PRELIMINARY REPORT
ON

Community Based Irrigation Management in the Tekeze Basin: *Impact Assessment*

A case study on three small-scale irrigation schemes (micro dams)

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TABLE OF CONTENTS Pages

LIST OF TABLES

Page

LIST OF FIGURES

Page

ABBREVATIONS

IWMI: International Water Management Institute

BoANR: Bureau of Agriculture and Natural Resources

Co-SAERT: Commission for Sustainable Agriculture and Environmental Rehabilitation in Tigray

REST: Relief Society of Tigray

ABSTRACT

Irrigation scheme development is on of the most commonly practiced strategy to secure food self-sufficiency in most of the developing countries. However, the development of this irrigation schemes result in a very huge loss on the environment and human health besides their benefit to the community. Therefore, it is very necessary to assess the impact of the irrigation intervention on the different members of the community. This research aims at assessing the impact of irrigation intervention on livestock production, farmers annual income, environment and health and women. These parameters will tell us a lot about the situation of the farmers' livelihood in general.

This research was conducted using a questionnaire based study system. A total of 150 farmers benefiting from irrigation schemes are interviewed using a formal questionnaire. The questionnaire includes issues on livestock, farmers' income, human health, the environment and women.

The result of the study indicates that the intervention of irrigation schemes increase the farmers annual income significantly. This enables them to feed their family more months than before. The irrigation also help the farmers to get better fodder for their livestock through increased straw and increased natural vegetation during the dry period. Besides the positives impacts of the schemes they also result in a very high environmental change; especially salinity and soil fertility decrease. Human health is also affected through increased malaria. Women benefited a lot from the schemes by producing vegetables and renting their land on the command.

To conclude, the intervention of irrigation schemes highly benefited the farmers in improving their livelihood. But the management systems are very poor so that a lot of negative environmental impacts have been observed.

1. INTRODUCTION

1.1 Back ground

In countries like Ethiopia where widespread poverty, poor health, low farm productivity and degraded natural resources are major problems the need to involve irrigated agricultural system in the agricultural practice of the country is very vital. The importance of intervening irrigated agriculture in the economy of developing countries results from the fact that rain fed agricultural system is not capable of supplying the desired amount of production to feed the increasing population. Irrigation is not needed for any inadequacy in the total supply of water by rainfall only, but because of the inadequacy of this supply at certain times of the year. This inadequacy of moisture will surely lead to the reduction of plant growth (Briggs and Courtney 1989). Therefore, irrigation is used in order to combat periods of moisture stress so as to fulfill the crop moisture requirement and increase the production. Irrigation practice is an expensive one, and in many cases can only be applied with profit to high value crops; it is also a procedure which requires careful control if adverse effects such as Salinization or soil erosion are to be avoided (Briggs and Courtney, 1989). It is obvious that for the purpose of irrigation the most important resource is water. Irrigation practice involves the management of this valuable resource. It is also well known that management becomes important when a productive resource becomes scarce; and there is hardly a situation in which this is true than in case of the water resource (Shah, Makin & Sakthivadives, 2001). Appropriate management of water resource is very crucial to get the benefit out of this valuable resource. But water management is not an end by itself, but it is a means to eradicate poverty, guarantee basic human rights to all, ensure gender equity and preserve the natural resource base for future generations (Schreiner & Van Koppen, 2001).

1.2 Types of irrigation in Tekeze Basin

Two types of irrigation are practiced in the basin

1. Full irrigation: This is a practice where the entire crop water requirement is provided by irrigation water.
2. Supplementary irrigation: is where irrigation provides only part of the crops water needs. Rain supplies the rest. For example a crop may be given a head start by sowing under irrigation a month before the rain begins, or water may be applied only during the critical crop maturing stage.

1.3 Impact of irrigation on livestock production

In the Tigray region livestock production is constrained with low productivity hampered by shortage of feed and water, prevalence of disease and low husbandry practices. Thus, the sector is contributing little to the economic well being of the community. To alleviate the situation of feed and water problem and to enable the livestock sector contribute much to the food security of the region irrigation intervention can have significant effect (REST, 1999). In places where there is high livestock population pressure resulting in grazing land encroachment, integrated forage development is necessary. In doing so grazing land enrichment, over sowing of closure areas and development of legume herbs using irrigation are practiced.

The tradition of milk production in the rural area has been eroded due to various factors. Farmers only keep local cows for oxen production, as the improved or exotic breeds require much feed. Thus milk assist the economy very little. Women are traditionally known to be engaged in dairy production and milk processing. Therefore development of animal feed means cash income generation and creation of employment for women. In this respect irrigation development has a lot to do. Irrigation development also avoids the severe conditions of water shortage for cattle.

1.4 Impact of irrigation on poverty alleviation

1.4.1-Impact on crop production

The effects of irrigation upon yields are more widely appreciated, and many studies have shown the benefits of reducing moisture stress. In general, maximum yields under irrigation require large in puts of additional water, and the marginal increase in out put are often low. In addition, irrigated crops tend to respond to increased inputs of fertilizer, especially nitrogen. Even at relatively low soil moisture, there may be marked increases in yields when fertilizers are applied, largely because the availability of moisture facilitates the uptake of nutrients. Thus, there are often benefits in irrigation in association with fertilizer applications, particularly where soils are liable to be **dry (Briggs and Couthery, 1989).**

1.4.2-Impact of Irrigation on Food insecurity

Most of the current theories on household food insecurity of many developing countries indicate that the economy of these countries is stagnating and their per capita in came is declining. One of the reasons for this is that these countries find them selves in a 'vicious circle' of poverty (low income leading them to low saving and investment, and low productivity of labor leading to house hold food insecurity.) The major factors that may contribute to house hold food insecurity are very many among these: supply, purchasing power, food transfer deficiencies, house hold composition, food performance, resource endowment, income level and access to income are those which are considered to be the main determinants.

When we look at the situation of Ethiopia, household food insecurity is widely spread and it is the fundamental cause of malnutrition in the country. Food balance sheet for the past 30 years indicated that there has been considerable slow down in production of food compared to the population growth. In the last three decades, the population has doubled. As a result, two important effects have occurred:

1. Per capita land availability has declined from year to year, which puts heavy pressure on land for human habitation and crop production, and
2. Per capita food grain production has declined, indicating lesser availability of food grains per capita.

Different studies give different reasons for the increasing trend of household food insecurity in the country one of the reasons given by Cursory (1990) as stated in Tesfay (1998) is that the current level of household food insecurity in Ethiopia is the over dependency of the farming community on erratic rain fed agriculture.

Recognizing the above-mentioned problems, the Ethiopian People's Revolutionary Democratic Front (EPRDF) led government has set national food security strategy for the country. Irrigation development constitutes one of the main strategies for solving the country's household food **insecurity (Tesfay, 1998).**

1.5 Impact of irrigation on income distribution by gender

Poor women are affected more strongly than poor men by water deprivation. Poverty critically aggravates women's workload in supplying drinking water. The burdens of the responsibility to provide the family with what it needs (food, water …etc) often falls disproportionably on women. Irrigation intervention, among other things, is one means to liberate poor women from such drudgery **(Shreiner and VanKoppen, 2001).**

Redressing gender inequalities in the productive water sector is important to improve incomes of both women and men, rather than continuing to ignore women's income needs. Among the poor, the incomes of both men and women are required to meet basic family needs. In households where women and men are responsible for different household needs, both type of need must be met. Women's income, however, benefits the family relatively more than men's because, reportedly, women spend higher proportion of their incomes on family expenditure than men do (Agrawal, 1994 as sited in Schreiner and Van koppen, 2001). Women's income is the major source of income in female-headed

households. Making poor women independent economically is critical factor that lead to reduction in fertility rates at micro level.

In the case of irrigation women's need as producers were usually ignored the allocation of newly developed irrigation schemes, accompanying agricultural inputs, training and marketing services are usually men focused. Male and female managed cropping unites co-exist especially in many ethnic groups in sub-Saharan Africa. In areas where men go for off farm employment and a lot is to be done on the irrigated fields, farming activities often become the free time activity for women.

1.6 Irrigation development in Tigray

Farmers in Tigray have been producing different crops under traditional irrigation since a long time. The diversion of perennial streams using temporary diversion structures during the dry season has been the major means of irrigation. In addition flood spreading using run off water form higher altitudes and upper catchment-areas is also practiced. Erratic rainfall in the region over the past years has resulted wide spread crop failure and has brought a growing awareness of the importance of irrigation. Therefore, small-scale irrigation development for food production became of primary interest in Tigray in view of the recurrent drought and famine condition experienced during the 1970's and1980's. The previous military government after 1984/85-famine period started the development of these small-scale irrigation schemes. The aim was to boost food production and achieve food self-sufficiency. From that time onwards, modern irrigation practices have been developed in Tigray.

So far irrigated agriculture play very small role in the Tigray's agricultural economy. Of the estimated 1.2 million ha of arable land, 99.5 percent is under rain fed cultivation (BoANR, 1998). Since 1995 the regional government has started massive irrigation development with a major objective of mitigating the problems of recurrent drought and minimizing the prevailing heavily dependence on rain feed agriculture mainly through irrigation developments in order to gradually attain household food security of the people of Tigray (Tesfay, 1998).

1.7 Problem statement and Justification

One of the drought prone areas in Ethiopia is the Tekeze basin. The existing perennial streams in the basin are not dependable sources of irrigation water due to their limitations in their number and flow rate. Thus, harvesting of the seasonal surface run off is the strategic option to promote irrigated agriculture in the basin (USDP/FAO/ECA, 1994). By so doing, it is aimed to improve livelihood of farmers with gender equity and to establish better food security level. In view of this, recently built small micro earth dams and ponds provide supplementary irrigation and supply water for both livestock and people. In the period between 1996 and 2001, 46 reservoir dams with a cumulative storage capacity and irrigable area of 46.91 million cubic meter and 3115 ha, respectively, have been constructed (COSARET, 2001).. However, the performance of these small earth dams is diminishing due to seepage, poor irrigation management and failure to harvest the designed runoff**.** As a result, part of the command-area remains un irrigated.

The main problem associated with irrigation in the basin include: early sedimentation of reservoirs, failure to harvest the designed run off, under utilization of all the harvested water in the dams due to under estimation of water use efficiency, poor agronomic practices, soil Salinization, failure to prescribe important soil and water conservation measures in the catchments of the dams and increased malaria and other water borne diseases. In the Tekeze basin, like other places in Tigray, feed and water shortage is major constraint for livestock production. To mitigate this problem irrigation is taken as one measure. Therefore, it is very necessary to assess the impact of small-scale water harvesting mechanisms in order to understand the potentials and risks associated with further water collection, storage and irrigation practices.

1.8 Objective of the study

The general objective of this study is to assess the impact of irrigation scheme development on the livelihood of the farmers. The study also has the following specific objectives:

To assess the impact of irrigation scheme development on-

- Livestock production
- Farmers' annual income
- Income distribution by gender
- Human health and the environment

2. MATERIALS AND METHODS

2.1 Description of the study area

This research is conducted on three small micro earth dams (Korir, La'elay wukro, and Mai-Nigus) ,which are considered to the representative of the Tekeze basin. The brief area description of each dam is presented below.

2.1.1 La'elay Wukro Dam

Location and physiography

This study area is found in the eastern zone of Tigray region Wukro wereda, Adikisanded tabia and La'ilay wukro kushet. It is located at 13°47' N latitude and 39°36' E longitude. It is 1.5 Km north east of Wukro town which is found about 45 Km north of the regional capital Mekelle. The average altitude of the area is about 2000m a.m.s.l.

The topography of the area is not uniform. The catchment area consists of mountainous terrain and gentle slope. The mountain portion is covered with scattered bush and grass while the gentle slope is serving as agricultural land. The command is more or less flat it is of about 2-4% slope and suitable for agriculture.

Geology and Soil

The soils of this site are of alluvial origin (fluvisol) and the parent material is sand stone. It is gradually transported from the surrounding mountainous area. Besides the fluvisols there is also some part that is covered with vertisol (BoANR).

Climate

The area has a monomodal rainfall pattern that the main rainy season is during summer from June to August. The remaining months are dry. The "belg" season in the area is from December to May with an average rainfall of 53.3mm and the "meker" season is June to November with an average rainfall of 457mm.The area is found on the dry "woynadega" agro ecological zone with a mean annual rainfall of 510mm. The temperature and rainfall data was obtained from Wukro meteorological station and it is shown in the following table.

Table 2.1 Climatic data of La'elay Wukro and Korir area

	Months											
	J	F	M	A	M	J	Jy	A	S	O	N	D
Rainfall (mm)	1.43	4.19	9.12	21.4	21.38	22.26	214.4	207.87	54.91	3.05	7.53	2.87
Max.temp. (°C)	16.6	17.5	18.9	20.1	20.6	20.8	18.2	17.7	18.3	18.1	16.7	15.9
Min.temp. (°C)	9.45	10.4	12.0	13.4	14.1	13.8	12.9	12.6	11.8	11.6	10.3	8.9

Source Co-SAERT 1997.

Vegetation

The study area has been degrading for long time. Now the soils in the area are exposed largely. The vegetation of the area is largely of bushes, which include Acacia spp and Euphorbia spp.

Land use

Rain fed crop production is the common land use practice in the site.

Table 2.2 Land use and sizes for La'ilay wukro irrigation scheme

Land uses		Size (ha.)
Cultivated land	**Rain fed**	**110**
	Irrigation	**51**
Vegetation	**Natural**	
	Afforestation	
Grazing land		**4**
Wasteland and infrastructure		**4**
Total		**169**

Source: Co-SAERT 1996

2.1.2 Korir dam

Location and physiography

This study area is found in the eastern zone of Tigray region Wukro wereda, Korir tabia and Korir kushet. It is located at 13°47' N latitude and 39°36' E longitude. It is 6 Km south of Wukro town which is found about 45 Km north of the regional capital Mekelle. The average altitude of the area is about 2000m a.m.s.l.

Geology and soil
The soils of Korir area are developed through the process of transportation from weathered limestone rocks. Soils in the catchments are developed on the limestone rock, and they are of shallow depth and rock outcrops appear with steeply slopes. Soils on the reservoir and command area are found with heterogeneous properties of clayey, silty and sandy colluvio- fluviate sediments washed down from the high lands. They include the most fertile vertisol and fluvisols (BoANR).

Climate
The area has similar climatic condition as that of La'ilay wukro area.

Vegetation
Shrubs and grasses dominate the area. The common plants are acacia spp.

2.1.3 Mai-Nigus Dam

Location and physiography
The study area is found in the central zone of Tigray region, La'elay Maichew Woreda, Dura tabia, and Dura kushet. It lies between latitudes of 14°07'00" and 14°09'20"N and 38°38'00" and 38°49'09"E longitude about 7km, west of Axum town. The elevation of the area ranges from 1650 to 2500m above sea level.

The topography of the area is not uniform. The catchment area consists of mountainous terrain and gentle slope, and considerably plain and hilly slopes. The mountainous portion is covered with scattered to good cover of bushes, while the gentle and hilly slope areas are mainly managed for agricultural lands and covered only to some extent. The command area is a flat land with a slope range of 1-3%. Therefore, it is suitable for mechanization and farm developments. There are no gullies observed within the command area except the main gully cut passing through it.

Geology and soils
The geology of the Mai-Nigus area is composed of uniform litho logy of igneous rock, which is granite. The dominant soil types of the study area are locally known as mehkaye, baekel, and walka. Farmers classify the soil types

straightforward, suggesting that the local soil classification is well correlated with fertility and productivity in the way they perceive it. The resulting ranking runs from: baekel (less fertile) < mekayih <walka (most fertile).

Climate

The area has a monomodal rainfall pattern with the main rainy season being during the summer from June to August. The remaining months are dry. It has mean annual rainfall of 662.7mm. It is found in the "woynadega" agro ecological zone. The meteorological data for temperature and rainfall is collected from different sources. The temperature data was collected from Seleklaka station and the rainfall data from Axum.

	Months											
	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	6.7	3.1	17.9	27.6	25.5	60.6	227.7	221.3	47.4	14.8	14.8	1.3
Max.Temp. (°c)	27.3	28.2	28.8	29.2	28.8	27.8	22.1	23.7	25.3	27	27	26.8
Min.Temp. (°c)	8.7	10.0	11.6	12.2	12.3	11.0	11.0	10.6	9.4	10.1	10.1	8.2

Table 2.3 The monthly rainfall and T° averages in Mai-Nigus area

Farming system and population

Farming system under rain fed agriculture

This area has mixed (crop and livestock) farming system, with emphasis on subsistence crop production. Rainfall is the most determinant environmental yield factor under dry farming conditions in the area and influences largely the cropping pattern. As it is largely determined by rainfall pattern cropping calendar is not fixed. During 'belg' or 'azmera' the rains are very rare. Therefore, farmers mostly use these rains for land preparation. 'Kiremti' is the main rainy season. Most of crops grown during this season are cereal crops such as teff (common), barley, wheat, maize, millet (rare). Legumes are also grown. Crops are harvested starting from mid October.

Farming system under irrigated agriculture

As farmers can grow crops twice in the irrigation sites a year, they have to prepare two different seedbeds relatively in short period of time. Most farmers

start with seedbed preparation for the irrigated crops in the early December. By the end of December or the first weak of January, all tillage operations for the irrigated crops are completed. The crops grown in the irrigated site are maize, onion, tomato, green pepper, Swiss chard, spices, carrot, chickpea, cabbage and potato. The first four are the major crops and their yield varies from year to year (table 3.4)

Table 2.4 Major crops yield at different year

Year	Crop types (Q/ha.)			
	Maize	Tomato	Onion	Green pepper
1997	69	161	92.5	75
1998	65.5	234	256	211
1999	80	198	160	126
2000	66.5	190	217.5	72
2001	63	187.5	135	64

Source: BoANR of the Wereda.

Catchment and command areas

The catchment covers a total area of 13.05km^2. The dominant soil type in this area is light clay soil. The area starting from the lower right end of the catchment and up to the central periphery of it is dominated by clay loam, with a dominant soil depth of < 25cm and reddish dominant soil color. This has a scattered to good vegetation cover of bushes and to some extent agricultural lands. The area which is found at the lower and upper central part of the catchment which continues up to the upper central end of the catchment has dominantly silt loam soil, with a soil depth of > 150cm and with a brown dominant soil color. This portion of the catchment is mainly put under agricultural practices and considerably under grazing land.

The command area is highly suitable with rational water management and agronomic practices. Since the ground water table is observed at about 1m depth

where the land is frequently irrigated and rarely at about 2m depth on other farms, there may be water logging problem if there is no good management of irrigation water. The dam can hold about 2.38 million m^3 of water to a height of 21m and can irrigate 123.9ha. of land under full season irrigation. But the area that can be irrigated depends on the amount of water stored during summer season. The areas that were irrigated by irrigation project starting from 1997 to 2002 are shown in table 3.4.

Table 2.5 Area under irrigation at different years

Year	1997	1998	1999	2000	2001	2002
Area under irrigation (ha)	10	40	91	108	79	109.3

Source: BOANR of the Woreda

Vegetation

Since the study area has been exposed to long time degradation, it is now seen largely bare and so the soil is exposed to the direct impact of raindrops. The vegetation of the area is largely composed of scattered bushes of *Cassia siamea* (yeferenge-digita) and *Maytenus arbutifolia* (Atat) and scattered to good cover of *Carrisa edulis* (Agam) and *Euphorbia spp.* (Kulkual). There are also few trees like *Eucalyptus camaldulensis*, *Dodonaea angustifolia*, *Accacia spp.*, *Euclea shimperi*, and *Azaderacta indica*. Considerably large area of the bush land, especially where 'Agam' and 'Kulkual' are dominant is under area closure in which the bushes are having good recovery

2.2 Methodology

2.2.1 Site selection

The sites for the study are selected based on factors such as size, accessibility, age of the scheme, availability of secondary data, access to market and other socio-economic criteria with in the basin.

2.2.2Data collection

The data for the study was collected from primary as well as secondary sources. The primary data was obtained from a formal household questionnaire survey, key informant discussion and direct observation. The secondary data was obtained from the Bureau of Agriculture and Natural Resources and published literatures.

A questionnaire was developed on the basis of the research objective. The questionnaire generally included questions that indicate the impact of irrigation development on livestock production, human health and environment, poverty alleviation and income distribution by gender, which generally serves as indicators for the impact of the irrigation scheme development on farmers' livelihood. (the questions are put in the index)

For the study a total of 150 farmers had been interviewed from the three irrigation schemes. In between some general information of the schemes and socio-economic conditions of the community were obtained through key informant discussions at site level. In the discussion community leaders, extension agents and knowledgeable farmers had participated. The community irrigation managers were also interviewed for more information.

2.2.3 Data analysis

In assessing irrigation development project the following welfare aims are more directly affected. (1) Food production (2) Livestock production (3) Environmental condition (4) Human heath. Therefore, measuring the impact of irrigation development on the household income, the observed environmental change, the condition of livestock in relation to production and number as well as food self sufficiency situation is related to the extent to which it promotes the above-mentioned aims.

To measure the impact of the irrigation development one of the project evaluation method, which is “before and after project” was used. Here the basic assumption is that household conditions are more or less similar in all socioeconomic parameters that can make differences in welfare or food security in between the times. To estimate the positive and negative impacts of the irrigation schemes a total of 150 farmers who are benefiting from the irrigation schemes were interviewed.

Qualitative data was analyzed by frequency count and it is presented using descriptive statistics such as percentages, means, graphs and tables.To assess the impact of the irrigation development on household food sufficiency food security index is calculated. In determining food security index the length of the average number of months of food shortage per household was the base for the calculation. The formula is:

$$Fi = 100^{*} (So - St) / 12 \text{ month}$$

Where, Fi = food security index

So = average length of food shortage periods before the development of the scheme

St = average length of food shortage periods after the development of the scheme (Tesfay, 1999).

3.RESULTS AND DISCUSSION

3.1 Basic household data

A total of 150 families who occupy land with in the proposed three irrigation schemes were interviewed,50 from each scheme. These families are chosen randomly from the total users of the irrigation schemes but taking only those families who are involved before and after the scheme development.

Family heads

Table 3.1 Family heads

Name of scheme	**Family heads**	
	Male headed	***Female headed***
Korrir	45	5
La'ilay wukro	38	12
Ma'y nigus	44	6

In three of the micro dams most of the interviewed families were male headed. As it is shown in the table, of the total of the 150 interviewee only 23 of them are female headed. According to the discussions made with some community elders mostly females get title or become a head of a family when their husband die or when they are divorced.

Household size

Family size is an important factor in determining the extent to which labor is available. It is assumed that the larger the size of the household, the more is the availability of labor for production purposes. Household size is also important in

relation to food self-sufficiency with in a family because those that have larger number of families are not able to feed their family with a very small land owned with in the irrigation scheme. The average family size of the three schemes is almost the same.

Table 3.2 Average household sizes

Name of scheme	**Household size**			
	Male		***Female***	
	Number	Percentage	Number	Percentage
Korrir	2	40	3	60
La'ilay wukro	3	60	2	40
Ma'y nigus	3	50	3	50

3.2 Impact of the Irrigation Schemes on livestock production

Small Scale subsistence crop and livestock production is the principal farming system in the study sites. Farmers use low yielding crop varieties and animal breeds in three of the irrigation schemes. It is obvious that livestock are an important asset in many parts of the country. Livestock plays an important role in the economy and oxen are the only source of draft power for plowing. Hence, most of the interviewed farmers own livestock before as well as after the irrigation scheme development. The gross livestock population for the selected sample size before and after the irrigation intervention is presented in table below.

Table 3.3 Gross livestock population for selected sample size before and after the development of the irrigation scheme

Livestock type	Name of scheme								
	Korir			**La'ilay wukro**			**Mai nigus**		
	Before	***After***	Increment (%)	***Before***	***After***	Increment (%)	***Before***	***After***	Increment (%)
Cattle	134	148	10.5	171	138	-19	196	157	-20
Sheep	0	0	0	58	10	-83	25	30	20
Goat	40	17	-57	65	11	-83	34	32	6
Horse	0	0	0	0	0	0	0	0	0
Mule	60	4	-93	0	0	0	0	0	0
Donkey	37	41	11	31	41	32	53	42	-21
Camel	2	1	50	0	0	0	0	0	0
Chicken	44	67	52	13	20	54	174	147	-15..5
Honey bee	4	38	850	0	0	0	0	0	0

NOTE: Negative sign indicates reduction in population of that specific animal

A significant change is observed in number of mules in korir dam after the development of the scheme. This is mainly the change of their living style from bringing salt from the Afar region, which is common alternative to the area to farming practice using irrigation. Therefore, after the start of the scheme the mules may not be as such important. There is also a significant change in number of sheep and goats in Lailay Wukro. The reason for this is probably shortage of grazing land due to inundation of the former grazing land by the reservoir and military settlement, In addition to this they invest their labor on irrigation practice. Other important thing is the huge increment in number of beehive. This is mainly associated with the expansion of irrigation so that ample of food is availabe to the bee, because of this they harvest a significant amount of honey. To conclude the development of irrigation scheme in the basin has a net positive impact in livestock production

Source of Water

The most important problems of livestock production in many parts of Ethiopia are shortage of food and water. The development of modern water harvesting like building of dams usually helps in mitigating the water shortage problem**.** In the case of the study sites, all of them have perennial water sources near to the villages. Consequently, the livestock drinks from either source depending on its relative proximity to the owning household. Only few of the farmers interviewed in each schemes use the dam as a source of water for their livestock

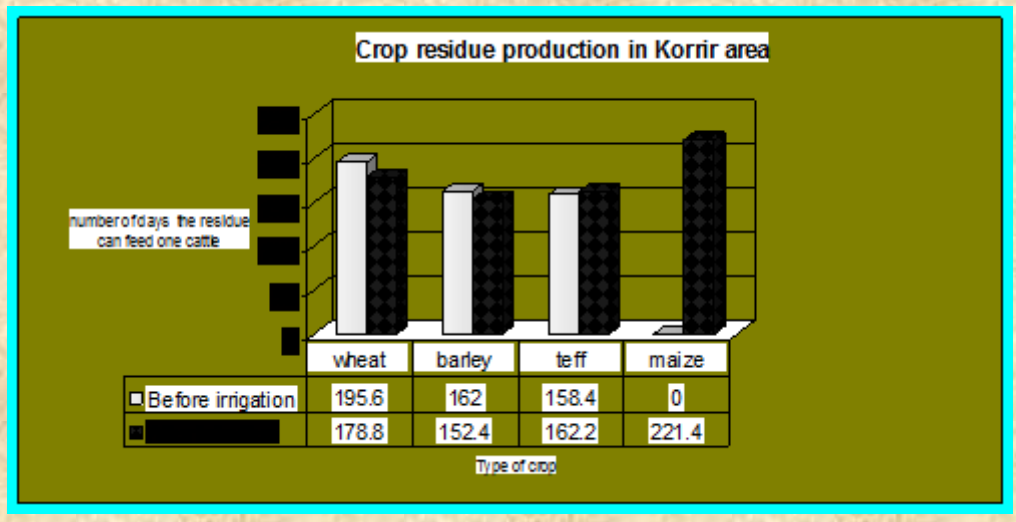
Source of Forage

The livestock population in the study sites seems much higher than the carrying capacity of the grazing lands. Thus, livestock has to depend heavily on stubble grazing and crop residue. Almost all of the respondents from the three irrigation schemes use crop residue and communal grazing land even though the reliability on the communal grazing land is minimum. 90%, 92% and100% of the respondents from Korrir, La'ilay wukro, and Ma'y nigus irrigation scheme respectively responded that the start of the irrigation has helped them to get better fodder. This happens in three ways in all of the schemes.

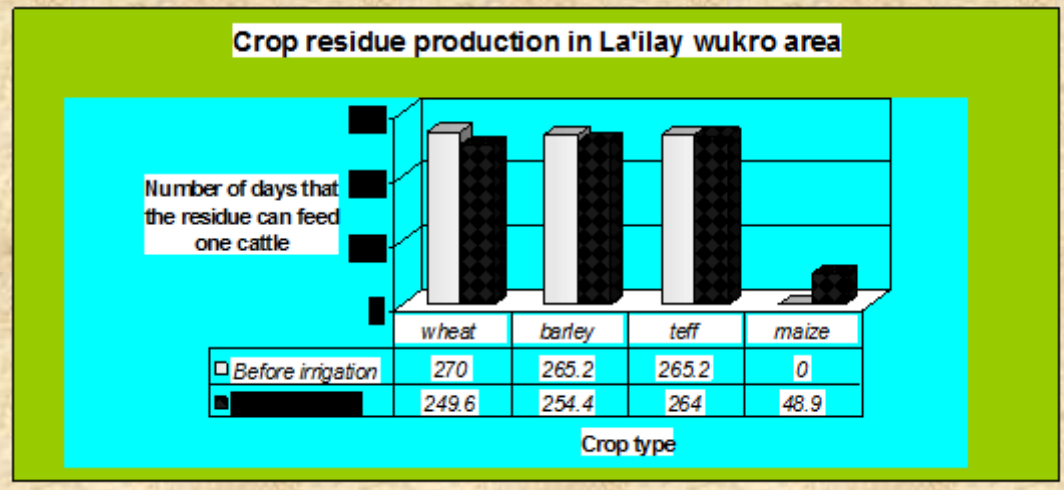
1) Farmers produce twice a year after the start of irrigation, hence, the crop residue obtained is higher than before.

2) 82%, 26% and 56% of the respondent farmers from Korrir, La'ilay wukro and Ma'y nigus respectively responded that the irrigation scheme helps them to produce fodder crops for their livestock. Elephant grass, alfalfa, susbania and lueceania are the common fodder plants produced.

3) The increased natural vegetation around the irrigated fields (near the canals) is source of fresh feed in the dry seasons.



As it is displayed by the graph maize production was not common before the introduction of irrigation and the crop residue wheat, barely ,and teff is also reduced. This is mainly the transfer of the land to the production of maize and other horticultural practices. Generally there is a net increment in forage production after the development of the scheme.



As it is shown in the graph there is a slight net increment in forage production. This is mainly the introduction of tomato, potato and vegetables, which have less contribution for dry forages instead of cereal crops.

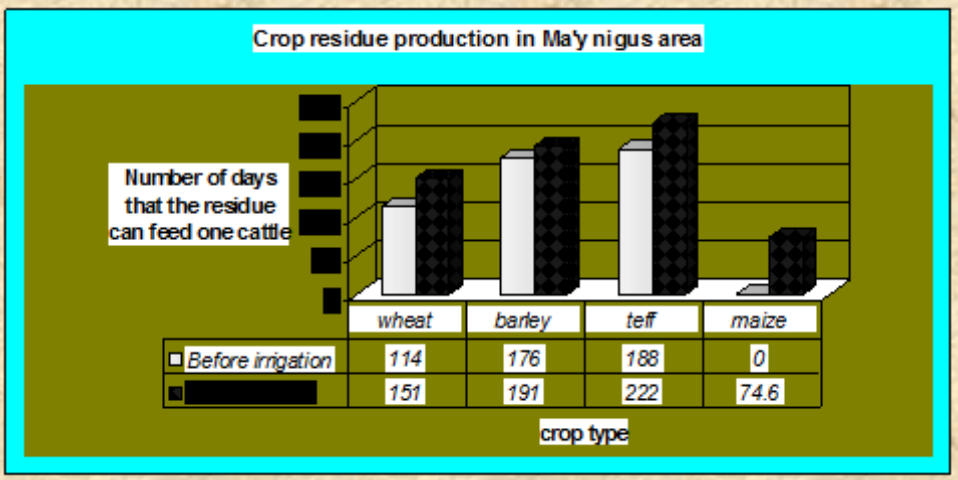


Figure 3.1.a,3.1.b,3.1.c. Crop residue produced from commonly grown crops in the study areas before and after the development of the scheme.

It is clearly shown that there is a large increment in forage production. And this depicts that the farmers are still producing cereal crops using irrigation .This is due to less market price during mass production of horticultural products.So farmers tendency to wards horticultural production is less as compared to other two dams, which are at relatively shortest distance from Mekelle.

The increase in the amount of produced fodder has resulted in increase of milk and meat production of livestock. The respondents claim that even though animal production has increased yet it isn't satisfactory. The reason behind is that the breeds owned by almost all of the farmers are local ones. In the Korir area 54% of the respondents have got their cattle number increasing while only 30% and 24% of the respondents from La'elay Wukro and Mai-Nigus schemes respectively responded that their livestock number is increasing after the start of irrigation. The reason for the decrease in the livestock in Mai-Nigus and La'elay Wukro irrigation schemes is similar. The main factors are repeatedly occurring draught that has been causing great loses, shortage of grazing land, particularly in Mai-Nigus and La'elay Wukro areas. In the former, establishment of area of enclosures besides to that lost to command area causes the shortage. In the latter, the present day command was grazing area while the inundated area was rain-fed cropland before the irrigation scheme development. In addition, the problem of grazing land shortage in this area is aggravated after a considerably large area is taken for military training, Some attitudinal change in understanding of the

farmers in preferring few with better quality than many with low and poor management, and lack of money to buy more livestock

The respondents were asked to mention the major problems of livestock production on the areas. According to their response the major problems are shortage of grazing land, drought and lack of money. And the farmers are asked to state the problems which hinder the production of livestock accordingly the results of the responses are presented in percentage in the following graphs.

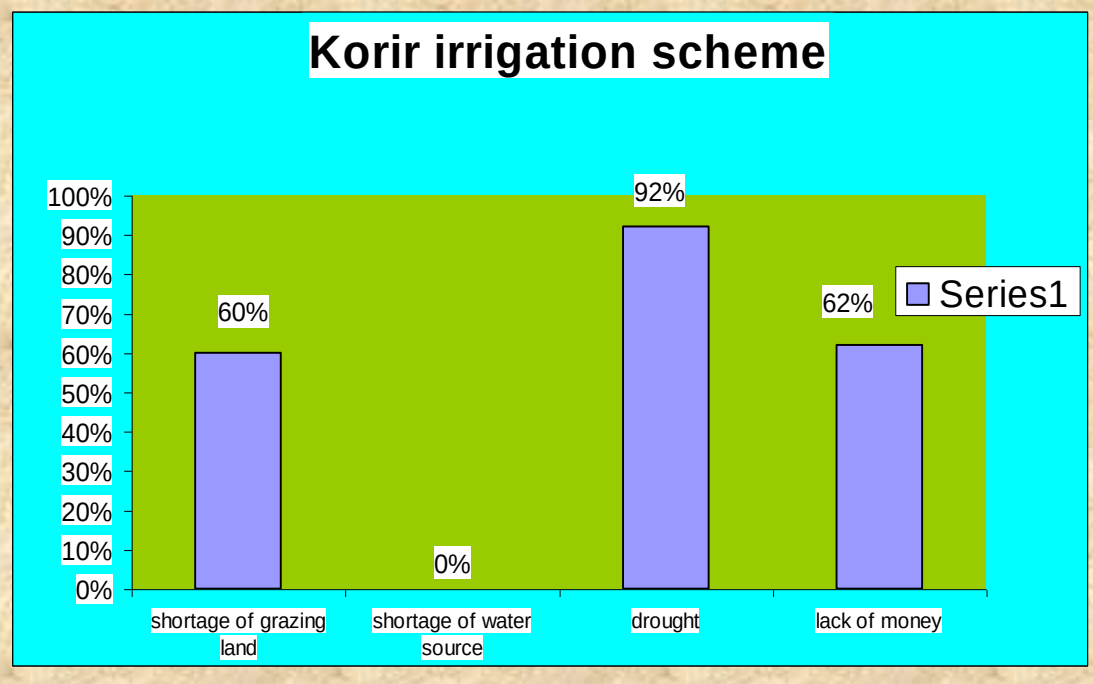


Figure 3.2a. Problems for livestock production in korir area

As the graph indicates drought is considered as a problem in livestock production by 92% of the farmers, lack of money by 62% of the farmers and shortage of grazing land by 60% of the farmers. However, any farmer in this specific site in production of livestock does not mention shortage of water as a problem. Since drought is well thought-out as major problem, the expansion of irrigation schemes will have a significant role in combating the problem.

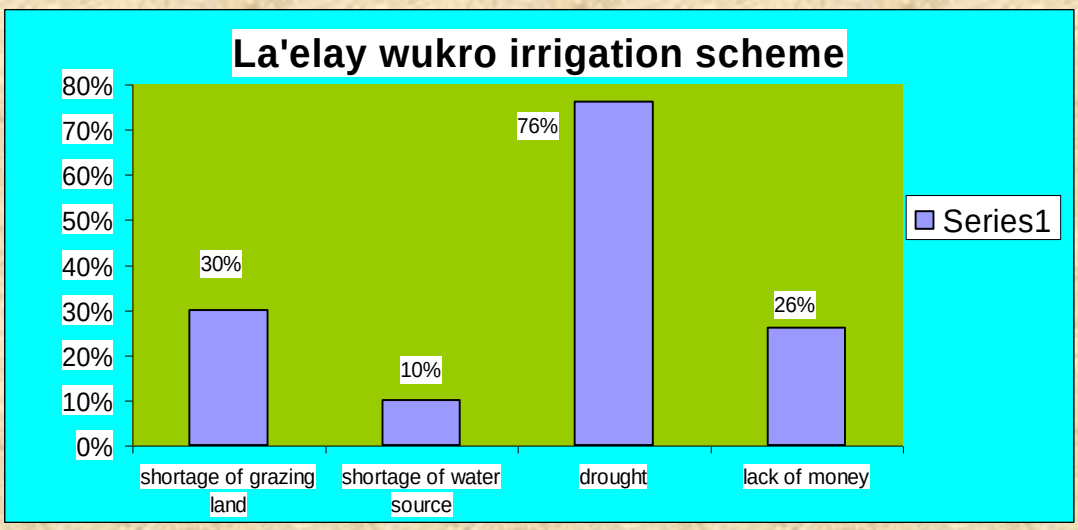


Figure 3.2b. Problems for livestock production in La'ilay wukro area

As the graph indicates drought is considered as a problem in livestock production by 76% of the farmers, shortage of grazing land by 30% of the farmers, lack of money by 26% of the farmers and shortage of water is also considered by10%of the farmers as a problem in production of livestock. Similar to korir, drought is again mentioned in this site as a major problem. Therefore, the expansion of irrigation will have a great share in alleviating the problem.

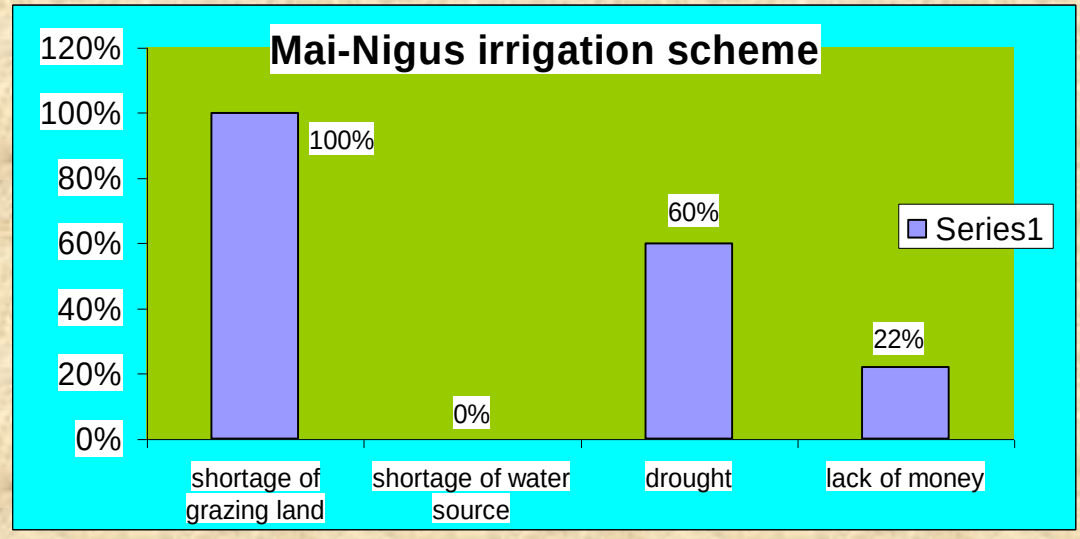


Figure 3.2c. Problems for livestock production in Ma'y nigus area

As the graph indicates shortage of grazing is considered as a problem in livestock production by 100% of the farmers, drought by 60% of the farmers and lack of money land by 22% of the farmers. However, any farmer in this specific

site in production of livestock does not mention shortage of water as a problem. Since shortage of grazing land is well thought-out as a problem and its main purpose to provide feed for animals. The expansion of irrigation will be come one of the priorities in production of forage for livestock. Like production of alfa alfa and other forage grasses.

There are no indications that the intervention of irrigation has introduced animal disease. the table below shows the common diseases that affect or mostly occur in the study areas.

Table 3.4 Common livestock diseases in the irrigation schemes

Type of disease		**Livestock attacked**
English name	***Local name***	
Pastrolosis	Tafia	All
Black leg	Ha'lafe	Cattle
Anthrax	Megerem	All
Lamp skin disease	Hich lam	All

Source (BoANR)

Even if the intervention didn't result in any diseases, according to the La'ilay Maichew wereda's Bureau of Agriculture and Natural Resources, the change in the environment has caused a decrease in the production of newly introduced high yielding goat breeds which were brought for the environmental condition with out the project, there is no concrete evidence for this it may be a coincidence .

In the Korrir irrigation scheme, another advantage obtained from the irrigation development is honey production. One of the reasons to this advancement is the increase in productivity of bees. This happens because flower from crops in the irrigated fields is abundant when getting flowers in the surrounding is mere a dream. Considering this situation, modern honeybee hives are being used after the start of the irrigation. In contrary to this, the problem of pesticides used in the irrigated fields is causing hindrance to this advancement.

3.3 Impact of The Irrigation Schemes on livelihood of the farmers

The main objective of any irrigation scheme development is to increase production by supplementing the rain fed production and\or by enabling farmers to grow crops twice in a year. All of the respondents in all of the study sites produce crops two times a year after the start of irrigation. Previously they used to grow crops only once a year. The commonly grown crops in the study sites are presented in the table below.

Table 5.5 Commonly grown crops in the study sites

Name of irrigation scheme					
Korrir		***La'ilay wukro***		***Ma'y nigus***	
Summer	***Winter***	***Summer***	***Winter***	***Summer***	***Winter***
Barley	Tomato	Barley	Tomato	Bean	Tomato
Wheat	Onion	Wheat	Onion	Wheat	Onion
Teff	Pepper	Teff	Pepper	Teff	Pepper
Finguremillet	Maize	Finguremillet	Maize	Finguremillet	Maize

Source (BoANR)

Agriculture is not only the main activity in the study areas it is also the major source of cash income for the majority of the population. Household gross income for this study was estimated as the sum of all income obtained from crop production (consumed and sold amount), livestock production, off-farm employment and other sources such as remittance. Since market prices for the different crops varies through out the year the monthly based market prices were averaged to obtain the average market prices for the years before and after the start of irrigation. (Secondary data from BoANR is used). The major sources of household income of the respondents are shown in the figures below.

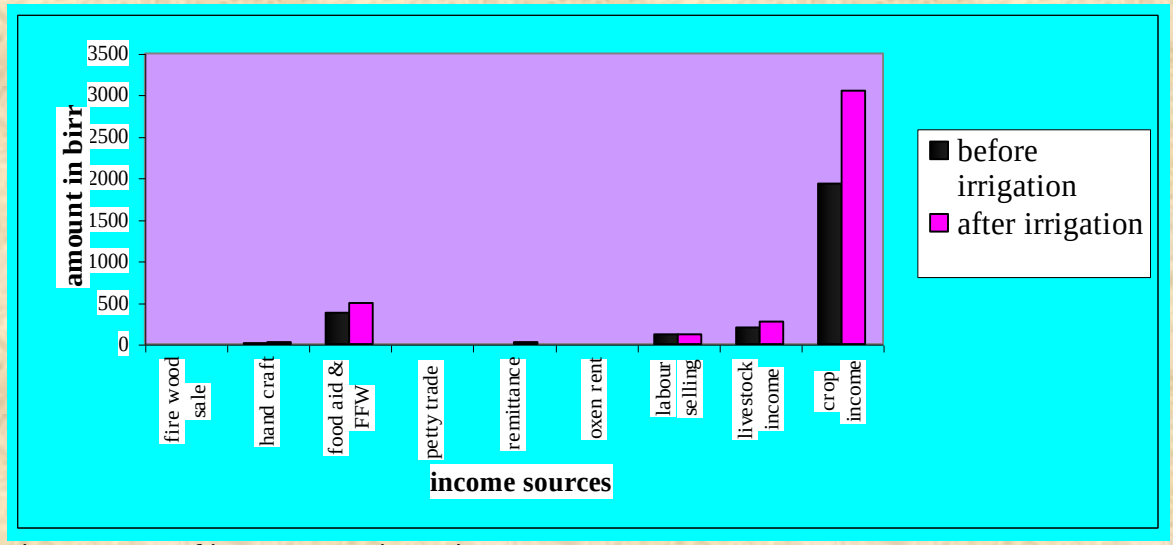


Figure3.3a Annual income sources in Korrir area *(three years are used for both cases)*

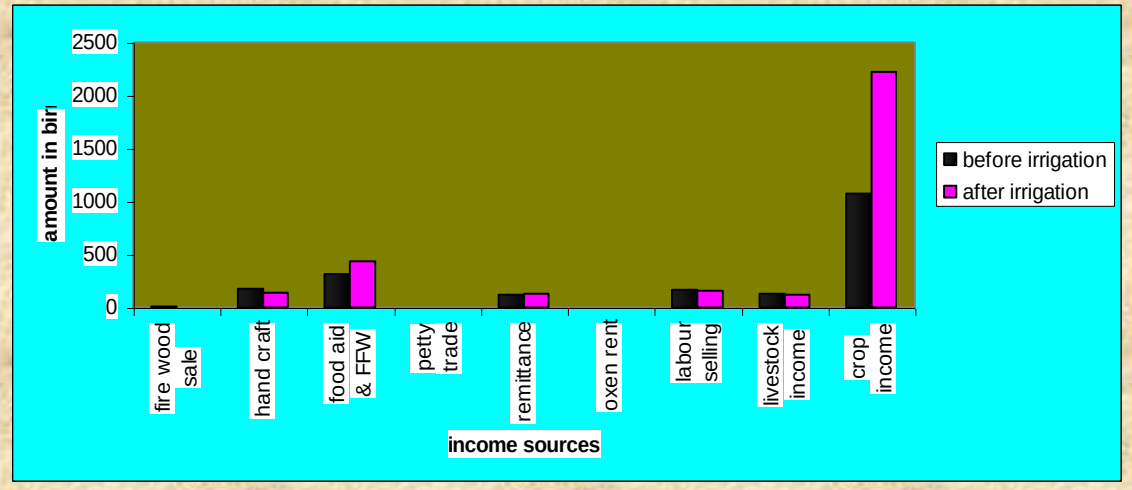


Figure3.3b Annual income sources in La'ilay wukro area

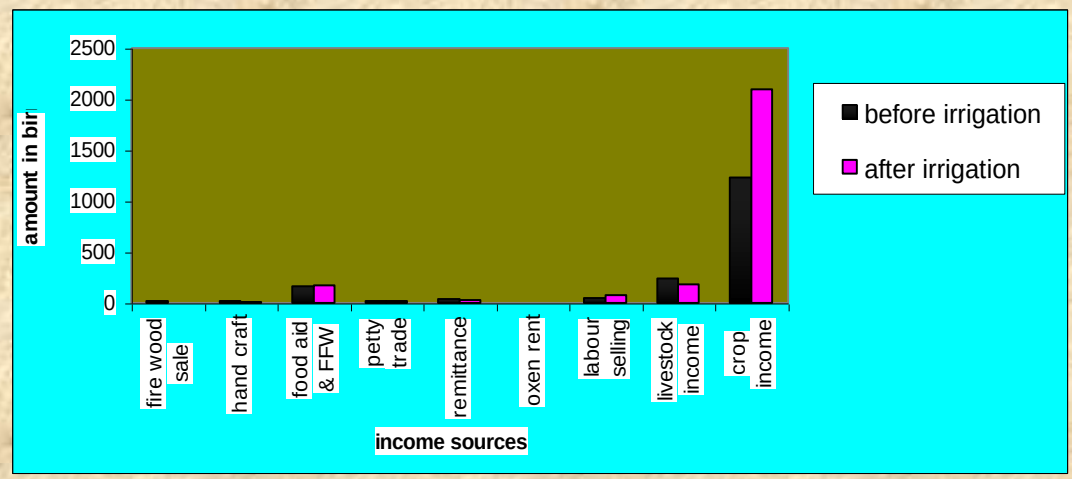


Figure3.3c Annual income sources in Ma'y nigus area

The results show that the respondents have greater income from crop production and food aid & food for work.

Household income distribution

One of the main indicators for the severity of household poverty is distribution of income across household members of the community. After the start of irrigation the income of 36%, 44% and 44% of the farmers in the sites of Korir, La'ilay wukro and Ma'y nigus respectively was found to be greater than the average for their group.

Average annual income (birr)			Differences
	Before	After	
Korir	2638	3975	1337
La'ilay wukro	1991	3199	1208
Ma'y nigus	1794	2600	806

	Minimum annual income		Maximum annual income	
	Before	After	Before	After
Korir	800	983	5080	9326

La'ilay wukro	526	1273	8880	10800
Ma'y nigus	953	1243	3180	6500

Tables 3.6 & 3.7 income distributions

When inter site comparison is made, the minimum and maximum average annual income for the sites were birr 1794 from Ma'y nigus and birr 2638 from Korir before scheme development. Similarly, 2600 from Ma'y nigus was found to be the minimum average annual income after the start of irrigation. The maximum was that of the Korir area which is birr 3975.

Though a household's income level is determined mainly by the household's access to resources such as capital, land and labor other factors such as agricultural management skills, agricultural extension supports, age and sex of household head are also very important (Tesfay, 1999). The results seem to show that farmers in Korir area have obtained the highest benefit from irrigation while those in Ma'y nigus area obtained the least. The differences may be due to the factors stated by the author above and better market area(mekelle). The farmers participated in the informant discussion share the same idea. As stated the problem of getting lesser benefit from irrigation is not only due to shortage of land, capital, labor and water but also lack of management skill and low market price. The age of the irrigation scheme may also have contribution to the observed differences; the older the scheme the more the users become experienced and the more the income obtained from perennial crops (fruit, fodder) would be. Or the longer the age the more seriously the area affected negatively (salinized, fertility decreased, canal capacity destroyed by siltation) and hence the more production affected.

Food insecurity

The major aim of any development intervention in a country is to be able to fulfill the necessary requirements of its population. Among those requirements, food is the major of all. In alleviating the problem of food insecurity one major thing to do is making sure that every house hold has the capacity of either producing or

purchasing its food requirement. In the attempt to meet this goal, irrigation scheme development is one of the major strategies used as a tool. As to the investigations done on three of the study sites most of the interviewed households are not able to feed them selves for the whole year even after the development of the irrigation schemes. This is due to low production obtained from irrigation, smallness of land holding which is really unlikely to feed average of six people per household, shortage of water for irrigation, and the like. The average food self sufficiency months for each of the dams are as follows

Name of scheme	**Average months of food self-sufficiency**	
	Before irrigation	***After irrigation***
Korrir	5	7
La'ilay wukro	5	9
Ma'y nigus	7	9

Table 4.6 Average months of food self- sufficiency before and after the irrigation development in the study sites

As it can be seen from the table, even if the farmers are not food self sufficient after the irrigation development, most of them feed themselves longer than before. The food security indexes for the three dams was calculated considering that the food shortage months average before the irrigation scheme development as 0%. The food security index for the three dams is as follows Korrir = 17%, La'ilay wukro =33% and Ma'y nigus = 17%. High percentage of food security index indicates high level of reduction in months of food shortage and low percentage of food security index indicates no change in the length of food shortage period after the intervention of the irrigation projects.

Growing food crops versus cash crops

The high investment costs involved in irrigation influence planners (government and NGO's) to work under pressure of economic criteria. Smallness of the land in the irrigated farming (0.2 ha average) compels farmers to concentrate on cash crops particularly vegetables; tomato, pepper, onion, cauliflower, cabbage etc (in the farmers' order of preference). Since producing food crops in such a small parcel is of very low return almost all, (98%) and 100% of the respondents in the Korrir and Ma'y nigus areas respectively prefer to produce cash crops. About 70%

of the respondents in the La'ilay wukro area prefer to grow cash crops. But due to constraints of labor and capital only 44% from Korrir and 70% from Ma'y nigus are actually producing these crops.

The reasons for choosing food crops by the 30% of the respondents in La'ilay wukro are-

- The obtained crop residue from the crops especially maize is best feed for cattle in the dry seasons
- Some of the respondents want fresh food (eshet) for household consumption and
- The others aren't willing to spend for labor wage for cash crop production lest crops may fail.

With the start of irrigation, the farmers have got the chance to produce new crops that they have never grown before. Among these are vegetables and fodder crops. Although they aren't old enough to give products, some respondents (10% and 14%) have planted fruit trees like orange and guava in the Korrir and La'ilay wukro areas.

Labor

Most smallholder activities all draw from the same family labor sources, supplement for certain operations by neighbor help and casual wage labor. The development of the irrigation schemes has created job opportunities for the near by farmers besides to the irrigation users in the traditionally slack dry times. Daily labor wage has increased in the three of the sites. The table below shows the situation.

Table 4.7 Average daily labor values before and after the start of the irrigation schemes in birr

Name of scheme	Before the irrigation		After the irrigation	
	Men	Women	Men	Women
Korrir	6	2.5	10	6
Lailay wukro	6	2.5	10	6
Mainigus	6	-	9	-

3.4 Impact of the Irrigation Schemes on income distribution by gender

The main objective of assessing income distribution by gender is to know the impact of irrigation scheme development on women. Women are affected in any situation that happens in a community. Even if the income of both men and women are required to meet basic family needs women's income however, benefits the family relatively more than men's. Because women spend a higher portion of their income on family expenditures than men do. In the case of irrigation women benefit a lot from the increased income generated from the sale of vegetables produced by the irrigation. The increased income will enable them to cover necessary expenditures of their families. As to the respondents, the start of the irrigation has highly benefited women. The benefits gained are-

- After the irrigation is started, those women who left their land with out any production during the rain fed production has started to produce using irrigation. This improves their annual income.
- Renting their land benefits those women who are not able to cultivate by them selves.
- During the dry periods, women sale vegetables from the irrigated farm every week. This helps them to fulfill family needs every week.
- The start of the irrigation helps the women to have opportunity for job in dry seasons of the year.(women in the study areas have little job in dry seasons other than household tasks).

3.5 Impact of the Irrigation Schemes on Health and the Environment

Impact on health

One of the ill effects of irrigation development is the introduction of pathogenic organisms or favoring the environment for already existing once. The common diseases in the areas are malaria and tuberculosis. There is no disease introduced as a result of the irrigation development in three of the sites but the prevalence of

malaria is found to increase in Korrir and Ma'y nigus irrigation scheme sites. Especially those households near to the irrigation fields and the dam and those individuals who have to pass some nights in the irrigation fields watching for thieves are liable to malaria even in the dry season. Previously malaria usually out breaks only from the mid of August to December. These months are the weeding and harvesting periods and there is a lot of work to do on field but some of the household members stay on bed for about a month. This results in a problem on the crop production process.

Impact on the environment

The potentially negative impacts of irrigation development may occur off-site as well as on-site. In this study all of the respondents from Korrir, La'ilay wukro and Ma'y nigus dam says that they have seen changes in the environment. The major problems observed are soil fertility decrease, salinization, excessive water use, water logging, and soil erosion.

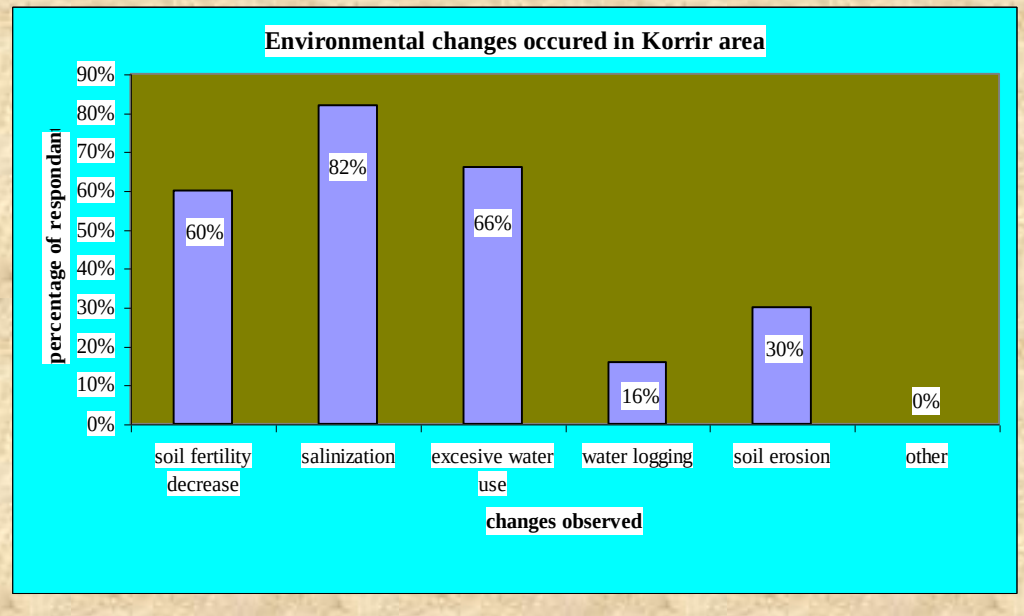


Figure 3.4a. Environmental changes observed in Korrir area

As the graph depicts Salinization is considered by 82% of the farmers as observed problem, excessive water use by 66%of the farmers, soil fertility reduction by 60%of the farmers, soil erosion by 30%of the farmers and water

logging by 16%of the farmers .And there is no Stated problem except these and the same procedural interpretation will be true for other dams.

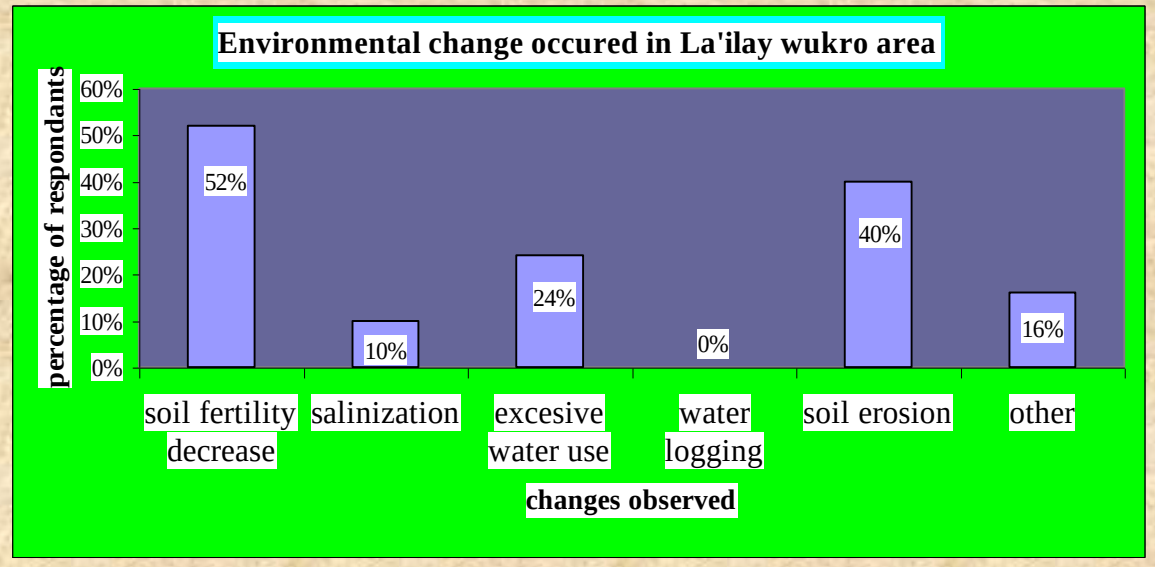


Figure 3.4b. Environmental changes observed in La'ilay wukro area

As it is shown in the graph soil fertility reduction is considered as a major observed problem due to intervention of irrigation practice, this is mainly because of the cultivation of the land twice a year with out appropriate soil fertility management

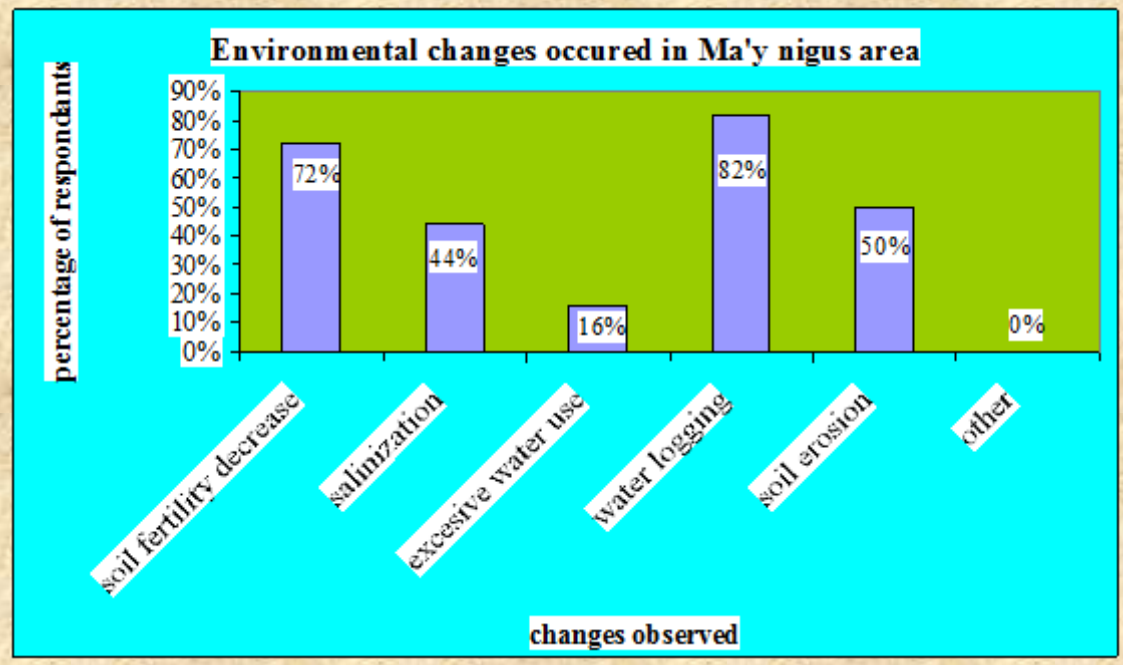


Figure 3.4c. Environmental changes observed in Ma'y nigus area

As the graph indicates water logging is the main observed problem due to intervention of irrigation .this is mainly the utilization of the irrigation water excessively and less provision of drainage.

The other negative impact resulted by the intervention of irrigation is the introduction of pests and destructive animals. Those pests who were commonly occurring in the rainy season are occurring during the dry season due to the water availability on the irrigation fields. Moreover, new pests that attack those newly grown vegetables that were not common in the area are resulted. Birds who are moving on the dams are also another distractive animals occur in the areas which are favored by the intervention of the irrigation schemes.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The need to intensify agriculture using irrigation in the economy of those countries, which are of short of food, is un doubtless. In doing so, excellent management is required to obtain the maximum benefit with the least negative impact. Failure to have an appropriate management entails disastrous effects on livestock and crop production, human health, the environment and the living condition of the community and as a whole on the countries economy.

In sum three of the irrigation schemes (Korrir, Lailay wukro, Mainigus) have positive impact on livestock production but the establishment of the latter two have aggravated gazing land shortage. 81, 26 and 36 percent of the respondents from the respective sites are producing fodder for their livestock using the schemes. Other reasons for the improvement are increased amount of crop residue and enhanced natural vegetation growth around the irrigated fields. Concerning production constraints, grazing land shortage and drought are major ones. Poverty is also one reason for owning only few heads of cattle. Honey production to augment household income is increasing amongst the farmers in the Korrir area after the start of irrigation. Though this is another positive impact of irrigation intervention it is not that much practiced in the two other sites.

Annual income of irrigation users has increased at about 51,61and31 percent in the Korir, La'elay Wukro and Mai-Nigus sites respectively. The improvement has resulted mainly from sale of vegetables produced using irrigation. The increase in income for those users who produce cash crops 69, 72, 41 percent but only37, 44.5, 7.7 percent for those who do not produce these crops. This plainly shows the necessity to concentrate on cash crop production so as to make use of the schemes to the maximum benefit. Even though the farmers are aware of the fact that cash crop production is more benefiting, the high labor demand of cash crop production has restricted them to concentrate only on food crop production.

Consequently only 44%, 60%, 70% of the respondents produce cash crops in Korir, La'elay Wukro and Mai-Nigus respectively.

At the current input application level and farming practice with such a small piece of land farmers are unable to feed themselves. There is however, reduction in the length of food shortage times. The irrigation users being capable of producing two times a year, now they are feeding themselves longer than before the schemes development. Previously food shortage times were 7,7 and 5 months but now these are 5, 3 and 3 for Korir, La'elay Wukro and Mai- Nigus areas respectively.

Women are obtaining benefits from the schemes. Those who used to leave their plots uncultivated have got the chance to make use of it. This is done either by renting or by giving it to share croppers. Further more, women have got job opportunities in daily labor basis. They also produce and sale vegetables though it is very meager

Three of the study sites have faced environmental problems as a result of irrigation development. Although the problem has not reached the extent that leads to complete land abandonment; salinization of soil, water logging and soil fertility depletion are posing considerable threat to the sustainable use of the schemes. All the problems mainly arise from mismanagement of the irrigated fields especially from misuse of water from canal to plot level. Farmers have also noticed few pest problems that are directly related to irrigation practices.

About human health, malaria is the main problem aggravated with the start of irrigation. The problem worsens where the villages are near to the dams and the irrigated fields and when farmers are to spend some nights at their farms watching for thieves.

In general, the development of the schemes has helped farmers in reducing the risk of drought by fostering livestock and crop production and by diversifying

income sources. Environmentally all the dams have negative impact that is aggravated by inappropriate irrigation management.

4.2 Recommendations

Based on the conclusion the following recommendations are forwarded

- ⇒ The irrigation schemes have created an opportunity to produce fodder crops. There fore there should be an extension service to initiate farmers to increase their income from livestock production using improved breeds.
- ⇒ In La'elay Wukro and Mai-Nigus areas farmers should be aided to develop skill in producing fodder crops so as to mitigate the prevailing problem of grazing land shortage.
- ⇒ Generally most of the farmers in the study areas are new to the technology (irrigation); and only few farmers are obtaining satisfactory changes in livelihood conditions, hence there is a need for further improvement in the farmers' agricultural activities. Consequently, governmental organizations as well as NGO's should support the farmers in managing the schemes. (more extension service have to be given)
- ⇒ With the decrease in soil fertility after intensively cultivating their pieces of lands, the farmers have to use fertilizer. Besides it is observed that the farmers' income rises through increased input application. However, one of the reasons for under utilization of the schemes is the incapability to spend on agricultural inputs. Hence farmers should be aided in getting fertilizers and other inputs.
- ⇒ The land holding in the irrigated fields being very small (0.2 ha) farmers use inorganic fertilizers repeatedly. Furthermore pesticides are being used widely. In the long run, these chemicals will surely lead to environmental contamination. To minimize such an impact farmers should be trained in preparing organic fertilizers, like compost and using non-chemical pest control methods.
- ⇒ Only few of the women landholders in the irrigated area are cultivating by them selves. Others are renting or giving their land to sharecroppers due

to labor and financial constraints. It is likely these women can obtain better benefit if they can get some financial and extension supports (credit services can play a considerable role here).

⇒ Only few farmers have honeybees in the study areas. However, flower from the irrigated crops is potential source of nectar. Hence, extension work is required in this area too.

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ANNEX

Questionnaire prepared for the study

COMMUNITY- BASED IRRIGATION MANAGEMENT IN THE TEKEZE BASIN: *Strategies to enhance human health, livestock and crop production and natural resource management*

WATERSHED CHARACTERSTICS

- Name of the watershed/irrigation scheme_____
- Size of the catchment_____
- Reservoir capacity_____
- Command area_____

House hold characteristicS

Wereda_____ Interviewer_____
Tabia_____
Kushet_____
Household number_____
Name of household head_____
_____
Household family size_____
Male_____
Female_____
Marital status of the household head_____

1. Single
2. Married
3. Divorced
4. Separated
5. Widowed
6. Other (specify)

Name of the respondent_____
_____
Age of the household head_____
Relationship of the respondent with the household head
_____

Living standard of the family: 1) Poor 2) Medium 3) Rich

-

Part one

IMPACT OF MODERN WATER HARVESTING ON LIVESTOCK PRODUCTION

1. How many of each of the following do you have?

Livestock type	Cattle	Sheep	Goat	Horse	Mule	Donkey	Camel	Chicken	Bee
Before irrigation									
After irrigation									

2. How far was that source from your village/house? _____
3. How many hours did you travel to reach the water source? _____
4. Where do you get water for your livestock now?

   _____

5 . How many hours did you travel to reach the new water source?

_____

6. What are the sources of feed for your livestock? _____
   1. Communal grazing land
   2. Private grazing land
   3. Crop residue
   4. Other (specify)
7. Does the start of irrigation help you to get better fodder for your livestock? Yes/No
8. (If yes) How?

_____

   1. Producing fodder using irrigation
   2. The natural vegetation increased after the start of irrigation
   3. Increased amount of crop residue
   4. Other (specify)
9. Is the production of your livestock increasing? (Milk & meat) Yes/No
10. (If yes) what do you think the reasons are?

_____

   1. Improved water availability
   2. Improved fodder availability
   3. Use of improved veterinary service
   4. Other (specify)
11. Is the number of your animals increasing? Yes/No
12. (If yes) What are the reasons?_____
13. (If no) What are the reasons?_____

14. What are the major constraints of animal production in your community?

1. Shortage of grazing land 2. Animal disease 3. Shortage of water source
4.Unreliable market 5. Insecurity 6. Drought 7. Other (specify)

15. What are the common livestock diseases in the area?

-

Before the start of the irrigation scheme			Now		
Disease	Local name	Livestock attack	Disease	Local name	Livestock attack

16. If you use veterinary services, how much do you spend for the service?
    Before the development of the scheme_____
    After the development of the scheme_____

Part two

IMPACT OF MODERN WATER HARVESTING ON LIVELIHOOD OF FARMERS

Impact of water harvesting on poverty alleviation

1. How many times do you produce in a year?
    i. Before the start of the irrigation scheme_____
    ii. After the start of the irrigation scheme_____
2. How much of the following do you produce per hectare per season?

Before the scheme development			After the scheme development		
Crop type	Amount (Qt)	Price/Qt	Crop type	Amount (Qt)	Price/Qt

3. How much straw do you get from a hectare of land after harvesting?

Before the scheme development			After the scheme development		
Crop type	Amount (Qt)	Use	Crop type	Amount (Qt)	Use

-

4. For what purpose do you use the straw?
Before the start of the irrigation scheme_____
After the start of the irrigation scheme_____
a. Animal feeding c. As energy source
b. Soil fertility improving d. Other (specify)

5. What amount do you get per annum from each of the following?

The income source	Income/Now	Income/before
Fire wood sale		
Hand craft (Weaving, carpenter, black smith)		
Food aid & FFW		
Petty trade		
Remittance		
Oxen rent		
Labor selling		
Livestock income		
Crop income		

6. How much surplus (on average in Qt) do you have for sale after each season?
a. Before the start of the irrigation scheme_____
b. After the start of the irrigation scheme_____
7. How much money do you make from the sale of this surplus?
a. Before the start of the irrigation scheme_____
b. After the start of the irrigation scheme_____
8. What are the benefits you get as you saved for house hold consumption out of the production?

9. Are you food self-sufficient? Yes/No
10. (If no) for how long are you able to stay from your last harvest?

Month	Month	Month
0-2	5	8
3	6	9
4	7	10

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11. Before the start of the irrigation scheme for how long were you able to feed the family from your produce? _____months
12. For how many months are you able to feed the family now? _____
13. How frequent do you sale your livestock?

	Before irrigation start		Now	
Type	Number	Value	Number	Value
Oxen				
Cows				
Sheep/goat				
Others				

14. Does any body in your household make money from seasonal labor? Yes/No
15. (If yes)

	Activity	value
Adult male	_____	_____
Adult female	_____	_____
Children	_____	_____

16. Does any increment in daily labor wage occur due to the irrigation scheme development in your area? Yes/No
17. (If yes) by how much?
    - Payment before project_____
    - Payment after project_____
18. Which crops do you prefer to grow under irrigation?
    - Food crops
    - Cash crops
    - Others (specify)

Why do you choose these crops20. Does the irrigation scheme give you the chance to produce new crops that you have never planted before? Yes/No

21. (If yes) what kinds of crops?
23. (If yes) how much do you get per month?
    - From milk_____
    - From milk products_____
    - From meat_____

Part three

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Impact of water harvesting on health and the environment

1. Did you use health service before you start irrigation practice? Yes/No
2. (If no) Why? _____
    1. Poor income level
    2. Poor availability of health service
    3. Other (specify)
3. Do you use any health service now? Yes/No
4. (If yes) Why?
    1. Improved income level from the irrigation scheme
    2. Improved availability of health service
    3. Other (specify)

5. (If the answer is yes for question number 1 and 3) which times do you use better service? _____
    a. Before the start of the irrigation practice
    b. After the start of the irrigation practice
6. What were the common diseases in the area before the start of the irrigation scheme?
7. What new diseases are observed in the area after the start of the irrigation scheme? _
    1. Malaria 2.Bilharzias 3. Others (specify)
8. At what time do the diseases occur?

Previously existing diseases	Newly introduced diseases

1.Sawing time 2.weeding time 3.Ploughing time
4. Harvesting time 5.Other time (specify)

9. How many members of the family suffer from the
    New diseases_____
    Previously occurring diseases_____
    From both_____
10. How many days does the sick person stay on bed?
    From the new diseases_____
    Previously occurring diseases_____
11. How much do you spent to cure from the diseases?
    From the new diseases_____
    Previously occurring diseases_____
12. Is there any decrease in a disease type due to the start of irrigation? Yes/No
13. If yes specify the disease
14. Have you seen any change in the environment after the start of the irrigation scheme? Yes/No

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15. If yes, specify

a. Excessive water use c. salinization e. Soil fertility decrease
b. Water logging d. Soil erosion f. others (specify)

16. Are any pests introduced with the start of irrigation? Yes/No
17. If yes, mention in name
18. At what time do these pests outbreak?

Part four

Impact of water harvesting on income distribution by gender

1. Does the irrigation scheme bring special benefit to women? Yes/No
2. (If yes) what are the benefit

3. What were the common works that are performed by women in the area before the start of the irrigation practice?
4. Does the irrigation scheme creates any opportunity of work for women? Yes/No
5. If yes what kind of works?
6. How much of the following do you produce?

	After irrigation is started		Before the start of irrigation	
	Amount	Price (Birr)	Amount	Price (birr)
Milk				
Butter				
Cheese				

7. Is vegetable production traditionally controlled by women? Yes/No
8. (If yes) How much of the following do you produce?

Type	**After irrigation is started**		**Before the start of irrigation**	
	Amount	Price (Birr)	Amount	Price (Birr)
Tomato				
Onion				
Cabbage				
Paper				
Carrot				
Cauliflower				
Others				