of permanent scheme construction supported by provincial TSB, technical advices to BEO/CEO officers, monitoring and evaluation at district level, facilitating the exchange of smallholder irrigation experiences amongst extension officers, and

Camp Level:

In charge of simple scheme development, e.g. identification of potential areas for the smallholder irrigation schemes, facilitation of the farmers including identification of the potential beneficiaries, arrangement of farmer-to-farmer visit in the camp, organizing them into irrigation group/club including permanent schemes, facilitation of the construction work, follow-up of operation and maintenance, etc.

If smallholder irrigation development ends up in village-by-village, concerned local authority is the village headman only. However, cluster-wise development can be pursued in case of simple schemes, for which number of potential sites ought to be developed simultaneously. If the concerned traditional chief and/or sub-chiefs are well informed of the development, dissemination from one site to another within the cluster could be well advanced.

Table 6.2.1 Technical and Administrative Lines

Technical Line		Traditional Line
Coverage	**Responsible**	**Dissemination Catalyst**
National	Deputy Director	
Province	Provincial TSB	
District	District TSB	Traditional Chiefs (3/district)
Block	BEO	Traditional Sub-chiefs (many)
Camp	CEO	Traditional Sub-chiefs (many)
Project	-	Village Headman (1/village)

Source: JICA Study Team

Considering there are 3 traditional chiefs in each of the districts under the two provinces and as an average there are 3.9 blocks in a district (74 blocks in the total 19 districts of the 2 provinces), the jurisdiction of a traditional chief could be more or less same as the coverage of a typical block extension area. A typical block consists of 5.5 camps (74 blocks vs. 410 camps in the 2 provinces). Though no data exists, it is said that there are several sub-chiefs under each of the traditional chiefs, implying a typical sub-chief may govern more or less same area as camp extension area.

From the above implication, one may say that if traditional chief is well informed of the development, there should be an opportunity that dissemination at block level, which means beyond a camp, could be facilitated. Also if traditional sub-chief is well informed of the development, there should be an opportunity that the extension at camp level may be advanced. Given a sort of assistance from the traditional chiefs and sub-chiefs, simple scheme development could be accelerated.

Village headman is automatically involved since the beginning of the development. Aside from him/her, it is recommended that sub-chief and traditional chiefs should be informed of the development. This arrangement on the traditional administrative structure could catalyze the extension of the smallholder irrigation development from one site to another in a form of cluster composed of several villages, beyond the cluster, and then beyond the camp and block areas.

6.2.2 Simple (Temporary) Irrigation Scheme

Simple irrigation scheme can be promoted by extension officers; in this case, BEOs and CEOs back-supported by district TSB officers. The entry point for promoting simple irrigation schemes is to be a preparatory TOT for the kick-off training. The kick-off training course, to be administered after the TOT, is the most important step for this simple scheme promotion. BEOs and CEOs from potential areas are invited to the kick-off training.

Upon completion of the kick-off training, trained BEOs/CEOs are to develop simple irrigation schemes at their own block/camp areas. They shall be provided fuel for their mobility with, if needed, spare parts for motorbike. District TSB officers may require allowances according to a government regulation when they discharge back-stopping to the BEOs/CEOs. Provincial TSB officers do the same. The trained BEOs/CEOs are supposed to carry out the extension of simple schemes over the dry season, and they may gather once again as the season is about to end. When they gather at the place where the kick-off training was held, they are to report their achievement. This opportunity can also work as a venue for refresher course as well as lesson sharing.

1) Trainings

The smallholder irrigation development programme is to cover whole of the target 2 provinces as far as there is potential for smallholder gravity irrigation development. There are in fact some camp areas, which have very little potential for gravity stream diversion as in the cases that they are located in a very plain area. In this case, number of BEOs/CEOs who are to be trained in smallholder irrigation development can be reduced and in turn the allocation be given to other areas having high potential for gravity scheme development. Therefore, some of the areas, e.g. blocks and camps, might be completely dropped from the training pipeline for smallholder irrigation development. However, the smallholder irrigation programme itself is basically to cover whole of the target 2 provinces at least at district level.

1.1) Overall Schedule

Available time for administering necessary trainings at the beginning of dry season may be about one month only. Developing smallholder irrigation project in a participatory way needs enough lead-time with the concerned farmer beneficiaries. Enough time should therefore be allocated to develop the projects on the ground. It is thereby recommended that trainings should be completed within one month which could accommodate one to two batches of one-week kick-off training plus a TOT which should also work as management meeting. In this sense, one batch of kick-off training with the preparatory TOT is recommended per provincial.

Training necessary for disseminating simple smallholder irrigation development is basically categorized in two: training of trainers (so called TOT) and BEO/CEO training. The BEO/CEO training course should be carried out two times; namely, first one is the kick-off training and the other is its follow up training. The training of trainers (TOT) should be administered before the kick-off training, thus this Study proposes three courses of training altogether in a season:

Table 6.2.2 Proposed Training Course and Time

Training Course	Proper Time
1. Training of Trainers (TOT) for the Kick-off Training Course	April - May
2. Kick-off Training Course (first BEO/CEO training)	Early May
3. Follow up Training Course (second BEO/CEO training)	November

Source: JICA Study Team

Training of Trainers (TOT) for the kick-off training course is to equip trainers with necessary skills of leading the sessions of the kick-off training. There are 11 trainers who have been trained under this

Study, who are composed of provincial TSB officers and district TSB officers under the target 2 provinces. Provided that they could be once again engaged in the kick-off training, this TOT is taken as refresher course and also should be a kind of management meeting that is to well define necessary arrangement of the kick-off training.

The kick-off training course is the main one during which all the necessary trainings will be given to the concerned BEOs/CEOs and also their supervisors i.e. district TSB officers. BEOs/CEOs together with district TSB officers are expected to learn what and how they should do to promote smallholder irrigation development in their jurisdictions. This kick-off training should mainly concentrate on irrigation technologies and probably a bit of irrigated agriculture since too many subjects may not be well imparted. Agriculture components are in fact important but at this stage compost manure should be stressed because irrigation exploits soil fertility so that always improving of soil characteristics should be undertaken together with irrigation.

At the end of the kick-off training, an action plan should be formulated by all the participant BEOs/CEOs and also at district level. Then, their achievement should be reported in the follow up training as compared to the action plan formulated beforehand in the kick-off workshop, or the first kick-off training would result in little action on the ground. The follow up training can also top up agriculture components, conservation farming, catchment area conservation, etc. as need arises.

Smallholder irrigations are expected to commence at the beginning of each dry season and come to an end as the dry season comes to the end. A cycle of construction/mending, planting, irrigation, harvesting and dismantling of the simple weirs when needed is repeated every dry season. Therefore, the proper time to administer the trainings is: April for the first TOT, April/May for the kick-off training, November for the follow up training. Overall schedule with irrigation development is illustrated in the following table:

Table 6.2.3 Overall Timeframe for Training

Item	Apr		May		Jun		July		Aug		Sep		Oct		Nov	
TOT		▲														
Kick-off Training			▲													
Follow up Training															▲	
Construction			▬	▬	▬	▬	▬	▬								
Planting						▬	▬	▬	▬							
Irrigation						▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	
Harvesting													▬	▬	▬	▬

Source: JICA Study Team

1.2) Training Participants

At what level the kick-off training and also follow up training should be held is an issue; either at provincial level or at district level. During the stage I period from 2012 – 2015, it is recommended to hold the kick-off and follow up trainings at the provincial level. Though the pilot project carried out under this Study has brought together both Northern and Luapula BEOs/CEOs at a specific place, Kasama Farm Institute, the kick-off and follow up trainings during the project implementation stage I period can be held separately, one in Kasama and the other in Mansa.

To make an arrangement in participant number by district, we can refer to the prioritization of the districts by three groups discussed in '4.5.4 Smallholder Irrigation Potential and Its Prioritization by District' in this Report. The exercise categorized all the districts in the 2 provinces into 3 levels of irrigation potential; 'A' being the highest potential, 'B' being the middle potential while 'C' means the least irrigation potential. This Study proposes about 80% of the BEOs/CEOs in the districts with potential ‘A’ should be invited to the kick-off and also follow up trainings over the project years of stage I, about 60% in the districts with the potential ‘B’ and about 40% in the districts with the potential ‘C’. This arrangement applies to the trainings during stage I only.

Then, thereafter from 2016 to 2020, the training can be held at district level with a shorter period of training days than that of the stage I. In fact, during the stage I period, they can learn each other beyond a district whereby they can be equipped with broader aspects of smallholder irrigation experiences. With this background, during the stage II period, already trained extension officers at that provincial level can be just refreshed at district level and the new participant BEOs/CEOs can learn from them. Therefore, the targeted BEOs/CEOs will have to be trained till the end year of stage I, and during the stage II from 2016 to 2020, the remaining BEOs/CEOs are to be trained at the district level.

During stage I, as aforementioned the kick-off training is recommended to take place at provincial level. Then, how many participants can be invited at a batch of training? From the management point of view for training, one-batch training can accommodate about 30 – maximum 70 participants. Taking these practices into account, it is recommended for the training to invite about 40 participants for Luapula province and 70 participants in Northern province per batch. Northern province covers bigger area than Luapula province, and therefore to complete the project in the specific period of time, different number of participants is recommended.

Table 6.2.4 shows the number of blocks and number of camps, trained BEOs/CEOs during the pilot project implementation in years of 2009 and 2010, target coverage during the implementation period as aforementioned, total number of BEOs/CEOs who are to be trained during the entire stage I period, and number of the BEOs/CEOs to be trained per annum during the stage I of year 2012 – 2015 and the same number to be trained during the stage II of year 2016 – 2020. Note that the number of participants during the stage II includes the targeted BEOs/CEOs as per district plus 2 TSB officers each of the district. From the table:

i) In Northern province, during stage I, 68 participants are to be trained per year, who are the targeted BEOs/CEOs and plus district TSB officers and provincial TSB officers concerned. One batch of training can accommodate all the 68 participants and whereby the training is held once a year at Kasama township.

ii) In Luapula province, during the stage I, 43 participants are to be trained per year, and they are BEOs/CEOs targeted and also district as well as provincial TSB officers. The training can be held at Mansa township once at the beginning of every dry season.

iii) During stage II from year 2016 to 2020, the training can be held by district as refresher course. Trainers are to be the district TSB officers and also active BEOs/CEOs who have accumulated a lot of experiences during the stage I implementation period.

Table 6.2.4 Training Plan for BEOs/CEOs for Simple Smallholder Irrigation Development

District	Potential	No. of Blocks*	No. of Camps*	Trained u/ P.P.	CEO/BEO Rest	Coverage	To be Trained	2012-2015	2016-2020
Mbala	A	4	18	7	15	80%	12	**3**	**20**
Mungwi	A	4	22	4	22		18	**5**	**23**
Luwingu	A	5	16	5	16		13	**4**	**19**
Kasama	A	4	26	3	27		22	**6**	**26**
Nakonde	B	3	10	3	10	60%	6	**2**	**10**
Isoka	B	5	24	3	26		16	**4**	**20**
Mpika	B	6	34	5	35		21	**6**	**26**
Mporokoso	B	4	26	4	26		16	**4**	**20**
Chinsali	B	5	32	0	37		23	**6**	**25**
Kaputa	C	2	10	0	12	40%	5	**2**	**7**
Mpulungu	C	3	15	0	18		8	**2**	**10**

Chilubi	C	3	9	0	12		5	**2**	**7**
District TSBs				19				**18**	
Provincial TSB				8				**4**	
Northern Total		**48**	**242**	**61**	**256**		**165**	**68**	**213**
Kawambwa	A	7	37	7	37	80%	30	**8**	**38**
Mansa	A	7	43	6	44		36	**9**	**42**
Mwense	B	5	24	3	26	60%	16	**4**	**20**
Milenge	B	0	13	3	10		6	**2**	**10**
Nchelenge	C	3	15	2	16	40%	7	**2**	**10**
Chienge	C	4	11	0	15		6	**2**	**8**
Samfya	C	0	25	0	25		10	**3**	**12**
District TSBs				7				**11**	
Provincial TSB				2				**2**	
Luapula Total		**26**	**168**	**30**	**173**		**111**	**43**	**140**
Grand Total		74	410	91	429		276	**111**	**353**

Note *: Not all the Block and Camp are manned with the extension officers. The staffing rates are 47% for BEOs and 88% for CEOs as of end 2009. Therefore, taking the number of blocks and camps as those numbers of BEOs and CEOs give an overestimated staff numbers. However, the Government is increasing the number of extension officers, and also since the coverage is set as 80%, 60%, and 40% according to the irrigation potential, numbers of Block and Camp are taken in the estimation of BEOs/CEOs to be trained during the project implementation period.

Source: JICA Study Team

1.3) Training Course Contents

Contents of the trainings refer to the ones administered during the pilot project implementation. Also, the training course for simple diversion scheme can be managed with the course for permanent schemes as was done during the pilot project implementation in 2010. Basically training for simple scheme is given to BEOs/CEOs and the other one, training for permanent scheme, is to district TSB officers. However, since district TSB officers concerned to the participant BEOs/CEOs for the kick-off training are also at presence in the same training as their supervisors, the two course contents for simple and permanent schemes can be undertaken in a batch of training by separating the participants into two groups; one for BEOs/CEOs and the other one for district TSB and provincial TSB officers.

In this regard, the detail course contents for the kick-off training of the simple scheme is given in the latter part of this chapter together with the course contents of permanent scheme. Following are only the module titles for the course contents of the simple schemes:

For the Kick-off Training;

Module 1 – Program Orientation
Module 2 – Overview of Community Based Smallholder Irrigation (COBSI) Development
Module 3 – COBSI Scheme (Temporary Diversion Weir)
Module 4 – COBSI Scheme (Canal, Ancillaries and On-farm Irrigation)
Module 5 – Irrigated Agriculture Development
Module 6 – COBSI Scheme (Temporary Diversion Weir and Canal Alignment, Practice in Field)
Module 7 – COBSI Scheme (Permanent Diversion Weir, TSB Officers Only)
Module 8 – Entry Planning (Action Plan Formulation)
Module 9 – Programme Evaluation and Closing

For the Follow up Training;

Module 1 – Program Orientation
Module 2 – Output Presentation of Smallholder Irrigation Development
Module 3 – Lessons Sharing among Participants
Module 4 – Irrigated Agriculture Development (Top Up to the Module 5 in the Kick-off Training)
Module 5 – Training Evaluation

2) Implementation on the Ground

Implementation responsibility for the simple schemes should center on camp level. There is only one CEO in each camp extension area. These CEOs will be equipped with necessary knowledge, skills and attitude to promote smallholder irrigation development through the aforementioned training. The training should preferably be administered to all the CEOs including BEOs; however this is not the case under the arrangement aforementioned. Also, since only a handful number of BEOs/CEOs per each of the districts are trained in a year, there should be an arrangement of peer-to-peer on-site training; training of those fellow CEOs, who have not participated in the kick-off training in a specific year, by the participant BEOs/CEOs trained in the kick-off training.

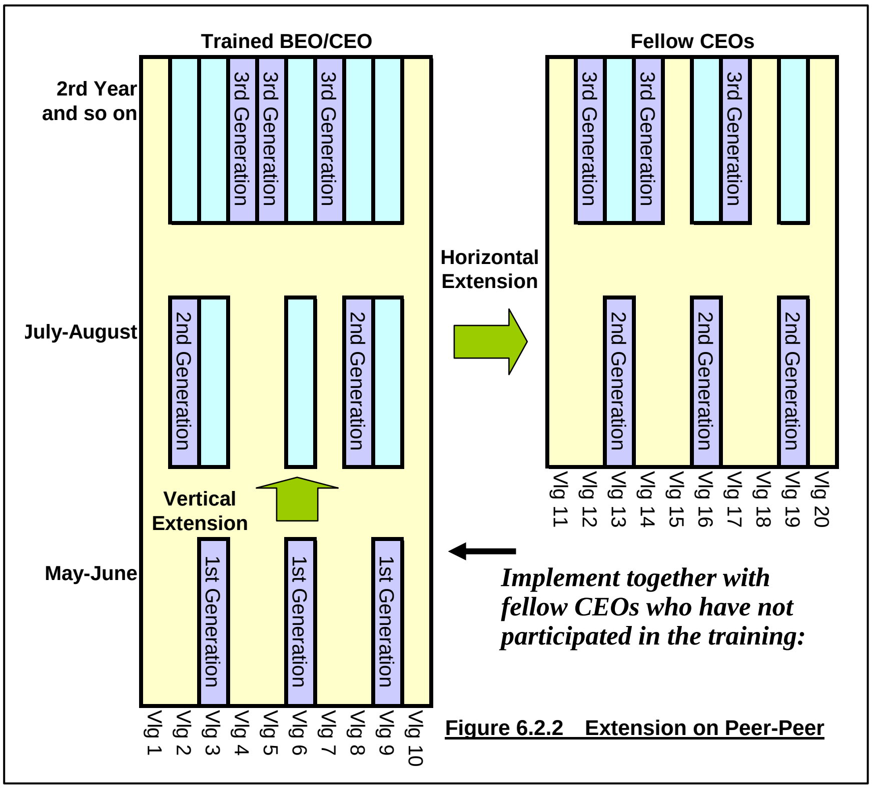


Figure 6.2.2 Extension on Peer-Peer

Upon completion of the necessary training, the BEOs/CEOs are supposed to explore smallholder irrigation development during which they should invite neighbor CEOs who have not yet been given the training. Through working together with the trained BEOs/CEOs, the fellow CEOs will learn what to do in facilitating farmers to develop smallholder irrigation schemes. This arrangement can be called another TOT (training of trainees) on the site. If those CEOs who have been trained on the site by their peers are to participate the kick-off training probably in a following year, they can very easily learn the necessary skills and technologies since they are already on-the-job-trained.

Given this arrangement above, Figure 6.2.2 shows conceptually how simple irrigation schemes are developed; for example, in May/ June the trained BEOs/CEOs develop a simple scheme together with fellow CEOs who have not participated in the training. In July to August the BEOs/CEOs can develop 2nd simple irrigation schemes and also the fellow CEOs who have by then learned the skills through working together develop their own 1st generation schemes. Then, they proceed in the following year as far as there is potential site and there are willing farmers. It is expected that as they proceed to following years, farmer to farmer extension would also be able to work since there will be more sites that can motivate nearby farmers each other.

District TSB will be the coordinator among the BEOs/CEOs and also the supervisor on the course of the implementation at their district level. Technical assistances from relevant TSB officer(s) at district level should be given to the BEOs/CEOs as back-stopping. A task force team may be arranged at this district level being the core of pursuing the implementation; namely, composed of CEOs, BEOs being the leader and district TSB officer as the technical advisor. The team may ask advices from crop officer at the district as far as crops are concerned and when approaching planting season.

6.2.3 Permanent Irrigation Scheme

Permanent irrigation scheme requires engineering knowledge and also experiences for civil works. Therefore BEO/CEO can hardly proceed on their own, and in this regard the office in charge of permanent irrigation schemes should be the district TSB and also provincial TSB. The priority implementation modality for permanent scheme centers on force-direct account. Since the scale of smallholder irrigation schemes are not big; namely, in most cases typical height of diversion weir being less than 3m and the typical length being less than 30m, no civil contractor is required in the construction and rather district TSB and provincial TSB can proceed on their own.

There is senior irrigation officer in each of the 2 provinces, who are equipped with necessary knowledge and experiences for irrigation and drainage engineering. However, most of the district TSB officers are not necessarily specialized in irrigation engineering nor civil engineering. In fact, the pilot project in 2010 carried out permanent scheme construction in 6 districts. Of them, one district TSB has never experienced any concrete or wet-masonry work and another 2 districts have also had very limited experiences in such civil works. Given this situation, training dealing with wet-masonry and concrete structure shall be arranged. Following are the implementation mechanism of permanent irrigation schemes.

1) Typical Procedure

A typical procedure of constructing permanent scheme is summarized in the Table 6.2.5 with the responsible office/officers, and following are the details;

Step 1: Identification of potential permanent sites can primarily be based on existing simple scheme sites. By observing existing sites, district TSB can know the beneficiaries' commitment whereby know if they are ready for the upgrading from the existing simple one to the permanent one.

Step 2: Permanent diversion weir rather needs solid and stable foundation unlike simple schemes. In fact, simple diversion weir can be put up even in deep *dambo* areas; on the other hand permanent structure does not. Permanent structure should be constructed on stable and hard foundation, and this condition should be confirmed by provincial irrigation engineer. If needed, auger boring shall be carried out along the expected weir longitudinal axis line. With the auger boring, we can know how much we should excavate in order to reach stable foundation.

Step 3: Upon confirmation of the site for permanent structure by provincial TSB, topographic survey for the site shall be carried out by district TSB. The survey shall be carried out along the expected weir construction line, namely, longitudinal survey for the site across the stream. Cross section survey for the site, parallel to the stream, is not necessary for those small-scale irrigation facilities.

Step 4: District TSB shall carry out the designing of the permanent structure and accordingly prepare for the BOQ (bill of quantify). With the prevalent prices for materials, labors, transportation, etc., the district TSB shall carry out costing as well.

Step 5: Following the step 4, the design, BOQ and the cost required shall be forwarded to the provincial TSB for their perusal. The provincial TSB shall scrutinize all the documents and drawings submitted by the district TSB, and if corrections are needed they put it back to or otherwise approve.

Step 6: Upon approval by the provincial TSB, organizing of the beneficiary farmers should start by CEO/BEO in charge of the area. The beneficiary farmers shall fully be informed for their responsibilities and role in the construction work. Since this Study maintains maximum participation from the beneficiaries, they shall provide all the available resources in and around the site. The resources are locally available materials for concrete and wet-masonry, e.g. sand, stones, cobbles, etc. Concrete needs crushed stones which shall also be crushed by the beneficiaries as long as stones are available there. Likewise, all the unskilled labors shall be provided as well. These conditions shall fully be delivered to the beneficiaries at the beginning and agreed upon.

Step 7: Upon agreement by the beneficiaries, they are supposed to start up-front preparation. Up-front means necessary materials for the construction of permanent facilities. These are, for example, sand, stones, crushed stones, etc. District TSB informs how much volume shall be prepared by material and CEO/BEO in charge can supervise day-to-day preparation work.

Step 8: Procurement of foreign materials shall be arranged by district TSB as long as such foreign materials are available in, for example, district center. In case district TSB can not manage in their area, provincial TSB can procure at provincial capital where most of the materials for civil work are available.

Step 9: In construction, all the unskilled labors are to be provided by the beneficiaries, mobilized by CEO/BEO. On the other hand, skilled labors required in masonry/concrete work and carpentry work are to be arranged by the district TSB. Of course, as long as such skilled labors are available around the construction site, they have to be arranged in the locality. Construction shall be supervised daily, and this is the task of the district TSB. Also, provincial TSB shall support the district TSB and in case district TSB is not experienced, the provincial TSB shall also be engaged in the construction day-to-day basis.

Step 10: Upon completion of the diversion weir, the main facility for the permanent scheme, beneficiary farmers can move to the canal construction. Since the weir is constructed by concrete or wet-masonry, the canal shall also be lined at least for some reach from the beginning, say at least 50m from the starting point of the canal. District TSB shall be in charge of the supervision of the construction.

Step 11: Almost in parallel with the canal construction, beneficiaries can also start up the on-farm development. On-farm irrigation method can be either furrow irrigation or sunken-bed irrigation. Beneficiary farmers, according to their plan of on-farm irrigation, are supposed to arrange their farms for irrigation.

Step 12: Operation and maintenance shall fully be done by the beneficiary farmers. Since the scheme undertaken here is a small-scale scheme, no government offices are engaged in the operation and maintenance of the structures. CEO/BEO in charge of the area can give advices how to operate, e.g., how to carry out rotational irrigation, and also how to maintain facilities. Should an accident occur which goes beyond the farmers' manageability, CEO/BEO shall inform the event to the relevant district TSB.

Table 6.2.5 Typical Procedure of Developing Permanent Scheme

Step	Work	In charge
1.	Identification of potential sites	District TSB
2.	Confirmation of the potential site	Provincial TSB
3.	Site topographic survey (profile, longitudinal)	District TSB
4.	Designing, BOQ preparation and cost estimation	District TSB
5.	Approval of the design, BOQ and project cost	Provincial TSB
6.	Organizing of farmers (mobilization of farmers)	CEO/BEO
7.	Up-front materials collection	District TSB, CEO/BEO

8.	Procurement of foreign materials/tools	Provincial/district TSBs
9.	Construction (direct force account) of the diversion weir	District TSB, Provincial TSB, CEO/BEO
9.1	Mobilization of beneficiaries in unskilled labor work	CEO/BEO
9.2	Arrangement of skilled labors	District TSB
9.3	Supervision of the construction	District TSB/provincial TSB
10.	Construction of the canal (to include lining work)	District TSB
11.	On-farm development	CEO/BEO
12.	Operation and maintenance	CEO/BEO

Source: JICA Study Team

2) Typical Construction Schedule

Construction schedule can be divided into 3 stages including design stage. First stage undertakes identification of the site, survey of the site and design of the expected structures, BOQ preparation and costing (corresponding to No.1 – No.5 in the aforementioned table). Upon approval of the design, BOQ and project cost, preparation for the construction is to start, which is the 2nd stage. This 2nd stage includes up-front preparation by the beneficiary farmers, and procurement and transportation of foreign materials and tools by district TSB/provincial TSB. Third stage is the construction of permanent facilities.

Since all the unskilled labors are to be provided by beneficiary farmers, there may be a case that the construction can hardly be finished within a season, for example, in case there is shortage of labor force provided by the beneficiaries. In this case, construction may be planned over years. However, to avoid possible damage to the already completed parts of permanent structure during flood season, the construction shall be planned to complete within a season as much as possible. Or otherwise, hired labor may have to be considered.

Typical construction schedule in accordance with dry season is summarized below; stage 1 can start in April and finish in May, stage 2 from May – June, and the stage 3 should start in July or even earlier than that. Typical civil construction may need one to three months to complete, whereby September or before than end of that month shall be the completion target of the construction.

Table 6.2.6 Typical Construction Scheme of Permanent Schemes

Work	April	May	June	July	August	September
Site identification, design, BOQ, Costing	■					
Up-front, procurement of foreign materials and tools		■	■			
Construction			■	■	■	■
Dewatering			■			
Core trench excavation			■	■		
Concrete/masonry work				■	■	■
Ancillaries (e.g. gate)						■
Completion						△

Source: JICA Study Team

2) Typical Training Module

Since permanent schemes planned under this Study is to be constructed by direct force account whereby no contractor is engaged, the district TSB officers should be equipped with necessary knowledge for irrigation and civil works. In fact, some of them are well experienced already but some are not. Therefore once a year at the beginning of dry season, relevant district TSB officers shall be invited and administered necessary trainings for permanent schemes. This training can be incorporated in the kick-off training as aforementioned.

Kick-off training is primarily meant for equipping BEOs/CEOs for necessary skills and knowledge for simple schemes. However, since their supervisor, who are the district TSB officers, are to participate in the kick-off training as well, the officers can be set aside from BEOs/CEOs for 1 – 2 days for equipping them with necessary skills and knowledge for permanent schemes. For those who have already such skill and knowledge, this session can work as refresher course. Presented below is a training contents proposed together with the ones for BEOs/CEOs. In these contents, Module 7 is provided only to district/provincial TSB officers while other modules are meant for all the participants including BEOs/CEOs:

Day 1:
Module 1 - Program Orientation
- Registration, and Pre-Training Knowledge Inventory
- Opening, Self Introduction, and Overview of the Training
- Surfacing of Participants' Expectation

Module 2 – Overview of Community Based Smallholder Irrigation (COBSI) Development
- Irrigation Development in Zambia, and Northern and Luapula Province
- Introduction to the Community Based Smallholder Irrigation Development

Module 3 – COBSI Scheme (Simple Diversion Weir)
- Identification of Potential Gravity Diversion Sites
- Weir Type and Construction Method

DAY 2:
Module 4 – COBSI Scheme (Canal, Ancillaries and On-farm Irrigation)
- Canal Alignment by Sprit Line Level
- Irrigation Water Requirement and Water Management
- On-farm Irrigation Method (Sunken bed and Furrow)
- Organizing of Farmers

Module 5 – Irrigated Agriculture Development
- Recommended Cropping Patterns
- Bokashi Compost (A quick Making Compost)
- Liquid Fertilizer

DAY 3:
Module 6 – COBSI Scheme (Practice in Field)
- Construction Practice of a Simple Diversion Weir in Field
- Practice of Canal Alignment with Sprit Line Level

DAY 4:
Module 7 – COBSI Scheme (Permanent Diversion Weir, TSB Officers Only)
- *Type of Permanent Weirs and Construction Method*
  - *Wet-masonry wall type (buttress supported)*
  - *Concrete-wall type (buttress supported)*
  - *Masonry gravity type*
- *Ancillary Facilities for Permanent Scheme*
  - *Sand sluiceway*
  - *Spillway*
  - *Canal lining*
- *Construction method*
  - *De-watering (diversion canal, and water bridge)*
  - *Excavation of core-trench*
  - *Mortar mixing*
  - *Wet-masonry placing*
  - *Concrete mixing, placing, and curing*

For permanent scheme meant for district/provincial TSBs

Shuttering
Reinforcing bar arrangement

DAY 5:

Module 8 – Entry Planning (Action Plan Formulation in the Season)
Entry Planning by District, and the Plan Presentation
Reporting Mechanics

Module 9 – Programme Evaluation and Closing

6.3 Target Setting and Benefit to Accrue

Implementation framework and the mechanism were discussed in the previous 2 sub-chapters. Following the discussions aforementioned, this sub-chapter presents the target of the smallholder irrigation development over the planned timeframe as well as tries to estimate benefit to be accrued. Targets are to be put up in terms of sites to be established, farmer beneficiaries to be targeted, and areas to be developed and irrigated. Those targeted are so established in referring to the actual results from the pilot project implementation, especially the results of 2010 pilot project.

6.3.1 Targets and Expected Benefit for Simple Schemes

To set the targets for simple diversion scheme development, following conditions are laid with reference to the results of the pilot project implementation.

1) In year 2010, 60 officers were trained and they together with fellow BEOs/CEOs had improved 193 sites and developed 181 sites. This indicates that a trained officer can improve 3.21 sites per year and newly develop 3.00 sites per year. It is, therefore, assumed that a trained officer can improve 3 existing sites and also develop new 3 sites during the Stage I implementation period (2012-2015) together with fellow CEOs who are to be trained on site by the trained officer.

2) During Stage II implementation period (2016-2020), short term training is arranged at district level. The training could be 2-day course and work as refresher training for those who have already participated in the kick-off training held in Stage I period. They are assumed to develop one new simple site each per year toward the end of the Stage II implementation. During the Stage II period, no improvement for the existing temporary schemes is planned. This is because improvement can be done much easier than the new development, whereby the trained officers are supposed to finish the improvement by the end of Stage I implementation.

3) The improvement in 2010 has undertaken total 193 sites, creating newly irrigated areas of total 192 ha. With this, it is assumed that a typical improved site is to newly irrigate 1.0 ha. On the other hand, the total 193 sites had been irrigating a total area of 205 ha before the improvement. It means a typical existing site used to irrigate 1.1 ha as average. This area of 1.1 ha is therefore set as the originally irrigated area before the improvement. With the improvement, a typical site is to enlarge the irrigated area to 2.1 ha.

4) For the new development, 2010 pilot project implementation established 181 sites, of which 146 (81%) sites could start irrigation at a total area of 131 ha. This means about 80% of the newly established in that year was able to start irrigation with a typical area of 0.90 ha as average. It is therefore assumed that 80% of the newly developed sites can start irrigation in the same year with a starting irrigated area of 0.90 ha per site.

5) Newly developed sites are to enlarge irrigated areas over years. It can start with 0.90 ha per site as mentioned in above 3), and then the irrigated area is assumed to enlarge up to 2.1 ha over 4 years. In fact, newly developed sites in 2009 had altogether irrigated a total farm land of 52 ha in the same year 2009, and then put another 70 ha under irrigation in the following year. From this

experience, enlarging the irrigated area from 0.90 ha to 2.1 ha as per site over 4 years can be achieved without much difficulty.

6) All the newly developed sites cannot start irrigation in the same year; for example, about 20% of the newly constructed sites in 2010 failed to start irrigation in the same year as mentioned in above 4). Of the 20%, 10% is assumed to start irrigation next year with an average irrigated area of 0.90 ha and enlarged to 2.1 ha over the 4 years. The remaining 10% is assumed not able to start irrigation, meaning one out of 10 newly constructed sites is assumed to fail. With reference to the results of the pilot project implementation in 2009, 6 sites out of 94 sites established in 2009 have not been able to start irrigation even in 2010, meaning almost complete failure. 6 failures out of 94 sites account for about 6%. Therefore 10% failure in the target setting is assumed safer side.

7) A typical improved site in 2010 accommodated 18 participant farmers, of whom about 60% had carried out irrigation (not all the members who participated in constructing diversion weir can benefit from irrigation due to land allocation, water shortage, and obligatory participation into the construction by the village authority). Therefore, a typical improved site is assumed to have 18 members but only 10 members can be benefited from irrigation.

8) A typical newly constructed site in 2010 accommodated 19 participant farmers, of whom only 38% of them had been able to start irrigation in the same year 2010. It is therefore assumed that a typical new construction site accommodates 19 members and at the first year only 7 members (38% of 19 members) are supposed to start irrigation. Then, over 4 years the irrigators are supposed to increase up to 10 members, equivalent to those for improved site.

9) There may be a tendency that as year passes by, achievement may get lower even under same input. This is because the highest and higher potential districts and whereby potential camps are to be developed in earlier years of the implementation while in the latter years less potential districts are to be undertaken. This arrangement entails reduction tendency over implementation years. How much it should be reduced in terms of achievement is very difficult to estimate. Therefore, in this target setting, as a simple assumption 5% reduction per year is aggregated toward the end of the Stage I (2012-2015) implementation and 10% reduction during the Stage II period (2016 -2020).

Based on the assumptions above, targets and expected benefits are summarized as shown in Table 6.3.1, and elaborated by Improvement during Stage I in Table 6.3.2, and by New Development during Stage I in Table 6.3.3 and by New Development during Stage II in Table 6.3.4. It is, in sum, targeted that throughout the Stage I and Stage II implementation periods, total 3,876 sites[3] are to be undertaken, of which 3,584 sites are to enjoy irrigation. With these sites, total 4,956 ha are to be irrigated benefiting as many as 32,732 farmers. The aggregated net profit arrives at ZMK 88.44 billion (US$ 18.40 million). Following are the detail by improvement and new development and by implementation stage:

1) During the Stage I implementation, total 1,232 sites are to be improved while another 1,232 sites are to be newly constructed. With the improvement altogether, total 1,232 ha of farm land will be irrigated benefiting total 12,321 farmers. The benefit in terms of net profit[4] is, with reference to the result of harvest survey for the pilot project, estimated at an aggregated amount of ZMK

[3] According to an inventory survey under this Study, there were total 1,153 potential sites composed of existing 1,024 temporary sites and 129 new potential sites. The target surpasses the identified potential sites by far. This is because BEOs and CEOs who were engaged in the inventory survey were not familiar to the concept of simple diversion schemes at that time, hence there must be much more potential sites for simple schemes than what they actually identified. In this regard, the target was set far more than the identified number of sites.

[4] Net profit here means gross income minus cost. Cost includes input such as fertilizer, seeds, chemicals and hired labors; however family labor is not counted in the estimation.

22.549 billon (US$ 4.69 million) over the 4 years. With respect to new development during the Stage I period, total 1,232 sites will be developed, of which 1,081 sites are to start irrigation. With the irrigation at 1,081 sites, a total area of 1,630 ha is to be irrigated, benefiting 9,207 farmers. The monetary benefit aggregated over the 4 years arrives at ZMK 25.255 billion (US$ 5.25 million).

2) In sum for the both improvement and new development during the Stage I project implementation period, total 2,464 sites will be undertaken, of which total 2,313 sites are to enjoy irrigation. These sites altogether are expected to irrigate total land area of 2,862 ha, benefiting as many as 21,528 farmers. The total net profit is to arrive at ZMK 47.804 billion (US$ 9.95 million) as aggregated value over the 4-year project implementation period.

3) During Stage II project implementation period, only new development is undertaken (it is assumed that all the exiting sites can be improved during the Stage I period). Over the period of 5 years for the Stage II project implementation, total 1,412 sites are to be undertaken, of which 1,271 sites are to start irrigation within the implementation period. These 1,271 sites together are to irrigate 2,094 ha, benefiting as many as 11,204 farmers. The aggregated net profit is expected to arrive at ZMK 40.636 billion (US$ 8.45 million) over the 5 years implementation period.

Table 6.3.1 Summary of the Targets Set for Simple Schemes during Stage I & Stage II

Particulars	Improvement	New Construction	Total	Remarks
Stage I (2012 – 2015)				
Sites Undertaken, No.	1,232	1,232	2,464	
Sites to start Irrigation, No.	1,232	1,081	2,313	
Area to be Irrigated, ha	1,232	1,630	2,862	
Farmers to Benefit,	12,321	9,207	21,528	
Economic Increment, M ZMK	22,549	25,255	47,804	Aggregated
Economic Increment, US$	4,691,471	5,254,447	9,945,918	Aggregated
Stage II (2016 – 2020)				
Sites Undertaken, No.	Not planned	1,412	1,412	
Sites to start Irrigation, No.		1,271	1,271	
Area to be Irrigated, ha		2,094	2,094	
Farmers to Benefit,		11,204	11,204	
Economic Increment, M ZMK		40,636	40,636	Aggregated
Economic Increment, US$		8,454,509	8,454,509	Aggregated
Grand Total (2012 – 2020)				
Sites Undertaken, No.	1,232	2,644	3,876	
Sites to start Irrigation, No.	1,232	2,352	3,584	
Area to be Irrigated, ha	1,232	3,724	4,956	
Farmers to Benefit,	12,321	20,411	32,732	
Economic Increment, M ZMK	22,549	65,891	88,440	Aggregated
Economic Increment, US$	4,691,471	13,708,956	18,400,427	Aggregated

Source: JICA Study Team

Table 6.3.2 Targets Set for Improvement of Simple Schemes during Stage I

Particulars	Unit	2012	2013	2014	2015	Total	Remarks
Reduction Factor		**1.00**	**0.95**	**0.90**	**0.85**		
Officers to be trained		111	111	111	111	444	
Sites to be improved, No.	3 sites/officer	333	316	300	283	1,232	
Area to be irrigated, ha	1.0 ha/site	333	316	300	283	1,232	0.100
Area originally irrigated, ha	1.1 ha/site	366	348	330	311	1,355	0.110
Area to be irrigated in total, ha	2.1 ha/site	699	664	629	594	2,587	0.210
Members to participate	18 mem/site	5,994	5,694	5,395	5,095	22,178	
Members to benefit	10 mem/site	3,330	3,164	2,997	2,831	12,321	Aggregated
Economic Increment, M ZMK	7.128 M/ha	2,374	2,255	2,136	2,018	8,782	22,549
Economic Increment, US$	1,483 $/ha	493,839	469,147	444,455	419,763	1,827,204	4,691,471

Source: JICA Study Team

Table 6.3.3 Targets Set for New Development of Simple Schemes during Stage I

Particulars	Unit	2012	2013	2014	2015	Total	Remarks
Reduction Factor		**1.00**	**0.95**	**0.90**	**0.85**		
Officers to be trained		111	111	111	111	444	
Sites to be developed, No.	3 sites/officer	333	316	300	283	1,232	
Members to participate	19 mem/site	6,327	6,011	5,694	5,378	23,410	
Sites able to start irrigation	90%	300	285	270	226	1,081	
Area to be irrigated (1st Y), ha	0.9 ha/site	240	228	216	204	1,630	0.177
Area to be irrigated (2nd Y), ha	1.3 ha/site	376	357	339			
Area to be irrigated (3rd Y), ha	1.7 ha/site	496	471				
Area to be irrigated (4th Y), ha	2.1 ha/site	616					
Members to benefit (1st Y)	7 mem/site	1,865	1,772	1,678	1,585	9,207	
Members to benefit (2nd Y)	8 mem/site	2,364	2,246	2,128			
Members to benefit (3rd Y)	9 mem/site	2,664	2,531				
Members to benefit (4th Y)	10 mem/site	2,964					Aggregated
Economic Increment (1st Y), M ZMK	7.128 M/ha	1,709	1,624	1,538	1,453	11,618	25,255
Economic Increment (2nd Y), M ZMK	7.128 M/ha	2,682	2,548	2,414			
Economic Increment (3rd Y), M ZMK	7.128 M/ha	3,537	3,360				
Economic Increment (4th Y), M ZMK	7.128 M/ha	4,391					
Economic Increment (1st Y), US$	1,483 $/ha	355,564	337,786	320,008	302,229	2,417,095	5,254,447
Economic Increment (2nd Y), US$	1,483 $/ha	558,038	530,136	502,234			
Economic Increment (3rd Y), US$	1,483 $/ha	735,820	699,029				
Economic Increment (4th Y), US$	1,483 $/ha	913,602					

Source: JICA Study Team

Table 6.3.4 Targets Set for New Development of Simple Schemes during Stage II

Particulars	Unit	2016	2017	2018	2019	2020	Total	Remarks
Reduction Factor		**1.00**	**0.90**	**0.80**	**0.70**	**0.60**		
Officers to be trained (Refresher)		353	353	353	353	353	1,765	
Sites to be developed, No.	1 site/officer	353	318	282	247	212	1,412	
Members to participate	19 mem/site	6,707	6,036	5,366	4,695	4,024	26,828	
Sites able to start irrigation	90%	318	286	254	222	191	1,271	
Area to be irrigated (1st Y), ha	0.9 ha/site	254	229	203	178	152	2,094	0.187
Area to be irrigated (2nd Y), ha	1.3 ha/site	399	359	319	266			
Area to be irrigated (3rd Y), ha	1.7 ha/site	526	473	421				
Area to be irrigated (4th Y), ha	2.1 ha/site	653	588					
Area to be irrigated (5th Y), ha	2.1 ha/site	667						
Members to benefit (1st Y)	7 mem/site	1,977	1,779	1,581	1,384	1,186	11,204	
Members to benefit (2nd Y)	8 mem/site	2,506	2,256	2,005	1,754			
Members to benefit (3rd Y)	9 mem/site	2,824	2,542	2,259				
Members to benefit (4th Y)	10 mem/site	3,142	2,828					
Members to benefit (5th Y)	10 mem/site	3,177						Aggregated
Economic Increment (1st Y), M ZMK	7.128 M/ha	1,812	1,630	1,449	1,268	1,087	15,022	40,636
Economic Increment (2nd Y), M ZMK	7.128 M/ha	2,843	2,559	2,275	1,990			
Economic Increment (3rd Y), M ZMK	7.128 M/ha	3,749	3,374	2,999				
Economic Increment (4th Y), M ZMK	7.128 M/ha	4,655	4,189					
Economic Increment (5th Y), M ZMK	7.128 M/ha	4,756						
Economic Increment (1st Y), US$	1,483 $/ha	376,919	339,227	301,535	263,843	226,152	3,125,289	8,454,509
Economic Increment (2nd Y), US$	1,483 $/ha	591,554	532,398	473,243	414,088			
Economic Increment (3rd Y), US$	1,483 $/ha	780,014	702,012	624,011				
Economic Increment (4th Y), US$	1,483 $/ha	968,473	871,626					
Economic Increment (5th Y), US$	1,483 $/ha	989,413						

Source: JICA Study Team

6.3.2 Targets and Expected Benefit for Permanent Schemes

To set the targets for permanent diversion scheme development, the results from the permanent scheme construction carried out under year 2010 pilot project implementation are referred to. Bases on the results, following conditions are laid in setting the target for permanent scheme construction;

1) In 2010, total 8 permanent schemes were constructed in 6 districts. These permanent schemes altogether irrigated 27.90 ha in 2010 dry season with the minimum case of 1.25 ha and the maximum case of 7.9 ha, arriving at the average irrigated area of 3.488 ha per scheme. Those permanent schemes are to enlarge the irrigated area up to 48.50 ha in total according to the design. This gives an average designed irrigated area of 6.06 ha. Therefore, in planning permanent scheme construction, a typical irrigated area is to start at 3.5 ha and then to be enlarged to 6 ha over 4 years as 4.5 ha in the 2nd year, 5.5 ha in the 3rd year and finally 6.0 ha in the 4th year.

2) Those 8 permanent sites have a total membership of 257 farmers, giving an average membership of 32 farmers. Not all of them were able to start irrigation in the first year. The membership for

simple schemes was 18 and 19 for improved sites and newly developed sites respectively according to the 2010 pilot project implementation. Since most of the permanent schemes are to be upgraded from simple schemes under this planning, the starting membership is assumed at 20 and then increased to 32 members over 4 years as 20 members in the 1st year, 25 members in 2nd year, 30 members in 3rd year and 32 members in the last 4th year.

3) How many permanent diversion schemes should be and can be constructed in a district is the most critical issue in the planning. During the pilot project implementation, out of the 6 districts 2 districts, Mporokoso and Mansa, could mange to construct 2 permanent diversion weirs otherwise finished in one weir each in other 4 districts. As aforementioned, at district level usually 1 – maximum 4 TSB officers are posted (average 2.8 in Northern and 2.0 in Luapula), not all of whom are engaged in irrigation but some in land husbandry and farm power & mechanization. Given this present human resource status and also referring to the results of the pilot project implementation, it is assumed that those districts endorsed with highest irrigation potential, marked as potential 'A'[5] are to construct 2 permanent schemes a year, districts with high irrigation potential marked as potential 'B'[6] to construct 1 permanent scheme a year, and then those with potential 'C'[7], the least potential districts, to construct 1 scheme over 2 years. This arrangement applies to both Stage I and Stage II implementation periods.

4) In addition to the construction modality above 3), which is so-called Direct Force Account Construction whereby TSB officers are to directly construct the permanent schemes with the beneficiaries, contract-out-construction is to be considered in this target setting. Engaging civil construction company can accelerate the dissemination of permanent schemes; however it incurs construction cost hike. Also, the construction modality may reduce the beneficiary's participation, whereby less sustainability might accompany. Therefore when engaging a construction company, manageability by TSB officers should be well taken into account. They should closely supervise all the construction sites. Given the present human resource status at district TSB office, it is assumed in this target setting that a district with 'A' potential can supervise 5 permanent construction sites and the one with 'B' potential does 3 permanent constructions sites per year. District with 'C' potential is not planned to have the contract-out-construction modality. This arrangement applies to both Stage I and Stage II implementation periods.

Based on the assumptions above, targets and expected benefits are summarized as shown in Table 6.3.5 and elaborated by Direct Force Account Construction modality in Table 6.3.6, and by Contract-out-construction modality in Table 6.3.37. It is, in sum, targeted that throughout the Stage I and Stage II implementation periods, total 657 permanent sites are to be constructed; composed of 198 sites under direct force account and another 459 sites under contract-out-construction. With these permanent sites altogether, total 3,614 ha of farm lands are to be irrigated. Beneficiary farmers are to count at 19,491. The aggregated net profit arrives at ZMK 59.579 billion (US$ 12.396 million). Following are the detail by direct force account construction and contract-out-construction and by implementation stage:

1) Under the Direct Force Account construction, total 88 and 110 sites are to be constructed during Stage I and Stage II implementation period respectively. These sites are to irrigate 429 ha and another 660 ha respectively, totaling 1,089 ha. Note that a part of 660 ha comes from area irrigated in Stage II period for those sites constructed in Stage I (irrigated area is assumed to increase over 4

[5] Districts with 'A' potential are Mbala, Mungwi, Luwingu, Kasama in Northern province and Kawambwa and Mansa in Luapula province.

[6] Districts with 'B' potential are Nakonde, Isoka, Mpika, Mporokoso in Northern province and Mwense and Milenge in Luapula province.

[7] Districts with 'C' potential are Kaputa, Mpulungu, Chilubi in Northern province and Chienge, Samfya in Luapula province.

years, whereby some increases take place in successive stage). Farmers benefited are to be 2,354 for the Stage I sites and 3,520 for the Stage II sites, totaling 5,874 members. Net profit is estimated at ZMK 6.978 billion (US$ 1.452 million) and ZMK 10.977 billion (US$ 2.284 million) respectively.

2) Under the Contract-Out-Construction, total 204 and 255 sites are to be constructed during Stage I and Stage II implementation period respectively. These sites together are to irrigate 995 ha and another 1,530 ha respectively, totaling 2,525 ha. There will be 5,457 farmers and 8,160 farmers to be benefited respectively in each of the stages, totaling 13,617 farmer members. Net profit is estimated at ZMK 16.177 billion (US$ 3.366 million) during Stage I and ZMK 25.447 billion (US$ 5.294 million) during Stage II respectively. Total net profit over the Stage I and Stage II implementation periods will arrive at ZMK 41.624 billion (US$ 8.660 million).

Table 6.3.5 Summary of the Targets Set for Permanent Schemes during Stage I & Stage II

Particulars	By Direct Force	By Contractor	Total	Remarks
Stage I (2012 – 2015)				
Sites Constructed, No.	88	204	292	
Area to be Irrigated, ha	429	995	1,424	
Members to Benefit,	2,354	5,457	7,811	
Economic Increment, M ZMK	6,978	16,177	23,155	Aggregated by Stage
Economic Increment, US$	1,451,857	3,365,669	4,817,526	Aggregated by Stage
Stage II (2016 – 2020)				
Sites Constructed, No.	110	255	365	
Area to be Irrigated, ha	660	1,530	2,190	
Members to Benefit	3,520	8,160	11,680	
Economic Increment, M ZMK	10,977	25,447	36,424	Aggregated by Stage
Economic Increment, US$	2,283,820	5,294,310	7,578,130	Aggregated by Stage
Grand Total (2012 – 2020)				
Sites Constructed, No.	198	459	657	
Area to be Irrigated, ha	1,089	2,525	3,614	
Members to Benefit	5,874	13,617	19,491	
Economic Increment, M ZMK	17,955	41,624	59,579	Aggregated by Stage
Economic Increment, US$	3,735,677	8,659,979	12,395,656	Aggregated by Stage

Source: JICA Study Team

Table 6.3.6 Targets Set for Permanent Scheme by Direct Force Account

Particulars	Unit	Stage I				Stage II					Stage I	Stage II	Total	Remarks
		2012	2013	2014	2015	2016	2017	2018	2019	2020				
Sites to be developed, No.		22	22	22	22	22	22	22	22	22	88	110	198	
Area to be irrigated (1st Y), ha	3.5 ha/site	77	77	77	77	77	77	77	77	77	429		1,089	Area per beneficiary=0.185ha (Area in Stage II total includes those areas who started irrigation during Stage II for the sites developed in Stage I)
Area to be irrigated (2nd Y), ha	4.5 ha/site	99	99	99	99	99	99	99	99					
Area to be irrigated (3rd Y), ha	5.5 ha/site	121	121	121	121	121	121	121						
Area to be irrigated (4th Y), ha	6.0 ha/site	132	132	132	132	132	132							
Area to be irrigated (5th Y), ha	6.0 ha/site	132	132	132	132	132						660		
Area to be irrigated (6th Y), ha	6.0 ha/site	132	132	132	132									
Area to be irrigated (7th Y), ha	6.0 ha/site	132	132	132										
Area to be irrigated (8th Y), ha	6.0 ha/site	132	132											
Area to be irrigated (9th Y), ha	6.0 ha/site	132												
Members to benefit (1st Y)	20 mem/site	440	440	440	440	440	440	440	440	440	2,354		5,874	Members in stage II include those who benefited during Stage II for the sites developed in Stage I.
Members to benefit (2nd Y)	25 mem/site	550	550	550	550	550	550	550	550					
Members to benefit (3rd Y)	30 mem/site	660	660	660	660	660	660	660						
Members to benefit (4th Y)	32 mem/site	704	704	704	704	704	704							
Members to benefit (5th Y)	32 mem/site	704	704	704	704	704						3,520		
Members to benefit (6th Y)	32 mem/site	704	704	704	704									
Members to benefit (7th Y)	32 mem/site	704	704	704										
Members to benefit (8th Y)	32 mem/site	704	704											
Members to benefit (9th Y)	32 mem/site	704												
Economic Increment (1st Y), M ZMK	7.128 M/ha	549	549	549	549	549	549	549	549	549	6,978		17,955	Aggregated value by stage (meaning recurrent benefit for the Stage I sites is not included in Stage II period).
Economic Increment (2nd Y), M ZMK	7.128 M/ha	706	706	706	706	706	706	706	706					
Economic Increment (3rd Y), M ZMK	7.128 M/ha	862	862	862	862	862	862	862						
Economic Increment (4th Y), M ZMK	7.128 M/ha	941	941	941	941	941	941							
Economic Increment (5th Y), M ZMK	7.128 M/ha	941	941	941	941	941						10,977		
Economic Increment (6th Y), M ZMK	7.128 M/ha	941	941	941	941									
Economic Increment (7th Y), M ZMK	7.128 M/ha	941	941	941										
Economic Increment (8th Y), M ZMK	7.128 M/ha	941	941											
Economic Increment (9th Y), M ZMK	7.128 M/ha	941												
Economic Increment (1st Y), US$	1,483 $/ha	114,191	114,191	114,191	114,191	114,191	114,191	114,191	114,191	114,191	1,451,857		3,735,677	Aggregated value by stage (meaning recurrent benefit for the Stage I sites is not included in Stage II period).
Economic Increment (2nd Y), US$	1,483 $/ha	146,817	146,817	146,817	146,817	146,817	146,817	146,817	146,817					
Economic Increment (3rd Y), US$	1,483 $/ha	179,443	179,443	179,443	179,443	179,443	179,443	179,443						
Economic Increment (4th Y), US$	1,483 $/ha	195,756	195,756	195,756	195,756	195,756	195,756							
Economic Increment (5th Y), US$	1,483 $/ha	195,756	195,756	195,756	195,756	195,756						2,283,820		
Economic Increment (6th Y), US$	1,483 $/ha	195,756	195,756	195,756	195,756									
Economic Increment (7th Y), US$	1,483 $/ha	195,756	195,756	195,756										
Economic Increment (8th Y), US$	1,483 $/ha	195,756	195,756											
Economic Increment (9th Y), US$	1,483 $/ha	195,756												

Source: JICA Study Team

Table 6.3.7 Targets Set for Permanent Scheme by Contractor Construction

Particulars	Unit	Stage I				Stage II					Stage I	Stage II	Total	Remarks
		2012	2013	2014	2015	2016	2017	2018	2019	2020				
Sites to be developed, No.		51	51	51	51	51	51	51	51	51	204	255	459	
Area to be irrigated (1st Y), ha	3.5 ha/site	179	179	179	179	179	179	179	179	179	995		2,525	Area per beneficiary=0.185ha (Area in Stage II total includes those areas who started irrigation during Stage II for the sites developed in Stage I)
Area to be irrigated (2nd Y), ha	4.5 ha/site	230	230	230	230	230	230	230	230					
Area to be irrigated (3rd Y), ha	5.5 ha/site	281	281	281	281	281	281	281						
Area to be irrigated (4th Y), ha	6.0 ha/site	306	306	306	306	306	306							
Area to be irrigated (5th Y), ha	6.0 ha/site	306	306	306	306	306						1,530		
Area to be irrigated (6th Y), ha	6.0 ha/site	306	306	306	306									
Area to be irrigated (7th Y), ha	6.0 ha/site	306	306	306										
Area to be irrigated (8th Y), ha	6.0 ha/site	306	306											
Area to be irrigated (9th Y), ha	6.0 ha/site	306												
Members to benefit (1st Y)	20 mem/site	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	5,457		13,617	Members in stage II include those who benefited during Stage II for the sites developed in Stage I.
Members to benefit (2nd Y)	25 mem/site	1,275	1,275	1,275	1,275	1,275	1,275	1,275	1,275					
Members to benefit (3rd Y)	30 mem/site	1,530	1,530	1,530	1,530	1,530	1,530	1,530						
Members to benefit (4th Y)	32 mem/site	1,632	1,632	1,632	1,632	1,632	1,632							
Members to benefit (5th Y)	32 mem/site	1,632	1,632	1,632	1,632	1,632						8,160		
Members to benefit (6th Y)	32 mem/site	1,632	1,632	1,632	1,632									
Members to benefit (7th Y)	32 mem/site	1,632	1,632	1,632										
Members to benefit (8th Y)	32 mem/site	1,632	1,632											
Members to benefit (9th Y)	32 mem/site	1,632												
Economic Increment (1st Y), M ZMK	7.128 M/ha	1,272	1,272	1,272	1,272	1,272	1,272	1,272	1,272	1,272	16,177		41,624	Aggregated value by stage (meaning recurrent benefit for the Stage I sites is not included in Stage II period).
Economic Increment (2nd Y), M ZMK	7.128 M/ha	1,636	1,636	1,636	1,636	1,636	1,636	1,636	1,636					
Economic Increment (3rd Y), M ZMK	7.128 M/ha	1,999	1,999	1,999	1,999	1,999	1,999	1,999						
Economic Increment (4th Y), M ZMK	7.128 M/ha	2,181	2,181	2,181	2,181	2,181	2,181							
Economic Increment (5th Y), M ZMK	7.128 M/ha	2,181	2,181	2,181	2,181	2,181						25,447		
Economic Increment (6th Y), M ZMK	7.128 M/ha	2,181	2,181	2,181	2,181									
Economic Increment (7th Y), M ZMK	7.128 M/ha	2,181	2,181	2,181										
Economic Increment (8th Y), M ZMK	7.128 M/ha	2,181	2,181											
Economic Increment (9th Y), M ZMK	7.128 M/ha	2,181												
Economic Increment (1st Y), US$	1,483 $/ha	264,716	264,716	264,716	264,716	264,716	264,716	264,716	264,716	264,716	3,365,669		8,659,979	Aggregated value by stage (meaning recurrent benefit for the Stage I sites is not included in Stage II period).
Economic Increment (2nd Y), US$	1,483 $/ha	340,349	340,349	340,349	340,349	340,349	340,349	340,349	340,349					
Economic Increment (3rd Y), US$	1,483 $/ha	415,982	415,982	415,982	415,982	415,982	415,982	415,982						
Economic Increment (4th Y), US$	1,483 $/ha	453,798	453,798	453,798	453,798	453,798	453,798							
Economic Increment (5th Y), US$	1,483 $/ha	453,798	453,798	453,798	453,798	453,798						5,294,310		
Economic Increment (6th Y), US$	1,483 $/ha	453,798	453,798	453,798	453,798									
Economic Increment (7th Y), US$	1,483 $/ha	453,798	453,798	453,798										
Economic Increment (8th Y), US$	1,483 $/ha	453,798	453,798											
Economic Increment (9th Y), US$	1,483 $/ha	453,798												

Source: JICA Study Team

6.4 Programme Implementation Cost and Disbursement Plan

Based on the targets set, this section estimates the programme cost by scheme; simple scheme and permanent scheme. For the simple scheme, costs required are for training of BEOs/CEOs and TSB officers, logistics support mainly for transportation and subsistence allowance, tools, etc. while those of permanent schemes are construction cost being the majority in addition to the same required for the simple schemes.

6.4.1 Cost for Simple Scheme Development

The major cost of developing simple schemes is for trainings. There are 3 training courses per year as TOT, kick-off training and follow up training. Conditions for cost estimation are as follows:

1) Trainings are held separately by Northern province and Luapula province. During Stage I period, TOT for Northern province is to call 10 officers while that for Luapula province it is to be 6 officers. Participants to the kick-off training are to be 68 officers for Northern province and 43 officers for Luapula province respectively as set in the aforementioned ‘6.3 Implementation Mechanism’.
2) On the course of the implementation during Stage I period, not only trained officers but also their fellow officers are to participate in the development of simple diversion schemes. Number of the fellow officers are planned to be half of the trained officers. The duration of their operation is planned from May to October, total 6 months per season.
3) During Stage I period, they are to be provided with fuel, 20 litre per month per officer, meal allowance (MA), and necessary materials such as technical manuals, leaflet, posters which also work as pictorial story, line level, etc. District is to be given 60 litre of fuel per month for monitoring purpose and province is to have 120 litre of fuel per month, together with MA and DSA as needed.
4) Upon completion of a season during Stage I implementation period, they are once again to gather for follow up training wherein they are to report their achievement. To this training, not only the original trained officers but also fellows who have actively participated in the smallholder irrigation development are to be invited. The officers to be additionally invited are set at 10% of the original kick-off training participants.

5) During Stage II, TOT is not planned but there may be a meeting to set how to operate the kick-off training at each district. Then net 2 days kick-off training is to be held at the district level inviting pre-set extension officers. Follow-up training is not planned in this Stage II since they can report their achievements together in their monthly, quarterly and annul reports. This means that the extension of simple schemes during the Stage II is to be taken as a part of their recurrent activities as much as possible. In this regard, fuel provision is set at only 40 litre per season per extension officer. MA and DSA are to be minimum, e.g. 6 times of MAs per extension officer per season, only one time per month for district monitoring, and 2 – 3 nights per month for provincial officers monitoring per month.

Based on the conditions above, programme costs for simple scheme promotion are summarized as shown in Table 6.4.1 by province and by stage. It is, in sum, to require total ZMK 1.180 billion (US$ 245,491) per annum during Stage I period for the 2 provinces and another ZMK 691 million (US$ 143,809) per annum during the Stage II period. Durations are set at 4 years for Stage I and 5 years for Stage II whereby programme costs for Stage I and Stage II arrive at ZMK 4.721 billion (US$ 981,964) and ZMK 3.457 billion (US$ 719,045) respectively for the 2 provinces, totaling ZMK 8.178 billion (US$ 1.701 million).

Given the area to be irrigated by stage, e.g. 2,862 ha and 2,094 ha respectively, the unit development cost arrives at ZMK 1.650 million (US$ 343) and ZMK 1.651 million (US$ 343) for Stage I and Stage II implantation periods respectively. Unit development cost at this range, say about US$ 340 – 350 per hectare, seems very minimum as compared to conventional irrigation projects wherein it could reach as much as US$ 10,000 per hector. This can be attributed to the materials with which the main structure, that is diversion weir, is constructed. The materials are almost all locally available, which do not incur cost.

Table 6.4.1 Summary of the Programme Cost for Simple Scheme during Stage I & Stage II

Particulars	Stage I (per year)	Stage II (per year)	Total	%	Remarks
Northern Province					
Training (TOT, Kick-off, Follow)	325,600,000	214,662,000	540,262,000	48	
Dissemination materials	20,984,000	14,910,000	35,894,000	3	1/
Fuel & servicing	158,793,600	82,842,800	241,636,400	21	
MA & DSA	169,950,000	90,360,000	260,310,000	23	
Stationeries	10,200,000	10,650,000	20,850,000	2	
Tools for construction	30,000,000	-	30,000,000	3	
Sub-total	715,527,600	413,424,800	1,128,952,400	100	
Luapula Province					
Training (TOT, Kick-off, Follow)	202,878,000	143,560,000	346,438,000	47	
Dissemination materials	13,202,000	9,800,000	23,002,000	3	1/l
Fuel & servicing	113,163,600	54,409,000	167,572,600	23	
MA & DSA	111,600,000	63,240,000	174,840,000	24	
Stationeries	6,450,000	7,000,000	13,450,000	2	
Tools for construction	17,500,000	-	17,500,000	2	
Sub-total	464,793,600	278,009,000	742,802,600	100	
Grand Total per annum, ZMK	**1,180,321,200**	**691,433,800**	**1,871,755,000**		
By stage (4 years for Stage I and 5 years for Stage II)					
Grand Total by Stage, ZMK	**4,721,284,800**	**3,457,169,000**	**8,178,453,800**		**2/**
Area to be irrigated by Stage, ha	**2,862**	**2,094**	**4,956**		
Unit Development Cost, ZMK/ha	**1,649,645**	**1,650,988**	**1,650,213**		
Unit Development Cost, US$/ha	**343**	**343**	**343**		**@4,808 as of Mar. 2011**

Source: JICA Study Team, Note: 1/ Technical manuals, leaflet, posters, line level. 2/ 4 years for Stage I and 5 years fro Stage II

6.4.2 Cost for Permanent Scheme Development

The major cost of developing permanent schemes is of course for the diversion structure, constructed with either wet-masonry or concrete wall. Cost estimation for permanent scheme is carried out by construction modality, e.g. direct-force-account construction and contract-out-construction. Conditions for the cost estimation are given of the following:

1) To construct permanent structure especially by direct force account construction, TSB officers should be well equipped with knowledge and skill for civil work e.g. wet-masonry work, concrete mixture and poring, shuttering (formwork), de-watering during construction, etc. These pertinent knowledge and skills can be implanted during a kick-off training held primarily for the purpose of promoting simple diversion schemes as was done during the 2010 pilot project implementation. Therefore no training cost should be included in this permanent scheme construction.

2) Fuel and servicing for motorbike and vehicles should be considered. The allocation is set as same as those in the simple scheme construction for direct force account construction and about half of that in case of contract-out-construction. Meal allowance (MA) and DSA are considered almost same as those cases of simple scheme construction but more intensively for district TSB officers who are the core player for permanent scheme construction. These MA and DSA are reduced to about half for contract-out-construction.

3) Construction cost for permanent structure changes according to the site condition. However as far as pilot project in 2010 is concerned, the cost for permanent scheme ranged from ZMK 32 million to ZMK 58 million per site with total cost of ZMK 327 million (see Table 6.4.2). With reference to this actual construction cost, typical unit construction cost as per permanent site is assumed at ZMK 50 million in case of direct force account construction and ZMK 75 million, increased by 50%, for contract-out-construction.

Table 6.4.2 Actual Construction Cost by Permanent Scheme under 2010 Pilot Project

District	Site	Type of Weir	Size of Weir	Materials, ZMK					Tools ZMK	Transport ZMK	Skilled labour ZMK	Total ZMK	Volume of Weir: m^3	Const'n Cost per m^3
			H(m)*L(m)	Cement	Sand	Stone	R. Bar	Others						
Luwingu	Chaiteka	Masonry W.	2.0*12.0	12,960,000	0	0	495,000	2,705,000	5,450,000	7,100,000	3,700,000	**32,410,000**	21.4	1,514,000
Mpika	Malashi	Concrete W.	2.3*15.0	9,900,000	1,000,000	0	3,795,000	5,625,000	1,630,000	1,750,000	15,400,000	**39,100,000**	26.5	1,475,000
Mporokoso	Kasonde	Masonry G.	1.4*8.0	9,440,000	2,800,000	11,200,000	1,420,000	860,000	2,580,000	550,000	6,100,000	**34,950,000**	14.4	1,915,000
Mporokoso	Chilala	Masonry G.	1.6*13.0	10,400,000	3,600,000	17,000,000	0	2,925,000	0	0	6,500,000	**40,425,000**	33.5	1,207,000
Mungwi	Nseluka	Concrete W.	1.8*12.5	11,270,000	0	15,950,000	3,300,000	5,615,000	5,830,000	1,570,000	9,800,000	**53,335,000**	22.3	2,392,000
Kawambwa	Chibolya	Masonry G.	1.8*24.0	24,480,000	1,875,000	2,750,000	1,390,000	6,176,000	3,090,000	5,440,000	12,540,000	**57,741,000**	51.4	1,123,000
Mansa	Kakose	Concrete W.	1.8*17.0	23,600,000	0	550,000	5,205,000	1,350,000	4,320,000	1,600,000	1,680,000	**38,305,000**	30.6	1,134,000
Mansa	Mililwa Lower	Earth dam	2.4*32.0	7,600,000	0	2,900,000	0	2,005,000	2,700,000	455,000	15,000,000	**30,660,000**	207.4	165,000
Total	8 sites			109,650,000	9,275,000	50,350,000	15,605,000	27,261,000	25,600,000	18,465,000	70,720,000	**326,926,000**	407.5	802,272

*Stone: Crushed stone, Masonery stone, Flat stone

Based on the conditions above, programme costs for permanent scheme construction are summarized as shown in Table 6.4.3 by province and by stage. In case of direct force account construction, project cost for permanent scheme construction arrives at total ZMK 1.425 billion (US$ 296,362) per annum totaling to ZMK 5.70 billion (US$ 1.19 million) during the 4-year Stage I period for the 2 provinces, and the same annual cost totaling to ZMK 7.125 billion (US$ 1.48 million) for the 5-year Stage II period. In fact, in developing permanent scheme, same construction quantity was assumed throughout Stage I and Stage II.

With this cost, total 22 permanent sites are to be constructed every year through Stage I and Stage II as average (14-15 sites in Northern and 7-8 sites in Luapula respectively) under direct force account construction. These sites altogether are to irrigate 429 ha by the end of Stage I and another 660 ha during Stage II implementation period. Therefore unit development cost arrives at ZMK 13.29 million (US$ 2,763) and ZMK 10.79 million (US$ 2,245) for Stage I and Stage II respectively. Average unit development cost through Stage I and Stage II arrives at ZMK 11.78 million (US$ 2,449)[8].

By engaging civil contractor, construction of permanent scheme can be accelerated. Lower part of the Table 6.4.3 shows the case of contract-out-construction. Under this construction modality, total 51 schemes are to be constructed for the 2 provinces every year. Construction cost per year accounts at ZMK 4.06 billion (US$ 843,618), totaling to ZMK 16.224 billion (US$ 3.374 million) for Stage I and

8 The construction cost of the permanent schemes proposed is relatively lower than other irrigation schemes. Because the proposed scheme focuses only on gravity diversion systems whereby neither dam nor pumping facilities is required, leading to lower construction cost.

another ZMK 20.28 billion (US$ 4.218 million) for Stage II. Therefore, unit development cost arrives at ZMK 16.31 million (US$ 3,393) for Stage I and ZMK 13.26 million (US$ 2,757) respectively, averaging them at ZMK 14.46 million (US$ 3,008).

Table 6.4.3 Summary of the Programme Cost for Permanent Scheme during Stage I & Stage II

Particulars	Stage I (per year)	Stage II (per year)	Total	%	Remarks
Direct Force Account Construction					
Northern Province					
Sites to be constructed	14.5 (58)	14.5 (73)	14.5 (131)		
Training (TOT, Kick-off, Follow)					included in simple sch.
Fuel & servicing	84,421,400	84,421,400	168,842,800	9	partly managed in simple sch.
MA & DSA	115,050,000	115,050,000	230,100,000	12	ditto
Stationeries	3,850,000	3,850,000	7,700,000	1	
Permanent structures	725,000,000	725,000,000	1,450,000,000	78	
Sub-total	928,321,400	928,321,400	1,856,642,800	100	
Luapula Province					
Sites to be constructed	7.5 (30)	7.5 (37)	7.5 (67)		
Training (TOT, Kick-off, Follow)					included in simple sch.
Fuel & servicing	46,985,800	46,985,800	93,971,600	9	partly managed in simple sch.
MA & DSA	72,450,000	72,450,000	144,900,000	15	ditto
Stationeries	2,150,000	2,150,000	4,300,000	0	
Permanent structures	375,000,000	375,000,000	750,000,000	76	
Sub-total	496,585,800	496,585,800	993,171,600	100	
Grand Total per annum, ZMK	**1,424,907,200**	**1,424,907,200**	2,849,814,400		
Grand Total by Stage, ZMK	**5,699,628,800**	**7,124,536,000**	12,824,164,800		**1/**
Area to be irrigated by Stage, ha	**429**	**660**	**1,089**		
Unit Development Cost, ZMK/ha	**13,285,848**	**10,794,752**	**11,776,093**		
Unit Development Cost, US$/ha	**2,763**	**2,245**	**2,449**		**@ 4,808**
Permanent (Contract-out-construction)					
Northern Province					
Sites to be constructed	35 (140)	35 (175)	35 (315)		
Training (TOT, Kick-off, Follow)					included in simple sch.
Fuel & servicing	61,405,200	61,405,200	122,810,400	2	partly managed in simple sch.
MA & DSA	84,450,000	84,450,000	168,900,000	3	ditto
Stationeries	5,600,000	5,600,000	11,200,000	1	
Permanent structures	2,625,000,000	2,625,000,000	5,250,000,000	95	
Sub-total	2,776,455,200	2,776,455,200	5,552,910,400	100	
Luapula Province					
Sites to be constructed	16 (64)	16 (80)	16 (144)		
Training (TOT, Kick-off, Follow)					included in simple sch.
Fuel & servicing	29,561,600	29,561,600	59,123,200	2	partly managed in simple sch.
MA & DSA	47,400,000	47,400,000	94,800,000	4	ditto
Stationeries	2,700,000	2,700,000	5,400,000	1	
Permanent structures	1,200,000,000	1,200,000,000	2,400,000,000	94	
Sub-total	1,279,661,600	1,279,661,600	2,559,323,200	100	
Grand Total per annum, ZMK	**4,056,116,800**	**4,056,116,800**	**8,112,233,600**		
Grand Total by Stage, ZMK	**16,224,467,200**	**20,280,584,000**	**36,505,051,200**		**1/**
Area to be irrigated by Stage, ha	**995**	**1,530**	**2,525**		
Unit Development Cost, ZMK/ha	**16,314,195**	**13,255,284**	**14,460,309**		
Unit Development Cost, US$/ha	**3,393**	**2,757**	**3,008**		**@ 4,808**

Source: JICA Study Team, Note: 1/ Technical manuals, leaflet, posters, line level. 2/ 4 years for Stage I and 5 years fro Stage II

6.5 Economic Feasibility in Investment

6.5.1 Cases for the Economic Analysis

Based on the project benefits and costs estimated above, economic analysis is carried out in this section; namely, to judge if the proposed above projects are feasible or not in terms of economic viability. The indicators employed here are Economic Internal Rate of Return (EIRR), and in addition Net Present Value (NPV) and Benefit by Cost Ration (B/C ratio). To estimate the NPV and B/C ratio, there should be a prescribed discount ratio. This discount ratio is set at 12%, which is the opportunity cost often referred to in projects in Zambian agriculture sector.

The analysis is carried out for the cases of simple scheme development and permanent scheme development separately. In case of simple scheme development, further such cases as 'Improved site', 'New Construction site', and 'the case both aggregated for Improved and New sites' are to be analyzed. For the case of permanent scheme, analysis is carried out in such cases as 'direct-force-account construction', 'contract-out-construction', and aggregated case for the both construction modalities.

Note that permanent scheme is constructed, in principal, by upgrading simple scheme. It means that in such cases the area irrigated by the permanent scheme automatically includes not only the area newly extended by the permanent structure but also the already existed area with the simple scheme. By this reason, the analysis for the permanent scheme undertakes 2 cases in terms of benefit, or in terms of the irrigated area, as 1) all the area including the one which had existed with the simple scheme, and 2) only the area newly developed by permanent structure. In addition to these analyses, a special case wherein the onset of benefit is delayed by 1-year, which means the benefit starts accruing from the 2nd year, is carried out as sensitivity analysis.

6.5.2 Results of Economic Analysis (IRR, NPV, B/C Ratio)

Table 6.5.1 shows the result of the economic analysis. From the table, it is identified that:

1) Economic viability in investing simple scheme development is very promising. In fact, EIRR for the simple scheme development cannot be calculated simply because the benefit at the 1st year is bigger than the investment cost at the same 1st year in all the cases of; 1) Improved Site, 2) Newly Constructed Site, and 3) the case both aggregated. In case that the benefit were delayed as being generated from the 2nd year, the EIRRs can be calculated, yet showing very high returns over 100%[9]. It means that the simple scheme is very much viable from the economic point of view due mainly to the little-cost in the construction.

2) NPV for the simple scheme development shows ZMK 46.03 billion in case of Improvement, ZMK 144.31 billion in case of New Construction, and ZMK 190.34 billion for the case both aggregated. These NPVs are very high, and thus B/C ratio becomes large as 4.2 to as much as 7.4. In the case that the benefit were delayed by 1-year, those NPVs and B/C ratios get lower, but still very much viable, e.g. B/C ratio ranging from 3.8 to as high as 6.5.

3) In case of permanent scheme development, EIRRs for the cases where the benefit is counted from all the irrigated area show very high values as 52% in case of direct-force account construction, 42% in case of contract-out construction, and 47% for the case both aggregated. These very high IRRs are counted on the low-cost investment per unit area. For example, irrigation development in Zambia in many cases costs about US$ 10,000 per hector while the unit investment cost in this project comes to only US$ about 3,000. Gravity irrigation scheme employed in this project costs little than the others e.g. reservoir and pumping irrigation schemes. As a result, NPV as well as B/C ratio for the permanent scheme development proposed in this plan show very high attractive values. For example, B/C ratio ranges from 2.7 to 3.1.

[9] EIRR for Improvement is 158.7% while the EIRR for New Construction is 156.0%, former of which is a litter bigger than the latter. On the other hand, NPV and B/C ratio are much higher in case of New Construction than the Improvement. There seems contradictory result in those values, however they are correct. This is because the benefit area per Improved site is 1.0 ha at the first year while that of New Construction site was set at 0.9 ha and it is supposed to increase to 2.1 ha over 4 years. Though irrigation areas from the 2nd year for the New Construction sites are obviously bigger than that of Improvement, at least the first year's area is reverse; Improved site is bigger than the New Construction in terms of irrigation area. It implies that this bigger benefit for the 1st year works very much in raising the IRR in case of discount ratio being quite big e.g. more than 100%. As a result, the IRR for the Improvement case was given bigger than that of New Construction case. On the other hand, NPV and B/C ration were calculated with a prescribed discount rate of 12%, which is the opportunity cost in Zambia. With this lower discount rate of 12%, the benefit discounted in mid to later years of calculation still has a magnitude in raising the aggregated benefit in estimating the NPV and B/C ratio. Thus, the NPV and B/C ratio were given much bigger in case of New Construction than the case of Improvement.

4) Permanent scheme development is basically done by upgrading a simple structure as aforementioned. The simple structure must have been irrigating some area. It means that the net benefit only on the permanent structure should be from the extended irrigated area with the permanent structure. Benefit from the only extended area with the permanent structure is, of course, smaller than that from all the irrigated area. Yet, EIRRs are still high even in this case as 27% in case of direct-force account construction, 22% in case of contract-out construction, and 25% for the case both aggregated. Accordingly, NPV as well as B/C ratio are still high, e.g. NPV ranging from ZMK 12.34 billion to ZMK 37.56 billion and B/C ratio ranging from 1.7 to 2.0. It means that the permanent scheme development is also very viable project from the economic investment point of view.

5) In case that the benefit is delayed by 1-year for the permanent scheme development, the economic return is reduced automatically. However, EIRRs can still be more than 30% in case of all the irrigated area counted and more than 18% in case of only extended irrigated area with the permanent structure counted. B/C ratios in these cases are more than 2.3 and more than 1.4 respectively. It means that even if the benefit were delayed by 1-year, the permanent scheme development can still be very much viable. Thus, it is concluded that the permanent scheme development can also be very much cost-effective project.

Table 6.5.1 Economic Feasibility in Investment (IRR, NPV, B/C Ratio)

Case	EIRR, %	NPV(12%), ZMK billion	B/C Ratio	Remarks
Benefit accrues as designed				
Simple (Improvement)	NA	46.03	4.247	Cannot be calculated since the benefit at 1st year is bigger than the cost of the 1st year.
Simple (New Construction)	NA	144.31	7.385	
Simple(Improvement + New Const'n)	NA	190.34	6.175	
Permanent (Direct F. Construction)	51.6	27.87	3.148	Benefit from all the irrigated area
Permanent (Contract-out Constriction)	41.6	59.18	2.666	
Permanent (Direct + Contract-out)	47.0	89.11	2.919	
Permanent (Direct F. Account)	26.8	12.34	1.951	Benefit from only newly extended area (existed area with simple scheme excluded)
Permanent (Contract-out Construction)	22.2	23.16	1.652	
Permanent (Direct + Contract-out)	24.7	37.56	1.809	
Benefit delayed by 1-year				**Done as a sensitive analysis**
Simple (Improvement)	158.7	39.32	3.773	
Simple (New Construction)	156.0	125.37	6.547	
Simple(Improvement + New Const'n)	157.2	164.68	5.478	
Permanent (Direct F. Construction)	35.2	23.24	2.791	Benefit from all the irrigated area
Permanent (Contract-out Constriction)	30.0	48.45	2.364	
Permanent (Direct + Contract-out)	32.9	73.75	2.588	
Permanent (Direct F. Account)	21.6	9.57	1.737	Benefit from only newly extended area (existed area with simple scheme excluded)
Permanent (Contract-out Construction)	18.3	16.50	1.464	
Permanent (Direct + Contract-out)	20.1	28.12	1.606	

Source: JICA Study Team

6.6 Implementation Disciplines: Lessons through the Pilot Project Implementation

This sub-chapter presents issues that have to be undertaken in implementing smallholder irrigation development. These issues are based on lessons learnt from the pilot project implementation, observation at the field, interviews to the farmers, discussion during workshops, etc.

6.6.1 Step-wise Development: Simple Scheme to Permanent Scheme

Smallholder irrigation development undertakes both simple and permanent schemes. In fact, since simple irrigation schemes can be built by farmer themselves, there are existing simple (temporally) schemes already a lot in the target 2 provinces. According to an inventory survey administered under this Study, there are as many as 1,024 temporary schemes while the permanent ones counted at 104 schemes as of mid 2009. In terms of area irrigated, the simple schemes altogether irrigate 1,772 ha while the permanent ones do 441 ha only, equivalent to about one forth the simple ones.

A fact is that there are many simple schemes which can enlarge service area given stable and ample water. Simple scheme can be put up very easily but unfortunately they often face difficulties in raising water level as required, and hence result in less available amount of irrigation water in the furrow (canal). Provided that this problem can be coped with permanent diversion structure, the beneficiary farmers would enjoy stable irrigation water leading them to higher yield of harvest.

Farmers can practice irrigation agriculture with simple irrigation scheme. It means that simple irrigation scheme can give a venue for farmers to practice irrigation agriculture. Irrigation agriculture entails a lot of things than rain-fed agriculture. Irrigator farmers should know and practice on-farm irrigation method, e.g. making furrow and/or sunken-bed, frequency of the irrigation and also the irrigation time per on-farm irrigation.

Since water is a common good, they have to know how to share the good amongst the members especially when the water flow becomes scarce. In this case, they may have to introduce rotational irrigation by farm block or just by dividing the canal into two or three reaches. They need to be well organized in carrying out rotational irrigation; otherwise rotational irrigation will not work. In sum, irrigated agriculture needs collective actions amongst the members, which is quite different from rain-fed agriculture practiced on basis of individuals.

Another issue can be soil depletion associated with irrigation. Irrigation turns the soil to be used two times in a year; dry season irrigation agriculture and rainy season agriculture which may be supported with supplemental irrigation. The two times usage of the same soil in a year will quickly deplete the soil unless otherwise the soil is well taken care of. With irrigation being introduced, many beneficiary farmers hope to cultivate vegetables than staple food. This is very much natural since vegetables give very good cash income opportunity and the dry season vegetable cultivation can be easier than that of rainy season. On the other hand, continuous vegetable cultivation will invite nematode into the soil. To cope with these issues, farmers have to introduce compost manure application, which can contribute primarily to improving the soil physical characteristics, and also crop rotation to subside the nematode.

If the farmers are well experienced with above issues before the introduction of permanent scheme, one can say there will be a high probability of successful irrigation project. Since permanent scheme needs much investment than simple scheme, any failure shall be avoided. Permanent scheme project is destined not to be failed. How to measure the possibility of success in permanent scheme project is very easy if the target farmers have experienced irrigation with simple scheme.

Therefore, the introduction of permanent scheme should be explored amongst the existing simple schemes as the first step. Or otherwise, whenever there is a request of putting up irrigation scheme, we should firstly consider if it could be done with simple structures or not. If the farmers’ desire can be met with simple structures, it shall go with it as the first step. Then after we have observed the farmers' performance in irrigation agriculture and also upon availability of fund, they can go to the next step, which is the construction of permanent structure.

This kind of step-wise development can give another positive impact apart from entailing high possibility of project success. The positive impact shows up during the construction of permanent structure. Construction of permanent structure requires longer time than that of simple scheme. It means they may have to surrender some income generating opportunities if they do not have irrigated dry season agriculture. During dry season, villagers seek income opportunities and try to be engaged in, for example, public works, catching and selling fish, etc. By being engaged in the construction of permanent irrigation scheme, they may lose these income opportunities.

However, if there is an existing irrigation scheme with simple structure, they do not have to loose at least the original income opportunity that is irrigation agriculture since irrigation agriculture can be kept on even during the construction of permanent structure. Construction of permanent diversion structure usually starts with diverting the stream water, making the construction site dry. This diverting of water is managed by making a detour channel, which can be connected to the existing irrigation canal. With this arrangement, the irrigation agriculture cannot be interrupted by the construction.

Detour channel is providing water to the existing canal. With this arrangement, dry season irrigated agriculture cannot be interrupted even during the construction of permanent structure.

Continuous irrigation agriculture even during the construction of permanent structure can provide food to the participant farmers. If the irrigated farmland cultivates Irish potato, green maize, sweet potato and vegetables, these can constitute good lunch stuff for the participant farmers. Participant farmers in the construction are supposed to take lunch at the site in order to save time. Provided that there is still irrigation agriculture during the construction, lunch arrangement at site during the construction can be easier, which can facilitate the speed up of the construction.

Taking all the above discussion into account, identification of the permanent scheme sites should firstly be made amongst the existing simple schemes. In this regard, step-wise development, from simple (temporary) scheme to permanent one, should always be in mind for the TSB officers who deal with permanent schemes. This step-wise development will assure project success and also project sustainability.

6.6.2 Public Equity amongst Villagers: Land Distribution

Irrigation obviously cannot serve all the villagers simply because irrigation cannot serve all the land but limited areas only according to the topography. Likewise, the amount of water available for irrigation is limited in most of the potential sites. Under these conditions, only less than one tenth of the whole villagers could have land within the potential service area in many cases.

Referring to the examples of pilot project in 2009, there are only 5 landowners per site while as many as 41 farmer members who want to try irrigated agriculture in case of improvement, and 6 land owners vs. 33 members in case of new development. For the pilot project carried out in 2010, 4 landowners against 18 members per site in case of improvement and 5 landowners vs. 19 members per site in case of new development. In short, landowners in the service area consist of only 11 % to 25 % of the total membership.

Table 6.6.1 Comparison between Membership and Landowners in the Service Area

Pilot Project	No. of Members	No. of Land Owners	Ratio
Improvement in 2009 (Per site)	4,060 (41)	465 (5)	11%
New Development in 2009 (per site)	3,118 (33)	536 (6)	17%
Improvement in 2010 (Per site)	3,490 (18)	716 (4)	21%
New Development in 2010 (per site)	3,381 (19)	841 (5)	25%

Source: JICA Study Team, based on the result of pilot project implementation.

Above situation may create jealousy to the haves, that is the land-owner in the service area. To the have-nots who do not have land in the service area, a mitigation measure is to divide the potential service area into small plots and rent out to them, either free or with a minimal rental fee only during dry season. Though this measure is in fact observed in many existing schemes implemented by the farmers themselves, it is not always the case. In some cases[1], landowners refuse surrendering a part of his/her land to other villagers, and they possess irrigation scheme as a private property. One of such examples can be seen in Lunda village, Kasama district, Northern province where there were as many as 4 private furrows before the commencement of pilot project aiming at constructing communal irrigation scheme (see box).

Private irrigation scheme in Lunda Village:

There are 4 private irrigation schemes, which withdraw water from nearby stream by gravity (meaning no diversion structure is put up in the stream). The first one was constructed as early as in 1962 by Mr. M. Chishimba. He saw an irrigation scheme opened near the senior chief's palace, and he started his own by just copying it. The 2nd furrow was constructed in late 1960s, motivated by the first irrigation scheme. 3rd one was constructed in 1979 by Mr. F. Chanda and the last one, the 4th one, was put up in 1984.

Other villagers, if want to use the water for irrigation, have to pay at an equivalent amount of 5 – 10% of what s/he is to harvest. They feel it is expensive. Water supplied from small furrows is not in fact enough to accommodate many other farmers. Hence there are only handful farmers who purchase the water for irrigation. As an example, there were only 4 other farmers in 2009, who purchased the water.

Furthermore, where farm families have nominal access to land, the insecurity of their rights to such land may dissuade the family from making any long term investment in improving the land such as planting tree, improving furrow, installing of fences, and construction of fish ponds. Farmers who occupy land merely with the permission of a landlord may even worry that their improvement of the land they occupy may lead to eviction as others may seek to cash in on investment.

This, however, was not the case for Nseluka farmers as a representative example for land distribution. Under the authority of the village headman suggested by the CEO in charge, they have agreed to share and allocate the land to others with secured access to the service area. The size of the plots shared is 50 meters each along the canal in general. In this case, the other side of the length was dependent on the distance between the canal and the peripheral down to the stream. From the way farmers are coordinating and cooperating in this area, there is overwhelming evidence that distribution of even relatively small amounts of land to others, who do not have, would provide a base for sustainable development in irrigation agriculture.

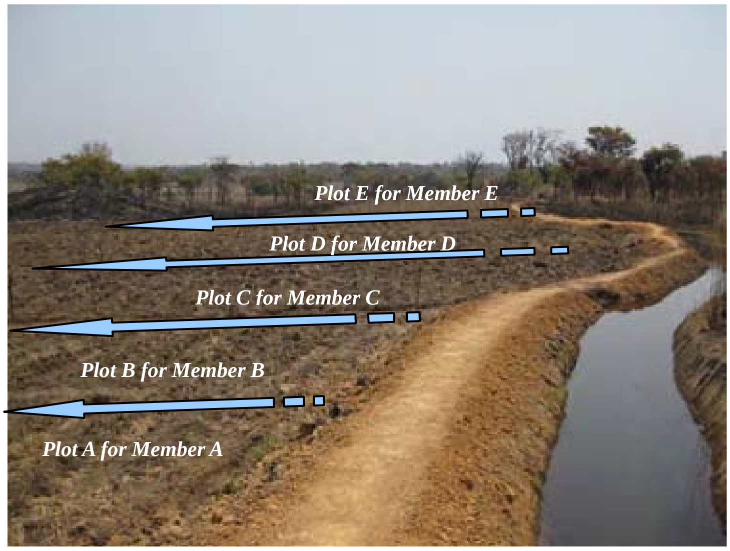
The village headman declared, upon completion of the canal digging, that the adjacent land lower than the irrigation canal belongs to no one, and this is the No Man's Land. By this declaration, the members who participated in the construction work were given secured access to the service area, and thus a

[1] Since land in Zambia is vast as compared to the population, such cases have not taken place so many. According to the reports from CEOs/BEOs, it was not more than 10%.

plot of 50m each along the canal at the one side of the farm was distributed to each and every participating farmer.

Small scale farmers have a keen awareness of the benefits of irrigation and are willing to invest their labor in the construction and maintenance of the schemes. But lack of land was the single most important barrier to dry season irrigation. However, the pilot project was interested in how dry season irrigation can benefit the less privileged in the rural communities, which includes families without access to land. It has been noted that lack of access to land is a serious constraint to the promotion of the irrigated agriculture as not all the farmers would have access to land along the constructed canal.

In Nseluka irrigation scheme, however, land allocation and sharing has generally not been an issue and all farmers have access to plots rendered for irrigation. With the arrangement as shown in the photo, all the participating members in Nseluka scheme started cultivating tomato, maize, onion, groundnuts, rape, etc. On top of that, the arrangement of the land sharing made easy for initiatives like compost making widely acceptable.



In Nseluka irrigation scheme newly established in 2009, the land was opened and distributed to all the participant farmers as shown in the photo:

Land allocation and sharing represent an especially useful strategy for promoting sustainable irrigated agriculture, including secure access to land and water, improved financial security, improved nutrition and improved social status as well. Where poor families lack secure rights to shared plots of suitable size and quality, arrangement to obtain and allocate land to such families can be a constructive and socially beneficial means for them. In other cases, landholders in the irrigation area may be asked to share their land with those with limited access to land. Whenever we try to develop community based smallholder irrigation scheme, we should bear the arrangement of land sharing between Not-haves and Haves.

There is however a concern about the land distribution. In Zambia, chemical fertilizer has long been applied with little measures of physical improvement, so that the soil has been exploited over the country especially in population congested areas. Irrigation agriculture, which in most cases uses the same land twice in a single year, exploits the soil fertility even further. Should the condition be left without taking any measures of improving the soil fertility, it would create social problem and the land owners would no longer be willingly to lend out the land to the others. Therefore, measures of supplementing the soil fertility and improving the soil physical characteristics, such as application of compost manure, should be strongly recommended to the irrigators. Therefore, the idea of dividing and lending out the irrigable area to members should always accompany a mean of not further exploiting the soils.

6.6.3 Role of the Traditional Local Leaders in Irrigation Development

When a group activity like irrigation development starts, the farmer beneficiaries normally form a club. The formation of club with election of the committee members has already become a custom in most villages in Zambia; hence there are often several club-based activities already in rural areas. When the villagers elect the committee members of the club, the village headman (VH) would not stand as the candidate for the committee members, but he or she facilitates the election.

Traditionally VHs as well as traditional chiefs are entrusted to manage customary land, allocate land to villagers, set social norms and rules, mediate problems within their jurisdiction. Experiencing the transition of rural society such as from subsistence economy to market economy, it seems that the authority of VH is now differentiated from that of the past time and local norms are getting weaker in recent days. However, local leaders are still respected and any development activities without involving the village headman do not work. Since there are some decisions in villages for which only the village headman can make, it is necessary for the irrigation related activities to be well in accord with the VH.

VH has the authority to distribute the lands in his/her territory to the villagers, especially in case the irrigation service area has not been yet vested to anybody. Even if the irrigation service area belongs to somebody, VH could advise the owner to lend out a part of his/her lands to the others who are the have-nots in the service area. Land issues may occur in some places whereby landowners may refuse to rent their land and there could be even such incident that an owner fills up excavated canal. Those issues can be solved with the initiative of the concerned VH. Therefore smallholder irrigation development should involve the VH from the initial stage.

In case there are several villages involved in an irrigation club, collaboration amongst the relevant VHs plays an important role. If an irrigation scheme extends to several villages, its development should always be well informed to all the VHs since the on-set. Likewise, if an issue beyond villages takes place, mediation between the concerned VHs may not work. In this case, the concerned VH reports the incident to the concerned traditional chief, and the chief precedes the mediation. In this regard, smallholder irrigation development should also be informed to the traditional chief as well.

Obviously, there was difference of the strength of local leadership. Since BEOs/CEOs usually know the situation very well and it is not so difficult to see the local leadership through a series of meetings/workshops such as entry and planning, and during the construction, attention should be paid to sense if local leadership is strong enough to mediate probable disputes such as land distribution and water scramble. If local leadership seems not strong, a study tour should be arranged to see other areas where local leaders are well discharging their duty rather than just administering a leadership training. Leadership training itself may disgrace the leadership that the VH may be thinking well esteemed; therefore outsiders like donors and also BEOs/CEOs should arrange an opportunity where the VH can learn how to improve the leadership. This kind of educational study tour could enhance the local leadership and the relationship with the villagers as well.

6.6.4 Site Development in a Stream

Developing smallholder irrigation schemes 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. Difficulty is that discharge record is not available for those relatively small streams. No one knows in fact how much the flow is to decrease toward the end of dry season except for big rivers e.g. Chameshi and Luapula rivers[2].

Though farmers may inform the reduction of the flow towards the end of dry season to about half or about one third, there is a tendency always to underestimate the retarding ratio, which may inevitably

[2] For Chambeshi river, the unit discharge of June is 4.46 liters/s/sq.km while that in November, the end of the dry season, is only 1.15 liters/s/sq.km, presenting 4 times difference. For Luapula river, the discharge at June 5.77 liters/s/sq.km while that of November is only 1.21 liters/s/sq.km, presenting about 5 times difference.

cause abandonment of part of irrigated area. 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. Therefore, it is recommended that at least at first year the development should not be ambitious or rather start with relatively small area; say assuming the flow to reduce to less than one fifth or even to one tenth. Generally, sites located near the source of stream is not retarded much while sites located far downstream from the source usually have bigger retarding rate.

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 traditional chief 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 may be limited in most of the smallholder irrigation potential sites especially towards the end of dry season. 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 and to be prepared 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 also needs to be closely examined and as need arises BEOs/CEOs should arrange a venue for discussion wherein the concerned villagers are expected to devise mitigating measures such as rationing of water, reducing of irrigation area, etc.

6.6.5 Planting on Water Availability

A recognized method to calculate crop water requirement uses “reference crop evapotranspiration, ETo” established by modified Penman method. Figure 6.6.1 below shows reference crop evapotranspirations at Chipita station by using the modified Penman method[3]. As heading to summer season, the ETo increases with October being the maximum but once rainy season comes, the ETo starts decreasing because of less radiation despite the high temperature during rainy season.

Kc, so called crop coefficient, converts the ETo into the crop evapotranspiration which is the net water requirement specific to the crop planted. The crop coefficient varies chiefly according to the kind of planted crop and the stage of crop growing. The

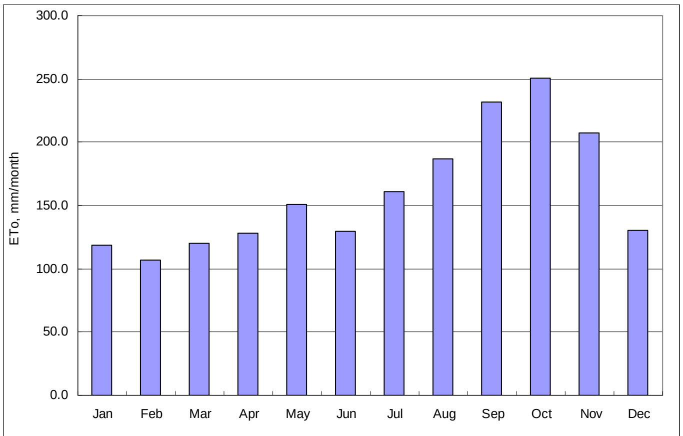


Figure 6.6.1 Ref. Crop Evapo-transpiration, mm/month

[3] Source: Agro-climatic Resources Inventory, 1988 and 1990 (30 years data). Though Chipita is located in Malawi, the latitude is 9 degrees 40 minutes S, which is corresponding to around Kasama. Also elevation at Chipita is more or less same as that of Kasama area.

stage usually consists of four; initial, development, mid, and late with the mid being the highest. An example of maize is given in the right figure.

Dry season irrigated agriculture can start as early as the beginning of May if the farmers start constructing simple irrigation facilities and/or carry out necessary maintenance works right after they have finished rainy season's harvesting. On the other hand, latest chance to plant dry season crop may be in August except for some cases[4] since farmers have to harvest by the beginning of December that is the season to prepare for rainy season agriculture.

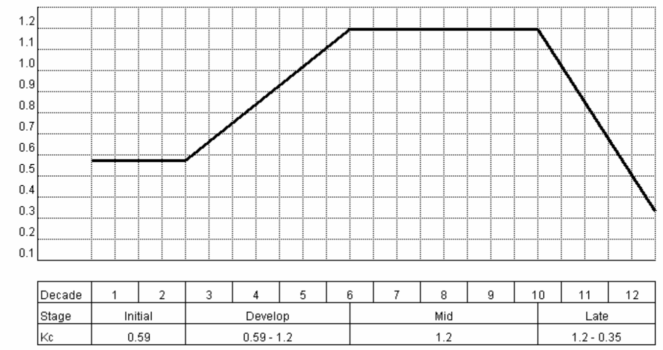


Figure 6.6.2 Typical Kc of Maize by Growing Stage

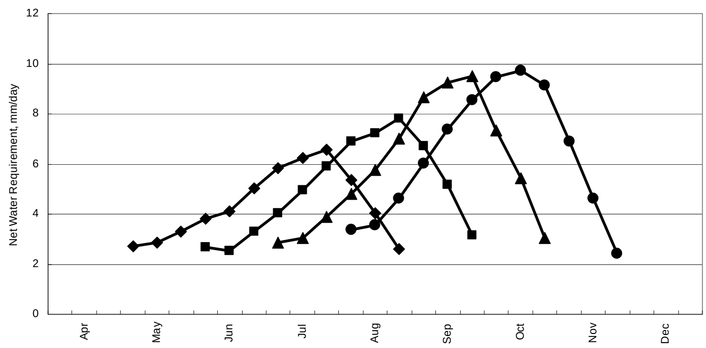


Figure 6.6.3 Net Water requirement by Planting Period

As briefly presented above, crop water requirement depends on not only crop growth stage but also climatic condition. This means water requirement of a crop will vary depending on when to plant. If mid stage of the crop growth occurs during high ETo period, in most case October, peak water requirement for the irrigation will also increase. Figure 6.6.3 shows net water requirement for maize depending on when it is planted.

The peak water requirement increases as the planting season becomes late. If maize is planted in early May, the peak net water requirement occurs in late July at 6.56 mm/day while it increases to as much as 9.71 mm/day when it is planted in early August (increased by 48%). Applying irrigation efficiency of 0.5 suitable for smallholder irrigation, the net water requirement is converted into gross that is the amount to be required at the diversion point. In case of early May planting, the gross peak is 1.52 l/s/ha taking place in late July while it is 2.25 l/s/ha at mid October when planted in early August (see Table 6.6.2).

Table 6.6.2 Peak Water Requirement for maize by Planting Period

Planting	Peak NWR mm/day	Peak NWR l/s/ha	Gross, l/s/ha	peak period
			Eff. 0.5	
Early May	6.56	0.76	1.52	Late July
Early June	7.81	0.90	1.81	Late August
Early July	9.52	1.10	2.20	Late September
Early August	9.71	1.12	2.25	Mid October

NWR: Net Water Requirement

Stream discharge becomes less and less toward the end of dry season, and marks the lowest in October or early November in most cases. Almost all the streams suitable for smallholder irrigation development do not have reliable stream flow record. Therefore no one is sure how much flow decreases as time goes toward October/November. However, observation at some of the pilot project sites indicates that the flows in the leanest period would be less than half to as little as one-fifth as compared to that of the beginning of dry season

[4] If farmers try 2 times cropping in a dry season, the 2nd crop would start in October or even in November. In this case, the 2nd crop is firstly irrigated with the canal and then carried over by rainfall. Most common 2nd crop may be maize, since the maize planted in October/November is to be harvested in February/March which is just prior to the harvest of common rain-fed maize. The harvest of maize at this time of period can give the farmers the highest price.

though it is very much dependent on the vegetation of catchment area.

Therefore, late plating faces two difficulties of: 1) more peak water requirement, 2) while less water available in the stream. This case takes place mostly in simple irrigation schemes. Physical facilities construction is often commenced in June – July and even in August due to necessary pre-arrangements of setting up of working group, provision of necessary tools, etc. The planting could be consequently done only in July to August in many simple diversion sites especially in the 1st year.

Most of the sites, on the other hand, may not be fully developed based on the land availability due mainly to the time constraint. This situation has occurred in many of the pilot project sites, which has in turn helped many sites of not facing sever water shortage despite the late plating. However, there are sites that the farmers unfortunately faced water shortage as moving to the end of dry season.

Taking above into account, it is strongly recommended: 1) to start planting as early as possible from the view point of water availability in the stream, though temperature in cold places may not allow some crops to grow, 2) do not develop full potential area in the first year, for example limit the development area to less than half of the potential, because no one is sure of how much stream water becomes finally less, and 3) do not depend on the report of stream flow from the farmers since they might exaggerate the stream flow expecting handouts to be brought by project.

Gross peak water requirements in aforementioned Table 6.6.2 give an idea of how much area can be irrigated by 1 litter flow per second; that is the reciprocal of the requirement. As most smallholder irrigation sites do not have storage pond, the irrigation cannot utilize the flow available during nighttime but daytime only. Therefore half area of the reciprocal should be considered as irrigable area with 1 litter flow per second. Table 6.6.3 can be referred when one needs to know how much area can be irrigated with the available water, which can be a guide for those who are promoting smallholder irrigation schemes.

Table 6.6.3 Irrigable Area with 1 litter Water per Second

Planting	Gross, l/s/ha Eff. 0.5	1/ Gross ha/l/s	1/ Gross/ 2 ha/l/s	irrigable area in acre by 1 l/s
early May	1.52	0.66	0.33	0.82
early June	1.81	0.55	0.28	0.69
early July	2.20	0.45	0.23	0.57
early August	2.25	0.44	0.22	0.56

Source: JICA Study Team

6.6.6 Land Size on Member Report and Actual One

In this Study, most of agricultural data are obtained through interviews to farmers directly or indirectly. Agricultural production outlook issued by MACO is not an exception; those data are also based on the interviews to the farmers at camp level, not an actual measurement. For instance, extension officers organize camp meetings to gather agricultural production data from farmer leaders from the villages in the camp. Farmers report how many limas are cultivated in their own village and how much of harvest obtained. In this mode of operation, reliability of the data depends largely on the accuracy of farmers' perception on cultivated area and crop production.

If farmers overestimate the size of their farmland, productivity per unit of land will be underestimated. Contrarily, if farmers underestimate the size of the land, productivity becomes higher than the actual one. To draw more reliable productivity data, therefore, difference between farmers own perception and actual size of cultivated area has been studied. As a part of harvest survey, a total of 339 plots of 188 farmers have been actually measured in 10 different irrigation schemes in six districts: Mansa, Kawambwa, Mpika, Mungwi, Mbala, and Kasama. The method employed was composed of two steps: ask a farmer the size of his/her plot and then measure it. By comparing the two figures, accuracy of the farmers' perception can be prospected.

Table 6.6.4, shows the result of the comparison. As an average of 188 farmer households, cultivated area was estimated to be 0.97 lima, which is 2,425 m^2 or 49.2 m square. While, the actual size of the cultivated are was averaged 0.90 lima, which is 2,250 m^2 or 47.4 m square. The actual size of the cultivated area was 92.4% of their estimation, that is, they overestimated their land by 7%.

Table 6.6.4 Comparison between Farmers Perception and Actual Land Size per Farmer (m^2)

Item	Per Household			Per Plot		
	Area Declared (lima)	Area Measured (lima)	Ratio (%)	Area Declared (lima)	Area Measured (lima)	Ratio (%)
Total	183	169		184	170	
Average	0.97	**0.90**	**92.4%**	0.54	**0.50**	**92.6%**
Max	5.48	5.15	475.0%	4.00	3.40	933.3%
Min	0.06	0.02	8.0%	0.01	0.01	8.0%
No. of Samples	188			339		

Source: Harvest Survey by the Study Team
Note: Average is weighted by the area irrigated.
Maximum and minimum figures in the "ratio" show the cases that showed the maximum and minimum percentage (Not the percentages of the areas in the columns of maximum and minimum)
As two incomplete samples were deleted from the household data, the total area is different between household data and plot data.
Irrigated area per household may include the accumulated areas of double cropping, even though it is a major case.

The range of this difference was significant. In the minimum case, the actual land area was only 8.0% of the farmer's estimation; she claimed her plot 25 m by 25 m equivalent to 625 m^2, while the actual size was 9.5 m by 4.7 m equivalent to only 45 m^2. She probably considered her plot by "limas." In the maximum case, on the other hand, the actual land size was 475% of the farmer's estimation. A farmer claimed his plot 50 m by 10 m equivalent to 500 m^2, while the actual size was 79 m by 30 m equal to 2,370 m^2. It is likely that they thought their plot using a unit of "lima" first and then converted into 25 m by 25 m in their mind especially in the former case. In this principle, a lot numbers of land size data around that size may be regarded as 25 m by 25 m and thus loose touch with the reality.

The same tendency was found in the cultivated area per plot. As shown in the right side of the table, an average cultivated area that farmers estimated was 0.54 lima, which is 1,350 m^2 or 36.7 m square, while the actual size arrived at 0.50 lima or 35.4 m square, that is 92.6% of their estimation. In the case of per plot data, maximum ratio reached 933%. A farmer estimated his plot of Chinese cabbage 12 m by 6 m equals to 72 m^2, while the actual measurement resulted in a square of 30.5 m by 23.0 m equals to 701.5 m^2.

In short, it was found that farmers in this area tend to overestimate their cultivated area and that productivity of crops per a unit of land is unnecessarily suppressed. Therefore, when computing productivity and/or profitability of irrigated agriculture per land, this distortion should be amended. One of the measures to rectify the farmers' tendency is that the actually harvested area should be reduced to around 92.6% of what the farmers claim, unless it is measured.

6.6.7 On-farm Irrigation Method: Due Consideration to Conventional Scooping

Since the beginning of the Study, on-farm irrigation method in this area has been a big issue among the JICA Study Team members. In this area, farmers are watering crops by hand using bowl or bucket (see photo right). It takes so much time and thus requires a lot of labor work. We have not had much idea why farmers continue this kind of water application method. During the site visit, some rational reasons have been identified.

First of all, there are mainly four types of on-farm irrigation methods: 1) carry water by bucket or like from furrow to the plot; 2) draw water from furrow to the farm plot and throw it on the top of ridges by hand using bowl; 3) do furrow irrigation with no additional water application work; and 4) do basin irrigation with no additional water application work. Most commonly observed is the type two. In some cases of this method, farmers dig a hollow on the on-farm furrow to reserve water and then pour water from it.

A possible reason that makes farmers go for this method can be found in the shape or height of ridges. As sometimes called as "*Fundikila*," farmers in this area often make big ridges, in which weeds or grasses are intermixed for compost making. As a big volume of biomass is put inside, the height of those *Fundikila* naturally becomes large: very often 50cm or even more.

A farmer applies water by hand. It takes so much time to complete his farm plot; this is the most common way of water application in this area.

When the height of ridge is more than a certain level, furrow irrigation will not work as farmers' hope (and irrigation engineers' hope). Therefore, it is necessary for those farmers who maintain big ridges to pour water on the top of ridges by hand. Furthermore, even if the actual height of ridge is not too high, it seems farmers just follow a traditional way that is still being practiced by the other farmers. In this case, it may take sometime for them to fully undertake standard furrow on-farm irrigation.

Another reason explained by the farmer comes from the skepticism to the unfamiliar method. Having less experience in a particular method, furrow irrigation in this case, farmers tend to hesitate applying it. In some villages, farmers claimed that hand irrigation works better than furrow irrigation. There was in fact a case the growth in a plot under hand irrigation was better than the one under furrow irrigation nearby.

It however seemed that irrigation was not practiced properly in the furrow irrigation plot, where excessive water was being applied and thus the root system was damaged (see photo right). The suggested point here is that, for the application of new method, it is not just a matter of effectiveness of either method but is associated with how those new methods are to be practiced correctly. For instance, appropriate volume of water or frequency of irrigation may change according to the types of on-farm irrigation method. Much has to be considered when introducing a new skill.

Tomato plants are exposed to the excessive water, being at risk on the root system. They should be set back with a certain space of clearance, and also water applied should be well controlled.

On the other hand, there found other reasons that encourage farmers to do watering by hands, although those findings cannot be generalized. A case is related to the time required. In an interviewed irrigation scheme, farmers practice a rotation irrigation in which each farmer is allocated only a limited time for irrigation: two to three hours per time. One farmer claimed that she could not complete irrigation unless otherwise she does watering by hand. There is a case farmers apply water by hand to accelerate the irrigation.

In addition, there may be cases that the hand irrigation works better in farming. There are farmers who do farming very much neatly as shown in the photo below. A farmer cultivates tomatoes around which there are hollows into which paddy husk and also chicken droppings are placed. In this case, if irrigation water is poured from top, the irrigation water can turn to be a sort of liquid fertilizer dissolving the nutrient in the chicken droppings. There is due reason in this case why the farmer depends on bucket irrigation.

In sum, though this Study proposes two major on-farm irrigation methods; furrow irrigation and sunken-bed irrigation, there may be due reasons farmers still continue bucket irrigation. Bucket irrigation obviously needs more labor work, yet given above rational reasons the farmers may prefer the labor work in cases. New on-farm irrigation methods should be introduced taking into account the field conditions.

Around tomatoes, there are hollows into which paddy husk and also chicken droppings are placed. If irrigation water applied from top, it can work as a liquid fertilizer.

CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

Taking the points below into account, this Study concludes that the community based smallholder irrigation (COBSI) development approach can be at the core amongst remedial measures in improving agricultural production whereby reducing poverty the people are suffering. The Government of Zambia should therefore embark, at her own cost or together with assistance from donors, on implementing and disseminating the COBSI development program in the target 2 provinces of Northern and Luapula as well as over the Country where applicable.

1) The smallholder irrigation development tried out throughout the pilot project implementation contributed to generating cash income whereby improving the livelihood of the beneficiary farmers. In fact, according to a harvest survey which covered 471 households, a typical farmer gained a net income of ZMK 1.55 million out of an average cultivated area of 0.873 lima (47 m square). This is equivalent to a top up income by 33% to what the typical farmer household used to earn, ZMK 4.67 million. Also, the net income is enough to uplift a typical poor farmer household to and beyond the poverty line. A typical poor needs ZMK 1.51 million to reach the poverty line, while the average net income from irrigated agriculture is ZMK 1.55 million.

2) Other positive impacts were observed, for example, in a way that the beneficiary farmers got capital from the irrigated agriculture to invest in fertilizers and improved seeds for following rain-fed crops. In fact, fertilizer application for the rain-fed maize was increased from 76 kg to 176 kg per household according to a harvest survey (valid sample number 327 households). Accordingly, the production of rain-fed maize has increased, e.g., from 18.1 bags (50kg/bag) to 31.5 bags per household—as much as 74% of increase with reference to the harvest survey (valid sample number 373 households). Thus, a spillover effect from irrigated agriculture is a re-investment in year round agriculture, improving their livelihood over a season.

3) In addition to the increment of income, vulnerability of the beneficiary farmers was also improved. There were specific months, e.g. January to March, when many farmers faced food shortage according to interviews. Farmers who faced food shortage had to engage themselves in working at "other" farmers' fields or borrow money, resulting in vicious cycle of poverty. The income from irrigation can now contribute to the stabilization of the income of those farmers who used to depend only on rain-fed income, one-time income per year. Likewise, income from irrigated crop in January, when parents face two major difficulties of school fee and food shortage, can be a big relief.

4) A principle concept of this Study is not to wait for someone else to come with investment but to start whatever the beneficiary farmers can do in their locality, i.e. starting up irrigated agriculture with simple irrigation schemes made out of locally available materials. Then, sometime after the beneficiaries have got used to irrigation with the simple structure, here comes an upgrading to permanent structures upon an investment availed. This upgrading approach, from simple one to permanent one, can ensure sustainability of the permanent-structured irrigation schemes since farmers have already learned how to irrigate with the simple structures.

5) The pilot project has put a total area of 572 ha under irrigation over the 2 years of 2009 and 2010, composed of 544 ha by simple schemes and 28 ha by permanent schemes. These areas were brought under irrigation by 568 simple schemes and 8 permanent schemes respectively. With this area irrigated, 7,131 farmers were benefited, composed of 6,874 farmers by simple schemes and 257 farmers by permanent ones. Though an irrigated area covered by one scheme may look very small, say only 1-4 ha per scheme in most cases, these great number of smalls can ultimately make

a big great.

6) One of the strengths that the MACO has is its extension structure already in place; not just at the provincial level, extension officers are deployed even at the block (BEOs) and camp level (CEOs) for whole Country. Proceeding hand in hand with the government's existing extension structure is another operation principle especially in disseminating simple structures to wider area. Putting the frontline extension officers, BEOs/CEOs, in the forefront of the development activities assisted by TSB supervisory offices was proved well workable to pursue a wide range of dissemination of simple schemes. Simple schemes can thus be disseminated through the existing extension structure.

7.2 Recommendations

There have been a number of issues that the JICA Study Team encountered during the Study. Through pilot project implementation, a number of solutions and/or recommendations were found. Below are some of these recommendations. As is the case with continuous processes, the recommendations made below are by no means exhaustive and may need to be changed or modified, depending on in-situ condition. However, it is believed that the ones covered here nevertheless constitute a broader spectrum capable of fitting in most conditions in implementing smallholder irrigation schemes:

1) Smallholder irrigation development should, as far as applicable, start with simple diversion structures. Simple structures can be put up with locally available materials only as proved through the pilot project implementation. It does not need monetary investment for the structures. Farmer themselves can construct most of the simple structures within half day to maximum, say, 2 days given a sound technical assistance from BEOs/CEOs. Extension by BEOs/CEOs can also be a good opportunity for the farmers to start irrigation since they are accessible by the farmers than the TSB officers at district/province. So far, there was a conventional belief that irrigation was an engineer's task. However, irrigation with the simple structures has proved that even extension officers can promote a lot. In order not to let the potential farmers wait long for irrigation, simple schemes should be tried wherever applicable.

2) Permanent structures should, in principle, be introduced by upgrading the simple structures. This upgrading approach can automatically ensure sustainability of the permanent schemes. This is simply because the beneficiary farmers for permanent structure are already used to irrigation with the simple structure. Therefore, as long as the permanent diversion structure continues functioning as designed, the beneficiary farmers will not fail in carrying out water distribution and thereby on-farm irrigation. Another benefit from the upgrade approach is that the irrigated agriculture which has been practiced with simple structure can not be hampered by the construction of permanent structure. During the construction of permanent structure, the site should be dried up by, for example, putting a detour channel, which can be connected to the existing canal. Thus, the stream water can be delivered to the existing canal even and the farmers can enjoy irrigation even during the construction of the permanent structure.

3) There is a limitation pertinent to the development of this community based smallholder irrigation schemes by its nature. As the scheme focuses mainly on gravity irrigation systems, there should be a perennial river and also ideal topographic condition so that neither reservoir nor pumping is required and water can be tapped by gravity. Those requirements were fulfilled at many places in Northern and Luapula provinces, whereby a lot of diversion schemes had easily been constructed through the implementation of the pilot project. Though the Country still has high potential of introducing this gravity irrigation scheme, there is a limitation in parts of the Country where most of the rivers are not perennial and/or flowing in a gorge, requiring pumping facilities. Therefore, introducing the gravity smallholder irrigation scheme should always refer to these requirements at

the onset of the development. Otherwise, other alternatives such as reservoir systems as well as pumping systems should be taken into account.

4) A concern on water right acquisition is highlighted in relation to any irrigation development project. In fact, since there is much water than what the rural population needs in the 2 provinces with rich rainfall, not much conflict on water allocation amongst the users has been reported by now. However, as the irrigation site increases, water right issue may arise. To cope with this, the development of an irrigation scheme in a catchment area should always be started from upper reach of the stream, and then move to downstream. In addition, TSB officers and extension officers are requested to facilitate the farmer groups to apply water right. In this case collaboration between the Department of Water Affairs and the DOA should always be sought.

5) Irrigation obviously cannot serve all the villagers simply because irrigation cannot serve all the land according to the topography. Also, the amount of water available for irrigation in potential sites may be limited, so that only less than one tenth of the whole villagers may have land within the potential service area in cases. This situation may cause other farmers' jealousy to the landowners and create social problem amongst concerned villagers. It is therefore recommended to divide the potential service area into small plots and lend out to the have-nots who are the farmers not having any land in the service area, either for free or with a minimal rental fee. This measure was observed in many sites under the supervision of village headperson, and contributed to equity amongst the villagers.

6) Another important point worth to mention is also a land issue. Some landowners have refused to lend their lands to other people. While water is a public good, it goes to land that is a private good, causing equity issue amongst concerned villagers. Equity amongst the concerned villagers and individual interest are somewhat bipolarized. To amicably settle the land issue, there may be such arrangements as: allocating larger portion to the landowners, paying reasonable rental fee to the owners, due caring of the land by renters by means of applying more compost manure, etc. Local leaders should also play a distinguished role to settle. Transparency since the onset of the development should be imparted and in this regard the local leadership in terms of equity is also challenged. Taking stranded farmers inclusive of the landowners and the local leaders to well organized area can strongly influence to solve the situation.

7) Irrigation, in most cases, if not all, over-exploits the land by intensive use of the same land for years. This in true sense means that in the near short-time, the land will be greatly affected, both physically and chemically, and in the end will hardly be able to produce anything. This problem is further exacerbated by the farmers' tendency of applying chemical fertilizer only. Though chemical fertilizer is highly effective, it has a disadvantage of disregarding the need to improve soil physical properties. Therefore, it is highly recommended to encourage farmers to apply more compost manure. Compost manure is good not only as nutrients but also for improving the physical characteristics of soil so that chemical fertilizer can be well retained in the soil to be fully consumed by the plants. In addition, irrigation canal avails of water by nature, which is a prerequisite of making compost manure. Irrigation canal can therefore promote compost making alongside the canal, which automatically solves the problem of transporting the compost manure. Compost should be promoted in these ways.

8) Irrigation can have an enough impact to change the fundamental lifestyle of farmer households. For years and years, major farming style in the area has been based heavily on *Chitemene* slush and burn agriculture in which limas of forest area are cut down to cultivate a small piece of land. As a result, natural forest has been gradually and widely decreased especially where population has increased. While, irrigated agriculture can provide farmers with an alternative means of

production, by which overdependence on *Chitemene* cultivation can be moderated. In fact, it was observed that the area under *Chitemene* has been, by and large, decreased after farmers started irrigation. Therefore, smallholder irrigation should be promoted also as a means of natural forest conservation.

9) Most potential sites are located in gentle hilly areas which are crisscrossed by streams. Under this situation, if there are no proper soil conservation measures, land degradation will undoubtedly occur or even be accelerated which will ultimately make it unfit for cultivation in subsequent years. Thus extension of smallholder irrigation should go hand in hand with land conservation measures. This may include creating a distance from the rivers to the edge of the field which should always remain under fallow, simple storm drains, vetiver grass planting along the main canal as well as along lower peripheral of service area, contour ridge and hedge, etc. In addition, there is an on-going national extension project, Scaling Up Conservation Agriculture. By linking up a technology extended under this programme, e.g. mulching, erosion of the farmlands by irrigation water can be minimized.

10) Irrigation development is not the end but the means to an end. For the frontline extension officers, therefore, promotion of smallholder irrigation development should always go with the encouragement of best agricultural practice. In this regard, taking agriculture as business, it is far important to address the market-oriented agriculture rather than just producing what other farmers cultivate. Diversification of crops in the area, for basic instance, helps avert the risk of extreme price decline. It should be also mentioned that the cropping timing is better tuned to hit the highest price when harvesting. For example, price of groundnuts per bag (50kg/bag) can change from 120,000ZMK in January to 65,000ZMK in March. Irrigation should be promoted as a helpful tool for farmers to fine-tune the timing of crop production even during the dry season.

11) Different from many conventional community based projects, no free seed and fertilizer have been provided in the pilot project. Participants to a workshop commented the approach of not providing any free input pursued under this Study as: “The approach tells the farmers the truth about life and is not just pleasing them by short-term assistance i.e. in terms of handouts.”, “The approach has instilled a spirit of self-reliance than ever before what farmers depended on handouts.” The approach of not providing any free seed and fertilizer may have been unique for the frontline officers. The JICA Study Team thinks that those who can access to the irrigation water which is a precious natural resource can still be categorized as better-off farmers. Yet, does it make any sense of equity to give free goods to those better-off? Though the principle concept may be unique as compared to conventional approaches, the pilot project at least showed that Zambian farmers can move ahead even without free handouts, suggesting the agriculture is their business.

12) The pilot project has established as many as 568 simple schemes. During the extension of the simple structures, there was a unique strategy the JICA Study Team took to the farmers who wanted free input as a condition that they were to try the irrigation with simple structures. One may think there may have been a great difficulty of motivating such farmers without giving free input. However, there was such simple measure as to leave the community and move to next potential site by saying ‘OK, that’s good. We go to next village by leaving you.’ If there is monetary investment already done, it will be very difficult for the goverment/donors to leave the site once after engaged. However, the measure, leaving the community, can be put in practice as the simple scheme does not require any monetary investment. The measure thus increases flexibility of the extension programme for smallholder irrigation schemes, which automatically raises the possibility of programme success. It is therefore recommended not to stick to a community which is not interested, and instead of wasting time move to next potential site.

13) Though irrigation brings about a lot of positive impacts, there could be some negative impacts, e.g. soil erosion, increased salinity, and increased cases of *schistosomiasis*. To cope with these issues, recommended measures are: 1) for the soil erosion; shortening of on-farm furrows, installation of small dissipaters along on-farm canals, and introduction of drop structures along main/secondary canals, 2) for the increased salinity; introduction of leaching water by increasing the amount of irrigation water itself by 5-10% in most cases, flush out of salt at the beginning of irrigation season if accumulated on the surface, and introduction of drainages which can push down the saline water into drainage whereby no salt accumulation on the ground takes place, and 3) for *schistosomiasis*, not to leave any stagnant water in the irrigation system, expose all the sections of canal under sunshine (grasses should be thoroughly cut and disposed), use gumboot to walk in the water, and feces are well treated with toilet facility.

THE STUDY
ON THE CAPACITY BUILDING AND DEVELOPMENT
FOR SMALLHOLDER IRRIGATION SCHEME IN NORTHERN AND LUAPULA PROVINCES

■ RATIONALE

The Study area of Northern and Luapula provinces has much rain and surface water as compared to other provinces in Zambia. Nevertheless, 90 % of annual rainfall is concentrated in rainy season from November to April. Further, uncertain rainfall pattern causes unstable agricultural productivity, resulting in food shortages in certain times. The area is, on one hand, endowed with gentle rolling-hills, which could be of high potential to introduce gravity irrigation for smallholder farmers using simple techniques.

Smallholder irrigation systems are expected to contribute to improving agricultural productivity of smallholder farmers in the target area. Their impact can be maximized when replicated in other regions where same geographical and natural environmental features prevail. Viewing it, the Government of Republic of Zambia (GRZ) requested the Government of Japan to conduct a comprehensive study on smallholder irrigation scheme development in the target two provinces. Upon this request, Japan International Cooperation Agency (JICA) dispatched an appraisal mission in June 2007, and the Scope of Works (SW) was agreed on June 27, 2007 between the two governments. The Study commenced in March 2009, and was completed in July 2011.

■ OBJECTIVES

The overall goal of the Study is to enhance food security in Zambia through promoting irrigated agriculture in community-based smallholder irrigation schemes. To this end, the Study aims at designing a comprehensive action plan to promote smallholder irrigation development in the two provinces. The process of the Study centers on the following which themselves are the objectives:

1) To formulate Action Plan (AP) to promote effective smallholder irrigation schemes for improving the agricultural productivity in Northern and Luapula Provinces, and
2) To transfer technology to and build the capacity of counterpart personnel and concerned communities in smallholder irrigation development through implementation of the Study.

■ THE STUDY AREA

The Study area covers Northern and Luapula provinces with 12 districts in Northern and 7 districts in Luapula province respectively. Total area of the two provinces is 198,393 sqkm equivalents to about 445 km square, which accounts for 26 % of the total national land. According to the National Census 2000, total population of the two provinces as of year 2000 is about 2 millions with the population density of 10 persons per sqkm. One of the typical characteristics of the Study area, and to greater extent of Zambia, is the low population density as compared to most of the neighboring southern African countries.

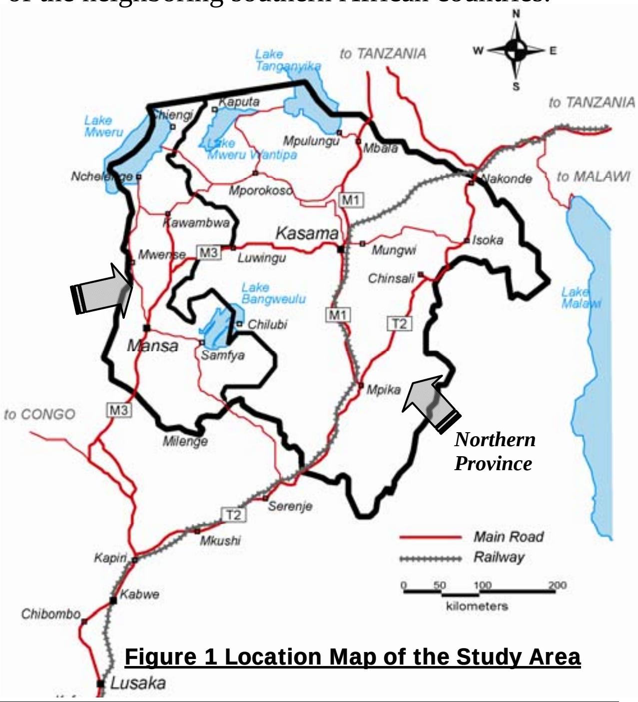


Figure 1 Location Map of the Study Area

■ THE STUDY APPROACH

During the first year 2009, a draft action plan for smallholder irrigation development was produced. To make the action plan feasible, some of the important hypotheses of the draft action plan have been verified through the actual implementation of certain components of the action plan–called pilot project implementation. The pilot projects started in the mid 2009 on demonstrative basis, and it was extended to a wider range of areas in 2010. In the year 2010, new component was added which was an upgrading from temporary facilities to permanent ones. The draft action plan was then finalized by reflecting the feedbacks and lessons from the implementation of those pilot projects.

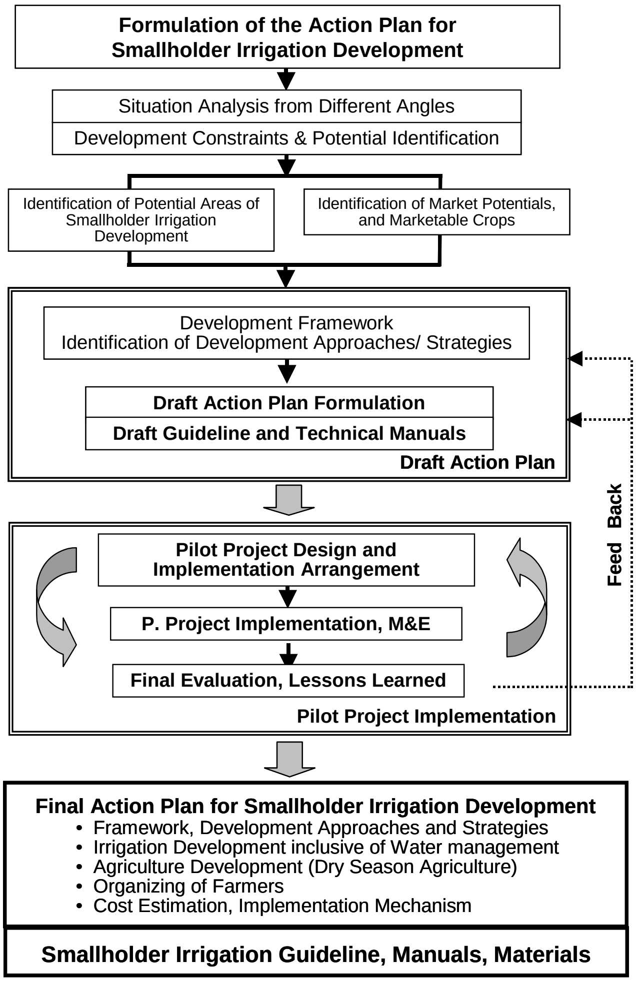


Figure 2 Study Approach and Overall Flow

■ NATURAL AND SOCIAL INDICES

The climate in the Study area is clearly separated into dry and rainy seasons. Most of the precipitation, about 90% of the annual rainfall, falls from November to April. According to climate records at Kasama station from 1933/34 to 2009/10, monthly rainfall peaks in December, reaching as much as 290 mm. The average annual rainfall for the periods is 1,310 mm, far exceeding precipitations in other parts of Zambia. The maximum annual rainfall at the station took place in 1961/62 with 1,889 mm, while the minimum was 902 mm recorded in 1952/53.

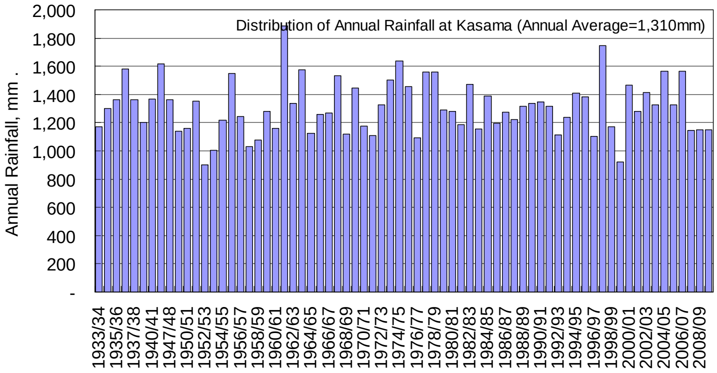


Figure 3 Long Term Annul Rainfall at Kasama Station

The major rivers are Chambeshi and Luapula rivers. Chambeshi river drains the central part of Northern province into the large Bangweulu swamps (5,000 sqkm), which further drains into Luapula river. Luapula river forms an international boundary with Democratic Republic of Congo (DRC), flowing finally into Congo river basin through Lake Mweru. The two provinces provide more surface water resources than other parts of Zambia: 304 cum/day/sqkm in Northern and 357 cum/day/sqkm in Luapula in a 10-year return period. Runoff depths are 168 mm for Chambeshi river basin and 161 mm for Luapula river basin. Runoff percentages account for 12.8% for Chambeshi river basin and 14.0% for Luapula river basin. Monthly runoff for Chambeshi river varies from 1.15 litre/s/sqkm to 13.56 litre/s/sqkm. Luapula river's lowest runoff is 1.21 litre/s/sqkm while the maximum is 10.90 litre/s/sqkm (see Figure 4).

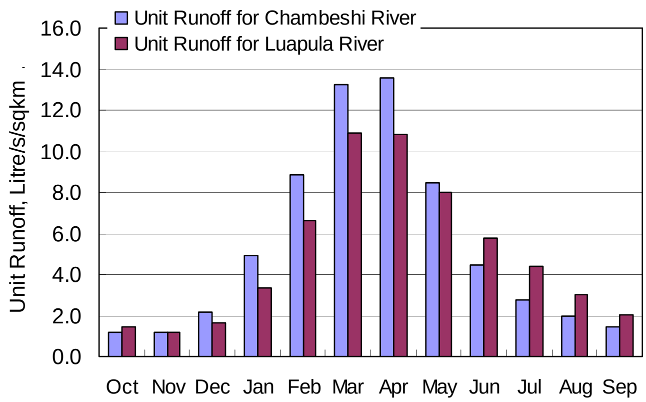


Figure 4 Monthly Runoff per sqkm Catchment Area

According to interviews in villages, there had been occasions when they were hit by drought. Apart from drought, there were heavy rainfalls which also damaged or sometimes devastated their crops than drought did: a village has had 3 times of heavy rains in 1962, 1963 and 1972 since the establishment of the village in 1947. Though the Study area is blessed with rich rainfall, the rainfall on the other side sometimes causes heavy damages on their crops, resulting in severe food shortage.

Majority of the farmers in the Study area depend on rain-fed agriculture including *Chitemene* (slush and burn cultivation), whereby maize, cassava, beans, and finger millet are cultivated. One of unique characteristics that well illustrate the agriculture in the area is a mixture of extensive and intensive agriculture; e.g., shifting cultivation can be sporadically found even along an irrigation furrow (a small irrigation canal). Since their farming depends on hand hoes, cultivated areas cannot reach so big: for example, only 0.73 ha/household (HH) for hybrid maize and only 0.50 ha/ HH for cassava, according to a baseline survey conducted under the Study. Cash crops such as vegetables, pulses, groundnuts are cultivated in far smaller areas: less than a quarter hector. Likewise, yields are not high, e.g. 1.93 ton/ha for local maize and 2.49 ton/ha even for hybrid maize.

Though yields are not much high, the estimated total productions of cereal and starch per capita arrive at 445 (226+219) kg/capita in Northern and 362 kg (72+289) in Luapula province, which far surpass the minimum requirement for their populations. It can be interpreted that farmers in the Study area no longer have to pursue self-sufficiency of staple food. Rather, they are in the stage of diversifying their diet to improve their nutritious balance – enough rationality to start vegetable production under irrigated agriculture.

Their major income comes from selling surplus of agriculture production. For example, according to the baseline survey in 12 villages, share of the crops in their income sources ranged from 53% to 92% with the overall average of 71% (value of self-consumed crops included). The average annual income per farmer household ranged from ZMK 2.92 million to ZMK 16.32 million (in fact, the biggest surpassed by far the others as the 2nd biggest was only ZMK 6.8 million). The overall average thus arrived at ZMK 5.82 million (or ZMK 4.67 million excluding the biggest income level). Gini index of all those samples is 0.40 (or 0.35), implying that the income gap is not yet much.

Poverty lines were also established based on Cost of Basic Needs method: ZMK 6.80 million for food poverty line and ZMK 1.40 million for non-food poverty line, suggesting the overall poverty line to be ZMK 8.19 million (US$ 1,571) for a typical family where there are 5.70 adult equivalent members. Based on this poverty line, the poverty ratio was estimated ranging from 29% to 76 % by village with an overall poverty ratio of 56%.

From a marketing survey carried out at 9 villages located near major towns along major roads, it was revealed that three-quarters of produces were shipped to market. With regard to the destination, on average 54.3 % is traded within the district while the 23.3 % goes towards other districts in the same province, then the rest, 22.5%, goes even outside of the province. While more than half of the farmers tend to choose local markets in their own district, over 20% of farmers target high potential big markets in other provinces.

Existing irrigation schemes in the Study area are categorized in two types: 1) permanent irrigation scheme, and 2) temporary irrigation scheme. The former is established with permanent structures like concrete diversion weir and dam reservoir to impound river/stream water. The latter is in most cases constructed by farmer themselves by utilizing locally available materials such as grass, clay soil, twigs, bamboos, or by just digging a water furrow to which stream water is withdrawn by gravity.

To identify irrigation schemes in the Study area, an inventory survey was carried out in 2009. The survey identified that there were 104 permanent irrigation schemes in the two provinces, composed of 67 sites in Northern and 37 sites in Luapula provinces. The total irrigated area of permanent schemes was reported 441 ha, only 4.2 ha as the average irrigated area per scheme. For temporary schemes, there were 1,024 sites, which irrigated a total area of 1,772 ha. This total area counts about 4 times of that of permanent ones. Irrigated area per site is not big: just 1.7 ha as the overall average.

There are mainly two types of irrigation scheme: left photo is a typical concrete weir, a permanent structure, while right one is a temporary stoppage

■ SMALLHOLDER IRRIGATION PLANNING

Planning started with the identification of SWOTs and development constraints and opportunities, which was followed by prioritization of irrigation potential by district. Then, action plans were formulated composed mainly of irrigation development and irrigated agriculture.

1. SWOTS, CONSTR'TS & OPPORTUNITES

Weaknesses identified are 'shortage of staff' and 'inadequate logistic support' relating to 'transport.'

Threats are 'natural calamities' such as drought and flood, 'poor infrastructure' especially poor road condition and its network, 'land tenure,' 'low adoption rate,' 'migration,' 'expensive farm input.' On the other hand, strengths include 'qualified/ knowledgeable and trained staff,' and 'well established organizational structure.' Opportunities are 'the area blessed with natural resources.'

Constraints observed are: 'large area coverage in agriculture extension,' 'lack of mobility,' 'shortage of technical staff in irrigation development,' and 'high cost of input.' On the other hand, development opportunities utilized for promoting smallholder irrigation are: 'wide coverage of mobile phone network,' 'radio programmes,' 'urbanized areas and local markets that ensure marketing potential,' and 'development fund available from Poverty Reduction Programme fund,' which can be utilized in establishing irrigation schemes.

2. POTENTIAL IDENTIFICATION

From an inventory survey carried out in 2009, an area of 9,792 ha has been identified as 'confirmed irrigation potential' in the two provinces, of which, a total area of 2,213 ha is already under irrigation. Therefore, the confirmed potential area remained is 7,579 ha. In addition, LANDSAT Image reading identified a total area of 149,400 ha as 'maximum probable irrigation potential.' Since this identification does not automatically guarantee the feasibility, it must be taken as an indicative figure of farmland availability near water sources.

Taking into account not only identified irrigation potential but also other critical parameters, e.g. stream density, existence of smallholder irrigation schemes, government officers' opinion, districts were prioritized into 3 groups in terms of smallholder irrigation development potential:

Group A (High potential districts): Mbala, Mungwi, Luwingu and Kasama in Northern, and Kawambwa and Mansa in Luapula provinces.

Group B (middle potential districts): Nakonde, Isoka, Mpika, Mporokoso, and Chinsali in Northern, and Mwense and Milenge in Luapula provinces.

Group C (low potential districts): Kaputa, Mpulungu, and Chilubi in Northern, and Nchelenge, Chienge, and Samfya in Luapula provinces.

3. ACTION PLAN FORMULATION

Major development opportunities and constraints were incorporated in the planning: 1) large extent of engagement of extension officers in smallholder irrigation development, in particular for simple (temporary) diversion schemes, 2) extensive involvement of beneficiary farmers not only in simple scheme development but also in permanent scheme construction, and 3) utilization of information technologies available such as mobile-phone, radio programme to widely disseminate the schemes and also to motivate farmers.

As for simple diversion structures, 4 types of diversion structures are promoted in the Plan: 1) inclined diversion weir, 2) single-line diversion weir, 3) double-line diversion weir, and 4) trigonal-prop supported diversion weir. As for permanent irrigation scheme, 3 types of permanent diversion structures are incorporated: 1) wet-masonry wall type weir with buttresses, 2) concrete wall type weir with buttresses, and 3) wet-masonry gravity type weir. To minimize the cement volume, the first two structures are designed with buttress.

As for construction, considering the financial affordability of the farmers, the principle should center on intensive manual work by the farmers themselves with full support by the extension as well as TSB officers. In this regard, even the construction of permanent structures should basically be carried out under direct force account by the government. Under this arrangement, district TSB procures necessary foreign materials such as cement, iron bars, and timbers for formwork and farmers undertake the labor work under the technical supervision of the TSB officers.

Implementation modality recommended in the Plan is a combination of simple and permanent schemes. Figure 5 shows an irrigated area extended by simple schemes on top of the irrigated area of permanent schemes.

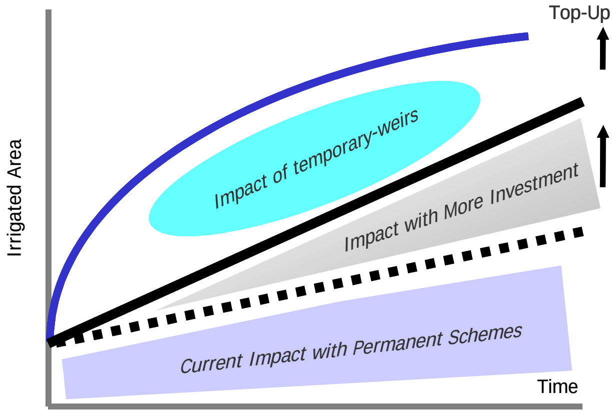


Figure 5 Implementation Modality

There is a difference in development mechanism in both schemes; development of permanent schemes comes on project-type development modality, or in other word, "construction" modality, while the development of simple schemes performs on programme-type development modality, or "extension" modality. Two modalities operate on different cadres of government officers: the former modality on TSBs, while the latter on Block or Camp Extension Officers (BEOs/CEOs). There is therefore no overlapping in the development modalities, which helps the government pursue the two schemes' development simultaneously.

The production of staple food is already sufficient to its population in the Study area. Therefore, market-oriented agriculture should be promoted rather than self-sufficiency of food crops. To this end, it is required to produce not just what farmers can produce but what the market wants. As 90% of the produces are already traded on the market according to a harvest survey carried out in the pilot project, market-oriented agriculture has much feasibility. By selling vegetables in dry season, on average 1.9 million ZMK/lima of net income can be expected, generating an enough impact for poor farmers to across the poverty line.

Low fertility of the soil is a deep seated problem in promoting crop production in the area. The area is widely covered by acidic soil called "acrisols" with average pH of sampled soil at 4.2. To cope with the unfavorable soil condition, application of organic fertilizer is recommended. Another effective countermeasure of soil problems is the application of intercropping especially with legume. Legume help improve soil fertility through nitrogen fixation.

Crop rotation is also a good method to avoid loosing particular nutritious elements in the soil and minimize the emergence of diseases. Brassica (rape, and cabbage) and Solanaceae (tomato, eggplant, and Irish potato) families are prone to the diseases caused by continued production, and thus rotation should be considered for those crops. Legume crops are highly recommended in the rotation system especially for those who cannot purchase enough amount of chemical fertilizer.

4. TARGETS, BENEFIT AND COST

4.1 Simple Scheme Dissemination

With regard to simple scheme development during Stage I project implementation period 2012 – 2015, total 2,464 sites will be undertaken in sum of the improvement and new development. Of them, total 2,313 sites are to be actually irrigated, accounting for the success rate verified by the pilot project. These sites altogether are expected to irrigate total land area of 2,862 ha, benefiting as many as 21,528 farmers. The total net profit is expected ZMK 47.804 billion (US$ 9.95 million) as aggregated value over the 4-year implementation period.

During Stage II project implementation period from 2016 – 2020 for the simple scheme, only new development is planned as it is assumed that all the exiting temporary sites can be improved during the Stage I period. Over the period of 5 years for the Stage II implementation, total 1,412 sites are to be undertaken, of which 1,271 sites are to start irrigation within the implementation period. These 1,271 sites together are to irrigate 2,094 ha, benefiting as many as 11,204 farmers. The aggregated net profit is expected to arrive at ZMK 40.636 billion (US$ 8.45 million) over the 5 years implementation period.

Programme costs for simple scheme promotion are ZMK 1.180 billion (US$ 245,491) per annum during Stage I period and another ZMK 691 million (US$ 143,809) per annum during the Stage II period. Programme costs for Stage I and Stage II are estimated ZMK 4.721 billion (US$ 981,964) and ZMK 3.457 billion (US$ 719,045) respectively, totaling ZMK 8.178 billion (US$ 1.701 million). Given the area to be irrigated by each stage, the unit development cost per hector arrives at ZMK 1.650 million (US$ 343) and ZMK 1.651 million (US$ 343) for Stage I and Stage II implantation periods respectively.

4.2 Permanent Scheme Construction

Though the basic construction modality for permanent scheme is by direct force account, engagement of civil contractor is also considered to accelerate the construction taking into account the limited staffing of TSB officers. It is targeted that throughout the Stage I and Stage II implementation periods, total 657 permanent sites are to be constructed; composed of 198 sites under direct force account and another 459 sites under contract-out-construction. With these permanent sites altogether, total 3,614 ha of farm lands are to be irrigated. Beneficiary farmers are to be counted at 19,491. The aggregated net profit arrives at ZMK 59.579 billion (US$ 12.396 million).

In developing permanent schemes, same construction quantity is assumed throughout the Stage I and Stage II. Project cost by direct-force-account is estimated total ZMK 1.425 billion (US$ 296,362) per annum, which means ZMK 5.70 billion (US$ 1.19 million) for the 4-year Stage I period and ZMK 7.125 billion (US$ 1.48 million) for the 5-year Stage II period. Average unit development cost for the 2 stages is expected ZMK 11.78 million (US$ 2,449). Project cost of contract-out-construction for permanent scheme accounts for ZMK 4.06 billion per year (US$ 843,618), totaling ZMK 16.224 billion (US$ 3.374 million) for Stage I and another ZMK 20.28 billion (US$ 4.218 million) for Stage II. Average unit development cost for the 2 stages arrives at ZMK 14.46 million (US$ 3,008) per hector.

5. Technical Package for Dissemination

This Study presents a 'Technical Package,' a set of dissemination materials. Since different cadres of offices are engaged in irrigation development, the technical package should be cascaded. The package consists of "comprehensive guideline" and "technical manual" which are in one volume. In addition, 2 kinds of leaflets and total 6 sheets of A-3 posters are included. Leaflet is meant to serve for a wide range of dissemination and to be used by frontline extension officers. The posters work as a kind of picture stories, which explain farmers the steps of, for example, how to establish a simple weir. Also, one of A-3 posters delivers a health issue whereby smallholder irrigation can contribute to improving rural population's nutrition.

■ PILOT PROJECT IMPLEMENTATION

In the pilot project, both simple irrigation schemes and permanent schemes were implemented. In 2009, the first priority was put on the simple schemes while in 2010, another scheme was added, that was an upgrade from the simple ones tried in 2009 to permanent ones: wet-masonry/concrete weirs with wider dissemination of simple schemes.

1. SIMPLE SCHEME PILOT PROJECT

Since the completion of a kick-off training carried out early in the 2009 and 2010 dry seasons, the trained officers have promoted smallholder irrigation schemes in their areas. Most of the trained CEOs implemented it by their own, while some of them sometimes waited for district TSB for backstopping. The Study Team, together with the counterparts, has followed up the implementation. The final outputs from simple scheme development are as follows:

1) During the 2-year pilot project implementation, total 95 officers, BEOs/CEOs and TSB officers, have been directly trained through the kick-off training courses, 3-day course in 2009 and 5-day course in 2010. They have also trained their colleagues mostly at the sites through Training of Trainers (TOT). Total 133 TOTs have been carried out by the officers who participated the kick-off training, wherein total 309 fellow officers were trained.
2) With regard to the improvement of existing temporary schemes, total 293 sites have been undertaken, composed of 100 sites in 2009 and 193 sites in 2010. Of the sites improved in 2010, 26 sites were newly developed in 2009. In the total of 293 improved sites, total 7,550 farmers have participated, while those who had started irrigation in the respective years were 4,393 farmers. Under the improvement category, 112 km of canal has been newly constructed composed of 27 km in 2009 and 85 km in 2010, with which there had been total 451 km of canal already existent, making the total length 563 km in the 293 sites. Those canals have newly irrigated the total area of 290 ha in addition to the original irrigated area of 354 ha, now making 644 ha.
3) With regard to new development of simple irrigation schemes, total 275 sites have been established, composed of 94 sites in 2009 and 181 sites in 2010. Of them, irrigation had started in 63 sites and 146 sites in the same year, totaling 209 sites. During the construction of these schemes, total 6,499 farmers have participated, while about one-third of the participants, 2,481 farmers, started irrigation in the same year. The total stretch of the canals arrived at 307 km in the 2-year period. Under newly developed 275 sites, farmers have opened total 366 ha of land, of which 183 ha were irrigated. In addition, another 70 ha was put under irrigation in 2010 in those sites newly established in 2009. Adding this 70 ha, there is a total area of 253 ha irrigated as of the 2010 dry season for the newly developed sites over the 2 years.
4) In sum, total 568 sites have been undertaken

during the 2-year operation, composed of improvement and new development. Of them, 527 sites have been put under irrigation by November 2010. Total 14,049 farmers have participated in the programme, creating as many as 6,874 irrigators who have actually benefited from irrigated agriculture. Total area irrigated comes to 544 ha. There was originally irrigated area for those sites improved: 354 ha in total. With this originally irrigated area of 354 ha, the total irrigated area under 527 sites comes to as much as 898 ha.

5) For the economic impact from the irrigated area, the newly irrigated area under the pilot project generated a sum of ZMK 1.069 billion in 2009 and another ZMK 2.805 billion in 2010. By the end of the 2010 agricultural season, total ZMK 3.874 billion has been generated out of the 527 sites where irrigation was already started. When considering the originally irrigated areas in those improved sites, the estimated net income comes to ZMK 2.130 billion in 2009, ZMK 4.269 billion in 2010 and ZMK 6.399 billion in the 2-year period. In US$ term, it is US$ 222,394, US$ 583,417 and US$ 805,811 respectively. When considering the originally irrigated areas, it comes to US$ 442,965, US$ 887,950 and US$ 1,330,915.

2. PERMANENT SCHEME PILOT PROJECT

One-day session in the kick-off training held in 2010 was rendered for permanent scheme construction, inviting provincial and district TSB officers only. During the session, the participants discussed and arrived at a consensus which districts should have permanent scheme construction. Eight permanent schemes were nominated for 6 districts. Following are the achievements including designed irrigated area and economic profit with regard to the permanent scheme pilot project in 2010:

1) Total 23 TSB officers, composed of 18 district TSB officers and 5 provincial TSB officers, were trained in construction of permanent schemes. With CEOs in charge of the area, they mobilized farmers and the construction had been managed under direct force account. By the end of the dry season 2010, all the 8 permanent schemes have been completed.

2) In all these 8 sites, some farm lands had been irrigated even during construction, since those sites were all upgraded from simple schemes. The total area irrigated in 2010 arrives at 27.9 ha and this is to be increased to 48.5 ha according to the design within a couple of years. There were 257 members engaged: 137 male and 120 female. A typical member irrigates 0.109 ha and it is to be increased up to 0.189 ha by design.

3) By applying a net profit of ZMK 7.128 million per hector, total 27.9 ha of irrigated area generated a net income of ZMK 199 million (US$ 41,363), and this is to be increased to ZMK 346 million (US$ 71,903) in a couple of years referring to the design. Likewise, the net average profit per irrigator arrived at ZMK 773,818 (US$ 161) in 2010 and this is to be ZMK 1.345 million (US$ 280) in years.

3. IMPACT FROM THE PILOT PROJECT

To know the impact of the pilot project, a harvest survey was carried out by questionnaire survey. Cost and gross income per lima (1/4 ha) were found at ZMK 738,000 and ZMK 2,520,000 respectively and thus net income resulted in ZMK 1,782,000 per lima as an average of major 10 types of crops. Note that this net income includes the value of what was consumed by the farmer households themselves.

It was also found that farmers cultivated an average area of 0.87 lima per household. Based on this result, an average net income per household arrives at ZMK 1.555 million[1]. Subtracting the monetary value of what were consumed by the households, disposable cash income comes to ZMK 1.291 million. The additional income of ZMK 1.555 million per household from the irrigated agriculture is commensurate to a top up of 27% to the original income (or 33% to the original income excluding the village of the biggest income level). This can be concluded as is very noticeable impact. Further, when comparing to the original income of those people ranked at 1 quartile, it can be as much as 64% increment (or 69% increment excluding the

[1] Total irrigated area for all the sites is 572ha (544ha by simple and 28ha by permanent)., and total net income is ZMK4.073 billion (ZMK3.874 billion by simple and ZMK199 million). Also, there are total 7,131 farmer beneficiaries. From this result, an overall average net income per farmer arrives at ZMK571,000, which is about one-third of the ZMK 1.555 million. The latter income, ZMK 1.555 million, came from the harvest survey which covered 27 sites, and included the original income from already existed irrigated farmlands in case of Improved Site. As well, the sites may have represented relatively better ones, as suggested by CEO in charge. Thus, the ZMK 1.555 million can be an indicator which can be achieved some time after the farmers have practiced and whereby increased irrigated agriculture.

village of the biggest income level).

Poverty Line established under the Study is ZMK 8,191,150 per typical household. The share of the poor people who cannot spend on the expenditure of this amount is defined as poverty ratio, ranging from 29.4% to 76.3% depending on the village with the overall poverty ratio of 56.2%. Poverty gap ratio is correspondent to the distance between the poverty line and the average expenditure level of those people who are below the poverty line. It means multiplying the value of poverty line by the poverty gap ratio provides the monetary value necessary for the average poor people to reach the poverty line.

Monetary value necessary to reach the poverty line ranges from ZMK 2.30 million to about ZMK 590,000 with the overall average of ZMK 1.507 million. With the expected additional income from irrigated agriculture, ZMK 1.555 million, a typical poor family of all the sampled households can now get out of the poverty, reaching to a level of ZMK 48,000 over the poverty line.

Investment in agricultural production for the next season is also an important consumption behavior of the farmers. In addition to fertilizer, which was first ranked, cost for “seed” including vegetables, rain-fed maize, and groundnuts came the fourth rank. Income is also spent for land preparation for the rain season agriculture. As a whole, frequency related to agricultural production accounted for 43%: fertilizer (23%), seeds (15%), land preparation (4%), chemicals (1%).

As for the change in use of chemical fertilizer, 300 households out of 327 households increased the use of fertilizer in the following rain-fed maize production. On average, farmers increased from 76 kg/household to 176 kg/household; 100 kg was newly added after they had started irrigation. The income from the irrigated agriculture must have contributed to this increase to a greater extent.

As above-mentioned, one of the spillover effects from irrigated agriculture is a re-investment in year round agriculture. Production of rain-fed maize has thus increased since farmers started irrigated agriculture. For an average of 373 farmers, their production of rain-fed maize has increased from 18 bags (50kg) to 31 bags per household—74% of increase. In fact, 333 farmers out of 373 experienced an increase in rain-fed maize production. Although the irrigated agriculture alone may not necessarily explain this increase, irrigated agriculture must have brought about some positive impact to this rain-fed agriculture.

■ Conclusion and Recommendations

This Study concludes that the community based smallholder irrigation (COBSI) development approach can be at the core amongst remedial measures in improving agricultural production whereby reducing poverty the people are suffering.

The Government of Zambia should therefore embark, at her own cost or together with assistance from donors, on implementing and disseminating the COBSI development program in the target 2 provinces of Northern and Luapula as well as over the Country where applicable.

Key recommendations are:

1) Smallholder irrigation development should, as far as applicable, start with simple diversion structures. So far, there was a conventional belief that irrigation was an engineer’s task. However, irrigation with the simple structures has proved that even extension officers can promote a lot. In order not to let the potential farmers wait long for irrigation, simple schemes should be tried wherever applicable.

2) Permanent structures should, in principle, be introduced by upgrading the simple structures. This upgrading approach can automatically ensure sustainability of the permanent schemes. This is simply because the beneficiary farmers for permanent structure are already used to irrigation with the simple structure. Therefore, as long as the permanent diversion structure continues functioning, the beneficiary farmers will not fail in carrying out the irrigation.

3) Irrigation development is not the end but the means to an end. For the frontline extension officers, therefore, promotion of smallholder irrigation development should always go with the encouragement of best agricultural practice. In this regard, taking agriculture as business, it is far important to address the market-oriented agriculture rather than just producing what other farmers cultivate. Diversification of crops in the area helps avert the risk of extreme price decline. Also, irrigation should be promoted as a helpful tool for farmers to fine-tune the timing of crop production.