BAHIR DAR UNIVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

DEPARTMENT OF ECONOMICS

COST BENEFIT ANALYSIS OF SMALL SCALE IRRIGATION TECHNOLOGIES: IN BAHIR DAR ZURIA AND DANGELA EXPERIMENTAL PROJECTS.

BY:MIHRET DESSIE

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THE COST BENEFIT ANALYSIS OF SMALL SCALE IRRIGATION SCHEMES: IN BAHIR DAR ZURIA AND DANGELA WOREDAS.

A Thesis Submitted to the Department of Economics of Bahir Dar University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Economics (Economic Policy Analysis)

BY

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Statement of Declaration

I**, Mihret Dessie Lakew,** hereby declare that this thesis work entitled **"Cost Benefit Analysis of Small Scale Irrigation Technologies: in Bahir Dar Zuraia and Dangela Experimental Projects."** submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Economics to the College of Business and Economics, Bahir Dar University, through the Department of Economics, is original work carried out by myself. To the best of my knowledge, the matter embodied in this thesis work has not been submitted earlier for award of any degree or diploma. Where other sources of information have been used, they have been duly acknowledged.

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Statement of Certification

This is to certify that this thesis entitled **"The Cost Benefit of Small Scale Irrigation Technologies": in Bahir Dar Zuria and Dangela Experimental Projects."** submitted in partial fulfillment of the requirements for the award of the degree of MSc. in Economic Policy Analysis, to the College of Business and Economics, Bahir Dar University, through the Department of Economics by Mr. Mihret Dessie, Id No. BDU0603263 was an original research work done under my supervision and guidance. To the best of my knowledge, this work has not been submitted earlier for award of any degree or diploma

Principal Advisor: **Surafel Melak (Assistant professor)**

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ACRONYMS

AAnCFl	Average Annual Cash Flow
ADLI	Agriculture Development Lead Industry
AFrtC	Average Fertilizer Cost
AIC	Average Investment Cost
ALbC	Average Labor Cost
AMnC	Average Maintenance Cost
AOxC	Average Oxen Cost
APsC	Average Pesticide Cost
ANRS	Amahara National Regional State
BoA	Bureau of Agricultural
BoRAD	Bureau of Rural and Agricultural Development
BoWRD	Bureau of Water Resource Development
CBA	Cost-Benefit Analysis
CSA	Central Statistical Authority
DBE	Development Bank of Ethiopia
ETB	Ethiopian Birr (Currency)
FAO	Food and Agricultural Organization
FHHs	Female Headed Households
FtF	Feed the Future
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
IFAD	International Fund for Agricultural Development
ILSSI	Innovation Lab for Small Scale Irrigation
IRR	Internal rate of Return
IWMI	International Water Management Institute
LDCs	Least Developed Countries
MHHs	Male Households
MoA	Ministry of Agriculture
MoARD	Ministry of Agriculture and Rural Development

MoWE	Ministry of Water and Energy
NGO	Non-Governmental Organizations
NAB	Net Average Benefit
NPV	Net Present Value
N/R	Not Applicable
OIDA	Oromia Irrigation Development Authority
O&M	Operation and Maintenance
ONCCP	Office of the National Committee for Central Planning
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PLI	Pastoral Livelihood Initiative
P vs F	Pulley verses Fodder
P vs T	Pulley verses Tomato
Rs	Indian Rupee
R&W vs F	Rope & Washer verses Fodder
R&W vs T	Rope & Washer verses Tomato
R&W	Rope and Washer
SAERP	Sustainable Agriculture and Environmental Rehabilitation Programme
SAERT	Sustainable Agriculture and Environmental Rehabilitation Tigery
SSI	Small Scale Irrigation
TAO&Mc	Total Annual Operation and Cost
TLU	Tropical Livestock Unit
USDA-ERS	United States Department of Agriculture Economic Research Service
USD	United States Dollar
USID	United States Agency for International Development
WHO	World Health Organization
Yrs	Year

ABSTRACT

In this paper we employed a cost-benefit analysis framework to examine the feasibility of small scale irrigation technologies (rope and washer and pulley) in Robit kebele of Bahir Dar Zuria woreda and in Dangeshta kebele of Dangela woreda. We used an experimental data collected from 54 sample target households of the Feed the Future Innovation Lab for Small-Scale Irrigation (ILSSI) project. The analysis is based on data collected through a pre designed field book. Data related to costs and income was collected from the start up to the final stage of the irrigation activity (i.e. any activities and costs that include land preparation, planting, weed and pest control, fertilizer application, operation costs related with the irrigation technology, harvesting and crop residue handling) and all benefits obtained in irrigation activities of the households that were important to study feasibility of SSI technologies. The OLS regressional analysis revealed as sex of household head, education of household head, amount of labor, demonstration site and type of crop are statistically significant at 5% significant level. The financial analysis result indicates that some of NPVs are positive at 7.25%, 8% and 12% interest rates for pulley with tomato; only positive at 7.25% for pulley with fodder in case of MHHs and positive for all interest rates for pulley with fodder in case of FHHs. The IRR is greater than the highest interest rate (i.e. 12%) for all the above combinations except pulley with fodder for MHHs. NPV is totally negative for rope and washer with all crop types. However, since data used in this study covers only one crop season where farmers have experienced problems related to late start of irrigation and on time delivery of seed and other inputs, further study is required

Key words: *Small Scale Irrigation, Net Present Value, Internal Rate of Return, Feasibility, Experimental Project*

CHAPTER ONE

INTRODUCTION

1.1. Background

Agriculture is the leading sector of Ethiopia's economy as the overall economic growth of the country largely depends on the agricultural sector. The sector provides employment to 83% of the population, contributed 41.6% to the country's GDP (MoFED, 2010) and 85%of its export earnings. Improving the productivity of the agriculture sector can thus undoubtedly benefit both the rural and urban population by providing more food and raw materials at lower prices; generate foreign exchange; provide a growing amount of labor and capital needed for industrialization; and provide market for industrial goods (MoA, 2011).

Although Ethiopia has abundant rainfall and water resources, its agricultural system does not yet fully benefit from the technologies of water management and irrigation (MoA, 2011).The majority of rural people in Ethiopia are among the poorest in the country, with limited access to agricultural technology, limited possibilities to diversify agricultural production given underdeveloped rural infrastructure, and limited access to agricultural markets and to technological innovations (Awulachew, 2010).Hence, the ability of the nation to address food and nutritional insecurity, poverty, and to stimulate and sustain national economic growth and development is highly dependent on the performance of agriculture. Yet achieving higher and sustained agricultural productivity growth remains on one of the greatest challenges facing the nation (Belay and Degnet, 2004; Spielman et al., 2010). Rain fall is erratic and unevenly distributed between seasons and agro ecological regions lead to poor yields, low productivity, food insecurity and poverty within the farming population, that emphasizing the need for irrigation in the country.

Irrigation is one means by which agricultural production can be increased to meet the growing food demands of the fast growing population of Ethiopia. Increasing food demand can be met in one or a combination of three ways: (i) increasing agricultural yield, (ii) increasing the area of arable land, and (iii) increasing cropping intensity by growing two or three crops per year using irrigation. Expansion of the area under cultivation is a limited option. However, increasing yields under both rain-fed and irrigated agricultural systems and cropping intensity in irrigated areas through various methods and technologies are the options for achieving food security (MoA, 2011).

The development of small-scale irrigation is one of the major intervention areas to boost agricultural production in the rural parts of Ethiopia. This helps poor farmers to overcome rainfall and water constraint by providing a sustainable supply of water for cultivation and livestock, strengthen the base for sustainable agriculture and provide increased food security to poor communities through irrigated agriculture (FAO, 2003).The dependence of most of the farmers on rain-fed agriculture has made the country's agricultural economy extremely fragile and vulnerable to the impacts of weather and climatic variability leading to partial or total crop failure, which in turn resulted in food shortages (MoWE, 2011)

In Ethiopia, modern irrigation began in the 1950s through private and government owned schemes in the middle Awash valley where big sugar, fruit and cotton state farms were established (FAO 1997).Ethiopia has high potential in water-led development, but it needs to find a solution for a critical challenges in the processes of planning, design, delivery and maintenance of its irrigation systems (Awulachew, 2010). The initial intervention of household irrigation enables Ethiopia to use its abundant labor though it is fragmented households and communities. The longer-term strategy of medium- and large-scale interventions (MSI and LSI) in combination with small-scale irrigation, will help Ethiopia overcome the connection between rainfall and agricultural growth goal (Awulachew, 2011)

Hussain and Hanjira (2004) confirmed a strong direct and indirect linkage between irrigation and poverty. Direct linkages operate through localized and household level effects, whereas indirect linkages operate through 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 to high-value market-oriented production. Increased production makes food available and affordable for the poor (Asayehegn et al., 2012).

Small-scale irrigation is a policy priority in Ethiopia for rural poverty alleviation and growth (MoFED, 2006), as well as climate adaptation (GoE, 2007). Only around 5% of Ethiopia's irrigable land is irrigated (World Bank, 2006) and less than 5% of total renewable water resources are withdrawn annually (FAO, 2005), so there is considerable scope for expansion.

The current government of Ethiopia has undertaken various activities to expand irrigation. The country's Agricultural Development Led Industrialization (ADLI) strategy considers irrigation development as a key input for sustainable development. Thus, there is a plan to accelerate irrigation particularly small-scale irrigation.

The potential benefits of small-scale irrigated agriculture are many such as- irrigation can mitigate production risk due to against rainfall variability and crop failure, allowing farmers to produce two or three crops annually. The potential impact on livelihoods includes higher consumption (through crop diversification), purchase of assets such as livestock, and investment in children's education. However, there are also significant challenges including the high cost of inputs (pumps, fuel, and agricultural inputs), pests and diseases affecting high value horticultural crops, storage problems and the perishability of some crops, plus transportation and market access problems, and increased labor demands(PLI Policy Project, 2010)

With this background, this study is designed to identify and analyze the cost benefit analysis of small scale irrigation technologies Dangela and Bhir Dar Zuria woredas in Awi and Mirab Gojam Zone respectively, and through that make recommendations to improve the effectiveness of interventions.

1.2. Statements of the Problem

Food crops production is affected by the vagaries of the weather but irrigation can hedge against the negative effects of weather variability agricultural production (Grove, 1989). An effective irrigation system is vigorous to increase food products during the dry seasons. This enhances continuous farming all year round and boosts food availability and opportunities for employment and general wellbeing.

In recent years, the government of Ethiopia has demonstrated commitment to small scale irrigation, emphasizing its importance to the country in its Growth and Transformation Plan (GTP). Through the Ministry of Agriculture (MoA) and the Ministry of Water and Energy (MoWE), the government has planned to boost small scale irrigation through empowering entrepreneurship in smallholder farmers and micro-businesses, less reliance on community coordination and infrastructure and utilize cost-effective existing technologies because of that irrigation is a promising means to increase farm income, improve food and promote quality of life in rural areas(MoA,2011).

Adoption of small scale irrigation technologies are important in order to meet growing food demand through three ways: increasing agricultural yield, increasing the area of arable land, and increasing cropping intensity. Expansion of the area under cultivation is a finite option especially due to the marginal and vulnerable characteristic of large parts of the country's land. Increasing yields in both rainfed and irrigated agriculture and cropping intensity in irrigated areas through various methods and technologies are viable options for achieving food security in Ethiopia. When there is failure of production as a result of natural causes such as drought, agricultural production can be stabilized and increased by providing for irrigation and retaining more rainwater harvesting for *in situ* utilization by plants (Awulachew et al., 2010).

Although the country has 4.5 million hectares of irrigable land, irrigation covers only 0.16 million hectares or about 5% of the total irrigable land (MoWE, 2011). The dependence of most of the farmers on rain-fed agriculture has made the country's agricultural economy extremely fragile and vulnerable to the impacts of weather and climatic variability leading to partial or total crop failure, which in turn resulted in food shortages (MoWE, 2011). Shortages such as legal system of land and water rights, support services (irrigation extension) and well established water users associations resulted in undermined irrigation management, ultimately risked feasibility and sustainability small scale irrigation(Asayehegn et al., 2012).

The Amhara region is the second most populous region in Ethiopia with a total population of 17,221,976 (CSA, 2007).The region have a long history of famine and drought where an estimated 18-20% of the population is chronically food insecure (BoARD, 2003).The Bureau of Agriculture and Rural Development (BoARD) listed erratic and unreliable rainfall, degraded natural resource base, high population density and low productivity caused by poor agricultural management practices" as major factors for the witnessed famine and food insecurity in the region. The region has substantial coverage of irrigable land with 0.95 million ha (6.1%) out of the total area of 15.5 million hectare within the four major river basins (BoWRD, 2014). However, the total area under irrigation is only less than 12 percent.

Using SSI for fruit and vegetable has been implemented since the 1950s with few agro industries in Ethiopia in order to produce sugar and agricultural food products. However, it is claimed that virtually no feasibility studies were done by most of the agencies constructing the technologies except those of OIDA and some projects that are planning to start coordinating their activities with the feasibility study, especially during project implementation (Awulachew et al., 2005). Hence, creating an information gap that needed to be filed. This study, therefore, intended to assess the feasibility of SSI technologies including water lifting technologies (Rope and Washer and Pulley) and crops (high breed tomato and onion) through trying to answer the following research questions in the study area.

1. Which of the small scale irrigation technologies and crops are more profitable?
2. Whether investment in and adoption of irrigation technology is feasible? If yes, at what discount rate?
3. What factors affect/contribute to the profitability/feasibility of small scale irrigation technologies?

1.3. Objectives of the Study

The overall objective of this study is to assess and document the feasibility of alternative small scale irrigation technologies (pulley rope and washer) in the study area:-

The specific objectives of the study are:

- To conduct comparative analysis of the profitability of different small scale irrigation technologies and crops.
- To carry out feasibility study of alternative small scale irrigation technologies at different loan interest rate.
- To analyze factors that affect/contribute to the profitability/feasibility of irrigation technologies.

1.4. Significance of the Study

This study was carried out on SSI technologies (pulley and rope and washer with onion, tomato and livestock fodder) introduced and being under experiment in Robit kebele of Bahir Dar Zuraia woreda and Dangesheta kebel of Dangela woreda. Hence, findings of the study yields new and contemporary information about the level of adoption of farm households on SSI, the cost benefit analysis of the ongoing experimental project intervention and its implication on sustenance and replication and welfare implications of the water lifting technologies to participating farm households.

1.5 .Scope of the Study

The study was undertaken in Robit kebele of Bahir Dar Zuraia woreda and Dangeshta kebele of Dnegela woreda. In order to gather and evaluate the data effectively and would maintain the scope within a stipulated time and financial limit, the study was conducted to the experimental project in the two kebeles only and emphasized on a limited number of households (54HHs) with two small scale irrigation technologies and three crop types (onion, tomato and livestock fodder) based on their choice of interest.

1.6. Limitation of the Study

The paper suffers from the following weaknesses. The first one is, since CBA was carried out by taking only one year stream of cost and benefits data where the farmers have experienced problems related to late start of irrigation and on time delivery of seed and other inputs. Thus, it is important to note that only one year’s data has been used in this analysis and therefore is missing the variability in returns that is characteristic of agricultural production. The second is because the study shall be carried out in a project under experiment. In a narrow scope, overall generalization could be impossible and all the findings and conclusions shall be applied only to the study area.

1.7 Organization of the Study

This thesis has five chapters. The second chapter reviews related theoretical and empirical literatures. Chapter three comprises of research methodology including data type and sources, method of data collection, method of data analysis, sample size and sampling techniques. In Chapter four analysis and discussion of main findings were presented. The final and fifth chapter summarizes main findings of the paper and drives relevant policy implication.

CHAPTER TWO

LITERATURE REVIEW

2.1Definitions and Concepts of Small Scale Irrigation

Irrigation is defined as the addition of water to lands via artificial means. It is essential to profitable crop production in arid climates. Irrigation is also practiced in humid and sub-humid climates to protect crops during periods of drought. Irrigation is practiced in all environments to maximize production and, therefore, profit by applying water when the plant needs it (USDA-ERS, 1997).

Irrigation in fact, is nothing but “a continuous and reliable water supply to the different crops in accordance with their different needs”. When sufficient and timely water does not become available to the crops, the crops fade away, resulting in lesser crop yield, consequently creating famine and disasters: irrigation can, thus, save us from such disasters (Nega, 2013).

Irrigation is Iany process other than natural precipitation which supplies water to crops, orchards grass or any other cultivated plants .Thus we shall include run-off farming, humid culture, and micro and manual irrigation because these area are important and significant feature of small scale development (Peter, 1997).Irrigation is one means by which agricultural production can be increased to meet the growing demands in Ethiopia (Awulachew et al. 2005)

Small-scale irrigation can be defined as irrigation, usually on small plots, in which small farmers have the monitoring influence, using a level of technology which they can operate and maintain effectively. Small-scale irrigation is, therefore, farmer-managed: farmers must be involved in the design process and, in particular, with decisions about boundaries, the design of the canals, and the position of outlets and bridges. Although some small-scale irrigation systems serve an individual farm household, most serve a group of farmers, typically comprising between 5 and 50 households (FAO, 1995).

Breuer and Netzband (1980) define **small-scale irrigation** as an appropriate technology which corresponds to the abilities and needs of its users, and every installation, which should share the following characteristics ,low level of capital costs, make use of local materials as much as possible, employment of local skill and labor, scheme small enough to be affordable and manageable by a small group of farmers, technology which is understandable to the users and compatible with local values methods, easy to operate and maintain at village or community level, dependence on outside help to be kept at a minimum, involving renewable energies such as wind, sun, animals rather than oil and electricity , system to be erected step by step so as to eliminate or rectify (possible) mistakes and to make the system flexible enough to be adapted to changing situations.

Adam and Carter (1986) have defined **small-scale irrigation** as the management of the supply of water to crops, which is initiated, organized and controlled by the landholder(s). The extent of such activities does not normally exceed 10 hectare per family and may be as little as 0. 1 hectare (Kay et al. 1985) use the term "informal sector irrigation" for irrigation practiced by individual farmers on a small-scale under their own responsibility, usually at low cost with little or no government support, and using technology they can understand and easily manage themselves.

Household: can be defined in this research as people living together and sharing the same goods and services for consumption. That is, a household member who did not live autonomously during the survey time at least for six months.

Woreda: is an administrative unit greater than kebele and corresponding to district.

Kebele: is the lowest administrative unit of established rural area.

2.2 History of Irrigation Development

Irrigation is a very old practice in the world. It is an old human activity and been practiced in some parts of the world for several thousand years. Rice has been grown under irrigation in India and Far East for nearly 5000 years. The Nile valley in Egypt and the plain of Tigris and Euphrates in Iraq were under irrigation for 4000 years ago. Today over 200 million hectares of land are irrigated in five continents this area increase from 117 million hectare in 1952 and is still growing (Peter, 1997).

Irrigation has long played a key role in feeding expanding populations and is undoubtedly destined to play a still greater role in the future. It not only raises the yields of specific crops, but also prolongs the effective crop growing period in area with dry seasons, thus permitting multiple cropping (two or three and sometimes four crops per year) where only a single crop could be grown. Moreover, with the security provided by irrigation, additional inputs needed to intensify production such as pest control, fertilizer, improved varieties and better tillage become economically feasible. Irrigation reduces the risk of these expensive inputs being wasted by crop failure resulting from lack of water (FAO, 1997).

The expansion of irrigation would be strongest (in absolute terms) in the more land-scarce regions hard-pressed to raise crop production through more intensive cultivation practices, such as East Asia South Asia and the Near East/North Africa, although in the latter region further expansion will become increasingly difficult as water scarcity increases and competition for water from households and industry will continue to reduce the share available to agriculture. China and India alone account for more than half (54 percent) of the irrigated area in developing countries. Although the overall arable area in China is expected to decrease further, the irrigated area would continue to expand through conversion of rainfed land (Nikos Alexandratos and Jelle Bruinsma, 1012).

The developed countries account for over a fifth of the world's irrigated area, 68 out of 302 million hectares. Annual growth of their irrigated area reached a peak of 3.0 percent in the 1970s, dropping to 1.1 percent in the 1980s and to only 0.1 percent over the last decade for which data are available (1997-2007). For the developed countries as a group only a very marginal expansion of the irrigated area (supplemented with improvements on existing areas) is foreseen over the projection period so that the world irrigation scene will remain dominated by events in the developing countries. In terms of annual growth, the projected net increase in land equipped for irrigation would represent a sharp slowdown as compared with the historical growth. The projected slowdown which applies to most countries and regions, reflects the projected lower growth rate of crop production combined with the increasing scarcity of suitable areas for irrigation and of water resources in some countries, as well as the rising costs of irrigation investment (Nikos Alexandratos and Jelle Bruinsma, 1012).

Irrigation got introduced to almost all LDCs in Africa relatively recently, with the notable exception of Sudan and some Nile countries. Population growth, urbanization and the resultant growing demand for rice and wheat have increased the demand for irrigation; but deteriorating economic conditions and declining public investments by donors and private financing have dampened irrigation development(Er. I. K. Musa et al, 2011)

Africa as a whole has not developed irrigation at the pace witnessed in other developing nations particularly in Asia. The continent receives, on an average, 124 mm less precipitation than the world average. As the rainfall is not evenly distributed, irrigation expansion in some countries was driven by rainfall availability. Furthermore, the development on the continent was uneven. About 31% of the irrigated area located in Egypt while five other countries Nigeria, Morocco, Algeria, Tunisia and Libya account for a further 25%. Of the remaining 44% that include all of the LDCs about 70% are located in Sudan and Madagascar(Er. I. K. Musa et al, 2011)

2.3. Small Scale Irrigation in Ethiopia

Small-scale peasant-based irrigation development in relation to food production in Ethiopia is of interest in view of the recurrent drought and famine conditions experienced by this country during the 1970s and 1980s and the high priority given by its Socialist government to boosting food production and achieving food self-sufficiency. These objectives have been specified in the Ten Year Perspective Plan (1984/85-1993/94) (ONCCP, 1984). Emphasis was placed on co-operative farming, large-scale agriculture on state farms, and government pricing and marketing structures in achieving these objectives. Nevertheless, the annual growth rate of the agricultural sector, which provides employment for about 90 per cent of the working population, declined from 3.3 per cent in 1953-1959 to 0.3 per cent in 1974-1980 (Robinson and Yamazaki, 1986),

No statistics exist on the location, area, and cost effectiveness of peasant irrigation in Ethiopia for the period before 1984/85, when the Ministry of Agriculture implemented thefirst government sponsored small-scale irrigation programme. Even most of the subsequent data are fragmentary and unreliable. But Ethiopian peasants have shown a great deal of initiative in developing irrigation schemes on their own, in various parts of the country. During most of its history in Ethiopia, irrigation was on a small scale, rudimentary and mostly seasonal. Simple diversion of streams by rock and earth dams was commonly practiced in many areas, and terracing with more elaborate water conveyance systems was widely used in the traditional areas of extensive plough culture in the northern highlands and in the areas of intensive hoe culture in the south and south-west (Kloos. 1991).

A decade after the MoA intervention started, a huge small-scale irrigation development programme was launched under an umbrella organization known as the Sustainable Agriculture and Environmental Rehabilitation Programme (SAERP) and funded by the United Nation's Economic Commission for Africa. Interventions into small-scale irrigation on the some Ethiopian Plateaus by Sustainable Agriculture and Environmental Rehabilitation Tigery (SAERT), like its predecessor, started with a micro-dam approach to small-scale irrigation development (Abera, 2004).

2.4. Gender and Small Scale Irrigation

Irrigation is a labor-intensive form of agriculture, often involving significant access to increased income. From a gender point of view, SSI can therefore have negative impacts on women (if men capture an unfair share of farm profits, or if women's labor burden increases without adequate compensation), or it can have positive impacts (by enabling women to increase their cash incomes and diversify family nutrition). The issue of access to land and water by women, including those who are household heads, needs to be considered, as does the participation of women in Water Users' Associations(Prof. Richard Carter and Dr. Kerstin Danert, 2006).

Gender of the household head is an important variable influencing the participation decision in irrigation. The total sample of the study is composed of 20% female headed households while the portion of female headed households who are irrigation users is reduced to 12%. Discussion with sample households revealed that female-headed households hardly faced labor shortage for irrigation as well as rain-fed farming due to physical, technological, socio-cultural and psychological fitness of farm instrument to males than females (Asayehegn et al, 2012).

According to the study conducted by (Eguavoen, et al, 2012) in Nile Basin Ethiopia that discuses women from female headed households indicated that they preferred to sharecrop their farmlands rather than engage in irrigation, as they lacked labour and capital. Woman farmers revealed that they could not irrigate their field at the right time, as they were not able make payment the water distributors that things are done with kinship bases which is difficult to access for women. From the study it was analyzed that the most common economic activities of women besides farming on family plots were the collection of cow dung and fuel wood, as well as working for a daily wage on other farmers' plots. The majority of male respondents and one third of the women respondents said that their life had improved through spending more time together as a family, especially because the men would spend less time in nearby town drinking.

According to (Nega,2013),the gender difference of household heads in irrigation participation and income indicated female lead households face shortage of labor and market information, made them rent/share out their land to the male headed household heads. As a result the likelihood of participation and income of female headed household heads are less than the male headed household heads.

2.5. Significance of Small Scale Irrigation

The value of SSI to a particular community needs to be considered in detail on a case by case basis. There are considerable improvements that can be made to rain-fed crop production, post-harvest practices, market linkages, pastoral traditions and other aspects of rural livelihoods, which may provide wider benefits than an SSI intervention. This said, SSI can enable farmers to increase production through intensification (by increasing to two or three harvests a year); improve nutrition and livelihoods through diversification, and raise income through commercialization (by growing and selling cash crops). In some cases SSI has enabled farmers to become self-sufficient year round from a previous dependence on food aid for three to six months of the year (Prof. Richard Carter and Dr. Kerstin Danert, 2006)

Management and technologies use: Small-scale schemes are attractive because the initial outlay involved is small, they can be executed quickly and yield quick results, they normally require no special expertise and equipment, and local expertise and re-sources, including human resources, can be easily mobilized for their execution. They can be built in areas where the tracts of irrigable land and the amount of water available are small, thus enabling "piecemeal" development in an area which otherwise would be inappropriate for large schemes(Thakurdas.v.1994),in such schemes, the study from the scientific point of view can be less vital because (i) local knowledge plays a greater role since beneficiaries know the local conditions very well; (ii) a step by step approach is adopted with each step small enough so if there is any mistake it can be set right; and (iii) flexible approach is followed so that planning can be changed at any step and losses or dislocation would be small. Last, but not least such schemes pro-mote sustainable development and are environment friendly.

A very significant feature of small-scale irrigation programs is that by involving the local community from the diagnosis and planning stage, to the design, construction, management and operation stages it can be made a truly "peoples' program"; in fact, this is the way many of developing countries. This not only cuts the cost of such schemes but also encourages the community to think of these schemes as their own, which is important to the success of any program undertaken in the public sector. Obviously, the personal touch is missing in large-scale projects. Small-scale schemes are, thus remarkable for their social cohesion and sense of common purpose (Thakurdas.v.1994).

Improve Income: The increases in net income from both agricultural and livestock activities for the representative farmer as a result of a changed cropping pattern or an increased crop yield that will become possible as a result of the SSI project. Based on the study of feasibility of irrigation schemes in Iraq, the net income increase for the representative farmer is estimated by agronomists to be 5400 USD/ha. As well as the indirect benefits that result from improved environmental management are assumed to be 10% of direct benefits for both the farmers directly affected by the project and those who are indirectly affected (Zagonari,2011)

According to *(Getaneh et al.,* 2013) keeping constant for other factors that influence incomes, access to irrigation has a significant positive impact on the mean total income of a household (ETB 3353 per year) a 27% increase over the mean income for non-irrigating households. Though, the econometric analysis alone cannot indicate directly why the increase in income occurs, irrigation allows the farmers to practice crop intensification and diversification, which increases crop yields and revenues from crop sales. Irrigation also increases the marginal land and labour productivity, increases the crop production and then promotes household income.

Crop production is by no means the only source of food and income that depends on water. Many poor households engage in home-based industries for which water is essential. And growing numbers of farmers, particularly in Asia, are finding that they can both increase rice yields and add a valuable source of protein and income by using the water in their rice paddies to raise fish (FAO, 2003).

Agricultural production, nutrition and health: Where it is possible, irrigation is the best option for increasing agricultural production. In Africa, where only 4 percent of cropland is irrigated, small-scale irrigation and rainwater harvesting projects have shown great potential for increasing yields and reducing vulnerability to erratic rainfall (FAO, 2003).

The ownership of wells and ponds was especially vital for people living some distance from the river or not having agricultural plots by the riverside. Well owners and people who could not irrigate from their neighbor's well described that well owners are able to produce more and a larger variety of crops for sale. There were also reported reductions in the cattle disease *gendy* (trypanosomiasis), which is associated with drinking dirty and stagnant water in the plains where cattle had to be driven in the dry season. On average, well owners reported having two more head of cattle 3 years after the construction of the well, and that they started being able to afford veterinary services. Farmers with wells estimated that their household income (including crops for subsistence) had doubled after the construction of wells (Eguavoen, et al, 2012).A recent FAO study of three projects in Africa found that introducing small-scale irrigation not only improved crop yields but also led directly to gains in nutrition and health (FAO, 2003).

2.6. Challenges of Small Scale Irrigation

A number of conditions must be met for successful small-scale irrigated horticultural development to occur: (1) availability of suitable land; (2) availability of water resource; (3) availability of labour; (4) availability of non-irrigation inputs to production; (5) access to markets; (6) capital resources; and (7) appropriate water lifting technology (Norman, 1992; Alien and Perry, 1996)

Irrigation farming has distinct advantages compared with rain-fed farming. Because of irrigation, the natural, ample, and regular supply of solar energy is allied firstly with the ample and regular supply of water, and, secondly with the nutrients brought by water (mainly by silting). Moreover, irrigation, particularly in the form of impounding, avoids the stress to plant growth that is connected with very high temperatures on the soil surface. However, against these advantages must be set definite costs and requirements: Irrigation farming necessitates a high level of investment in water supply, delivery, distribution works, land preparation, and in several inputs. These costs are comparatively high on every level. It demands a continuous high level of labour input to supply the water and prepare and maintain the fields. It, as a rule, requires the cooperation of the farmers. In large-scale schemes this is very often a reason for mal or dysfunction. In addition to agricultural knowledge it also requires special technical skills (Breuer and Netzband, 1980).

Although small-scale irrigation may have several advantages, it is never skeps from problems. The problems have become more critical in drought-prone areas where small-scale irrigation is expected to solve problems of declining agricultural productivity. Small-scale irrigation in these areas has two sets of problems. The first category includes problems that are associated with the specific environmental characteristics of the agro-ecosystem. The second category includes common problems that drought-prone and degraded areas share with all other small-scale irrigation systems, irrespective of their agro-ecological context (Abera, 2004).

Traditional water lifting equipment is usually produced by local artisans using local materials. Examples in West Africa include the chadouf and the rope and bucket. The major advantage of these technologies is their low cost. The major disadvantage of traditional water lifting devices is their low flow rate capacity and resulting small size of irrigated plots which, in turn, limit production and incomes. This technique is very arduous and time consuming, allowing for a flow rate of only about 1000 liters of water per hour when water is 4.5 meters from ground level. Not unlike most sub-Saharan African countries, approximately 80 percent of horticulturists in Burkina Paso use this type of water lifting system (Government of Burkina Faso, 1995).

The ineffectiveness of irrigation in stabilizing yields could be due to several factors adoption of more unstable but productive crops, inefficient water management and the fact that irrigation is itself dependent on rainfall. More than irrigation, soil conservation practices and such other means of drought proofing may actually help in stabilizing yields. Sometimes, over-exploitation of ground water resources without taking adequate steps to ensure recharge on the basis of a systematic watershed development and planning, have led to considerably reduced returns from irrigation and even losses. Such watershed development, however, requires community organization and participation, involving both irrigated and dry areas in the concerned regions (Nadkarni, M. V, 1984). In general, it is claimed that projects implemented based on the will and expectations of the beneficiary communities are the ones that succeed. On the other hand, those that are not in line with the peoples' expectation failed. Pump projects are not very successful, as the farmers cannot immediately handle the technology or afford the electricity fees for the pumps. Pump maintenance has also proved to be critical and poses major challenges to farmers, as spare parts are difficult to find (Awulachew et al., 2005).

2.7. Studies on Small scale Irrigation

The scope of irrigation to contribute to poverty alleviation by enhancing the ecology and increasing the productivity of land cannot be disputed. Because of its potential, irrigation has been embraced by governments and the international community as an all-embracing remedy to the problems facing developing countries in general and the agriculture sector in particular. Because of all these potentially negative a host of environmental, social, fiscal, managerial, agricultural and economic problems, and taking into account the factors of cost-effectiveness, sustainability and ease of management, small-scale irrigation schemes especially designed to help the poorest segments of the rural population, which constitute its target groups. Its investment options center on on-farm water and land development, with the objective of incorporating farmers in the decision-making process and the day-to-day management of these systems (FAO, 1996).

There are indications that even in its primary role of stabilizing yields, irrigation technologies has not been quite successful. In a study of yield uncertainty in most cases, agriculture, it was found that not only across districts in respect of food grains as a whole, but even across individual crops at the state level, irrigation was not significantly correlated with stability in yields. Across crops, highly irrigated were found to have highly unstable yields, whereas relatively rainfed crops showed less instability. (Nadkarni and Deshpande. 1980 and 1982)

A finding point out that opportunity cost of irrigation in the form of neglect of other than irrigated lands, in an earlier study of well irrigation. It was found in the course of field work in Kolar district of Karnataka, India that farmers devoted less attention and resources to the dry parts of their holdings if they had irrigation on other parts. This neglect is, however, more likely to be direct and full in the form of parts of the holding left uncultivated. Such a negative effect of irrigation, even in a land hungry countries, could result mainly from scarcity of resources, particularly credit, which may not keep step with the development of irrigation potential. This factor is likely to be more relevant in the case of small and marginal holdings (Nadkarni, 1984).

According to (F. Hagos and K.Mamob, 2014) the NPV result reveled that both dug well and bore well investment are profitable from privet investor’s point of view. Under full cost recovery, the cumulative net present value for dug well is on average USD 1394.8, 10578.70 and 8386.18 NPV of return at 8, 12.25 and 16.5 interest rate per annum, respectively. The CBA on groundwater irrigation in Raya Valley and Kobo Valley showed us, positive NPV ata 9.5% discount rate, implying that investment in groundwater irrigation in the study area is generally profitable even at the highest discount rate. Similarly, the IRR was found to be higher than the highest lending interstate 9.5 %(Gebregziabher et al, 2013).

By using Tobit and Logit models to examine the impacts of selected small-scale irrigation schemes in the Lake Tana basin of Ethiopia on household income and the likelihood of poverty, respectively from a sample of 180 households that are using any of the four irrigation systems had statistically significantly higher mean total gross household income than households not using irrigation. Controlling for other factors that influence incomes, access to irrigation has a significant positive impact on the mean total income of a household (ETB 3353 per year) a 27% increase over the mean income for non-irrigating households. Although, the econometric analysis alone cannot indicate directly why the increase in income occurs, irrigation allows the farmers to practice crop intensification and diversification, which increases crop yields and revenues from crop sales. Irrigation also increases the marginal land and labor productivity, increases the crop production and then promotes household income (Getaneh et al., 2013).

Empirical evidence in India analyzed that, it is on output and income from agriculture per hectare of gross sown area that the impact of irrigation is felt most among all things. Output is valued here in terms of actually realized prices on the marketed portion of production. In the holdings where no sale took place, prices realized by farmers in the same size class or nearest were used. The gross output per hectare in wet village (with 30 per cent and more irrigation) was Rs.3385, which was 3.2 times higher than in dry villages. Paid out costs per hectare also were higher, but by only 2.3 times. Whereas farmers on the whole could get only Rs 406 as income per hectare (net of paid out costs only) in dry villages, they obtained Rs 1939 in wet villages, a difference by nearly a factor of 5. Though the relative differences were significant, the absolute level of achievement per hectare even in wet villages has not been impressive enough (Nadkarni, 1984).

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter is going to show details about the way facts on the ground will be generated and what methodology will be employed to examine and analyze the data in order to address the research questions. Descriptions on the nature of data and their consistency with the purpose of research, used experimental project to arrive at the respondents, the analytical tools used are addressed.

3.1. Description of the Study Area and the Project

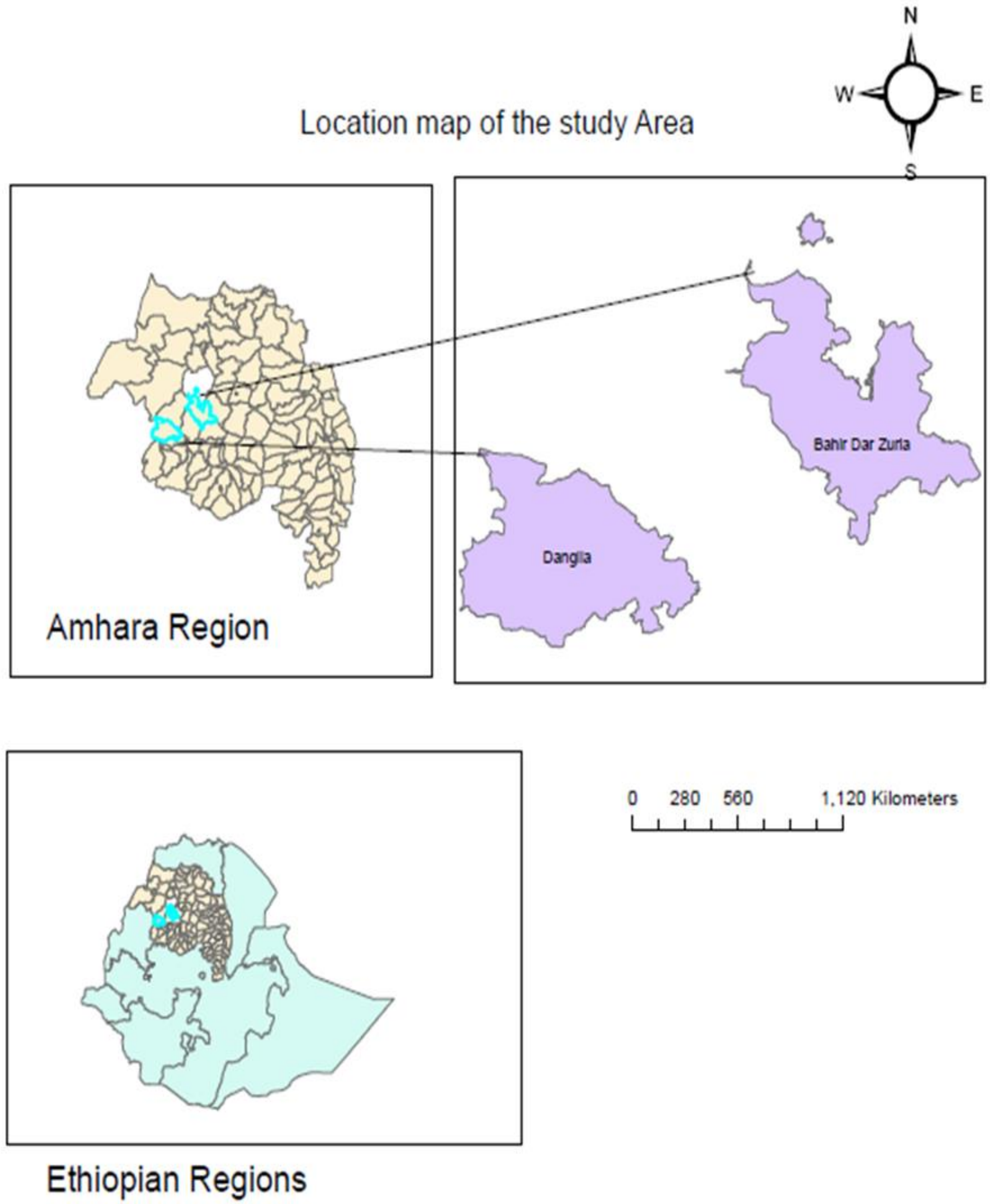
3.1.1. Bahir Dar Zuria Woreda

Bahir Dar Zuria is one of the woredas in West Gojam zone of Amhara Region. The woreda is bordered on the south by Yilmana Densa, on the southwest by Mecha, on the northwest by the Lesser Abay River which separates it from Semien Achefer, on the north by Lake Tana, on the shores of Lake Tana situates the city and special zone of Bahir Dar, and on the east by the Abay River which separates it from the Debub Gondar Zone.Based on the 2007 population census the total population of the woreda is 182,730, of whom 93,642 are men and 89,088 women. With an area of 1,443.37 square kilometers, Bahir Dar Zuriya has a population density of 126.60, which is less than the Zone average of 158.25 persons per square kilometer. There are about 40,893 households, resulting in an average of 4.47 persons to a household. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 99.7% reporting that as their religion. The livelihood of 86% percent of the total population in the woreda depends on agriculture. The woreda has a land area of 128, 290 hectares. From this, about 11 percent is cultivated for irrigation. Crop production, livestock and chate products are the principal sources of livelihoods. With the domination of Maize and Millet other crops like teff, and legume crops are the main crops grown in the area, while cattle, sheep and equine animals are also the commonly reared livestock types in the woreda.

Geographically, the woreda is located between 11.40^0N and37.27^0 E. The altitude of the woreda is between 1800 and1900 meters above sea level. The agro-ecological converge of the worda is sub-tropical (weina *Dega***)** (Bahir Dar Zuria Woreda Agricultural Office, 2014).

3.1.2 Dangela Woreda

Dangela woreda is one of the eighth woredas and three town administrations of Awi zone; in ANRS. It is located about 80 km south west from Bahir Dar regional city, 36.83° N and 11.25° E. Dangila is bordered on the south by Faggeta Lekoma, on the southwest by Guangua, on the northwest by the Jawi, and on the northeast by the Mirab Gojjam Zone. Towns in Dangila include Addis Alem, Dangila and Dek. In the woreda, there are 27 rural Kebeles among which 16 of them have access to a perennial river. Average annual rainfall is about 1600 mm, but varies between 1180-2000 mm. Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), this woreda has a total population of 158,688, an increase of 6.44% over the 1994 census, of whom 80,235 are men and 78,453 women; 27,001 or 17.02% are urban inhabitants. With an area of 918.40 square kilometers, Dangela has a population density of 172.79, which is greater than the Zone average of 107.44 persons per square kilometer. A total of 35,610 households were counted in this woreda, resulting in an average of 4.46 persons to a household, and 34,635 housing units. The woreda has a land area of 106,830 hectares from this, about 6 percent is cultivated for irrigation. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 97.9% reporting that as their religion, and 1.88% of the population said they were Muslim. The bases of the livelihood of the woreda.is basically Agriculture and the dominant crops are Maize, millet, teff and potato crops are the dominantly grown in the woreda .Lives tock types are cattle, sheep equine animals and goats are also the commonly reared in the woreda. (Dangela woreda agricultural office administration office, 2014).



Source: Bureau of Finance & Economic Development

Figure 3.1 Woredas in which the study sites are located

3.1.3 Feed the Future Innovation Lab on Small Scale Irrigation (ILSSI)

Mission of the project is to seek and implement the most efficient small-scale irrigation systems to battle poverty and nutrition problems in water-scarce Tanzania, Ethiopia and Ghana; evaluate impacts and synergies of technologies and practices. In the case of Ethiopia the project is under practice at Dangela and Bahir Dar Zuria woerdas in Amahra region, Admi Tulu woreda in Oromia region and Lemo woreda in south nations nationalities and peoples region. The Innovation Lab on Small- Scale Irrigation (ILSSI) is a cooperative research project being implemented through the United States Agency for International Development (USAID) Feed the Future (FtF) program. The project is to enhance food security and reduce poverty by developing and introducing gender-sensitive, small scale irrigation systems into food and agriculture production on small farms. Such irrigation schemes may support production of high value crops including forages for livestock. It is being implemented a five-year project in Ethiopia, Ghana and Tanzania aimed at benefiting the region's farmers by improving effective use of scarce water supplies through interventions in small-scale irrigation(Adegoke, A.T, 2015).

3.2 Data Source

The target households in experimental projects are composed of female and male headed households. The total targeted households was 54 i.e. 8 female headed and 14 male headed for Dangela woreda and 10 female headed and 22 male headed households for Bair DarZuria woreda. In case of Bahir Dar Zuria woreda we couldn't found female headed households as planned; the experimental was conducted according to the local situations. Target household needs to have access to source of water suitable for the respective water lifting technology (i.e. the shallow-wells are an appropriate water source for rope &washer and pulley/bucket). And for those households selected for rope and washer pumps, the depth of their wells shouldn't be more than 12m; each target household should provide different area of land for irrigated vegetables and for irrigated fodder for feasibility test of the proposed technology. Irrigated fodder (Napier grass or commonly known as Elephant grass) and tomato (high valued hybrid variety) was demonstrated in Bahir Dare Zuria woreda and local variety onion was demonstrate in Danegela woreda based on their interest of preference. Each selected household should have been willing to sign a credit agreement and repay the actual value/investment cost of the technology.

Both woreda offices of agriculture officials suggested the cooperative office, which usually works hand in hand with the agricultural offices, are favored to administer the credit contracts with farmers. With this arrangement, the money can be used as revolving fund within the respective woredas/kebeles for further scaling out the technologies. Farmers has been given 3 years to repay the loan in one year installments. Each target household was agreed to grow the same vegetable or fodder variety and use the same type of input (i.e. seed type, fertilizer, pesticide) in the demonstration plot during the same cropping season.

3.3. Data Type and Method of Data Collection

This study was based on primary experimental project data and secondary sources to computed NPV and IRR. Experimental project data on farm input, output and demographic characteristics. Each target household with help of data collectors supposed to be record and kept data related to all activities done on the experimental plot including every irrigation and agronomic activity that are connected with costs and benefits based on a field book that was given to the farmers. Filed books prepared in English language. To remove communication barriers with target households and obtaining required information, filed books were translated into Amharic language.

In addition to the filed book, at the end of crop season information was collected through focus group discussions with the two woredas agricultural office irrigation experts, development agents and targeted households at the end of crop season. Focus group discussions were first held with targeted households who adopt small-scale different irrigation technologies and crops with respective technologies. A second discussion was with development agents. After thoroughly discussing the problems and opportunities of irrigation technologies with farmers and development agents, a focus group with each woreda irrigation experts was undertaken.

Moreover, secondary data that could supplement the primary data were collected from report documents, Woreda Offices of Irrigation Development, Woreda Offices of Agricultural Development, Woreda and Kebele Multipurpose Cooperatives Offices and of Water Lifting Technology Manufacturers are some of the offices from which secondary data were obtained.

To obtain reliable and accurate data for the study, the researcher closely flow the targeted households in experimental projects to have personal observation and to made discussion with the targeted households, agricultural experts and extension agents in specified periods of time.

3.4. Methods of Data Analysis

After data was collected, it was encoded into Excel sheet and Stata. In this study, both descriptive, financial and regressional analyses were used to compute feasibility of SSI technologies. Average well depth, number of beneficiary, average area of irrigated land, amount of average investment costs, average operation and maintenance (O&M) cost , average annual cash flow socio-economic and demographic characteristics of the sample households are presented. In addition, financial analysis based on investment cost (installation costs of the water lifting technologies), operational & maintenance costs and discount rate were applied to compute Net Present Value (NPV) and Internal Rate of Return (IRR) and multiple regressional analysis were applied to infer factors that affects the feasibility of SSI technologies.

3.5. The Theoretical Framework: Net Present Value and Internal Rate of Return

Cost–benefit analysis

The purpose of cost-benefit analysis is to provide a consistent procedure for evaluating decisions to investigate the feasibility of investments. This might appear as an obvious and sensible way to proceed, but it is by no means the only one (examples of alternative procedures are majority voting, collective bargaining, the exercise of power, or the assertion of rights). So described, cost-benefit analysis clearly embraces an enormous field (J. Drze and N. Stern, 1987).

To calculate the financial feasibility of an enterprise or a project, a cost-benefit analysis (CBA*)* is often used**.** CBA is a widely used financial and economic appraisal tool for projects. It is particularly useful when a choice has to be made out of several projects and when the project involves a stream of benefits and costs over time, covering more than one year (Casler, Anderson, and Aplin, 1993)

The most common CBA analysis method of discounting measures of project worthiness are net present value, benefit cost ratio and internal rate of return (F. Hagos and K.Mamob, 2014) .For this paper we focused on NPV and IRR the description of which is given below.

3.5.1 Net Present Value (NPV) Test

The NPV is a preferred method for evaluating the economic worthiness of an investment, because the method considers the time value of the entire stream of net cash flows over the life of the investment (Casler, Anderson, and Aplin, 1993). The NPV of the project is the sum of the present values for each year's net cash flow less the initial costs of the investment (Kay, 1981). An NPV greater than zero implies an actual rate of return on the investment that is greater than the discount rate used, the minimum acceptable rate of return that must be earned by a capital expenditure. We use the weighted average cost of capital as the discount rate (Casler, Anderson, and Aplin, 1993).

According to (Roger,et al, 1996)this is the process of compounding. Generally, a principal lent at the rate i, with annual compounding, will be worth some amount after some years where. Thus the net present value (NPV) of a project is the present value of the net cash flow associated with it. If the project has a non-negative NPV, then it should be undertaken, otherwise not. The decision rule is, that is, go ahead with the project only if NPV > 0. In SSI farmers wishing to maximize its net worth should rank available projects by NPV, and undertake those for which NPV >0 i.e. Project is economically feasible.

$$NPV = \sum_0^T \frac{N_t}{(1+ i)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.$$

where t is use lifetime in year , N_t is the net cash flow in year *t*, and i is discount rate. We can calculate cash inflow form output that are collected in each intervention by the project and cash out flow from both implicit and explicit costs.

3.5.2 The Internal Rate of Return Test

According to (Roger, et al, 1996) an alternative test for CBA is the internal rate of return (IRR) test, according to which a technology should be undertaken if its internal rate of return is greater than the rate of interest. The internal rate of return for a technology is the rate at which its net cash flow must be discounted to produce an NPV equal to 0. In our case technologies' IRR is found by setting the left-hand side here equal to zero, and then solving the equation for the interest rate, which is IRR solution. The IRR is, that is, the solution for *x* in

$$0 = \sum_0^T \frac{N_t}{(1+x)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.2$$

where T, is the total life of the of the given technology, Nt is net cash flow, x is IRR and t indicts each operation year.

The IRR can also test, for the same input data, give the same result as the NPV test. In this case, because of the time profile of the net cash flow, it involves multiple solutions i.e. with the aid of computers, IRR calculations is applied trial-and-error to determine NPVs for various interest rates. Thus, the IRR function provides the internal rates of return for a series of income or cash flows represented by the numbers in values. An IRR is the rate for which the NPV equals zero. The cash flows must occur at the equal intervals, such as annually, monthly or daily (Roger, et al, 1996).

Interest/Discount rate: The Development Bank of Ethiopia (DBE, 2010) increased the lending interest rate from8% to 8.5% for priority investment sectors and to 9.5% for non-priority sectors. Investment in agriculture in general and irrigation in particular is among the priority investments (Gebregziabher et al, 2013).From our survey period we obtained that the multipurpose cooperative of the two woredas issue the loan for these technologies were based on the interest rate at 7.25%. Thus, different discount rates ascending from 7.25% were applied to compare and perform sensitivity analysis related to financial feasibility.

Service Life of the Water Lifting Technologies: Good quality rope and washer pumps can last for 20 years or more as was proven in Nicaragua (Peter et al, 1993) .The lifetime of the rope pump varies from three years for a communal rope pump of moderate quality and fairly maintained, to more than 12 years for a family rope which is well maintained rope pumps are used by communities or individual households (Lammerink et al, 1995). Rope and washer pumps require less maintenance than other equivalent pumps and their simple design means that repairs can often be done by users and require few spare parts due to this it has small maintenance cost (WHO,2003). The pulley wheel can last 12 years and above with the light maintenance (WHO, 2003). According to technology manufacturer and farmers in Awi zone experienced in both rope and washer and farmers in Bahir Dar Zuria woreda experienced in pulley lasts for more than ten years of service life. Thus for the purpose of this study we you 10 years of service life to calculate the NPV and the IRR.

3.6 The OLS Regression Model

The multiple linear regression model is used to study the relationship between a dependent variable **(i.e.** factors affecting the feasibly small scale irrigation technologies) and one or more independent variables (i.e. sex, age, education etc.).

$$\ln \hat{y}_i = \grave{x}_i \hat{\beta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.3$$

Where $\hat{y}_i$ natural logarithm of yield of small scale irrigation technologies $\grave{x}_i$ is vector of covariates and $\hat{\beta}$ is estimators of factors affecting feasibility / profitability (Marno_Verbeek, 2004)

3.7 Definitions of Variables

This sub section describes explanatory variables and outcome variables included in OLS model and cost and benefit variables considered in the CBA analysis with empirical evidences and eligibility criteria of SSI. Accordingly, several variables including household characteristics and socio-economic factors are hypothesized to determine factors that affects feasibility of the SSI technologies.

Operation and maintenance costs (O&M): Annual operation and maintenance costs (in ETB) for small- scale irrigation systems. These are lobar, oxen, seed, fertilizer, spare and pesticide costs which are decisive factors of feasibility of the SSI technologies since these costs are appeared trough the life time of the project with the fixed time interval.

Investment costs: These are onetime payment made for the purchasing and installation cost of water lifting technologies for SSI before the starting of the project or at year zero.

Net annual benefit: A periodic constant receipts, that is series of receipts at fixed intervals, guaranteed for a fixed number of years or the lifetime of one or more individuals. The same level of net annual benefits occurs repeatedly over time at a fixed time interval. In the CBA analysis for SSI technologies, cash inflow items of annual benefits may be the same over a certain period of time.

Dependent variable: In this study, in the case of using OLS model the independent variable for factors affecting feasibility is natural logarithm of yield of irrigation technologies.

Covariate (Explanatory) Variables: These are variable which affects the feasibility of SSI technologies for the participant households. Based on the economic theory, empirical findings, and own observation, the covariate variables are specified as follows

Age of the household head (Age): Age is used to indicate the general experience of the household head. At younger ages the probability of participation performance in small scale irrigation will increase. But as the farmer gets older and older his managerial ability and physical capacity are expected to decrease as a result the overall labor hours will decline and the demand for leisure will increase. Hence, age is hypothesized to have positive and negative effect on farmers ‘performance in small -scale irrigation.

Household head Sex (sexhead): This is a dummy variable, which takes a value of 1 if the household is male and 0 otherwise. Male household heads are expected to have higher yield compared to female household heads because of better labor inputs used in male-headed households than the female headed ones. Moreover, with regard to farming experience males are better than the female farmers since it is assumed that male household heads have more exposure and access to information and new interventions than female household heads, which might enable them to high performance in the small scale irrigation.

Education of household head (eduh): is a continuous variable measured in maximum grade attended. Empirical evidences show that education is positively associated with irrigation return performance (Aseyehegn, et al, 2012). Therefore, education of the household head is hypothesized to positively affect practices in SSI).

Labour (labor): A number of total labor force used in the irrigation activity measured in man/day

Livestock holding (Livesthld): This refers to the total number of livestock measured in tropical livestock unit (TLU). A household livestock size in TLU is calculated by multiplying the number of each type of animal by an appropriate conversion factor and then summing. Households, who own many cattle, need more time to rearing. That means a household has allocated his/her parts of time for rearing purpose. Therefore, it is hypothesized that, more livestock holding negatively relating SSI scale practice and hence performance.

Plot size (plotsize): - Land under irrigation (in hectares) in micro economic labor theory area of land is negatively related with marginal productivity of labor. As the cultivated land size increases provided other associated production factors remain constant, the likelihood that the holder gets more output is high. Hence farmland is the major input for agricultural production in rural households (Kamara et al. 2001).

Farm Income (farmincome): It is a continuous variable which refers to part of the total amount of income measured in birr that is earned from farm activities which are related to agriculture. Therefore, in this study it is hypothesized that income affects the members' performance in SSI.

Site_Dummy (site): The districts in consideration (1=if Bahir Dar Zuria; 2=otherwise)

Crop Dummy (croptype): The crop in consideration (1=; if tomato 2=if onion 3=if fodder)

Technology Dummy (technotype): The technology in consideration (1=if pulley; 2=if rope and washer)

Damage Dummy (Damage): The damage in consideration (0=if not damage; 1 otherwise) used as control.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results from the cost benefit (financial) analyses. The CBA made use of tools to compute NPV and IRR and descriptive analysis such as averages of some variables to compare technologies, crops varieties and gender differentials. CBA analysis was carried out to identify the feasibility and factors of affecting profitability of small-scale irrigation technologies at different discount rates.

4.1 Results of Descriptive Statistics Analysis

4.1.1 Description of all the technologie used in this analysis

The feasibility of water lifting technologies on small holder farmers could be captured by cost benefit analysis tools the Net Present value (NPV) and Internal Rate of Return (IRR). The study focused on54 framers in the two woredas (Dangela 22 and Bahir Dar Zuria 32) who has wells and by letting them to have two types of water lifting technologies (pulley and rope & washer) with different types of corps i.e. onion, tomato and fodder. These technologies are used to irrigate 0.34 hectare in Danegela and0.4 hectare in Bahir Dar Zuria woredas.After adopting the technologies based on experimental approach it is possible two evaluate the feasibilities.

Table 4.1 describes the technologies with cope types. The average well depth for pulley and R&W were 4.96m and 6.88m respectively in Dangela woreda and average well depth of pulley with tomato, pulley with fodder, R&W with tomato and R&W with pulley were 11.14m, 8.33m, 9m and 11.04m respectively in Bahir Dar Zuria. The average depth and average irrigation plot area in Danegela woreda is smaller than in Bahir Dar Zuria woreda. In Dangela woreda, the average investment cost for the technologies pulley and rope &washer were ETB 1232 and ETB 3975, respectively. Similarly, in Bahir Dar Zuria woreda, the average investment costs for pulley with tomato, pulley with fodder, R&W with tomato and R&W with pulley were ETB1374, ETB 1348, ETB 4175 and ETB 4175, respectively. From our study for pulley with onion and for rope &washer with onion the computed average operation and maintenance(O&M) costs and average annual cash flows were ETB 1099,ETB 1233 ETB 422, and ETB 635 respectively. Similarly, for pulley with tomato, rope &washer with tomato, pulley with fodder and rope and washer with fodder the average operation and maintenance (O&M) costs and average annual cash flows were ETB 994,ETB 734, ETB 845, ETB 937,ETB 2824, ETB 794, ETB 1181, and ETB 871respectively. From the above figures we can clearly observe that in Dangela woreda average

O&M costs were higher and average annual cash flow were lower as compared to Bahir Dar Zuria woreda

Table 4.1. Description of all the technologies used in this analysis

Site Name	Technology type	Crop type	Average depth (m)	Number of Beneficiaries households	Average area of irrigated land per household (m^2)	Average investment cost(ETB/well)	Average O&M cost	Average annual cash flow (in ETB)
Dangela	pulley	Onion	4.96	11	156.27	1232	1097	422
Dangela	R & W	Onion	6.88	11	152.72	3975	1227	635
Bahr Dar Zuria	pulley	Tomato	11.14	11	131.1	1374	994	2866
Bahr Dar Zuria	R&W	Tomato	9	6	161.1	4175	734	794
Bahr Dar Zuria	pulley	Fodder	8.33	9	100	1348	845	1181
Bahr Dar Zuria	R &W	Fodder	11.04	6	80	4175	937	871

Source: Own filed book data

4.1.2 Socioeconomic Characteristics of Sample Households

Table 4.1.2 below represents socio-economic characteristics of the sample households (discrete variables). Sample households were composed of both male and female household heads. Gender of the household head is an important variable in feasibility of small scale irrigation technologies**.** It was found that among the total sample household heads 66.7% of them are male headed while 33.3% are female headed households.

When we see the comparison by site, out of 54 households 59.3 are in Bahir Dar Zurai woreda and the remaining 40.7 are in Dangela woreda and then site also important for feasibility of small scale irrigation.

Type of technology plays an insignificant role for profitability of SSI. The distribution of total sample in terms types of technology has shown that, 57.4 % were pulley and 42.6 % rope and washer.

Crop type plays an important role for feasibility of small scale irrigation technologies. It has different return, immunity for diseases and market price .The distribution of total sample respondents in terms of crop type shown that, 31.5 % were tomato, 40.7% onion and 27.8% fodder.

Table 4.2. Socio-economic characteristics of the sample households (discrete variables)

Variable		Frequency	percent
sexhead	Female (1)	18	33.3
	Male (2)	36	66.7
site	Bhir Dar Zuria (1)	32	59.3
	Dangela (2)	22	40.7
technotype	pulley (1)	31	57.4
	rope & washer(2)	23	42.6
croptype	tomato(1)	17	31.5
	onion (2)	22	40.7
	fodder (3)	15	27.8

Table 4.3 represents socio-economic characteristics of the sample households (continuous variables). Age of the household head of sample respondents ranged from 18 to 65 years with mean of 42.03 years. It was found to be statistically significant suggesting age has influence on the profitably of small scale irrigation technologies.

Education of household head plays a key role for feasibility of small scale irrigation. The average years of household head s education was 1.85 with the minimum of 0 to the maximum of 12. The t-test shows us the level of education is statistically significant at 5% level of significant for the feasibility of small scale irrigation technologies.

The average size of irrigated plot of the surveyed households equals to 135.9 m^2 with a minimum of 50 to a maximum of 272 m^2. The t-test revealed that the size of plot statistically insignificant at 5% level of significance and it shows plot size is not a factor for the feasibility of small scale irrigation technologies. In the study area the size of plot was determined based on the acquisition of irrigated land near to the water wells.

Farm animals have significant role in rural economy. They are source of power, food, such as, milk and meat, cash, animal dung for organic fertilizer and fuel and means of transport. Farm animals in the study area also serve as a measure of wealth in rural area. The types of livestock found in the study area were cattle, equine, sheep, goat and chicken. To help the standardization of the analysis, the livestock number was converted to tropical livestock unit (TLU). Conversion factors used were based on Storck, et at. (1991) and indicated in annex. The average livestock holding of respondents was 5.14 TLU, where the minimum is 0 and the maximum is 16.12. In this study t-test revealed us that there was insignificant for feasibility/profitability small scale irrigation s at a 5% significance level.

Table 4.3.Socio-economic characteristics of the sample households (continuous variables)

Variable |	Obs	Mean	Std. Dev.	Min	Max	T- value
headage	54	42.04	11.83	18	65	-2.71*
eduhh	54	1.85	3.24	0	12	-2.15*
Plotsize	54	135.9	45.1	50	272	-0.5
livstkhld	54	5.14	3.26	0	16.12	1.44
lbor	54	20.64	11.11	5.58	50.94	4.64*

Remark: * significant at 5%

Source: Computed from own filed book

The average number of labor used in irrigation activity in the irrigation season was 20.64 with a minimum of 5.58 to a maximum of 50.94. The amount of labor force used in the household is important for feasibility of small scale irrigation. The main source of labour for crop production either in the irrigated or rainfed agriculture in the study area is family labour. However, Female headed households hire lobar for some activities like ploughing digging the wells. Amount of Labor per day was found to be statistically significant at 5% level of significance suggesting effective use of labor is an important factor influencing households' profitability of using small scale irrigation technologies.

4.2 Financial Feasibility Analysis

In this sub section, the feasibility of SSI technologies in all participant households at two experimental project areas is analyzed based on financial sensitivity analysis with the combination of different technologies against various crops. The experiment was conducted for both sexes. For financial sensitivity analysis to be computed the costs data (i.e. investment and O&M costs), the annual cash flow and net annual cash flow and Excel sheet were applied.

Table 4.2 presents the financial feasibility analysis at different technology against onion for both genders in Danegal woreda using the three discount rates (7.25%, 8% and 12%) for ten years service life of the technologies. From the table we can observe that different average investment cost was needed to be invested for different technologies; ETB 1233 and ETB 3975 for pulley and R&W respectively as well as different average O&M cost and average yields for the some crop type was obtained through the experiment process. From our computation pulley with onion was found to be low average O&M costs (ETB1097)as compared to R&W with onion (ETB 1227)whereas the average yield was vise-versa.

The analyzed results reveled us for both onion with pulley and rope& washer the NPV was found to be negative and the IRR is not applicable (N/A) at 7.25% interest rate (i.e. threshold discount rate for this study), implying that small scale irrigation investment with the combination of local variety onion with these technologies were not financially viable (table 4.2).These results are against the previous studies by F. Hagos and K.Mamob, (2014) and Gebregziabher et al and (2013). Based on discussion with the agricultural experts and targeted households, this might be because of the seed was local varieties which are easily attacked by disease results in low yield, lack of experience and delay of planting time that limits the full potential utilization of the technology (i.e. two-three round irrigation activities) and other reason was high O&M costs.

Irrespective of the analyzed results, the discussion made with the participant households and experts revealed us, framers were very interested for the technology R&W with high valued hybrid varieties of vegetables. In addition high demand for R&W water lifting technology was recorded including non-targeted households in the project area. Based on the discussion factors for the high demand of R&W are shallowness of the well depth that makes easy for water lifting activities and the suitability of the technology to safe the water in the well for home consumption. The result shows that, in the study area we have to apply flexible and step by step approach to improve the profitability. Our findings are in line with the previous studies that examined the small scale irrigation management and use of technologies (Thakurdas.v.1994).

Table 4.4.**Sensitivity analysis based on different technologies against onion, Dangela woreda(in ETB)**

	Pulley with Onion	For 10 Yrs		**R &Wwith Onion**	For 10 Yrs
	Average investment cost	1233		Average investment cost	3975
	Average labor cost	893		Average labor cost	985
	Average fertilizer cost	41		Average fertilizer cost	25
	Average seed cost	131		Average seed cost	123
	Average oxen cost	22		Average oxen cost	24
n=11	Average maintenance cost	10	**n=11**	Average maintenance cost	70
	Average pesticide cost	0		Average pesticide cost	0
	Total average O&M costs	1097		Total average cost	1227
	Average annual cash flow	422		Average annual cash flow	635
	Net annual benefit	-675		Net annual benefit	-592
	NPV@7.25%	-5,457		NPV@7.25%	-7,478
	NPV@8%	-5,335		NPV@8%	-7,359
	NPV@12%	-4,506		NPV@12%	-3,675
	IRR	N/A		IRR	N/A

Source: Own filed book data

Similarly, table 4.3 below presents the financial feasibility analysis at different technology against different crop types (i.e. tomato and fodder (Napier grass) for both sexes in Bahir Dar Zuria woreda using the three discount rates (7.25%, 8% and 12%). The targeted households were have various combination of technologies and crop types having different average investment cost, average O&M cost and average yields in ETB. Tomato with pulley was computed to have low average investment cost, high average O&M cost and high average yield as compared to tomato with R&W having high average investment cost, low O&M cost and low yield. In the some table we had also fodder (Napier grass) with pulley and R&W the former has low average investment cost, high average O&M cost and high average yield and the later has high average investment cost, low average O&M cost and low average yield.

As also observed from table 4.3 sensitivity analysis in the combination of tomato with pulley the NPV was found to be positive at 7.25%, 8%, 12% and even positive at the highest interest rate equal to 136.2%the computed NPV result was ETB 10, 675, ETB 10, 359, ETB 8,217and ETB 0.08respectively and IRR was136%.This result revealed us with this specific technological combination we could have huge profit even at very high interest rate, 136.2%.Similarly, the financial analysis result computed based on the combination of pulley with fodder was found to be positive NPV at 7.25, 8%, 12% and in addition, the resulted NPV was ETB 891, ETB 839 and ETB 491respectively and the IRR was 21% which is higher than the highest lending interest rate (12%).These results are again in line with the studies byF. Hagos and K.Mamob, (2014) and Gebregziabher et al (2013).

According to woreda agricultural experts and development agents, high valued hybrid crop varieties, good management, high market price, and suitability of technology were some factors that affect the feasibility of small scale irrigation in the study area. According to the farmers who were planted tomato, when they go to the market they used to sale their products at price half higher than the market price because of the high fruit quality. On the other hand, the financial analysis result calculated based on the combination of R&W with tomato as well as fodder was negative NPV at all lending interest rate. From this combination (R&W with tomato) we have the average investment costs, average O&M costs and average yield ETB 4175, ETB736 and ETB 794 respectively. And the average investment costs, average O&M costs and average yields of combination of fodder with R&W was ETB 4175, ETB937 and 871 respectively (tabl4.3).

Some factors for not viability of this technology were the highest average investment cost and lower average yield. In addition, the discussion with target households and experts showed us there is very high level demand up to a community level for the technology pulley with high valued hybrid tomato variety and fodder (Napier grass).Our finding from FGD showed us one factor for the framers to be reluctant to R&W was the lengthy of the well depth that makes hard for water lifting activities in turn it was not effective to increase the yield in quality and quantity. Farmers were not interested for this technology due to this some farmers detach and substituted it with pulley as well as some of them were refused to repay the loan .These findings are also in line with many of previous studies that small scale irrigation practice could be effective Getaneh et al, (2013) or not effective Nadkarni and Deshpande,(1980 and 1982), Awulachew et al., (2005)and Nadkarni, M. V, (1984) in terms of improving yield in turn income and profitability.

Table 4.5. Sensitivity analysis by different technologies with different crop types, Bahir Dar Zuria woreda (in ETB)

	Pulley with Tomato	**10 Yrs**		**R&W with Tomato**	**10 Yrs**
	Average investment cost	1374		Average investment cost	4175
	Average labor cost	742		Average labor cost	477
	Average fertilizer cost	15		Average fertilizer cost	7
	Average seed cost	33		Average seed cost	28
	Average oxen cost	21		Average oxen cost	20
	Average maintenance cost	22		Average maintenance cost	86
n=11	Average pesticide cost	161	n=6	Average pesticide cost	118
	Total Average O&M costs	994		Total Average O&M costs	736
	Average annual cash flow	2866		Average annual cash flow	794
	Net annual benefit	1872		Net annual cash benefit	60
	NPV@7.25%	10,675		NPV@7.25%	-3,513
	NPV@8%	10,359		NPV@8%	-3,508
	NPV@12%	8,217		NPV@12%	-3,435
	IRR	136%		IRR	-26%
	Pulley with Fodder	**10Yrs**		**R&W with Fodder**	**10 Yrs**
	Average investment cost	1348		Average investment cost	4175
	Average labor Cost	750		Average labor Cost	783
	Average fertilizer cost	14		Average fertilizer cost	19
	Average seed cost	48		Average seed cost	40
	Average oxen cost	15		Average oxen cost	9
	Average Maintenance cost	18		Average Maintenance cost	86
n=9	Pesticide cost	0	n=6	Pesticide cost	0
	Total Average O&M costs	845		Total Average O&M costs	937
	Average annual cash flow	1181		Average annual flow	871
	Net annual benefit	336		Net annual benefit	-66
	NPV@7.25%	891		NPV@7.25%	-1,567
	NPV@8%	839		NPV@8%	-1,551
	NPV@12%	491		NPV@12%	-1,433
	IRR	21%		IRR	N/R

Source: Computed own filed book data

4.3 Financial Feasibility Analysis by Gender

In this sub section, the feasibility of SSI technologies by gender from the two experimental project areas were analyzed based on financial sensitivity analysis for the combination of each technology. The some as the above discussion for both sexes; for financial sensitivity analysis to be computed the costs data (i.e. investment and O&M costs), the annual cash flow, net annual cash flow and Excel tools were applied.

Table 4.4 represents sensitivity analysis by gender with different technologies against onion, in Dangela woreda by applying the some methods and discount rates in the above analysis to compute NPV and IRR. The number of beneficiaries were 8 MHHs, 3 FHHs, 6 MHHs and 5 FHHs for onion with pulley

Table 4.6. Sensitivity analysis by gender with different technologies against onion, Dangela woreda (inETB)

	Pulley with Onion	For 10 Yrs		**R &W with Onion**	For 10 Yrs
	Average investment cost	1231		Average investment cost	4041
	Average labor cost	790		Average labor cost	706
	Average fertilizer cost	44		Average fertilizer cost	25
	Average seed cost	129		Average seed cost	118
	Average oxen cost	23		Average oxen cost	23
MHHs	Average maintenance cost	10	**MHHs**	Average maintenance cost	70
	Average pesticide cost	0		Pesticide cost	0
n=8	Total average O&M costs	996	**n=6**	Total average O&M cost	942
	Average annual cash flow	476		Average annual cash flow	1183
	Net annual benefit	-520		Net annual benefit	241
	NPV@7.25%	-4,465		NPV@7.25%	-2,220
	NPV@8%	-4,371		NPV@8%	-2,244
	NPV@12%	-3,722		NPV@12%	-2,392
	IRR	N/A		IRR	-8%
	Pulley with Onion	For 10 Yrs		**R &W with Onion**	For 10 Yrs
	Average investment cost	1235		Average investment cost	3935
	Average labor Cost	1166		Average labor Cost	1330
	Average fertilizer cost	33		Average fertilizer cost	26
FHHs	Average seed cost	140	**FHHs**	Average seed cost	128
	Average oxen cost	21		Average oxen cost	27
n=3	Average maintenance cost	10	**n=5**	Average maintenance cost	70
	Average pesticide cost	0		Average pesticide cost	0
	Total average O&M costs	1,370		Total average O&M cost	1581
	Average annual cash flow	112		Average annual cash flow	328
	Net annual benefit	-1,248		Net annual benefit	-1,253
	NPV@7.25%	-9,117		NPV@7.25%	-11,661
	NPV@8%	-8,897		NPV@8%	-11,428
	NPV@12%	-7,389		NPV@12%	-9,835
	IRR	N/R		IRR	N/A

Source: Computed own filed book data and onion with R&W respectively. In this analysis the O&M costs for FHHs were high (i.e. ETB 1370 and ETB1581 for the two combinations) due to large labor cost this might happened because of that women lead households mostly use employed labor that may not as effective as the home labor as well as employed lobar my takes extended time to complete a certain task.

From table 4.4 the NPV for all technologies was negative and the IRR was found to be N/R but one of the technologies (onion with R&W) with MHHs was computed -8%. Similarly, expect R&W with onion that is owned by MHHs all technologies were found to be negative average net annual benefit. However, in case of sensitivity analysis for both sexes the average annual net benefit was found to be negative and the IRR was N/R for both technologies. Thus, positive average net annual benefit and the -8% IRR rather than N/R was strengthening our discussion above with the agricultural experts, and targeted households in Dangela woreda. In addition, the above result again strengthen our result obtained from discussion about the increasing demand for R&W with high valued hybrid variety crops in the some study area.

In table 4.5 below represents the financial sensitivity analysis by gender with different technologies against different crop types, in Bahir Dar Zuria woreda using the three discount rates 7.25%, 8% and 12% as like that of pervious computations.

In table 4.5 for MHHs the numbers of beneficiaries for all technologies expect pulley with tomato were five and the number of beneficiaries for R&W with tomato and fodder were 4 and 1 respectively for FHHS. The NPV for pulley with tomato was positive even at very high interest rate, 211% that is greater than the result in the case of sensitivity analysis both sexes together that was 136.2% and the IRR was 212% implying, that the technology had very huge profit for MHHs. In another way the NPV is negative at all interest rates for FHHs in the some technology. The NPV for pulley with fodder found to be only positive at 7.25%and the IRR was 8%for MHHs which is less feasible than in the case of both sexes that was positive at all interest rates, 7.25%, 8% and 12% and the IRR was 21%. This finding point out that FHHs was more feasible as compared to MHHs in this technological combination. On the other hand in the case of R&W with tomato and fodder for both sexes; the NPV found to be negative for all interest rates and the IRR was negative for MHHs and N/R for FHHS. The N/R IRR implies that the average annual cash inflow was extremely low as compared to cash out flow for this technology that means the yield was very low. The above result showed us the technologies for male headed households were financially feasible in two scenarios whereas for women headed households was only one scenario. Discussion with sample households revealed that female-headed households faced labor shortage for irrigation than males. The gender difference of household heads in feasibility indicates female-headed households face shortage of labor and then made them employ labor. Similar result were reported by Prof. Richard Carter and Dr. Kerstin Danert, (2006), Asayehegn et al, (2012), Eguavoen, et al, (2011) and Nega, (2013). As a result the financial feasibility of female headed households are less than the male headed households for most of the technologies expect pulley with fodder.

Table 4.7. Sensitivity analysis by genderwith different technologies against different crop types, Bahir Dar Zuria woreda (in ETB)

	P vsT	10 Yrs		R&W vs T	10 Yrs		P vs T	10 Yrs		R&W vsT	10 Yrs
	AIC	1404		AIC	4175		AIC	1317		AIC	4175
	ALbC	810		ALbC	477		ALbC	693		ALbC	413
	AFrtC	17		AFrC	7		AFrC	14		AFrC	22
MHHs	ASedC	34	MHHs	ASeC	28	FHHs	ASeC	30	FHHs	ASeC	20
	AOxC	19		AOxC	20		AOxC	25		AOxC	23
	AMnC	22		AMnC	86		AMnC	22		AMnC	86
n= 7	APsc	176	n= 5	APsc	176	n= 4	APsc	132	n= 1	APsc	0
	TAO&Mc	1078		TAO&Mc	749		TAO&Mc	916		TAO&Mc	564
	AAnCFl	4058		AAnCFl	953		AAnCFl	734		AAnCFl	0
	NAB	2980		NAB	204		NAB	-184		NAB	-564
	NPV@7.25%	17,718		NPV@7.25%	-2,581		NPV@7.25%	-2,398		NPV@7.25%	-7,485
	NPV@8%	17,211		NPV@8%	-2,598		NPV@8%	-2,363		NPV@8%	-7,370
	NPV@12%	13,776		NPV@12%	2,696		NPV@12%	-1,104		NPV@12%	-6,573
	IRR	212%		IRR	-11%		IRR	N/A		IRR	N/R
	P vs F	10 Yrs		R&W vsF	10 Yrs		P vsF	10 Yrs		R&W vsF	10 Yrs
	AIC	1351		AIC	4175		AIC	1345		AIC	4175
	ALbC	739		ALbC	693		ALbC	833		ALbC	1395
MHHs	AFrC	20	MHHs	AFrC	20		AFrC	28		AFrC	17
	ASeC	50		ASeC	43	FHHs	ASeC	45	FHHs	ASeC	25
	AOxC	13		AOxC	10		AOxC	18		AOxC	9
n= 5	AMnC	18	n= 5	AMnC	86		AMnC	18		AMnC	86
	APsc	0		APsc	0	n= 4	APsc	0	n= 1	APsc	0
	TAO&Mc	840		TAO&Mc	852		TAO&Mc	942		TAO&Mc	1532
	AAnCFl	1093		AAnCFl	787		AAnCFl	1203		AAnCFl	1292
	NAB	199		NAB	-65		NAB	261		NAB	-240
	NPV@7.25%	14		NPV@7.25%	-4,299		NPV@7.25%	415		NPV@7.25%	-5,416
	NPV@8%	-15		NPV@8%	-4,269		NPV@8%	376		NPV@8%	-5,357
	NPV@12%	-202		NPV@12%	-4,056		NPV@12%	116		NPV@12%	-4,938
	IRR	8%		IRR	N/R		IRR	14%		IRR	N/R

Source: Computed own filed book data

4.4. Results of the Econometric Model

In this particular study, to identify and analyze factors that affect the feasibly/profitability of small scale irrigation technologies, the OLS model has been used and analyzed. Ordinary least square model were used with ten demographic and socio economic variables such as age of the household head in years, education of household head, sex of household head, amount of labor used for irrigation activities, livestock owned in TLU, size of plot, farm income, total livestock owned in TLU, site, type of crop used for the irrigation, type of technology, and finally we use damage dummy as control are entered and analyzed with the help of Stata.

4.4.1 Estimation Procedures

Prior to the estimation of the parameters of the model, the data have been tested for multicollinearity, hetroskedasticity and normality problems using different STATA commands. Multicollinearity problem arises when at least one of the independent variables is a linear combination of the others. If there is multicollinearity problem: standard errors are inflated (creates very large standard errors), sign of the estimated regression coefficients may be opposite of hypothesized direction, smaller t-ratios that might lead to wrong conclusions (Wooldridge, 2003)

The study also runs the Ordinary Least Square (OLS) model to identify factors that affect the feasibility of small scale irrigation technologies. It is presumed that not all the statistically significant qualitative and quantitative explanatory variables of the model have the same level of importance on feasibly of small scale irrigation technologies for participant households. The importance of the qualitative and quantitative explanatory variables for the feasibility of small-scale irrigation technologies can be seen by statically significance level at 5%.

Accordingly; sex of household head, education of household head, amount of labor used for irrigation activities, site of the demonstration and type of crop are statistically significant variables for the feasibly of the small scale irrigation technologies irrigation at 5% level of significance .

Table 4.8 Ordinary Least Square estimation of model variables

Explanatory Variables	Coefficient	P-value
headage	-.032	0.011 *
site	-2.11	0.000*
eduhh	-.09	0.035*
sexhead	1.12	0.001 *
croptype	.74	0.000*
technotype	.36	0.175
Plotsize	.00	0.740
livstkhld	.06	0.191
Damage	2.73	0.000
lbor	.06	0.000*
_cons	1.71	0.081

Dependent variable	Natural logarithm of yield
Number of obs	54
F(10, 43)	19.06
Prob > F	0.0000
R-squared	0.8159
Adj R-squared	0.7731

Source: Computed from own filed book data

Note: * indicate statistically significant at 5% level

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study has addressed the feasibility of small scale irrigation technologies in Dangela and Bahir Dar Zuria experimental projects. Primary data sets using filed books, close following up and focus group discussion with targeted households woreda experts and development agents were drawn from 54targeted households. In this study, both descriptive and financial sensitivity analysis methods of data analysis were employed.

The description results of technologies shows that there is difference between two projects in terms of depth of wells, average investment costs, average O&M cotes and average annual cash flow in SSI technologies. The technology in Dangela woreda have lower well depth, average investment cost and average annual cash flow and higher average O&M cots than the technologies adopted in Bahir Dar zuria woreda.

The result of financial analysis computed for both sexes at the sometime shows that the combination of technologies and crop in Dangela woreda were not feasible. All average annual cash flows and the NPV was found to be negative at all interest rates, 7.25%, 8% and 12% and the IRR were N/R. This might be because of the seed was local varieties that are easily attacked by disease results in low yield, lack of experience, delay in time of planting that limits utilization full potential of the technology and other reason was high O&M costs.

The financial analysis result by gender for the some study area reveled us the some result with slight difference; this difference was positive average annual cash flow and negative IRR in the case of onion with R&W for MHHs.

The financial analysis result in Bahir Dar Zuriaworeda shows that for the combination of pulley with tomato and pulley with fodder in the case of analysis of both sex targeted households were feasible. The computed NPV was positive at all interest rate and IRR was 136% and 21% respectively. The huge profit obtained in this case was because of the seed was high valued hybrid varieties, high market price and the well adoption of this technology (pulley). In contrast, rope& washer with tomato and rope & washer with fodder were infeasible; both had negative NPVs and IRRs at all interest rates.

The analysis result based on gender in the some woreda revealed us pulley with tomato and pulley with fodder were feasible for MHHs and both sexes respectively. The former was highly profitable than the later due to the some pervious reasons. In addition, for the former one the computed NPV was positive for all interest rates and it was still positive at the highest interest rate, 211% the IRR was 212% whereas, in the latter case the NPV was only positive at 7.25% for MHHs and the IRR was 8%.Moreover, NPV was positive at all interest rates for FHHs and the IRR was 16%. On the other hand, the combination of R&W with two crop types for both sexes and pulley with tomato for FHHs were not feasible.

The gender difference of household heads in this study indicated that female headed households were effective only pulley with fodder and as the O&M cost was higher than the male headed households.

The regression result in the Ordinary Least Square (OLS) for the feasibility of small-scale irrigation technologies five variables were found to be significantly creating variation on the feasibility of small scale irrigation technologies for the participant's household. The variables that turned out to be statistically significant include: sex of household head, education of household head, amount of labor, site of demonstration and type of crop.

Therefore, it is concluded that small-scale irrigation development with rope & washer with some improvement in Dangela woreda and pulley in Bahir Dar Zuria is a better option for small holder households to enhance feasibility.

5.2 Recommendations

Based on the findings what we have got in the analysis part, in both descriptive and financial analysis, the following policy recommendation can be drawn for further consideration and improvement of small scale irrigation development in Dangela and Bahir Dar Zuria woredas.

Though the study revealed that the two small scale irrigation technologies have negative NPVs in Dangela woreda, rope & washer was found to be positive annual cash flow for MHHs. In collaboration with the result obtained from discussion and high demand of this technology irrespective of the NPV result strengthen that this technologies could be feasible in the study area with some improvements. Thus, the ongoing project should redesign the experiment by changing the inputs like high valued improved onion and tomato seeds and by letting farmers to start planting early to use the full potential of this technology hence to improve the feasibility.

The study revealed that from the financial analysis of small-scale irrigation technologies in Bahir Dar Zuria woreda pulley with tomato for MHHs and pulley with fodder for both sex lead households were feasible. Demand was created and increase up to the community level, this implies that the technology was well adopted by the time of experiment practice. Therefore, the government and, or the multipurpose cooperative and another stakeholders should deliver this profitable small scale irrigation inputs to the community.

The gender difference of household heads in small scale feasibility indicated female-headed households face high O&M cost and only profitable in one technology and crop combination. Therefore, governmental and non-governmental organizations like the ongoing experimental project has to find out ways to decrease the O&M costs and to make gender indifference adoption of technologies. For instance, intensive training for female headed households.

The study result shows that age negatively affects feasibility of small scale irrigation technologies. Aged farmers has less amount of labor for irrigation activities which is more labor incentive. Therefore, focus has to given for young households to boost feasibility of small scale irrigation technologies.

Crop type has also positive impact on feasibility of small scale irrigation technologies. High valued hybrid varieties of corps are more profitable. Therefore, emphasis have to given on high valued hybrid varieties of crop types.

Furthermore, the empirical result also shows that, labor has also significantly correlated with the profitability of small scale irrigation technologies. The amount of labor used in irrigation activities increases the profitably of irrigation technologies for participants. Therefore, concern has to given to increase profitability of small scale irrigation technologies.

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ANNEXES

Annex 1. Ordinary least square estimates of model variables

lnYield	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
headage	-.0323541	.0121159	-2.67	0.011	-.0567883	-.00792
site	-2.113251	.2862175	-7.38	0.000	-2.690463	-1.536038
eduhh	-.0905424	.0416973	-2.17	0.035	-.1746329	-.0064518
sexhead	1.09157	.3147254	3.47	0.001	.4568654	1.726274
croptype	.7445911	.1884625	3.95	0.000	.3645203	1.124662
technotype	.3646531	.2642147	1.38	0.175	-.1681866	.8974928
Plotsize	.001125	.003364	0.33	0.740	-.0056592	.0079092
livstkhld	.0586718	.0441946	1.33	0.191	-.0304551	.1477986
Damage	2.736321	.3111383	8.79	0.000	2.108851	3.363791
lbor	.0616639	.0118776	5.19	0.000	.0377104	.0856175
_cons	1.71135	.9564808	1.79	0.081	-.2175773	3.640277

Dependent variable	Natural logarithm of yield
Number of obs	54
F (10, 43)	19.06
Prob > F	0.0000
R-squared	0.8159
Adj R-squared	0.7731

Annex 2.Kernel density of estimated for OLS regression for SSI technologies participants

Annex 2. Variance inflation factors for Continuous variables to test multicollinearity

Variable	VIF	1/VIF
Plotsize	1.78	0.561897
sexhead	1.74	0.576008
croptype	1.66	0.603782
livstkhld	1.61	0.620858
headage	1.59	0.628917
site	1.56	0.641065
eduhh	1.41	0.707208
lbor	1.35	0.742237
technotype	1.35	0.742786
Damage	1.24	0.807419
Mean VIF	1.53	

Anex 3. Conversion Factor for Tropical Livestock Unit (TLU)

Animal Category	**TLU**	Animal	TLU
Ox	1.1	Goat	0.09
Cow	1.00	Donkey	0.0s
Heifer	0.50	Horese	0.80
Bull	0.6	Mule	0.70
calves	0.20	Poultry	0.01
Sheep	0.01		

Source: Storck, et at. (1991)

ANNEXES 4. FILED BOOK

FIELD- BOOK FOR COLLECTION OF AGRONOMIC AND WATER MANAGEMENT PRACTICES

Note: Tables below are to be filled by each target household and water lifting technology for vegetable and folder data but here we put sample of it because the filed book is detail and very large

Name of the selected household head: ________________________________

Year: __________________________________

Cropping season: __________________________________

Irrigation technology installed: ____________________________________

Area of the plot considered for this project (m^2):_________________________________

Average daily wage rate in the surrounding area (in ETB): ______________________________________

Irrigated crop variety: ____

Land Preparation

Land clearing

Did you do land clearing (y/n): _______________________________

Name of herbicide used	
Total amount of herbicide used (ml)	
Cost of roundup/herbicide applied to the field (in ETB)[1]	
Average daily wage rate in the surrounding area (in ETB)	

[1] Cost includes for rental cost of associated equipment, such as Knapsack sprayer

	1st Application		2nd Application		3rd Application		4th Application	
Date of application								
Amount of herbicide used (ml)								
	Total number of people	Hours per person	Total number of people	Hours per person	Total number of people	Hours per person	Total number of people	Hours per person
Male family members								
Female family members								
Male hired people								
Female hired people								
Exchange male people								
Exchange female people								

NB: We have the following consecutive tablesfor vegetable data format 1. Land leveling and Land preparation 2.plounig 3 .Fencing, planting 4.Weed and pest control5.weed and pesticide usage6.Bird livestock or wildlife scaring 7.Fertilizerapplication 8. Irrigation9.Harvesting.

Operation costs related with the irrigation technology, if any

Date	Spare parts (e.g. washers, rope etc.)		Maintenance	Other, specify
	Name	Cost (Birr)		

Did the maintenance or repair person come to the farm premises or did the farmer have to take the irrigation technology to the maintenance or repair shop?___________________________

FIELD- BOOK FOR COLLECTION LIVESTOCK DATA

1. Utilization of harvested fodder

Dateof harvest	Amount of hours it took to harvest	Person that did the harvesting	Amount harvested	Amount sold if any	Income from sales	Amount given to friends	Amount fed to livestock	Type of livestock fed (dairy cow/dry cow/calf/ox/ shoats/	No. of livestock fed by the fodder

2. Other feed types fed to the livestock which are fed by the irrigated fodder

Date fed	Amount of hours it took to feed	Person that did the feeding	Type of feed	Amount of feed	Types of animals fed	No. of animal fed	Cost of the feed (ETB)

NB: .We have the following consecutive tables for fodder data format 1. Milk production if any from the cows fed with the irrigated fodder 2.Condition scoring estimates of live weight of livestock fed to irrigated forages(score body condition 1-5: 1= least, 5=best) this can be done fortnightly 3. Livestock purchases 4. Livestock sales 5. Livestock labour