ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

INSTITUTE OF REGIONAL AND LOCAL DEVELOPMENT STUDIES

IMPACT OF IRRIGATED AGRICULTURE ON HOUSEHOLD FOOD SEECURITY: THE CASE OF DIBDBO IRRIGATION SCHEME, TIGRAY, ETHIOPIA.

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN REGIONAL AND LOCAL DEVELOPMENT STUDIES

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Table of Contents

Page

List of Tables

List of Figures

List of Photos

Abstract

The purpose of this study was to assess the impact of irrigated agriculture on household food security in rural areas of Tigray, Ethiopia with special reference to *Dibdbo*[1] irrigation scheme (dam). The study has three major objectives. The primary objective was to examine the irrigation water management practices of the scheme. The second objective was to assess internal and external problems associated with irrigated agriculture and the third objective was to assess the impact of irrigated agriculture on household food security. The "before and after the project" approach was used for the study by taking 42 households as a sample.

Results are based on household survey, key informant discussion, focus group discussion, direct observation and life-history. Data were collected for the period 1988-1990 E.C (before the project) and 1996-1998 E.C (after the project) and analysis was carried out with the help of various methods and techniques such as Lorenz curve, Gini-coefficient, Poverty ratio (or Head count), Poverty gap and Squared poverty gap.

The result of head count ratio showed that before the project intervention, nearly 83% of the households were identified as poor. By contrast, only about 36% of the households were living below the poverty line after project intervention. Moreover, the overall poverty gap was 0.37 and 0.28, indicating that poor households needed an additional of 37 percent and 28 percent of the present income to attain minimum basket of basic needs before and after the project.

The Gini coefficient derived from the Lorenz Curve is 0.27 and 0.23 for households before and after the project respectively, which implies that the distribution of income is considered as relatively equal among the households before and after the project.

[1] Dibdbo is the name of the dam which is drived from the name of the kebele where the dam is located.

1. INTRODUCTION

Ethiopia is situated in the "horn of Africa" and lies between 3°30′ and 14°50′ North latitudes and 32°42′ and 48°12′ East longitudes. It has a surface area of about 1.127 Million km^2, of which 1,119,683 km^2 land and 7,444 km^2 water area. The country has a land boundary length of 5311 km. Ethiopia in the horn of Africa has special features because of its topography, geology and climate (Awulachew, 2001). Ethiopia is the second most populous country in sub-Saharan Africa (SSA) (and third on the continent) having a total population of 73,918,505 and 83.9% dependent on agriculture and live in rural areas (CSA[2], 2008).

Agriculture is heavily reliant on rainfall and productivity and production are strongly influenced by climatic and hydrological variability that are reflected as dry spells, droughts and floods. Droughts and floods are endemic, with significant events every 3 to 5 years, with increasing frequency compared to two or three decades ago. Droughts destroy watersheds, farmlands, and pastures, contributing to land degradation and causing crops to fail and livestock to perish.

Although the majority of cropping in Ethiopia is 'rainfed agriculture', there are four major categories of productive use of water in agriculture: (1) 'rainfed agriculture', (2) 'supplementary irrigation', (3) 'irrigated agriculture', and (4) 'livestock'. It is also important to note the importance of coupling the soil fertility management and nexus of soil-water in the crop production and productivity improvement (Awulachew, 2005).

Ethiopia also covers 12 river basins with an annual runoff volume of 122 billion m^3 of water with an estimated 2.6 billion m^3 of ground water potential. This amounts to about 1743 m^3 of water per person per year: a relatively large volume. But due to economic water scarcity which is

[2] CSA= Central Statistical Authority

described through lack of water storage capacity and large spatial and temporal variations in rainfall, there is not enough water for most farmers to produce more than one crop per year with frequent crop failures due to dry spells and droughts. Moreover, there is significant erosion, reducing the productivity of farmland.

Agriculture is by far the dominant sector. Most of Ethiopia's cultivated land is under rainfed agriculture. Less than 40% of the arable area (13.2 million ha, or 12% of the total land area) is currently under cultivation, AfDB[3] (2003). There is progressive degradation of the natural resource base, especially in highly vulnerable areas of the highlands, which aggravates the incidence of poverty and food insecurity in rural areas. Ethiopia imports about 15% of its food. The government has designed a comprehensive food security strategy that targets the chronically food insecure especially in highly vulnerable areas: marginal and semi-arid areas that are largely moisture deficient, including pastoral areas, with high population pressure. If such measures can be effectively and sustainably implemented, they can make significant difference (Awulachew, 2005).

Improving soil and water conservation is the first action to improve the water supply for agriculture, i.e., making a higher percentage of rainwater that falls onto a field available for plants, Rockström (2000). Water for agriculture is increasingly recognized as a major constraint to improving the lives of the rural poor and is an important component of rural livelihood programs that need to be yet strongly established in Ethiopia.

Poor management of agricultural water leaves almost all part of the country highly susceptible to rainfall variability which depicts itself in terms of prolonged dry spells and droughts. The prolonged dry spells,

[3] AfDB= African Development Bank

may not be pronounced in wide areas in a given year. However, it could cause significant harm to production and productivity of agriculture. On the other hand, drought that occurs in a given period or year could show clear impact on the total agricultural produce that could also be pronounced through gross domestic product and gross national product.

Agricultural water management embraces a whole range of wider practices including in situ moisture conservation, water harvesting, rainwater harvesting, supplementary irrigation, irrigation, various techniques of wetland development such as treadle pumps, drip irrigation systems, sprinklers systems, etc, IWMI (2006). When these interventions could be applied appropriately, they could enable not only overcome the above problems, but also improve productivity of agricultural sustainable economic development.

The challenge that Ethiopia faces in terms of food insecurity is associated with both inadequate food production even during good rain years (problem related to growth of population), and natural failures due to erratic rainfall. Therefore, increasing arable land or attempting to increase agricultural yield alone cannot be a means to provide food security in Ethiopia, due to environmental impacts (expansion into marginal land, deforestation) and unpredictable natural factors (climate).

The modern history of Ethiopia shows that the country has failed to adequately feed itself. Food deficit and famine occurrences in the country is claimed to be as a result of the erratic nature of rainfall or drought. Ethiopia has faced three large-scale drought induced food shortage and famine in recent times (i.e. in 1974, 1984/85, 1994 and 2002/03), which claimed thousands of lives. In 2002/03 about 15 million people (over 20% of the total population) were under food aid need.

Irrigation and improved agricultural water management practice could provide opportunities to cope with impact of climatic variability enhance productivity per unit of land, increase the annual production volume significantly. Irrigated agriculture started in Ethiopia in the 1960 with the objective of producing industrial crops (sugar and cotton) on large-scale basis. Local farmers however, had already been practicing irrigation by diverting water from rivers in the dry season for the production of subsistence food crops as traditional irrigation. The experience in modern small-scale irrigation (SSI) development and management started in the 1970s by the Ministry of Agriculture (MoA), in response to major droughts, which caused wide spread crop failures and consequent starvation. The sector could be used to reduce family risks that are associated with crop failures resulting from droughts. Currently government gives emphasis to develop the sub-sector to fully tap its potentials by assisting and supporting farmers to improve irrigation management practices and the promotion of modern irrigation systems (Teshome A., 2006). Although irrigation potential in Ethiopia is estimated at 3.7 million hectares under conventional gravity irrigation, when rain water harvesting and supplementary irrigation, ground water use, and water lifting technologies are considered, it is believed that the potential could be significant. The current level of irrigation development is at about 250,000ha, with further planned for implementation. According to Teshome A. (2006), currently, irrigated agriculture produces less than 3 percent of the total food production of the country.

The government has revised its strategy for irrigation development. The previous development target was to put additional 274,612ha by 2016, Awulachew (2005), WSDP (2002). The ministry of water resources is currently undertaking a total of thirteen irrigation projects located in different parts of the country. They constitute approximately a total area of 493,603 ha and envisaged to be completed before the end of the irrigation development program planning period in 2016, Teshome A. (2006). This revised target is mainly related to large and medium scale irrigation and it is expected that the small scale irrigation sub-sector which is under the Ministry of Agriculture and Rural Development will also strive similar targets.

1.1 Statement of the Problem

The economy of Tigray region, like the other regions of Ethiopia, is based on agriculture. Agriculture in the region continues to be dependent on natural precipitation while rainfall is inadequate, unpredictable and uneven in distribution. This has lead to high levels of moisture stress in which production from the rain-fed agriculture is severely curtailed subjecting large sectors of the population to extreme levels of food poverty. Therefore, reduction of rain fall dependence through better management and development of water resources for agricultural production is a key strategy in this drought prone, food deficit region.

Based on this, since 1995, the regional government has started massive irrigation development, mainly in areas affected by recurrent drought like the study area. So far out of the total irrigable land of the region, only 18,200 hectares, which is 6.1%, is being irrigated.

Although different moisture conservation and water harvesting technologies such as micro-dams, river diversion, spate irrigation, pumped irrigation and different types of ponds were constructed in the region by different organizations such as *Co-SAERT*[4] and *REST*[5], their sustainability and contribution to household food security is not properly understood.

According to Woldeab (2003) since the mid-1980s, successive Ethiopian governments have been engaged in the construction of irrigation infrastructure in response to drought and famine. Many of the irrigation systems have either a poor record of performance or they are not operational. And little is known about why this is so. Based on this Woldeab (2003) tries to enquire in to how the state intervened and what had been the reactions and responses of farmers to the government

[4] CO-SAERT is an abbreviation for commission for sustainable agriculture and environmental rehabilitation in Tigray.

[5] REST is an abbreviation for relief society of Tigray.

initiatives. Woldeab's study tries to look in to the social dimensions of irrigation with particular emphasis on state intervention and life-worlds of farmers. However, other literature review concerning the impact of irrigated agriculture on household food security is not available or is not known. The present study is an attempt in this direction.

1.2 Objectives of the Study

The objectives of the study are:-

1. To examine the irrigation water management practices of the scheme,
2. To assess internal and external problems of the scheme,
3. To assess the impact of irrigated agriculture on household food security.

1.3 Significance of the Study

The result of the study may provide some insights for local and regional policy makers in irrigation development in the region in general and the study area in particular. The result of the study can also be used as a reference for other researchers who want to study on the same issue in other areas having similar agro-climatic and socio-economic conditions.

1.4 Research Questions

The main research questions of the study are:

1. How is the overall management of the irrigation scheme?
2. What are the main problems encountered in the irrigation scheme?
3. What is the impact of irrigated agriculture on household food security?

1.5 Limitation of the Study

- The interview method of data collection required the respondents to recall, from their memories, the bulk of data particularly the annual expenditure and income for the past years. Thus, the responses were not 100 percent reliable. To minimize this problem, every possible effort has been made to draw out as accurate and reliable information as possible by cross questioning.
- Household food security is a function of multitude factors. In this study only some variables which were assumed to affect the incidence dominantly are included. The study could have been much comprehensive had a number of parameters been included.
- The time and finance provided to undertake the research is small. The study would have been more comprehensive otherwise.

1.6 Presentation of the Study

The study has five chapters. Chapter one presents the introductory part which comprises statement of the problem, specific objectives, significance of the study, research questions and limitations of the study. Chapter two presents the review of the relevant literature. The third chapter outlines the main features of the study area, the nature and sources from which relevant data have been collected and the statistical tools and techniques employed in the study. Chapter four presents the findings of the study. Chapter five provides the conclusions and recommendations of the study.

2. LITERATURE REVIEW

An attempt has been made to present the review of past studies related to the theme of the present study in this chapter. On the basis of the past research and in agreement with the objectives of the present study, the work done on different aspects of irrigation and irrigation development, irrigation and household income/food security, irrigation water management, and major problems associated with irrigated agriculture is reviewed under the following headings.

2.1 Irrigation and Irrigation Development

Irrigation is artificial watering of land to sustain plant growth. Irrigation is practiced in all parts of the world where rainfall does not provide enough ground moisture. In dry areas irrigation must be maintained from the time a crop is planted. In areas of irregular rainfall, irrigation is used during dry spells to ensure harvests and to increase crop yields.

It is expected that through an optimal development of water resources, in conjunction with development of land and human resources, a sustainable growth of food production can be achieved. Since the mid-1980s, the Ethiopian government has responded to drought and famine through promoting and construction of irrigation infrastructure aimed at increasing agriculture production. These are traditional, small, medium and large-scale irrigation schemes performing at different levels.
Irrigation development has positive socio-economic and some negative environmental impacts. Formally accounted overall irrigation development is estimated at some 5 – 6 percent of the developable potential of 3.7 million ha.

The irrigation area in year 2002 was 197,000 hectares with a coverage distribution of 38 percent traditional, 20 percent modern communal, 4 percent modern private and 38 percent public schemes (MoWR, 2002).

The revised figure puts the total irrigated area at about 250,000 hectares (Awulachew, 2005). This number gives a per capita irrigated area of about 30 m^2. This value is very small compared to 450 m^2 globally. The targeted growth expansion (according to the 2001 Water Sector Development Plan), is also not significant and not expected to bring a significant change and the much-needed economic growth. Considering the population growth and the targeted development of the 2002 water sector development strategy, the per capita irrigated area only reaches 45 m^2 per head by the year 2015 and does not move the sector significantly. Therefore, given extreme meteorological and hydrological variability in Ethiopia, it is important that significant attention be given to enhance better water control, use and management of the water resources for agricultural production through irrigated agriculture. Corollary to this, the revised strategy, according to Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (MOFED, 2006), puts the large and medium-scale irrigation growth by year 2010 at an additional 493,000 hectares, which is an improved plan on previous strategy.

The project related to this paper known as "Impact of Irrigation on Poverty and Environment (IIPE)" is sponsored by the Austrian Government to be executed by the International Water Management Institute (IWMI) in collaboration with Austrian and Ethiopian Universities, Research Institutions and relevant ministries in Ethiopia. One of the expected outputs of the project is to establish a comprehensive data and information database on irrigation and drainage sub-sector.

Often the availability of reliable and consistent data and information on surface and ground water is one of the basic requirements for development, use and management of water resource, in order for water managers to make well-informed decisions, as well as for researchers to make proper analysis and arrive at reasonably accurate conclusions.

In Ethiopia, the major problems associated with the generation of reliable data and information on water resources management consists of a lack of consolidated strategy, including institutional linkages, processes of collection, storage, analysis, and dissemination. A clear example of this is the lack of consistent and reliable figures on irrigated agriculture from various sources in Ethiopia.

Recognizing this fact and in an effort to contribute to the knowledge base of the water sector of the country, IWMI (together with other partners) has conducted a survey on existing small, medium and large-scale irrigation developments in Ethiopia and created a database in Geographic Information System (GIS). The creation of this database on irrigation and drainage is the first of its kind in putting together the existing data in an organized manner and make it available for end users.

The database contains spatial data of river basins, river networks and existing irrigation schemes (small, medium and large-scale) in each administrative region of Ethiopia; and the potential that can be realistically irrigated in each river basin. Although the already developed database is a very useful output, it is considered as an evolving working document which will be updated from time to time as additional information and recent developments emerge.

Ethiopia has 12 river basins. The total mean annual flow from all the 12 river basins is estimated to be 122 BMC (MoWR, 1999). Moreover, Ethiopia has 11 fresh and 9 saline lakes, 4 crater lakes and over 12 major swamps or wetlands. Majority of the lakes are found in the Rift Valley Basin. The total surface area of these natural and artificial lakes in Ethiopia is about 7,500 km2.

As compared to surface water resources, Ethiopia has lower ground water potential. However, by many countries' standard the total exploitable groundwater potential is high. Based on the scanty knowledge available on groundwater resources, the potential is estimated to be about 2.6 BMC (Billion Metric Cube).

2.2 Irrigation and Household Income/Food Security

Wagnew Ayalneh (2004) studied socio-economic impact of community-based small-scale irrigation in the upper Awash Basin of four irrigation schemes. The study findings highlight that small-scale irrigation for food security enhancement is technologically and socio-economically demanding intervention currently being undertaken in rural Ethiopia. However, the high yields obtained in irrigation and other benefits such as increased incomes and employment creation are indicators that irrigation can bring sustainable agriculture and economic development if properly planned. The study of the four small-scale irrigation schemes in the Awash Basin has revealed that higher gross income; higher return on capital and higher input use by irrigator households was achieved compared with the non-irrigator households.

Moorthy and Mellore (1972) studied the cropping pattern, yields and incomes under different sources of irrigation in Aligarh district of Uttar Pradesh and found that availability of perennial irrigation raised the intensity of cropping, changed the cropping pattern and enabled different groups of farmers to use best quality of seeds at right time and to reap bigger margin of profits.

Eng. C.K. Chiza (2005) indicated the following points about out comes of irrigation.

Food Production and Productivity

Irrigation has a multi-faceted role in contributing towards food security, self-sufficiency, food production and exports. It encompasses a wide range of interventions that enhance productivity and result in to profitability for the rural farming population and the nation as a whole.

For the substantial areas managed by smallholder through traditional irrigation systems or water harvesting, it assists with both food production and cash crops enabling farmers and surrounding communities to benefit both directly and indirectly from the crops produced. In large-scale commercial farms, it enables crop production for local and export markets with significant impacts on the country's economy.

Poverty Reduction at Household level

When enough support and attention is given for both the software (management of the irrigation water) and hardware (engineering) aspects, irrigation has major positive impacts at household and village level and contributes significantly to poverty reduction strategy objectives.

Reduced Migration from Rural to Town

If both existing productivity in the rainy season is increased and made more reliable and if the returns to dry seasonal casual labour exceed the opportunity cost of alternative casual urban or construction employment, migration of rural population especially the youth, from rural to town is reduced.

Intizar Hussain and Munir A. Hanjira (2003), suggests that there are strong linkages between irrigation and poverty. These linkages are both direct and indirect. Direct linkages operate via localized and household-level effects, and indirect linkages operate via aggregate or sub national or national level impacts. Irrigation benefits the poor through higher production, higher yields, low risk of crop failure, and higher and year-round farm and non farm employment. Irrigation enables smallholders to adopt more diversified cropping patterns, and to switch from low-value subsistence production to high-value market-oriented production. The indirect linkages operate via regional, national and economy-wide effects. Irrigation investment act as production and supply shifters, and have a strong positive effect on growth, benefiting the poor in the long run. Further, irrigation benefits accrue to the poor and landless in the long run, although in the short run relative benefits to the landless and land-poor may be small, as the allocation of water often tends to be land-based. Sporadic instances of the negative externality effects of irrigation point to the management issues, and call for a comprehensive response mechanism from the planning and political community alike

The result of a case study on assessing impacts of irrigation on poverty alleviation by International Water Management Institute (IWMI) in 2002-2003 in 26 selected irrigation systems in Bangladesh, China, India, Indonesia, Pakistan and Vietnam showed that these countries together account for over 51 percent of global net irrigated area and over 73 percent of net irrigated area in Asia, with most of this area located in China, India and Pakistan.

The following points summarize some of the key findings and conclusions from the country case studies: (1) Irrigation has a strong land augmenting impact; the value of per hectare crop production under irrigated settings is about twice than under rain-fed settings. (2) In areas where communities and households depend to a great extent on agriculture for their livelihoods, access to irrigation is a necessary, but not a sufficient condition for poverty alleviation; access to other production inputs and services is also important to enhance benefits of irrigation for poverty alleviation. (3) Overall, the study findings suggest that irrigation reduces poverty significantly; however, the anti-poverty impacts of irrigation vary across and within irrigation systems.

Analyses from the country studies provide evidence that incidence and severity of poverty are significantly high in those settings where land and irrigation water distribution is inequitable, irrigation infrastructure is poorly managed, and farmers' access to production enhancing technologies and support measures is limited. Where these factors are favorable, the incidence of poverty is relatively low. Also, the studies indicated that poverty may be adversely affected where irrigation is mismanaged leading to land degradation problems, such as water logging and salinity, and abandoning of lands in the long term.

2.3 Irrigation Water Management

Zenebe (2000) studied impact of irrigation on crop production in Malaprabha command area (India). According to this study, to increase crop yields a number of agricultural inputs like improved seeds, proper fertilizers, improved management and requisite irrigation water are necessary. Proper development and management of the water input, is of paramount importance since the success and efficiency of other inputs are dependent on the quantity, quality and timing of water supply and the level of control over it.

Mekuria (2003) compiled a study visit report on Small-scale irrigation for food security in sub-Saharan Africa. The study visit was undertaken by sixteen experts (5 from Ethiopia, 2 from Ghana, 2 from Kenya, 2 from Malawi, 3 from Tanzania and 2 from Zambia). According to the report, the six countries have their own way of irrigation water management practices and institutional arrangements. For example,

In Malawi, there are not many properly established farmer organisations managing irrigation schemes, yet river diversion and motorised pump-based schemes require that farmers work in groups. This has led to some influential farmers monopolising irrigation facilities that were meant for groups of farmers.

In Kenya, a new proposed Water Act recommends the establishment of two distinct bodies namely, Water Resources Management Authority (WRMA) that will be charged with the responsibility of managing the water resources of the country and the Water Supply and Sanitation

Board (WSSB) that will be responsible for water development in the country. The Horticulture and Traditional Food Crop Development Project (HTFCDP) and the Horticultural Crops Development Authority are effectively working with smallholder irrigation development.

In Ghana, a computer programme for irrigation water delivery scheduling has been developed and the monitoring system has been improved. A manual for the Operation and Maintenance of irrigation facilities has been prepared and is being used in training courses. Both the Ghana Irrigation Development Authority and farmers' cooperatives have become aware of the importance of water management through the improvement in the plot-base and system-base management.

In Ethiopia, water management and infrastructure maintenance was found to be one of the bottlenecks affecting the sustainability of small-scale irrigation (SSI) development. Consequently, after the construction of the SSI scheme, WUAs will be established. All beneficiaries will be members of the WUA. The WUA will be a legally recognised body responsible for the management of the scheme; it will facilitate water distribution, maintenance and operation of the scheme. Several WUAs could be organised into a larger co-operative association. Finance is the major constraint limiting the capacity of most WUAs.

In Tanzania, Traditional Irrigation Program (TIP) has made remarkable achievements in improving and developing traditional irrigation. Through the TIP programme, the adoption and use of various techniques in water management and the improvement of irrigation infrastructure have resulted in more secure water availability for the members and reduced conflicts over water (e.g., lined canals, low pressure sprinklers and drip irrigation).

2.4 Problems in Irrigated Agriculture

The following are some of the key findings on constraints facing irrigation development in sub-Saharan Africa (Mekuria, 2003):

- **Environmental factors:**

➢ Water scarcity and poor water quality especially as related to sediment concentration;

➢ Land degradation as a result of poor operation and maintenance activities - this is partly related to inefficient water management resulting in water wastage and water logging as well as land-use regulation.

- **Capacity of the farmers:**

➢ Lack of know-how in and access to, the opportunities of irrigation technology;

➢ Weak economic base of most farmers and the relatively high development costs involved in developing irrigation schemes.

- **Government policy; institutional and legal support:**

➢ Limited or no priority given to irrigation development during national and local planning and budgeting;

➢ Poor management structures in place to support farmers and promote irrigation development. For example, the infrastructure to facilitate agricultural development is underdeveloped;

➢ A land tenure system that does not encourage farmers to invest in permanent improvements on their plots and make improvements which can be used to obtain credits for further development;

➢ Unclear water rights and their enforcement.

Moreover, the following are problems that are frequently encountered in irrigation schemes, especially those in formal "modern" sector (CTA,1998):

- Higher costs and lower benefits than had been estimated beforehand;
- Rapid deterioration of physical infrastructure;
- Poor cost-recovery of scheme services to farmers;
- Labour shortages during peak seasons;
- Low cropping intensity and yields;
- Cropping pattern (the farmers were not given chance to choose the crops of their choice-it is imposed on the farmers)
- Insecurity in irrigation water supplies;
- Low overall irrigation efficiencies;
- Destruction of structures, or theft of parts of them (e.g. metal gates);
- Canal choked by weeds and silt;
- Physical drainage system no longer even recognizable;
- Salinity problems, especially in arid and semi-arid zones;
- Unreliable and erratic input supplies;
- Negative environmental impact, especially with regard to pests and diseases, both for man and crops;
- Market for the produce;

2.5 Food Security Concept

According to the FAO (Food and Agriculture Organization of the United Nations):

Food security means access by all people at all times to the food needed for an active and healthy life. At the household level, food security refers to the ability of the household to secure, either from its own production or through purchases, adequate food for meeting the dietary needs of its members. For food security at a household thus needs sufficient and secure income to buy its food at prevailing prices, and/or access to agricultural resources, like land, machinery and credit, to produce its own food.

Food security at household level is closely linked with poverty. Poor people do not have enough access to agricultural production resources to produce their own food, nor sufficient income from other sources. They can not afford their basic needs, including the food needed for a healthy and productive life.

Food security for all people can only be accomplished structurally by poverty eradication. This should apply to all members of the household and especially women in cases where the food situation in the household is mainly their responsibility.

2.6 Food Security Indicators

Ingrid Nyborg and Ruth Haug (1998), established general food security indicators which are common to all definitions of food security for assessing the effect of development programs.

These include:

- Increase in the number of months' food stores lasts,
- Decrease in the number of months the hunger period lasts,
- Increase in yield level or production estimates e.g. measured in kg per person,
- Increase in household income and savings,
- Increase in number of meals per day,
- Increase in heard numbers such that extra animals can be sold in difficult times,
- Improvement in infant mortality and child death rates,
- Improved anthropometric measures (nutritional status),
- Reduced food price, and
- Increased employment/real wage rate.

3. METHODOLOGY

A case study approach was used to conduct the research. With in the case study method major primary data collection methods such as survey method, Key informant interview, focus-group discussion, direct observation and life history of some beneficiaries were applied to collect both quantitative and qualitative data from the project and beneficiaries. Moreover, secondary data was also collected from different sources to supplement the primary data.

All research methods have their advantages and their limitations. Hence it is common to combine several methods in a single piece of research, using each to supplement and checkup on the others, a process known as triangulation. Based on this, the different research methods used in this study are given below.

3.1 Primary Data Collection Methods

3.1.1 Survey Method

During the survey all beneficiary households of the project were first stratified by their plot location i.e., head, middle and tail end. Then households from each plot location were selected using random sampling technique. The household survey was conducted using questionnaires which cover demographic characteristics, household socio-economic factors, plot location, water management practices, cropping pattern, agricultural input and yield, and marketing. Six well trained enumerators were used to help in administering of the questionnaire with strict supervision of the researcher.

Formation of the Questionnaire

Based on the main research questions of this study, detailed questionnaire was prepared. Then pretesting was done with six beneficiaries of the project. Based on the findings of the pretest the final questionnaire was developed.

3.1.1.1 Sample Size and Sampling Technique

From experience gained during the pre-test survey and consideration of the resource available both financial and time, 42 sampled households (which is 15% of the total beneficiary households), was taken. The sampling technique used in this study was the one discussed under the survey method above. That is all the beneficiary households of the project were first stratified by their plot location (i.e., head, middle and tail); then households from each plot location were selected using random sampling technique. List of each beneficiary household was obtained from the roster of the extension agent of the study area. Random number generated from a random number table was used in selecting the sample households.

Steps used in selecting a random sample from each plot location:

- Calculating the sampling interval (the number of households in the population divided by the number of households needed for the sample),
- Selecting a random start between 1 and sampling interval,
- Repeatedly add sampling interval to select subsequent households. Based on this, households presented in the following table are selected.

The reason for selecting beneficiary households from each plot location was to ensure representation of each segment in the overall sample. Table-3.1 below shows number of households selected from each *kushet*[6] and plot location.

[6] *Kushet* is a name for a village found with in kebele in Tigray region.

Table-3.1 No. of Household heads by Kushet and Plot Location

Number of Household Heads by Kushet			Plot Location			Total
			Head	Middle	Tail (end)	
Kushet Mesehel	No. of household Heads	Male	7	6	3	16
		Female	2	4	2	8
		Total	**9**	**10**	**5**	**24**
Kushet Adikerees	No. of household Heads	Male	4	7	3	14
		Female	1	1	2	4
		Total	**5**	**8**	**5**	**18**
		Grand Total	**14**	**18**	**8**	**42**

Source: Own survey data (2000)

3.1.2 Key Informant Interview

After interviews of the selected households were completed, some general information of the study area and socio-economic activities of the community were obtained by making key informant interview with six participants. In the interview, community leaders, water committee members, project level extension workers have participated. The information obtained from the interview was used to supplement and triangulate the information obtained using the household questionnaire survey. The data gathered included copping strategy during drought, main problems of agricultural production of the study area and impact of the irrigation scheme on the community.

3.1.3 Focus Group Discussion

Focus group discussion was conducted to complement and cross-check the information obtained from individual interviews. A total of ten people including religious leaders, beneficiary households and elders who know the study area very well have participated.

3.2 Secondary Data Collection

The primary data collected through the major primary data collection methods listed above was supplemented by gathering secondary data through reviews of literature sources and annual reports of the *wereda* and/or *tabia*.

3.3 Impact Assessment Approach

Impact assessment/evaluation is the process of determining the welfare change due to given intervention (project, programme or policy) and whether changes are attributable to the intervention.

The two general approaches for measuring impact are "before and after intervention" comparisons and "with and without intervention" comparisons.

This study used the "before and after intervention" comparison. To see the impact of the irrigation scheme on household food security, the crop production, income, employment opportunity and other food security indicators of the sampled households was collected and compared for the years 1988-1990 E.C (before project intervention) and 1996-1998 E.C (after project intervention). The reason for selecting these six years, three years before the project and three years after the project intervention, is that climate (especially rain fall) which is the main determinant factor for crop production was more or less the same in the study area. 1991 E.C was the first production year of the scheme; 1994/95 E.C was a drought year in most parts of the country; in 1999 E.C the command area (irrigated area) was redistributed for farmers. Climatic condition, especially rain fall, before 1988 E.C was erratic in the region, therefore, selecting the three years (1996-1998 E.C) was reasonable for two reasons. First, these three years had relatively similar climatic condition like the years of 1988-1990 E.C. Second, households can respond to the income-expenditure questions with relative accuracy from their memories for the years 1996-1998 E.C than for the years 1991-1993 E.C for the reason that recent data is relatively easy to remember than earlier data. In situations where people do not have the habit of recording information (say their annual income and expenditure), it is relatively easy for them to remember the very recent one.

3.4 Methods and Techniques of Data Analysis

The following methods and techniques were used for data analysis: Lorenz curve, Gini-coefficient, poverty ratio (or head count), Poverty gap and squared poverty gap.

Setting Poverty Lines

The first step that needs to be clear in the analysis of poverty is to identify whether an individual is poor or not. For this purpose, poverty line plays a crucial role in quantifying the various indicators of well-being in to a single index. Although the choice of poverty line is always arbitrary (World Bank, 2000), the common argument is that there is a minimum level of consumption of goods and services below which it is difficult to sustain our life.

In this study a poverty line was calculated by summing up expenditures required for minimum nutritional requirements per day and other essential non-food consumption per year for a household having a family of five. The recommended 225 kg (2.25 qtl) per person per year was taken as food poverty line expenditure. The annual expenditure requirement per person for essential non-food consumption items was derived from the aggregate average expenditure of the household survey. In other words, a poverty line was first calculated by taking in to account income required to achieve a minimum nutritional requirement and non-food expenditure requirements such as cloth, medicine, school, social and religious ceremonies, and farm inputs and others.

Table-3.2 Total household minimum annual income requirement

S.No.	Type of expenditure	Amount (Birr) /Year
I	Food Expenditure	
1.1	Grain	2,813.00
1.2	Meat and Milk	500.00
1.3	Oil	250.00
1.4	Fuel	200.00
1.5	Sugar, Coffee and others	250.00
	Total Food Expenditure	**4,013.00**
II	Non-food Expenditure	
2.1	Cloth	300
2.2	Medicine	100
2.3	School	200
2.4	Social and Religious ceremonies	250
2.5	Farm inputs and others	250
	Total Non-Food Expenditure	**1,100.00**
	Grand Total Annual Expenditure	**5,113.00**

This gives a total minimum annual income requirement of birr 5,113 which is equivalent to 522 US dollars. For this analysis, birr 14 or 1.4 US dollar per day was taken as poverty line for comparison of poverty of households before and after the project. Based on this, the following formulas were used:

3.4.1 Methods and Techniques of Poverty Analysis

3.4.1.1 Poverty Ratio or Head Count Ratio/Incidence of Poverty, P_o

This is the most commonly used single variate measure of poverty. This measure estimates the percentage of population below a specified poverty line. In other words, this is the share of the population whose income or consumption is below the poverty line, that is, the share of the population that can not afford to buy a basic basket of goods.

Put simply,

$$P_o = q/N$$

where q is the number of people earning income below the poverty line. and N the total number of people in the sample.

3.4.1.2 Depth of Poverty (Poverty Gap, P_1)

This measures how far an individual's income or consumption falls short from the poverty line across the whole population. It is obtained by adding up all the short-falls of the poor (assuming that the non poor have a short-fall of zero) and dividing the total by the population. In other words, it estimates the total resources needed to bring all the poor to the level of the poverty line (divided by the number of individuals in the population).

Mathematically, P_1 can be depicted as follows,

$$P_1 = 1/N \sum_{i=1,2...}^{q} [Z - Y_i]/Z$$

Where;

Y_i= Consumption expenditure or income of the poor

Z= Poverty line

q= Number of the poor

N= Size of the sample population

3.4.1.3 Poverty Severity (Squared Poverty Gap, P_2)

This takes in to account not only the distance separating the poor from the poverty line (the poverty gap), but also the inequality among the poor. That is a higher weight is placed on those households further away from the poverty line.

The measures of depth and severity of poverty are important complements of the incidence of poverty. It might be the case that some groups have a high poverty incidence but low poverty gap (when numerous members are just below the poverty line), while other groups have a low poverty incidence but a high poverty gap for those who are poor (when relatively few members are below the poverty line but with extremely low levels of income or consumption).

Depth and severity might be particularly important for the evaluation of programs and projects. A program might be very effective at reducing the number of poor (the incidence of poverty) but might do so only by lifting those who were closest to the poverty line out of poverty (low impact on the poverty gap). Other interventions might better address the situation of the very poor but have a low impact on the overall incidence (if it brings the very poor closer to the poverty line but not above it).

The severity index measures the severity of poverty by squaring and averaging the gap between the income of the poor and the poverty line. It is given by the formulae,

$$P_2 = 1/N \sum_{i=1,2...}^{q} [Z - Y_i]^2/Z$$

Where;

Y_i= Consumption expenditure or income of the poor

Z= Poverty line

q= Number of the poor

N= Size of the sample population

3.4.2 Methods and Techniques of Measuring Income Distribution

There are a wide variety of measures which are used by economists to measure income distribution. The following is a brief description of the procedure for computing some of the commonly used measures of income inequality.

3.4.2.1 The Lorenz Curve

This is a graphical measure of income distribution and income inequality. The information required to draw Lorenz Curve consists of a frequency table showing the distribution of income by decile groups of households. In simpler words, the table should show for each of the decile groups, its share in the aggregate income. To draw a Lorenz Curve, the cumulative percentage of income-receiving households is represented on the horizontal axis, the cumulative percentage of aggregate income on the vertical axis, and the curve represents the locus of all the combinations of the two cumulative percentages. The diagonal line represents a perfectly equal distribution of income, and hence is known as the line of equality. In general, the farther the Lorenz Curve is from the line of equality, the higher the degree of income inequality is.

The Lorenz Curve is a simple and commonly used measure of income inequality. It could be used to compare income distribution over time and across space. Its limitation is that, whereas it can show the difference in income inequality, it can not quantify it.

3.4.2.2 The Gini Coefficient

The Gini coefficient is a single measure of relative poverty and the most frequently encountered in studies of income distribution. It is the most commonly used measure of income inequality these days. When the ratio is approximated from the Lorenz Curve, it represents the proportion of the area lying between the diagonal and the Lorenz Curve (concentration area or area of inequality, to the total area under the diagonal. The

simplest computation of the Gini proceeds by taking the sum of the areas under all trapezoids and subtracting this from the total area under the diagonal to give the concentration area. The required ratio then follows. As a measure of income concentration, the Gini coefficient ranges from zero to one – the larger the coefficient, the greater the inequality. Thus zero represents perfect equality and one represents perfect inequality.
In actual fact, the Gini coefficient for countries with highly unequal income distribution lies between 0.5 and 0.7, while for countries with relatively equal distributions, it is on the order of 0.2 and 0.35.

3.5 Theoretical Framework

3.5.1 Theoretical Framework on Food Security

Food security means access to all people at all times to the food needed for an active and healthy life. At the household level, food security refers to the ability of the household to secure, either from its own production or through purchases, adequate food to meet the dietary needs of its members. Food security at a household level thus needs sufficient and secure income to buy its food at prevailing prices, and/or access to agricultural resources, like land, machinery and credit, to produce its own food (Taye Asefa, 1999).

Different literature reviews suggest that there are strong linkages between irrigation and poverty. These linkages are both direct and indirect. Direct linkages operate via localized and household-level effects, and indirect linkages operate via aggregate or sub national and national level impacts. Irrigation benefits the poor through higher production, higher yields, lower risk of crop failure, and higher and year-round farm and non farm employment.
Irrigation enables smallholders to adopt more diversified cropping patterns, and to switch from low-value subsistence production to high-

value market-oriented production. Increased production makes food available and affordable for the poor.

The indirect linkages operate via regional, national, and economy-wide effects. Irrigation investments act as production and supply shifters, and have a strong positive effect on growth, benefiting the poor in the long run. Further, irrigation benefits also accrue to the poor and landless in the long run, although in the short run relative benefits to the landless and land-poor may be small, as the allocation of water often tends to be land-based. Despite that, the poor and landless benefit, in both absolute and relative terms, from irrigation investments. Recent advances in irrigation technologies, such as micro-irrigation systems, have strong anti-poverty potential.

Water–Poverty Nexus

Land and water are two key natural resources upon which poor people depend for their livelihoods, and often more heavily than the non-poor. Poverty is an outcome of complex interactions of these and other resources, institutions, actions and policies and their ultimate outcomes. It would be naive to perceive that all rural poverty problems could be solved through improving the Poor's access to water alone. However, though water is only a single element in the poverty equation, it plays a disproportionately powerful role through its wider impacts on such factors as food production, hygiene, sanitation, food security, and the environment. Indeed, development agencies, groups, and experts worldwide are increasingly recognizing the important impact that water can have on poverty (Intizar Hussain, 2004).

Irrigation–poverty linkages

Within agriculture, irrigation water is a vital resource for many productive and livelihood activities. As a production input in agriculture, irrigation water is an important socioeconomic "good", with a positive role in poverty alleviation. Access to reliable irrigation water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming. This, in turn, opens up new employment opportunities, both on-farm and off-farm, and can improve incomes, livelihoods, and the quality of life in rural areas. Overall, irrigation water, like land, can have an important income-generating function in agriculture specifically, and in rural settings in general (Munir A. Hanjra, 2004).

There are five key dimensions on how access to good irrigation water contributes to socioeconomic uplift of rural communities and alleviating poverty. These are production, income and consumption, employment, food security, and other social impacts contributing to overall improved welfare. These poverty-reducing variables are interrelated. In general, access to good irrigation allows poor people to not only increase their production and incomes, but also enhances their opportunities to diversify their income base, and to reduce their vulnerability to the seasonality of agricultural production and external shocks. Thus, access to good irrigation water can contribute to poverty reduction, and to moving people from ill-being to well-being.

Further, there are three main pathways through which irrigation impacts poverty. These are:

- Micro-pathway: through increasing returns to physical, human, and social capital of the poor households (productivity and distribution pathway);
- Meso-pathway: through integrating the poor into factor-product and knowledge/information markets (market participation pathway); and

_ Macro-pathway: through improving national growth rates and creating second-generation positive externalities (growth pathway).

These pathways are very much interlinked. What happens on one particular pathway does have impact on others. The details of the pathways are given below (Intizar Hussain and Munir A. Hanjra, 2004).

Micro-pathway

Irrigation enables the poor and smallholders to achieve higher yields. The productivity of crops grown under irrigated conditions is often substantially higher than that of the same crops under un irrigated/rain fed conditions. Higher productivity helps to increase returns to farmers' endowments of land and labor resources. Apart from yield improvements, higher productivity partly stems from higher land use intensity and cropping intensity. Irrigation affects cropping intensity positively (Dahawan and Datta, 1992).

Access to good irrigation enables crop-switching: substituting low-yielding and low-profitable crops with new high-yielding and more profitable crops. This implies switching from subsistence production to market-oriented production. Further, crops can be grown year-round. Thus irrigation culminates in what is commonly known as crop diversification, and enables the poor and smallholders to spread risk more evenly over the course of a year (Reardon and Taylor, 1996). In fact, crop diversification is both an income maximization and risk minimization strategy. The role of irrigation in enabling the adoption of green revolution technologies, including modern varieties of rice and wheat in Asia, and their effects on income, employment, prices, food security and overall growth, are well documented in the development literature.

Increased employment for the poor may originate from the labour-intensive nature of irrigation developments/ construction and subsequent maintenance, and from intensive cultivation both on their own farm, as well as on the farms of other large farmers who may find it difficult to provide extra labour from family resources during peak times. Crop intensification, diversification, and market-oriented production make food available and affordable for the poor and rich alike. Nevertheless, the main beneficiaries of low and stable food prices are the poor and landless households in rural areas and the urban poor, as they tend to be net buyers of food and spend a major part of their monthly expenditure, up to three-quarters, on basic food.

Meso-pathway

The micro-pathway operationalizes the meso- and macro-pathways. The meso-pathway works at the local, community and regional levels and refers mainly to the secondary benefits of irrigation. For example, the effects of additional employment may spill over to landless workers in adjoining rainfed areas, who may migrate to irrigated areas to take advantage of the employment opportunities. Landless households in Bihar are known to be a major source of labor for Punjabi agriculture in India. Similarly higher wage and lower food prices benefit the general community, let alone the irrigated community. Further, development of irrigation infrastructure eventuates in supply and provision of other infrastructure. For example, an irrigation infrastructure funding decision influences both government and private sector decision making. Governments tend to allocate more resources and infrastructure facilities to high-potential favored areas to enhance their political interests. Financial institutions, such as banks, respond to similar incentives and tend to open their branches to these high-potential areas, which in turn may become nuclei of growth. This sets into motion a process of market integration and technological transformation, which makes modern infrastructure and financial services accessible to the poor. Access to low cost institutional credit has strong productivity-enhancing and consumption-smoothing effects, which has significant influence on poverty.

Macro-pathway

The macro-pathway works at the national and transnational or global level. It is widely acknowledged that economic growth is important for poverty alleviation. As long as irrigation infrastructure development can induce technological change and trigger economic growth, it should contribute to poverty alleviation. Economic growth helps to raise long-term and sustainable income, and is therefore a necessary condition to pull poor people out of poverty permanently, although it is by no means a sufficient condition. For example, the poverty impact of growth could be eaten up if population growth rates are very high. As most of the poor live in rural areas, growth effects must be concentrated in those areas and activities that directly benefit the poor. Different authors agree that agricultural growth serves as an "engine" of economic growth, and irrigation-led technological changes are the key drivers behind this productivity in the agriculture sector. This is due to its potential to increase overall food grain productivity, employment and income, and thereby alleviate poverty and hunger.

Hypotheses and the framework

As already implied in the foregoing discussion, one of the major factors that determines the ability of a household to acquire adequate food throughout the year is its ability to produce or purchase food. Implicit in this is the ability of the household to use available natural, physical and human resources efficiently.

3.4.2 Theoretical Framework on Irrigation Management

Irrigation System as "Socio-economic" System

Repetto (1986) states:

> *"To a large extent, the current emphasis on management as the critical problem in public irrigation reflects acceptance of the long-dominant engineering perspective. Most engineers, who still run virtually all irrigation agencies, conceptualize irrigation projects as hydraulic systems designed and built to operate in certain ways. If they don't actually operate that way in practice, then, according to the engineers "they are not being managed properly". However, seen not as hydraulic but as socio-economic systems, those same irrigation projects are designed to operate in quite a different way".*

That means, to ensure that target groups really benefit from village irrigation, more attention should be given to socio-economic aspects. The farmers have to participate in the identification, implementation and monitoring of schemes. It should be emphasized that the farmer has to be considered as a partner in irrigation development, and not as a tool which carries out the wishes of planners and engineers.

Tiffen (1984) states:

> *"It is no use planning irrigation scheme because suitable land and water resources exist: the facilities will decay unless there are motivated people to use and care for them".*

For this study an irrigation system is considered as a socio-economic system which gives more attention for the "software" of the irrigation system than the hardware. No matter how good the engineering works are, the end result which matters most is the socio-economic well-being of the people involved, and if the project can not consider this, then the scheme will fail.

Irrigation development involves various stakeholders whose roles, if not well defined and co-coordinated, could be counter-productive.

Stakeholders include not only those who initiate, implement and benefit from irrigation projects, but also those who are directly or indirectly affected by such projects. Nevertheless, the most essential stakeholder is the farmer, who, if not properly integrated in the project development, may not feel obliged to play his/her role effectively, thus jeopardizing the sustainability to the scheme (Stephen, 2002). Stakeholders should be integrated from the beginning of a project through effective co-ordination and clear definition of their roles.

Irrigation is not simply a mechanical task of delivering water to crops. It is a human activity and a social undertaking. The success of every project depends on the quality of the human effort invested in it. Moreover, an irrigation project is not only a system for producing crops but also, perhaps even primarily, a place for a community of people and families to live healthy lives while working cooperatively and contributing to the food security of their region. Therefore, as in other human activities, the first requirement for the success of irrigation development is that the workers engaged in the activity must be strongly motivated and committed to the task. The second requirement is that they must be properly informed, not merely trained in the performance of routine operations but also enabled the fundamental principles of proper irrigation management. The third requirement, of course, is that the irrigation workers must be given access to (preferably, an opportunity to acquire) the material inputs necessary for the best performance of their work (REST, 2002).

3.6 Area Description

3.6.1 Description of the *Wereda*

3.6.1.1 Bio-Physical Environment

Climate Condition

Wet and dry are the two seasons in the *wereda*[7]. The *wereda* includes three common agro-ecologies (dega, weina dega and kola) that vary from 1,500 mm-3,200 mm. There are both mono-modal and bi-modal types of rainfall pattern with most of the rainfall recorded during months of July and August. The mean annual rainfall of the *wereda* and the study area are 579 and 747mm. respectively (*TFSCO-SERA*[8] project, 2002).

Natural Vegetation

There are some indicators that the area was covered by natural forest once. But natural forest area has been largely destroyed, mainly through encroachment of subsistence cultivation. The vegetation cover is rapidly decreasing due to cutting of trees for house construction and agricultural implements. The main cause of deforestation and degradation in the *wereda* are (1) population growth, (2) Over grazing, (3) traditional farming practices. In order to preserve and regenerate the natural forest, area closure is being practiced and promising result is observed.

Geology and Soil

The major soil types of the *wereda* are stony loams and sandy loams. The soil fertility is very low. The organic contents and available nutrients are low with poor soil physical properties.

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[7] Wereda is a name given for a district with an administration hierarchy below Zone in Tigray.

[8] *TFSCO-SERA* is an abbreviation for Tigray Food Security Coordination Office-Strengthening Emergency Response Ability.

3.6.1.2 Socio-Economic Condition

Population

wereda Ahferom is the most populous *wereda* in the central zone of the Tigray region. The total population of the *wereda* was 173,651 out of which 83,992 are male and 89,659 are female. The population living in rural area was 150,240 i.e. 86 % of the people live in rural areas. And the sex ratio was 0.93 i.e. the number of male was less than the number of female (CSA, 2008).

Land use and Production System

Land use

The total land area of the *wereda* is estimated to be 133,500 hectares. Out of the total land area, 23,073 ha or 17.3 % is arable, 16,102 ha or 12% is grazing land, 43,274 ha or 32.4 % is forest and wood land, 29,729 ha or 22.3% is bare land and 21,322 ha or 16% is residence (*TFSCO-SERA* project, 2002).

Production System

Agriculture is the main economic base of the rural people in the *wereda*. About 95% of the population depends on this sector. Both crop and livestock production (mixed farming) is the dominant economic activity of the people. Dominant crops grown in the area are Sorghum, Barley, Wheat, Teff, and Maize. Pulses are secondary important. The reason for putting the major area under food crops is that farmers are not self-sufficient in food production.

3.5.2 Description of the Project Area

In *Dibdbo tabia* there were about 2,458 households of which 1,924 are male-headed and the rest 534 are female-headed households. Moreover, out of the total population of the *tabia,* i.e., 9551, 5018 (52.5%) were male and 4533 (47.5%) are female (BoARD, 1999 E.C).

The dominant crops grown in the study area before project intervention were Teff, Wheat, Millet, Barley and Hanfets (wheat and barley mixed). After project intervention, in the irrigated land, horticulture crops such as onion (21.6%), pepper (14.4%), potato (7.6%), tomato (1.7%) and horse bean (1.7%) were grown. These crops were grown on the one hand in small portion of the irrigated land of the household and on the other hand mainly for consumption purpose. The dominant crop grown in the irrigated land (53%) was maize (*BoARD, 1999 E.C*).

3.5.3 Description of the Dam

Dibdbo irrigation scheme is located in central zone, Ahferom *wereda, Dibdbo Tabia* and Mesehel & Adi-kerees *kushets* of Tigray region. Geographically, it is situated at 14° 13' 28" North in latitude, 39° 05' 00" East in longitude, and at an average altitude of 908 m a.s.l.

The site can be accessed during both wet and dry seasons through Adigrat-Adwa main road.

This dam is one of the operational irrigation schemes constructed by *REST* in the region. The construction of the dam was completed at the end of 1990 E.C and started irrigating land since 1991 E.C. The scheme was initially proposed to irrigate 70 hectares of land and to benefit 280 households. The scheme has reservoir capacity of 1.02 million meter cube (M^3) water. Moreover, the scheme has $7km^2$, 15m and 17.8m catchment area, crest length and dam height respectively. Since land redistribution did not take place in the irrigated area of the scheme, each household does not have equal hectares of irrigable land. The dam is operating below its potential. The average life span of the scheme is 22 years. Double cropping practiced in the scheme. Land redistribution in the project area was undertaken in 1999 E.C one year after this study.

Photo-3.1 Ato G/tsadkan G/mariam (*Abo-mai*[9] of *Dibdbo* Dam)

Photo-3.2 *Dibdbo* Dam

[9] Abo-mai is a local name meaning father of water who opens and closes the outlet gate.

4. RESULTS AND DISCUSION

This chapter presents and briefly discusses the major results of the study on *Dibdbo* irrigation schemes.

4.1 Irrigation Water Management Practices of the Scheme

Irrigation Water Utilization and Management

The study shows, the total irrigable area is irrigated by three big canals which locally called *qorqor*[10]. That means the whole area is irrigated using canal number one, canal number two and canal number three. Each canal irrigates a specific area of land and benefits a specific group of farmers. For example, canal number one irrigates an area up to 12 ha of land and benefits 68 households. This canal covers areas that range from Shehaqa up to Mai-dir; canal number two covers an area from Enda-agamat up to walaka has about 16 ha of land and benefits 95 households. Canal number three which fall from Geza-adem up to Ayebleomn irrigates about 19 ha of land and benefits 117 households. Here each farmer knows from which canal he is going to irrigate his plot (locally called *Lota*[11]). Each canal has 2-3 days of irrigation interval. The main reason to irrigate the whole command area on canal basis is to control the utilization of the water in the whole command area more effectively by the *abo-mai.*

According to the findings, farmers in *Dibdbo* irrigation scheme irrigate their field at an interval of 12 to 15 days for cereal crop like maize and at 7 to 10 days interval for vegetable crop like onion. Irrigation is done for a period of 2 hours for 0.25 ha.

[10] *Qorqor is a local name for big canals (most of the time for secondary canals).*
[11] *Lota is a local name for a plot having 30m*50m area.*

Crop and Irrigation Water Requirement

Efficient and sustainable water management in an irrigated cropland helps to ensure optimum use of irrigation water for crop production (Chakraborti, 1998). Scheduling that result in either excessive or inadequate water application can significantly reduce the potential for profitability. In most irrigation projects around the world, there is a strong discrepancy between the actual distribution of water to the farmers and the irrigation schedules as determined by the crop water requirement. As a result considerable amount of water diverted for irrigation is not effectively used for crop production. It is estimated that of the diverted water on average, only 45% is used by the crop the rest being lost through conveyance and application. Of the total water loss, 40% occurs at farm and field level with a direct effect on crop production (Smith, 2000).

The study also documents the absence of irrigation practice based on crop and irrigation water requirement. The common irrigation practice exercised in the scheme is that each farmer has the right to apply as much water and stop irrigating and pass the water to the next user only when he/she believes his/her farm is well watered. As a result, wastage of water by runoff and over-watering is common.

Water Users Association (WUA) and Water Committee

In Ethiopia, water management and infrastructure maintenance was found to be one of the bottlenecks affecting the sustainability of small-scale irrigation (SSI) development. Consequently, after the construction of SSI scheme, WUAs is established. All beneficiaries will be members of the WUA. The WUA will be a legally recognized body responsible for the management of the scheme; it facilitates water distribution, maintenance and operation of the scheme.

The study indicates that before 1997 E.C there was no water management practice and institutional arrangements in *Dibdbo* irrigation system. After the construction of the scheme WUAs were not established immediately. As a result water of the dam was not used by the beneficiaries efficiently. According to Yirgalem Tafere, development agent of *Dibdbo tabia*, only 50-60% of the irrigation water was used properly. it was in 1997 E.C that the WUA and the Water Committee were officially established by users in consultation with development agents of the agriculture office of the *tabia*.

The water committee of the *dibdbo* irrigation system was composed of three members in 1998 E.C, five members in 1999 E.C and five members in 2000 E.C. The committee has chairperson, vice chairperson, secretary and the rest are members. There was only one female member in the committee in 1999 E.C. Moreover, there is only one water distributor (*Abo-mai*) in the scheme. The committee members are elected every year while the *abo-mai* was elected by the beneficiaries after the construction of the dam was completed. He has served for about ten years. The out let gate is opened and closed by the *abo-mai*. During the key informant interview and group discussion, the participants respond that the reason for the *abo-mai* to stay for about ten years is that he is hard worker and genuine specially in distributing the dam water for farmers according to their turn. As is indicated in the by-law in annex-II, the *Abo-mai* has a monthly salary of birr 200 which is decided by the water committee.

The scheme has a by-law. The by-law of the scheme was written by the beneficiaries themselves with the technical assistance of the office of *tabia* agriculture development (extension) agents. The by-laws of the scheme are presented in annex-II.
The major duties and responsibilities of the *abo-mai* in the management of the irrigation water of the scheme is to open and close the outlet gate,

distribute dam water for farmers according to their turn, and check whether farmers made their irrigable land free of weeds and use DAP/Urea for their plot before irrigating. In *Dibdbo* irrigation scheme, a farmer who didn't make his land free from weeds and didn't use DAP during sowing and UREA during hoeing for his/her land will not get irrigation water. So it is a must to use DAP/Urea so that he/she can get irrigation water. This obligation is included in the by-law of the scheme and is presented in appendix-II.

Moreover, the *abo-mai* reports the names of the farmers who did not follow the by-law to the water committee for punishment. The water committee on the other hand controls the overall activity of the scheme. The committee controls the day- to-day activities of the *abo-mai* in the scheme; punish those who violate the rules of the scheme and resolve conflicts over water utilization which can not be resolved by the *abo-mai*.

4.2 Internal and External Problems Encountered in the Scheme

The following are some of the major problems encountered in irrigation expansion in the study area:

4.2.1 Low Community Participation in the different phases of the project

Communities of the study area are not expected to participate in each and every phases of the project especially in areas that require specific skill such as engineering. However, they have to participate in phases of the project which demand local knowledge and material. For example from the very beginning the community should be informed about the project which is going to be constructed in their area. The *wereda* administration together with the constructing body that is REST should made a thorough discussion with the community regarding the positive and negative impacts that could come if the project is constructed in the area. In *dibdbo* irrigation scheme however, very big numbers of people (actually in thousands) were participated only during the construction stage of the scheme as daily labourers.

In the beginning, the engineers assumed that the farmers could not understand the design or the functions of the structures and explanation followed after implementation. In a participatory planning method, farmers' manageable role in each step will be distinguished. Farmers will be asked how they expect the water to reach their farms, how they want to be grouped. Moreover, farmers will be allowed to give their suggestions on where the irrigation structures to be placed in the design, where to be the grazing land and together with the engineers alternatives and amendments will be made where needed (Wouter, 2002). Successful implementation requires participation in the planning and implementation process by all stakeholders, in order to create a sense of ownership of, and consequent commitment to, the project.

4.2.2 Absence of Socio-economy Study Document

It is a usual practice that when there is a construction of any water harvesting scheme such as dam, diversion or spate irrigation, socio-economic of the beneficiaries and the study area is studied. The team that is involved in undertaking the socio-economic study of the beneficiaries and the study area is expected to include in his study report the demography, the proposed cash crops to be grown, the crop and irrigation water requirement and the cropping pattern and is also expected to submit the report document to the concerned bodies such as the agriculture office of the *wereda* or *tabia.*

However, the study document for *dibdbo* irrigation scheme, which comprises these all important information, was not given to the *wereda* or *tabia* administration bodies. As a result the cropping pattern in the scheme was based on the experience, personal preferences and available resources of farmers.

4.2.3 Environmental Problems

As is in many different parts of the region, salinity, water lodging, sedimentation, and malaria are the problems that come hand in hand with the expansion of the dam.

About 40.48 percent of the sampled households responded that water logging was their main problem followed by salinity problem responded by 26.19 percent of the households. In the command area about 5 *lota* (5*30m*50m= 7,500m^2 or 0.75 hectare of land is affected by salinity and water logging. The major symptoms of the area affected by salinity is that the color of the plants (grasses) grown in that area become yellowish, there are some white ash seen over the affected area and that white ash has a salty taste. And because of this the affected is not now used as irrigated area. Photo 4.1 below shows area affected by salinity.

Photo-4.1 Irrigated area affected by salinity.

Sedimentation is also a problem in the scheme. This can be attributed in part to the cultivation of the areas near to the dam. Livestock of the nearby *tabias* graze around the dam and drink water from the reservoir. When the livestock graze around and drink water from the dam, they affect the texture of the top soil found around the dam and become susceptible for erosion by water and wind. Therefore, every year the reservoir is silted. However, since the volume of water in the reservoir is not measured every year, the amount of the reservoir's water displaced by the sediment is not known.

Photo-4.2 Livestock drinking from the dam (left) and grazing around the dam (right).

Of course in 1999 E.C the gullies which feed water to the reservoir were treated by constructing a gabion. Around 20 gabions were constructed across the gully. However, some of the gabions are now in bad condition and need rehabilitation. In any case catchment treatment (watershed management) should be undertaken intensively in the area for the increased life of the reservoir.

Photo-4.3 Gabions found in good (left) and bad (right) condition.

4.2.4 Over Irrigation

Over irrigation is a problem in the scheme. During my stay in the study area I observe over irrigation of crops is most common leading to inefficient use of irrigation water for the following reasons. (1) Irrigating crops is not based on crop and irrigation water requirement; (2) payment for water used (water charge) is not based on quantity of water used and the amount paid per household per year is very small (at most birr 7); (3) awareness of beneficiaries about over and/or under-irrigation is limited; and (4) management of irrigation water in the area is limited.

4.2.5 Government Policy; Institutional and Legal Support Problems

Poor extension services, absence of workable cost recovery schemes, absence of cooperative societies, weak organizational management of WUA, limited leadership roles of women in irrigation management are the major problems faced in *dibdbo* irrigation scheme. The details are given as follows.

Very little extension service was in place. Although today there are three extension agents who work with farmers in each tabia or farmers' training centre, during the years 1996 and 1997 E.C there was no such extension agents. Because of this the farmers in that scheme didn't get enough extension service and have little sense of farming as a business. As a result, farmers had not been able to move from producing traditional crops to producing high-value crops. Moreover, the extension agent assigned in *Dibdbo* scheme has other duties outside the scheme i.e. he is assigned to deal with two or three peasant associations. Because of this each peasant association or scheme gets extension services from the extension agent on interval bases not on daily bases.

In the scheme over irrigation is practiced which lead to miss-utilization of the scarce resource, water. This is partially because of the absence of cost recovery system. Farmers pay very little amount of money, a maximum of 7 birr per year.

In the scheme there were no cooperative societies. Moreover, female headed households were not participated in the leadership roles of the irrigation management. It was only during 1999 E.C (a year which is out of the scope of this study) that one female headed household selected in the water committee. It was in 1997 E.C that the WUA and the water committee established in the scheme. However, the water committee was not strong enough to manage the scheme.

4.2.6 Market Availability

Since most of the farmers were producing maize, which was mainly used for household consumption, market problem was not as such a critical issue in the study area. However, some farmers were also producing cash crops like tomatoes, onions, potato and pepper. Because of the perishable nature of the vegetables, prices fluctuate frequently and farmers were often forced to sell at low prices in the local market. Moreover, farmers exchange their onion product for grain in western zone of Tigray because of the low price of onion in the local market.

4.2.7 Input Supply and Credit System

The study shows farmers use more inputs, like fertilizer, improved seeds and chemicals after the project than before. However, the availability of some inputs such as pesticide does not meet the demand. And because of the high price of fertilizer, most households face problems in repaying back. The study shows about 47.6 percent of the surveyed households use fertilizers and pesticide; 69 percent of them take credit service from Dedebit Credit and Saving Institute (DECSI).

4.2.8 Production System

Although the farmers seem happy with the current level of production (two harvests per year), the crop production mix is poor and there is a heavy dependence on local grains such as maize, wheat, barley, and teff. Farmers clearly lack good agronomic practices. Random cropping is still practised with farmers (own survey data and observation, 2000).

The study shows that most of the farmers did not harvest cash crops. Their irrigated land is covered mostly with maize (50.4%), which according to the farmers' opinion, is used both for household food consumption and the residue for their livestock and is more suitable for the area.

4.2.9 Lack of Monitoring and Evaluation

Undertaking monitoring and evaluation of development projects has paramount importance for immediate remedial action and also is used as a feedback for other similar new projects during project designing and planning. In *Dibdbo* scheme there is complete absence of monitoring and evaluation activities after project hand over or when the project is in full operation.

4.3 Impact of Irrigated Agriculture on Household Food Security

In assessing the impact of irrigated agriculture on household food security in the study area, the following food security indicators which are common to all definitions of food security are used.

These include:

- Increase in the number of food secure months (decrease in the number of months the hunger period lasts),
- Increase in the numbers and varieties of livestock such that extra animals can be sold in difficult times, and
- Increase in yield level or production (increase in household income),
- Increased employment.

4.3.1 Food Supply from Agricultural Production

Food supply from agricultural production is expressed in terms of how many months food supply a household obtains from agricultural production. Before project intervention, the average food availability of households from agricultural production was four months. After project intervention the percentage of households that had less than or equal to four months of food supply from agricultural production was about 7.14 percent. Those who have 5-6 months of food supply from agricultural production were 26.19 percent. Moreover, the percentage of households producing seven to eleven months of food supply was 40.48 percent; and those with twelve months of food supply account for 26.20 percent. Table-4.1 below shows number of months of food supply from agricultural production.

Table-4.1 Number of months food is available from own production (After the Project)

No. of months food is available	No. of households	Valid Percent	Cumulative Percent
<=4	3	7.1	7.1
five	1	2.4	9.5
six	10	23.8	33.3
seven	1	2.4	35.7
eight	6	14.3	50.0
nine	7	16.7	66.7
ten	1	2.4	69.0
eleven	2	4.8	73.8
twelve	11	26.2	100.0
Total	42	100.0	

Source: Own Survey data (2000)

4.3.2 Livestock Possession as Food Security Indicator

The most important contribution of livestock to agricultural production in the study area is the use of oxen as draft power for plowing and threshing. The number of oxen owned is particularly significant in relation to crop production, as two oxen are required for ploughing. Households with only one ox are dependent on hiring a second, usually in exchange either for their own one ox, or human labour.

Those with two or more oxen are in a very advantageous position, as they are not only can hire out their oxen for additional labour and/or cultivate additional land for half the harvest, but can also choose the most optimum time for ploughing and working on their own land, a considerable advantage where rain fall is scarce and unpredictable. Delays in land preparation can have significant impact on production. Given the key role it plays in the subsistence economy, oxen ownership is a very commonly used indicator of relative household wealth.

The study shows before the project intervention, nine households were with out ox, eight farmers with one ox, twenty farmers with two oxen, four farmers with three oxen and one farmer with four oxen. Comparatively, after project intervention, nine households were with out ox, fifteen farmers with one ox, ten farmers with two oxen, four farmers with three oxen, three farmers with four oxen and one farmer with six oxen. Household's livestock possessions such as cattle, sheep, goat, donkey and beehive before and after the project intervention were more or less the same if not worsened. The result of this analysis shows that there is no difference in the number and variety of livestock holding by households before and after project intervention.

4.3.3 Land Holding Status of Households

The shows in the study area there was no redistribution of the irrigated land after the construction of the dam is completed. Based on this there is a substantial difference in land holding status among the beneficiary households. The study shows before the project the average land holding status of the households was 2.85 *tsmad*[12], the highest being 5 *tsmad* and the lowest being 1 *tsmad*. On the other hand, the mean land holding status of the household after the project was 1.3 *tsmad*, the maximum being 3 *tsmad* and minimum 0.25 *tsmad* for irrigated agriculture and 1.55 *tsmad*, the maximum being 4 *tsmad* and minimum 0.5 *tsmad* for rain fed agriculture (own survey data, 2000).

4.3.4 Leased-out and leased-in Land

Limited access to productive land was considered by farmers as one of the main causes of food insecurity (Sen, 1992). Studies conducted by *CO-SAERT* in 1996 show that the average household land holding ranges between 0.5 and 1.5 hectare. Nowadays, due to increasing population land lessens is becoming common phenomena among the young generation and has to some extent forced them to migrate to towns to seek for work or to participate in food for work programs.

During the key informant discussion, most of the participants stressed that ownership of land or access to even small pieces of land mainly from the irrigated land for farming has lead to a substantial effect on the food security status of the rural households. Since there is no more unclaimed or unused land in the area, people are trying to cope with land shortage by hiring or leasing-in from other farmers.

During the study households were asked why they leased-in and/or leased-out their land. Out of the total households interviewed, that is 42, eleven households (26.2%), of which seven female and four male, leased-

[12] Tsmad is a local unit of measurement which is equal to 0.25 hectare.

out their land. Out of the eleven households who leased-out their land, seven households responded both shortage of family labour and lack of oxen as their main reason to lease-out their land. Moreover, shortage of family labour responded by two households, lack of oxen responded by one household and long distance from residence responded by one household were their main reason to lease-out their farm land.

Similarly out of the total interviewed households, seventeen (40.5%) farmers, of which one is female leased farm land from other households. Out of the seventeen households who leased land, fourteen households responded that access to land and access to yield and crop residue (locally called *haser*[13]) were their main reason to lease land from other farmers. Three households replied access to yield and *haser* only as their main reason to lease-in land. Land leased-in activity is mostly practiced by resource rich farmers.

The usual agreement during leased-in/out is crop sharing that is in kind, where a certain proportion of the harvest is given to the land holder in exchange for use of the land. Half of the harvest was the most common arrangement practiced in the study area.

4.3.5 Labour Availability

The study shows irrigated farms are more labour intensive than non-irrigated one. The family labour supply is not enough for irrigated farming. As a result, non-family labour was used by irrigator farmers. Labour is both exchanged (*lifinti*[14]) and hired to overcome labor bottlenecks. Hired labour is most used at ploughing, weeding and harvesting.

The study shows about 38 percent of the households faced labour shortages during ploughing, weeding and harvesting. They solve their

[13] *Haser* is a local name for crop residue or crop bi-product which is used as food for livestock.

[14] *Lifinti* is a local name for labour exchange (reciprocal labour) among farmers during different agricultural activities.

labour shortage by hiring daily labourers (38 prcent of the farmers) and labour exchange (14 percent).

4.3.6 Land Fragmentation

The study shows the average number of plots of the households is 3.9 plots; the minimum being one plot, replied by one person and the maximum is more than seven plots, replied by five households. When the households were asked whether their farm land is fragmented or not, twenty households (47.6 percent) replied yes it is fragmented and twenty two (52.4 percent) replied it is not fragmented.

The study also shows the main reason for land fragmentation in the study area was variation in land fertility (90%, 18 farmers), shortage of land (50%, 10 farmers) and land tenure system (40%, 8 farmers). The major problems encountered by the households due to land fragmentation, according to the study result, was inconvenience to cultivate (100%, all farmers), inconvenience to look after (100%, all farmers) and tiny plots (10%, two farmers). Table-4.2 below shows the number of plots of households.

Table-4.2 Number of plots of the sampled households

Number of Plots	Number of Households	Valid Percent
one	1	2.4
two	9	21.4
three	9	21.4
four	14	33.3
five	2	4.8
six	2	4.8
more than seven	5	11.9
Total	42	100.0

Source: Own survey data (2000)

Household Income Sources

Agriculture is not only the main activity in the area it is also the main source of cash income for most of the vast majority of the population in the study area. Household annual gross income in this case was estimated as the sum of all income obtained from crop production (consumed and sold), sales of livestock and off-farm employment.

The major sources of household income before and after the project intervention are shown in table-4.3 below.

Table- 4.3 Household Income Sources and its Share

S.No	Source of Household Income	Share from Total Income (%)	
		Before the Project	After the Project
1	Farm Income	55.9	64.7
2	Off-farm Income	38.8	27
3	Sales	5.3	8.3

The study shows that thc main sourccs of income of the households before the project intervention were agricultural production (55.9%), off-farm income sources (38.8%) and sales of livestock (5.3%).

Moreover, after project intervention, 64.7% of the household's income comes from agricultural production followed by off-farm work (27.0%) and sales of livestock (8.3%). The reason for the decrease in the share of off-farm household income after the intervention of the project is that some households who were engaged on different off-farm activities before the project are now (after the project) fully engaged in their irrigated plot. As a result, farm income increases but off-farm income decreases after the project.

The major household's off-farm income sources in the study area before project intervention were food aid (44.9%), stone selling (18.1%), masons (11.0%) and eucalyptus selling (10.5%). Moreover, food for work (53.4%),

stone selling (25.0%), and masons (13.1%) are the main off-farm income sources of the household after project intervention.
From the results of the study, it is observed that before the introduction of the project (1988-1990 E.C) about 45% of the sampled households were assisted by food aid during food shortages. However, in recent years food assistance is given to the people in the form of food for work program which means food assistance is attached to developmental activities in the area such as soil and water conservation activities, afforestation programs, gully rehabilitation and the like. But food aid is still given to households who are aged and disabled.

The study also shows that off-farm income of the household before the project is higher than after the project. However, the difference is small indicating that the beneficiary households were still involved in off-farm activities by renting-out their irrigated land (due to different reasons).

Household Survival Mechanisms

Household responses during food insecurity and famine might be different for different areas and different people. Survival is defined as the ability of households to keep all or some of its members alive under sever food deficit with in the existing social, economic and moral institutions of society (Diriba, 1995). Households were asked how they had responded to the recent crises. The responses recorded are given below.
About (80.9 %) of the sample households respond that, before the project, they were dependent on food aid. A majority of the sample households (92.8 %) respond that, after the project, food for work was their main survival mechanism. About 23.8 percent of the households revealed that selling eucalyptus as their main survival mechanism. Selling stone is another survival mechanism reported by 19 percent of

the households. Of the 42 households twelve, (8 from mesehel and 4 from adikerees *kushets*), were female-headed households.

4.3.7 Results of Poverty Analysis

The estimates of poverty namely head count; poverty gap and squared poverty gap are evaluated in order to assess the status, depth and severity of poverty before and after the project intervention in the study area.

4.3.7.1 Poverty Head Count (P_o)

The result of head count ratio showed that before the project intervention, nearly 83% of the households were identified as poor. By contrast, only about 36% of the households were living below the poverty line after project intervention.

Table-4.4 Poverty Head count Index of households

Description	Poverty Head Count (PL-I)	
	Poor (%)	Non-Poor (%)
Before project intervention	83	17
After project intervention	36	64

Source: Own survey data (2000)

4.3.7.2 Poverty Gap (P_1) and Squared Poverty Gap (P_2)

Table-4.5 below reveals that the overall poverty gap was 0.37 and 0.28, indicating that poor households needed an additional 37 percent and 28 percent of the present income to attain minimum basket of basic needs before and after the project respectively. This implies that depth of poverty or the level of income transfer needed to bring all poor households in the sample was higher before the project than after the project. Furthermore, the severity of poverty through squared poverty gap of the households was found to be 14 percent and 8 percent before and after the project intervention respectively.

Table-4.5 Summary of Poverty gap and squared poverty gap indices

Intervention period	Poverty Gap	Squared Poverty Gap
Before project intervention	37	14
After project intervention	28	8

4.3.8 Results of Income Distribution Analysis

A closer look of the distribution of income among the households shows that the average annual income per household before and after the project was birr 3,913.40 and birr 6,161.86. An income difference of birr 2,248.46 between before and after the project intervention is highly significant given the low average per capita income in the study area.

After the project the income of 20 households (47.6%) was found to be greater than the average which is birr 6,161.86. The minimum and maximum incomes per household (after the project) was birr 2,270 and birr 14,608 respectively. However, before the project, only 45.2% of the households had their income greater than the average income of birr 3,913.40 and the rest are found below the mean. The minimum and maximum incomes per household (before the project) was birr 715 and birr 10,875 respectively.

To compare the distribution of income of the households before and after the project, Lorenz Curve and Gini coefficient were performed. The results are given below in figure-4.1.

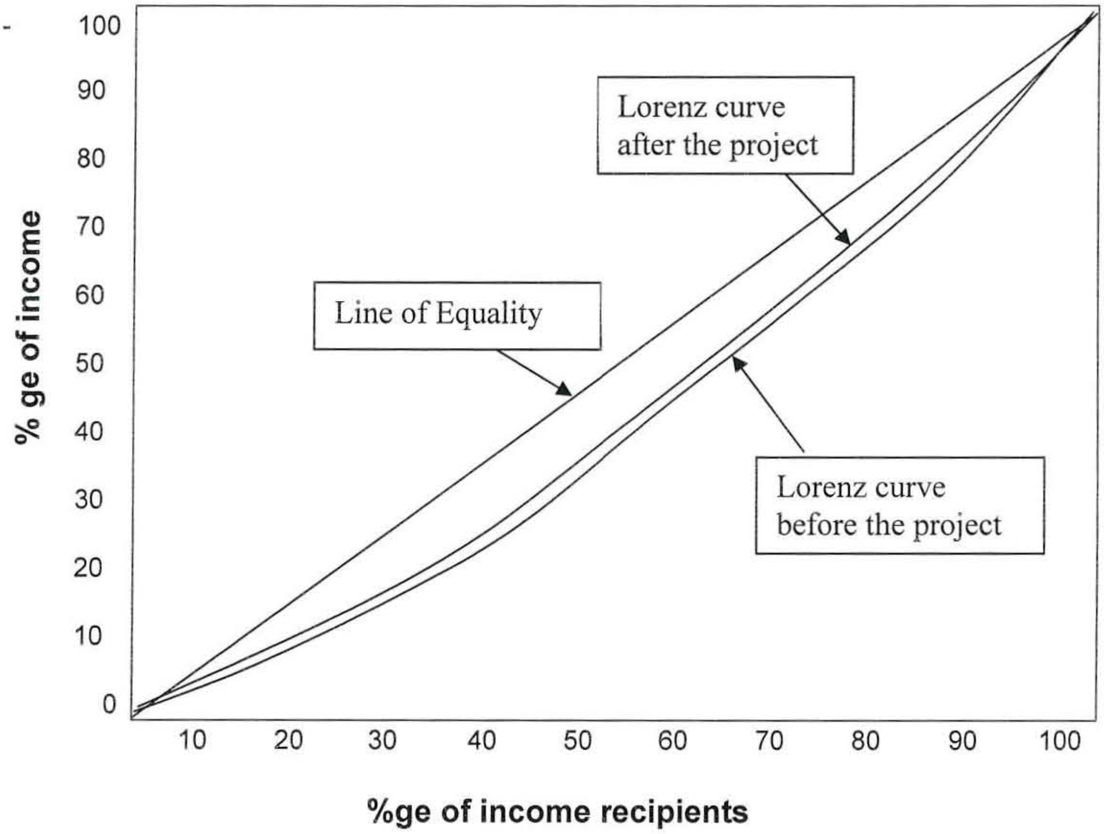

Figure-4.1 Lorenz Curve before and after the project

The Gini coefficient derived from the Lorenz Curve is 0.27 and 0.23 for households before and after the project respectively, which implies that the distribution of income is considered as relatively equal among the households before and after the project.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

5.1.1 Irrigation Water Management of the Scheme

- The absence of strong water management practice and institutional arrangements in the scheme hinders efficient utilization of the irrigation water.
- Although irrigating the command area on qorqor (canal) bases helps the Abo-mai control the utilization of water, it does not avoid the wastage of water mainly due to over irrigation.
- Irrigation practice is not based on crop and irrigation water requirement. As a result, wastage of water by over-watering is common.
- Unlined canals are observed in the scheme with the likelihood of high seepage losses.

5.1.2 Major problems encountered in the scheme

- Environmental problems such as salinity, water lodging, sedimentation, and malaria are some of the problems which affect efficient utilization of the scheme water.
- Social and institutional problems as reflected by poor extension services, absence of workable cost recovery schemes, absence of cooperative societies, weak organizational management of WUA, limited leadership roles of women in irrigation management are other major problems which hinders irrigation development in the scheme.
- Absence of socio-economic study document and lack of community participation on the different phases of the projects are also other problems which affects irrigation development.

5.1.3 Impact of Irrigated Agriculture on Household Food Security

- Irrigation development increases the number of months of food availability from agricultural production. Before project intervention, the average food availability of households from agricultural production was four months. After the project, however, the average number of months was increased to six.
- Irrigation intervention in the area increases crop yields and income of the households. The result of the survey has shown that the average annual income per household before and after the project was birr 3,913.40 and birr 6,161.86 respectively.
- The poverty estimates were found to be lower after the project than before the project. The poverty head count index was 83 percent before the project and 36 percent after the intervention. Similarly, the overall poverty gap (depth of poverty) was 0.37 and 0.28. Moreover, the severity of poverty was found to be 14 percent and 8 percent before and after the project intervention respectively. Based on this, although the poverty estimates after the project is lower than before, the project's contribution especially in addressing the depth and severity of poverty is less.
- The scheme also creates better employment opportunity and awareness on farmers about intensified farming practices. Moreover, farmer's out-migration during the dry season has been reduced.
- In conclusion, most of the comparisons indicated that the development of the irrigation scheme in the area brings a positive impact on household food security. However, due to the absence of appropriate irrigation water management practices in the area, maximum positive impact of the scheme on beneficiary households could not be attained.

5.2 Recommendations

- Smallholder irrigation is important to agricultural development and to food security. To be successful, the smallholder irrigation system should be based on the wide participation of the farmers using the bottom-up approach to planning. Gender mainstreaming is important at all levels of the development process; women should be able to own land, participate at the leadership level, share in the economic benefits, etc.
- At present the beneficiaries of the scheme are not charged for the scarce water they are using. This may lead to the misuse of the scarce resource and finally may lead to low water use efficiency. It is, therefore, highly recommended that appropriate regional water charge pricing policy or re-investment fund should be introduced for all sources of irrigation water.
- Good erosion control measures and re-afforestation programmes should be work out for the catchment area. The treatment of catchment areas with soil conservation measures should start before starting the construction or at the minimum simultaneously all along the construction period with plans and mechanisms of continuous maintenance of the scheme.
- As water is the limiting factor in the expansion of irrigated areas, it is recommended that water-saving technologies such as lining of canals and/or drip irrigation should be undertaken. This is because such technologies can: increase water use efficiency, prevent degradation of the environment and benefit more farmers.
- Farmers should organise themselves into co-operatives. These co-operatives should provide credit facilities at reasonable interest rates, draft by-laws, search for group market places, etc. Organising farmers into groups will help them acquire a better negotiation potential for selling their products.

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ANNEX-I QUESTIONNAIRE

I. Basic Household Characteristics

1. Location

   i) Zone ________________
   ii) Wereda ______________
   iii) Tabia ______________
   iV) Kushet ______________
   Agro-ecological zone: 1= Dega, 2= W/dega, 3= Kolla ☐

2. Name of Household Head ________________

3. Sex, 1 = Male _, 2 = Female ___ ☐

4. Religion, 1 = Orthodox, 2 = Catholic,
   3 = Protestant, 4 = Muslim 5 = Others (Specify) ☐

5. Demographic characteristics

   Household composition:

S.No (1)	*List of HH Members (2)*	*Family Relationship (3)*	*Age (Years) (4)*	*Sex (5)*	*Marital status (6)*	*Literacy Status (7)*	*Occupation (8)*

Column (3): (Family Relationship): 1=HH head, 2= Spouse, 3= Son, 4= Daughter, 5= Relative, 6= Dependent, 7= Other (specify)

Column (5): (Sex): 1 = Male, 2 = Female

Column (6): (Marital status): 1 = Married, 2 = Unmarried, 3 = Divorce, 4 = Widowed, 5= Separated

Column (7): (Literacy status): 1 = Illiterate, 2 = Read & write 3 = Primary (1-8), 4 = Secondary (9-10), 5 = Tertiary (11^+)

Column (8): (Occupation): 1 = Farmer, 2 = Daily laborer, 3= Student, 4= Civil servant, 5= Unemployed

6. Labor wage income (only those family members whose occupation is labor wage)

Family member S.No.	Local (in village it self)		Migration (work out of village)		
	No of days worked in a year	Wage rate per day (birr)	place	No of days worked in a year	Wage rate per day (birr)

II. Land Holding and Crop production

7. What kind of farming practice do you use?
   1= Rain fed, 2= Irrigated, 3= Both ☐
8. Land holding status of the household (before & after the project)

S.No	Land holding status (ha or tsmad)	Before the Project	After the Project	
			Rain-fed	Irrigated
1	Land owned			
2	Land leased in			
3	Land leased out			
Total land				

9. If leased out your irrigated land, what are the reasons for leasing out?
   1= Lack of oxen, 2= lack of credit, 3= Shortage of family labor ☐
   4= others (specify)

   If leased out your irrigated land, what was the rental contract agreement?

   1= if on cash, how much (Birr)?_______
   2= if in kind, what per cent of the total yield?______

10. If leased in an irrigated land, what are the reasons for leasing in?
    1= access to land, 2= access to irrigable land, 3= others (specify) ☐

    If leased in an irrigated land, what was the rental contract agreement?
    1= if on cash, how much (Birr)?_______
    2= if in kind, what per cent of the total yield?______

11. Do you have shortage of labor? 1= Yes, 2= No ☐

If yes, (i) when (season/months)________________________________

(ii) for which activities___________________________________

12. When you encounter labor shortage, how do you overcome the difficulty?

(i) Through help from relatives, friends and neighbors

(ii) By employing laborers, ☐

(iii) Others (specify)

13. If you employ laborers, specify

(i) The no of laborers you employ_________

(ii) The time (month/season) you employ laborers___________

(iii) The wage rate you pay__________

(iv) Your total labor cost per year (in birr)_______

14. How many different plots do you own?

Irrigated plots_________, Irrigated area_________ha

Rain fed plots_________, Rain fed area_________ha

15. Do you consider your land holding fragmented? 1= Yes, 2= No ☐

If yes, what, in your opinion, are the reasons for land fragmentation in the area?

1= Shortage of land, 2= Variation in land fertility ☐

3= Land tenure system, 4= others (specify)________

Again, if yes, what are the major problems you encounter? (due to land fragmentation)

1= Inconvenience to cultivate, 2= Inconvenience to look after ☐

3= Tiny plots, 4= others (specify)___________

16. Which crops do you normally grow?______________________________

Why do you prefer to grow such crops?

1= Suitable for the area ☐

2= House hold consumption

3= More economical

17. Major crops grown and production before the project?

S. No	Crop Type	***Area (ha or tsmad) and Yield by Year***					
		1990 E.C		***1989 E.C***		***1988 E.C***	
		ha or (tsmad)	Yield (qt)	ha or (tsmad)	Yield (qt)	ha or (tsmad)	Yield (qt)
1	Teff						
2	Barley						
3	Wheat						
4	Sorghum						
5	Maize						
6	Millet						
7	Total						

18. Major crops grown and production after the project?

S. No	Crop Type	***Area (ha or tsmad) and Yield by Year***					
		1998 E.C		***1997 E.C***		***1996 E.C***	
		ha or (tsmad)	Yield (qt)	ha or (tsmad)	ha or (tsmad)	Yield (qt)	ha or (tsmad)
I	**Rain Season**						
1	Teff						
2	Barley						
3	Wheat						
4	Sorghum						
5	Maize						
6	Total						
I I	**Dry Season**						
1	Onion						
2	Potato						
3	Tomato						
4	Carrot						
5	Total						

III. Household Food Security

19. Do you produce enough food for your family?
 1= Yes, 2= No ☐

 If yes, for how many months was it enough? __________

 If yes, number of meals taken per day________________

 If not, which copping mechanisms were used during months of food shortage?
 1= Food aid, 2= Through purchase, 3= Selling animals,
 4= Selling trees and fire wood, 5= Reducing the no. meals per day ☐
 5= Reducing the quantity of food intake per day, 6= Through participation in Food For Work Program, 7= Gifts/donations from friends & relatives, 8= others (specify)

20. Number of Livestock possessed

S.No.	Animal	Number of Animals Possessed	
		Before the project	After the project
1	Cattle		
2	Draft oxen		
3	Sheep		
4	Goat		
5	Donkey		
6	Horse		
7	Mule		
8	Camel		
9	Poultry		
10	Bee hive		

21. Do you get extension services? 1= Yes, 2= No ☐

 If no, why not?______________________________________

22. Do you use modern inputs? 1= Yes, 2= No ☐

 If yes, what type of modern inputs do you use?

 1= Improved seeds, 2= Fertilizer, 3= Pesticides ☐

 If not, why not?

 1= Not available, 2= Not affordable, 3= Not interested ☐

23. Do you get credit service? 1=Yes, 2=No ☐

If yes, when?________(E.C)
If yes again, how much?_________(birr)

S. No	Purpose for which credit is taken	Amount (br)	Source of credit	Interest rate/year
1	Purchase of agricultural inputs			
2	Purchase of oxen			
3	Purchase of other animals			
4	Purchase of bee-hive			
5	Purchase of poultry			
6	Social function			
7	Petty trade			
8	Consumption (food, cloth,---)			
9	Others (specify)			

Source of credit: 1 = Dedebit bank, 2 = Cooperative society, 3 = Commercial bank, 4 = Money lenders, 5 = Friends & relatives, 6 = Others (specify)

IV. Income and Expenditure Assessment

24. Income Sources

What are the main sources of household income before and after the project?

24.1 Sales of crops

S. No	*Crop type*	*Unit*	*Quantity Sold*						*Unit price (birr)*	*Total annual sales (birr)*
			After the project			*Before the project*				
			1998 E.C	*1997 E.C*	*1996 E.C*	*1990 E.C*	*1989 E.C*	*1988 E.C*		
	Teff									
	Barley									
	Wheat									
	Sorghum									
	Maize									
	Onion									
	Potato									
	Tomato									
	Carrot									
	Others									

24.2 Sales of bi-products

S. No	Bi-product type	Unit	Quantity Sold						Unit price (birr)	Total annual sales (birr)
			After the project			Before the project				
			1998 E.C	1997 E.C	1996 E.C	1990 E.C	1989 E.C	1988 E.C		
	Honey									
	Egg									
	Hide & skin									
	Others									

24.3 Sales of animals

S. No	Animal type	Unit	Quantity Sold						Unit price (birr)	Total annual sales (birr)
			After the project			Before the project				
			1998 E.C	1997 E.C	1996 E.C	1990 E.C	1989 E.C	1988 E.C		
	Cattle									
	Ox									
	Sheep									
	Goat									
	Donkey									
	Horse									
	Mule									
	Camel									
	Poultry									
	Bee-hive									

24.4 Off-farm income sources

S. No	Off-farm Activity	No. of H.Hs engaged	Total Annual Income (Birr)					
			After the project			After the project		
			1998 E.C	1997 E.C	1996 E.C	1990 E.C	1989 E.C	1988 E.C
1	Daily Labor							
2	Petty trading							
3	Black smith							
4	Weaving							
5	Masons							
6	Wood craft							
7	Selling Eucalyptus							
8	Selling Fire wood							
9	Selling Charcoal							
10	Selling Drink							
11	Food For Work							
12	Food Aid							
13	Sales of stone							
14	Sales of Sand							
15	Guarding salary							
16	Others (specify)							

25. Expenditure

25.1 Food consumption Expenditures

S. No	*Food items*	*Unit*	*Quantity Consumed per Year*						*Unit Price*	*Source*
			After the project			*Before the project*				
			1998 E.C	*1997 E.C*	*1996 E.C*	*1990 E.C*	*1989 E.C*	*1988 E.C*		
1	Teff	Qt								
2	Wheat	"								
3	Barley	"								
4	Maize	"								
5	Sorghum	"								
6	Oil	Lt								
7	Vegetables	Kg								
8	Sugar	Kg								
9	Milk	Lt								
10	Coffee	Kg								
11	Meat	Kg								
12	Salt	Kg								
13	Honey	Kg								

Source: 1 = Own production, 2 = Purchased, 3= Food For Work,
4 = Food aid, 5 = others (specify)

25.2 Non-food Expenditures

S. No	Expenditure Items	Annual Estimated Cost (birr)					
		After the project			Before the project		
		1998 E.C	1997 E.C	1996 E.C	1990 E.C	1989 E.C	1988 E.C
1	Human Health						
2	Education						
3	Clothing and Shoe						
4	Transportation						
5	House Repair/Mainten.						
6	Energy/fuel /wood						
7	Farm tools						
8	Farm Inputs (Fertilizer...)						
9	Animal Health						
10	Animal Feed (Fodder)						
11	Religious Ceremonies						

25.3 Government taxes paid

S.No	*Type of tax*	*Annual Amount Paid (Birr)*					
		After the project			Before the project		
		1998 E.C	1997 E.C	1996 E.C	*1990 E.C*	*1989 E.C*	*1988 E.C*
1							
2							

V. Irrigation Water, its management and Institutions

26. Do you pay irrigation water fee? 1= Yes, 2= No ☐

If yes, how much do you pay per year?______(Birr)
If yes, what is the purpose of the collected money?________________

____

27. Where is the location of your irrigation plot? ☐
1= head, 2= middle, 3= tail end

28. Do you get sufficient water for your plot? 1= Yes, 2= No ☐

29. How many times in a year do you harvest?________

30. Is there water users association in your scheme?

1= Yes, 2= No ☐
If yes, who established the association? ☐
1= by our selves, 2= by government

31. Does the association have legal entity? 1= Yes, 2= No ☐

32. What is the advantage of being having legal entity?________________

____

33. Does the association have water management committee?
    1= Yes, 2= No ☐

34. What is the function of this water management committee?__________

____

35. Does the water management committee have bylaws to manage the scheme? 1= Yes, 2= No ☐

36. Are there female-headed households in the water management committee? 1= Yes, 2= No ☐
    If yes, how many?________________
    If yes again, what is her/their responsibility?__________________
    If not, why not?____________________________________

37. Is there irrigation cooperative society in the scheme?

    1= Yes, 2= No ☐
    If yes, what is the advantage of this irrigation cooperative?
    1= sell products at higher price, 2= get supply of inputs,
    3= get storage service, 4= get transport service, 5= others (specify) ☐

38. Do you undertake catchment treatment (watershed management) in the scheme? (Yes/No)____
    If yes, what benefits do you get?____________________________

    ____

    If no, why not?____________________________________

    ____

39. Who controlled the distribution of the irrigation water?____________

    ____

40. Was there any conflict associated with utilization of the irrigation water (among farmers and/or between farmers and Abo-may)? (yes/no)_________
    If yes, what was the source of the conflict?____________________

    ____

    If yes again, who solved the conflict?________________________

    ____

    If yes again, how is it solved?______________________________

41. What are the major problems (internal and external) you face in utilizing the scheme efficiently? 1= Lack of input supply, 2= Shortage of Labor, 3= Lack of marketing, 4= Lack of access road and high transportation cost, 5= Conflict in water utilization, 6= Water logging 7= Water shortage, 8= Others (specify) ☐

42. Where do you sell your irrigation products?

1= on farm, 2= local market, 3= wereda market, ☐
4= zonal market, 5= regional market, 6= others (specify)

43. What Impact do you see in general due to the presence of this irrigation scheme on your livelihood?

S.No.	Impact of Irrigation Development	Rank
I	**Positive Impact**	
1	Change in Feeding Habit	
2	Increase in Production	
3	Diversification of Crop Grown	
4	Reduce Crop Failure	
5	Reduce no. of months of hunger period	
6	Increase Employment Opportunity	
II	**Negative Impact**	**Rank**
1	Create Malaria	
2	Create conflict among farmers	
3	Water Logging	
4	Salinity	
5	Others (specify)	

- Name of Interviewer ______________
- Date of Interview ______________
- Starting Time ________________
- Ending Time ________________

ANNEX-II BY-LAWS OF DIBDBO IRRIGATION SCHEME

The following are the by-laws which were used in the scheme by the beneficiaries in 1998 E.C (which were written in Tigrigna) translated to English.

- Method of sowing and hoeing will be on technique basis; a farmer who is not lead by the technique will not get irrigation water; a farmer who does not work the technique and hoeing properly (cheked/evaluated by experts) will be fined 10 birr, if he/she does not correct his/her mistakes for the second time (after he/she is supported to correct his mistake), he/she will not get irrigation water;
- A farmer who diverts irrigation water with out the knowledge (permission) of *abo-mai* will be fined 50 birr if he/she does not pay the 50 birr his/her land will not get water;
- A farmer who get irrigation water (with the knowledge of *abo-mai*) but does not use it efficiently will be fined 30 birr; if he/she give the water for another person (with out the knowledge (permission) of abo-mai, he/she will be fined 50 birr;
- Abo-mai will distribute water for farmers on their turn and controls it. If he does not give water for farmers on their turn and if water is lost due to lack of controlling, *abo-mai* will be fined 20 birr;
- Water will be distributed on turn basis. A farmer who passes his turn will get water on the second round;
- Clearance of canal will be undertaken every week. However, if there is any sudden problem on the canal, the problem will first be checked by the water committee and development agents then the canal will be cleaned by the beneficiaries;
- Irrigation program will be on canal basis. That is:
    - canal number one which covers an area from Hasheka up to Mai-dir,

    - canal number two which covers an area from Enda-agamat up to Walaka and,
    - canal number three which covers an area from Geza-adem up to Ayebleomn.
- A farmer whose irrigable land is infested by weeds will not get irrigation water;
- Every farmer must use:
    - DAP during sowing and/or planting, and
    - Urea during hoeing, otherwise he/she will not get irrigation water;
- Permission and prohibition of irrigation water for farmers is the responsibility of water committee and development (extension) agents,

Monthly salary for *abo-mai* is birr 200; and is determined/decided by water committee.

DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university, and that all the sources of materials used for the thesis have been duly acknowledged.

Name: *Ataklti Hailu Meles*

Signature: ____________

Date: July, 2009

This thesis has been submitted for examination with my approval as a university advisor.

____

WOLDEAB TSHOME (PhD)

Date: ____________