ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
ENVIRONMENTAL SCIENCE

Socio economic and environmental impact assessment of community based small-scale irrigation in the Upper Awash Basin.

A case study of four community based irrigation schemes

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Table of contents

List of Tables

Page

List of Figures

Pages

Acronyms

μs/cm	Micro-semen per centimeter
^0C	Degree centigrade
ACQUASTAT	FAO's Global Information Systems of Water and Agriculture
APHA	American Public Health Association
CARE	Cooperative for Assistance and Relief Everywhere.
CFU-	Colony Forming Unit
COSER	Commission for Sustainable agricultural and Environmental Rehabilitation
CRS	Catholic Relief Service
CSA	Central Static Authority
DA.	Development Agents
DAP	Die ammonium phosphate
EEC	European Economic Commission
EPA	Environmental Protection Authority
EPRDF	Ethiopian People Republic Democratic Front
ESRDF	Ethiopian Social Rehabilitation Development Fund
EVDSA	Environmental Conservation Studies and Research Desk
EWWCA	Ethiopian Water Works Construction Authority.
FAO	Food and Agricultural Organization (of UN)
FFW	Food For Work
GDP	Gross Domestic Product
Ha	Ha
HH	Households
IDD	Irrigation Development Department (of the former MOA)
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
Km^2	Kilometer square
m	Meter
M^3	Meter cube
masl	Meter above sea level

ml/l	Milligram per liter
mm	Mil meter
MOA	Ministry of Agriculture
MWR	Ministry of Water Resources
NGO	Non-Governmental Organization
OIDA	Oromiya Irrigation Development Authority
ONCCP	Office of the National Committee for Central Planning
PA	Peasant Association
ppm	Parts per million
SAER	Economic Commission of African and Environmental Rehabilitation
SCF_UK	Save the children Fund- United Kingdom
SPSS	Statistical software package
SSI	Small Scale Irrigation
T/year	Ton per ha
TU	Tertiary Users
USAID	United States Agency for International Development
WAPCOS	Water and Power Consultancy Services
WHO	World Health Organization
WRDA	Water Resources Development Authority
WSDP	Water Sector Development Program
WUA	Water User Association
WUT	Water Users Team
WWDSE	Water Works Design and Supervision Enterprise

Abstract

This study aims to examine the role of small-scale irrigation in food security through increased income and its environmental impact in the Upper Awash Basin. Its main objective is to assess the profitability and sustainability of community based small-scale irrigation schemes in the selected study areas. The study attempted to assess the benefits, costs and environmental impacts of small-scale irrigation schemes.

Results are based on Household survey and focus group discussion. Data was collected at household level. Information on household, crop production, market and irrigation management was collected In addition, irrigation water samples were collected for irrigation water quality study and physical and chemical analysis were done

The study findings highlights that small-scale irrigation for food security enhancement and sustainable environment is technologically and socio-economically demanding intervention currently being under taken in the rural Ethiopia. However the high yields obtained in irrigation and other benefits such as increased incomes, employment creation, and food security are indications that irrigation can bring sustainable agriculture and economic development with out affecting the environment negatively if properly planned.

The study of the four small-scale irrigation schemes in the Awash Basin has reveled some factors that are important for the successful implementation of small-scale irrigation schemes. It has come out clearly that an irrigation can be comparatively well designed and in a sound technical state but other issues related to land allocation, population pressure, input supply, market situation, health situation can affect the sustainability of small-scale irrigation schemes.

1. Background, Rationale, and Research Method

1.1 Background

Ethiopia's renewable surface and ground freshwater amounts to 123 and 2.6 billion cubic meters per annum respectively (CARE 1998). Its distribution in terms of area and season and its contribution to the sustainable growth to the economy is not well documented. Floods and drought, and lack of means to store water in times of plenty place Ethiopia at risk of drought and chronic food shortages (CARE 1998). Excess runoff is also responsible for the soil erosion in the highlands. Recent studies show that the sediment yields in different rivers range between 180 and 900t/year per km^2 (Rodecco, 2002). It is estimated that the Trans-boundary Rivers alone carry about 1.3 billion tones of sediment each year to neighboring countries (MoWR, 1993). Poor watershed management and farming practices have contributed to these rates.

Rapid population growth and the consequent encroachment of food crop farming on environmentally sensitive areas has created a vicious cycle of declining soil fertility, erosion, low crop yields, feed shortages, progressive land degradation, and reduction of areas under fallow and greater exploitation of marginal areas. The declining productivity in rain fed agriculture and the need to double food production over the next two decades, arise the needs for effective and efficient irrigation. However, there are important issues associated with land and water resources management like salinisation, nutrient depletion, water pollution, loss of vegetation cover, soil erosion, over grazing, soil degradation and groundwater depletion. These processes could lead to long-term deterioration and reduction of the potential and actual productivity of land, with adverse effects on agricultural productivity and serious food security implications at both the national and local levels (Kamara and McCornick, 2002*)*. Water related policies, programs, strategies and laws, are in place to combat these trends (Gulilat, 2002). But the current challenge is implementation; harmonization of the water sector with other sectors, capacity gaps and opportunities in linking existing research and capacity building activities (Gulilat, 2002). In general, sustainability of the management of water supply schemes is a challenge for the sector.

The country has an estimated irrigable land of about 1.5-3.5 million ha of which only about 5% ha developed to date, with about 55% of the developed area being traditional irrigation (MoWR, 2001a). At the end of the 1990s, the area under small-scale irrigation was estimated at around 65 thousand ha while that of medium and large-scale were appraised at 112 thousand ha, of which 22 thousand ha were new small-scale irrigation schemes implemented since 1992 (WWDSE 2001). The country has a National Irrigation Development Strategy to use water and land potential to meet food self-sufficiency, generate export earnings, and provide raw materials for industry on a sustainable basis (MoWR 2001). Specific objectives include expanding the irrigated area, improving the productivity of water in irrigated agriculture, ensuring the financial and technical sustainability of irrigated areas, and effective mitigation of water-logging and salinity.

Awash and Tekeze river basins are the most important basins for irrigation in Ethiopia. The Awash is the most developed with large-scale and small-scale irrigation located along its banks**.** At present, out of the total irrigated area, 48% of the irrigated farms are concentrated in the Awash Valley (.MoWR, 2001b). Four categories of irrigation are common in Ethiopia including traditional schemes, modern communal schemes, public schemes, and agro-industrial estate owned and private commercial schemes (Dessalegn Rahmato 1986; IFAD

1987; WAPCOS 1990; Estifanos Zerai 1996). Mixed livestock cropping is practiced in the upper Awash basin, but in the middle and lower part, pastoralism is more common. In Awash Basin, micro dams have been constructed to provide domestic water; water for livestock and water for food crop and animal feed production. However, many externalities are associated with irrigation in the basin. They include soil salinization, sedimentation of dams, up-slope erosion, water contamination and increased water-borne diseases. Incidence of water related diseases such as malaria; schistosomiasis and diarrhea have been associated with the development of irrigation agriculture in the small dams in Tigray and elsewhere in Ethiopia

The purpose of the research is to study the impact of existing small-scale irrigation system in the upper Awash Basin on the basis of socio-economic and environmental effect by employing socio-economic surveys and environmental assessment techniques. Some of the research questions are:

- How is sedimentation and damage to irrigation infrastructure due to flooding, erosion, and sedimentation controlled?
- How is the irrigation engineering work done in the command area?
- How are the soil fertility maintenance and the prevention of salinization in the irrigated plots conducted?
- What are the cropping systems and agricultural practice in irrigated as well as non-irrigated plots?
- How is the pest management system in irrigated plot conducted?
- How is farm labor and traction power supplied to the farm?
- What are vector borne, water contact and water born diseases in the scheme, which are caused by irrigation practice?
- How is the irrigation management system?

- How is the participation of community in irrigation design, operation and maintenance?
- How is the research and extension support, market and credit facility to the schemes?
- What is the overall progress of the implementations of irrigation program?
- What measure is required to improve the performance of irrigation schemes?

This study attempts to find out the socio-economic and environmental impacts of small-scale irrigation schemes by comparative analysis of households and water sample analysis, thus contributing to a better understanding of community based small-scale irrigation sub sector.

1.2 Statement of the problem

Irrigation has contributed significantly to poverty reduction, food security, and improving the quality of life for rural populations. However, the sustainability of irrigated agriculture is being questioned, both economically and environmentally. The majority of existing traditional and modern irrigation schemes are micro level in size, serving households usually not more than 200 to 300 in number (Tahal, 1988). Many of these schemes are based on stream and river diversions but some may be dependent on small dams and perennial springs. These traditional and modern small-scale irrigation systems may be described as forms of water user cooperatives. Each beneficiary has access to water on an equal basis, and equity in water distributions is a strong factor. Small-scale, modern and traditional irrigation are complemented by rain fed agriculture, and the crops grown are after horticultural crops and vegetables.

The increased dependence on irrigation has not been without its negative environmental effects. In sub-Saharan Africa more land is going out of irrigation each year than can be developed for irrigation because of the difficulty of planning and conducting sustainable schemes (http://www.cm.ksc.co.th/~bruns/6assess.html). Inadequate attention to factors other than the technical engineering and projected economic implications of small -scale irrigation schemes in Ethiopia has led to great difficulties (CRS, 1999). Decisions to construct dams or upgrade traditional irrigation systems have often been made in the absence of sound objective assessments of their environmental and social implications (CRS, 1999).

In 1980's as a result of the famine of 1984/85, small-scale irrigation schemes were given emphasis. However, progress was slow. Irrigation development did not attempt to involve the farming population, which has a long tradition of water management for small-scale agriculture use. The government upgraded several schemes without the consent of the communities concerned even though there were few occasions when stakeholders were involved in any aspect of water resources development. As a result, many of the small-scale irrigation projects have been operating below the required economic efficiency and affected the environment without any mitigation measures. This low level of efficiency and lack of sustainability may have been due to by the following factors (Girmay Tesfaye et.al, 2000)

- Economics of small-scale irrigation are not well understood
- Provision of inputs, services and technical advice is difficult because Small-scale irrigation systems are often scattered widely.
- Lack of efficient utilization of water resources
- Lack of viable product markets and marketing institutions

Small-scale irrigation has the potential to meet the demand for food security, agricultural diversity and productivity. There is considerable experience with small-scale irrigation, but the extent and potential has not been quantified and general documentation is sparse (CRS 1999). Information on water requirements of crops, the inputs and environmental effects are hardly available. Even if such data may be available they may not be accurate and reliable (CRS, 1999).

In most cases water users associations manage the irrigation schemes. However, un-economic plots and the inefficient use of water and conflict on equity basis of land allocation are observed (CRS, 1999). Irrigation plots are very valuable and there is tendencies to divide and sub divide them for lease to outsiders. Upstream land uses affect the quality of water entering the irrigation area; particularly the sediment content and chemical composition.

Water-borne or water-related diseases are commonly associated with the introduction of irrigation. The diseases most directly linked with irrigation are malaria and bilharzias (schistosomiasis). Other irrigation-related health risks include those associated with increased use of agrochemicals and deterioration of water quality.

The sustainability of small-scale irrigation projects depends on the maintenance of the implemented schemes and mitigation measures taken. The potential for integrating crops and livestock management in crop–livestock systems remains largely unexploited.

Negative environmental impacts of irrigation development occur off-site as well as on site. The effects take place upstream of the land to be developed, where a river is to be dammed for the purpose of supplying irrigation water. Another set of problems is generated downstream from the irrigated area by the disposal of excess water that may contain harmful concentrations of salts, organic wastes, pathogenic organisms, agrochemical residues, and causing siltation, water logging and erosion. Sometimes full utilization of the water creates water shortage to downstream affecting ecosystem negatively.

There is a need for research and capacity building to understand the complex issues of water and land management, so as to enhance national and local capacity to deal with water and land management issues to enhance food security, reduce poverty and speed up national economic development. Hence this research will assess the social or economic benefits and environmental effects of different community based small-scale irrigation development schemes in the Upper Awash Basin and identify options to improve irrigation performance.

1.3 Objectives of the study

Small-scale irrigation for food security enhancement and sustainable environment in the rural population is technologically, and socio-economically demanding option. The sustainability of small-scale irrigation largely depends on the socio-economic, institutional and management planning. Hence, the overall objective of this study is to assess the profitability and sustainability of community based small-scale irrigation schemes in the selected study areas. More specifically, the proposed study will attempt to:

1. Assess the benefits, costs and environmental impacts of different small-scale irrigation schemes in the Upper Awash basin.
2. Identify major constraints and environmental problems of small-scale irrigation development and propose alternative management options.

1.4 Relevance of the Study

Irrigated agriculture is a priority in the agricultural transformation and food security strategy of the Ethiopian Government. Increased availability of irrigation and less dependency on rain-fed agriculture is taken as a means to increase food production and self-sufficiency of the rapidly increasing population of the country. In line with the development policy of the country, regional states and NGOs are promoting irrigation development so as to increase and stabilize food production in the country.

Under the 15- year Water Sector Development Program (WSDP), irrigation development sub-program, a total of 1606 small-scale irrigation schemes planned to be implemented mainly for the provision of food requirements (MoWR, 2001). Foreign governments and multi-lateral agencies are expected to partner with government of Ethiopia and Non-government organizations (NGOs) to foster this program. Other non-governmental organizations and communities are also undertaking water resource development activities with the same objective. Large numbers of earthen micro-dams and river diversions have been built in the Awash basin. Besides development of new schemes, some traditional systems are also being rehabilitated.

Rapid growth of small-scale irrigation constitutes a major requirement for the agricultural development and food security strategies in the country. However, this achievement should be assessed in an integrated manner. The planning process for irrigated agriculture should assess the socio-economic, institutional and management issues as well as the technical issues.

Information on the impact of irrigation on the individual farm household in terms of food security and incremental income, farmers interest in small-scale irrigation, level of government and NGOs support, community groups and water users associations, access to credit and other services and environmental effects of small scale irrigation need to be well documented for planning purposes. Information collected from the study will help government policy makers, development agents, and NGOs to formulate appropriate policies, design effective extension and development programs. The farmers and researchers will also use the out come of the study as well.

1.5 Data Sources and Collection Procedures

1.5.1 Sampling Method

Among the number of community based small-scale irrigation schemes in the Upper Awash basin, four irrigation schemes from four woreda's were selected for the study based on accessibility, experience and type of scheme. These were Doni scheme from Boset woreda, Batu Degaga scheme from Adama woreda, Godino scheme from Ada Liben Woreda and Markos scheme from Wolemera woreda in East and west Oromyia region. Sample households from the four irrigation schemes and peasant association were selected using random sampling techniques. Sample populations were classified into two groups: irrigators and non-irrigators. These were selected from the same kebele where irrigation schemes are found and the difference is limited only to access to irrigation water. 30 irrigators and 30 non-irrigator farmers were selected from each peasant association where the schemes are located. The total population of irrigators and non-irrigator farmers of the four peasant association are 627 and 3207 respectively. The 240 farmers, (120 irrigators and 120 non irrigators) selected are considered to be representative sample and can generated reliable information.

1.5.2 Household sample survey

The household survey was conducted using questionnaires which cover demographic characteristics, household socio-economic factors, plot characteristics, water management practices, cropping pattern, agricultural input and yields at plot level, marketing and conception of constraints and environmental effects. In addation, physical environmental effects of irrigation like impact of dams on flooding, siltation, erosion, gully formation; local sanitation facilities were assessed by direct observation of the farms and villages. Eight enumerators (12 grade complete) and development agents who are residing in each peasant association were employed to assist in household survey. The fieldwork was conducted during February to March 2004.

1.5.3 Community level survey

Focus group of 5-8 farmers was elected from elders, religious leaders, water committee members, young people and women who know the village very well. Discussion with agriculture Bureaus, irrigation Bureaus, and service cooperative Bureaus was also held in each woreda. The following data were collected at community level by focus group discussion.

- Details of existing land use, farm size, land tenure and water rights for both men and women farmers;
- Demographic data, disaggregated by sex, age and ethnicity;
- Number of male and female headed households;
- Cropping system pattern (for rain fed and irrigated crops) and technologies used
- Assessments of market and price prospects, and access to these markets
- Environmental impact like flooding, siltation, erosion, water borne, vector borne and water contact diseases on dams, down stream effect etc.

- Organization and management structure of the irrigation scheme.

1.5.4 Irrigation Water sample collected for chemical and physical characteristics

Water samples were collected from each site at different locations for water quality analysis. 12 water samples from the four schemes were collected from three different locations. The collection points were, at the junction where the diversion canal starts, at mid point in the irrigation system, and finally before the water joins back the river. All samples were collected by grab method. Samples collected at specific location at a given time at once and at only one particular point in the sample medium. Three samples were collected from each site in a plastic bottle thoroughly cleaned by detergent. The samples were then filtered using Whitman's no.42 filter paper and stored at 4 ^{o}C until analysis was carried out. The cations (Sodium, Potassium, Magnesium, Calcium, Boron and silica) were determined by atomic absorption spectrometer (Varian SP-20) using their respective hollow cathode lamps. Titration using phenolphthalein and methyl orange indicators measured carbon dioxide and Bicarbonate, respectively. Chloride was titrated by 10mm $AgNO_3$ to K_2CrO_4 endpoint ethile and a specific ion selective electrode assayed Fluoride. Sulphate was determined as $BaSO_4$ particles in a turbid solution. Nitrate was estimated using Varian DMS 80 spectrophotometer set at two different wavelengths. Analysis was done by Geological Survey Agency.

1.5.5 Water sample collected for bacteriological characteristics analysis

Water samples from the four schemes were collected from two different locations in each scheme. The collection points were, at representative points where most framers use the water for domestic use in the irrigation system. Eight samples were collected in a plastic bottle. Microbial analyses were conducted within 48 hours of sample collection using 100ml sample in International Livestock Research Institute (ILRI) laboratory using Standard Methods for the Examination of Water and Wastewater of American Public Health Association (APHA) (1999). The water samples were filtered through membrane filter rinsed with sterile water. The filter paper was put on the lauryl sulphate agar plate. Precaution was taken not to trap air bubbles underneath the filter. The petridishes were incubated for 24 hrs at 37 ^{0}C and all yellow colonies were counted. Then all yellow colonies were inoculated to a separate Brilliant Green Bile Broth 2% to examine for gas formation after 24 hrs at 37 ^{0}C.

1.5.6 Secondary data

Secondary data such as maps, baseline information of the schemes, environmental policies and development plans and other studies were collected from Government and Development Agencies records.

Secondary data from NGO's working in the woreda's, near by state farms, Melkasa Research Center, Oromiya irrigation development office, Ministry of water resources and National Metrological services Agency were collected and used in the research work**.** In addition, Internet sources were employed.

1.5.7 Methods of data analysis and Presentation

Comparative data analysis was carried out using the SPSS statistical software package. The purpose of the analysis was to show the flow of goods services and cash in a small farm system and to see the links between the farm and the household and between these two entities and the effect on the environment.

1.6 Scope and Limitation of the study

This research was conducted to assess the socio-economic and environmental impact of community based small-scale irrigation in the upper Awash basin. However, this study is subject to the following limitations.

- Time series information is difficult to collect from the farmers since they are not recording and remember only the most recent ones. It was not possible to take more than one-year data.
- Pesticide residue and soil analysis, which are very important to see the environmental effect of irrigation, was not done because of fund and time shortage.

1.7 Organization of the Paper

The thesis is organized as follows: Chapter one is an introduction of the study. This chapter contains statement of the problem, research objective and methods of data collection and analysis. The next chapter presents an overview of the literature on irrigation development and its impact on socio economic and environment of the farming community. Chapter three deals with the general background information about the study area and description of sample irrigation schemes. Chapter four presents results and discussion. Chapter five presents conclusions and their implications for small-scale irrigation development and environment. This section concludes by presenting recommendations.

2. Literature Review

2.1 Irrigation Development in Ethiopia

It is difficult to know exactly how much irrigated land exists in Ethiopia, however recent estimates put the total area of land at 160 000–198 000 has. This estimate includes traditional, communal, private and public schemes. Many schemes are concentrated (approximately 48%) in the Awash Valley, where 92% of all large schemes were built prior to 1990 (ACTS, 2002).

Modern irrigation had started at the beginning of the 1960's by private investors and was concentrated in the middle Awash valley. Then, expanded to the Awash Basin and the Wabi Shebele Basin. At the beginning of the 1970s, about 100 thousand ha of land was estimated to be under modern irrigation in Ethiopia, about 50% of which was located in the Awash Basin (Wetterhall, 1972). With the 1975 rural land proclamation, the large irrigated farms were nationalized and placed under the responsibility of the Ministry of State Farms while small-scale irrigation schemes were transformed into Producers' Cooperatives. After the major famines of 1984/85, the government began to focus on the potential of small-scale irrigation as food security and started promoting farmer and community-oriented small scale irrigation by providing assistance and support to local communities for rehabilitating and upgrading traditional schemes, (Habtamu G.1990).

The Irrigation Development Department (IDD) of the Ministry of Agriculture (MOA) was established and is responsible for the development of small-scale irrigation starting from 1985 on wards. SSI development was traditionally seen as infrastructure development, and grouped with rural roads and similar construction teams and largely staffed with engineering oriented personnel. Seventy five percent of the staff of the IDD, as described by Habtamu in 1990, was engineering cadres. The typical Irrigation and Rural Water Supply Team under the IDD was comprised of three brigades: earthen dam construction, diversion weir construction and land development. The department struggled over the years with less than optimal, centralized funding and staffing limitations to meet the challenges and opportunities of SSI development in Ethiopia.

With the change in the government in 1994, the IDD was dissolved and replaced by the Regional Commission for Sustainable Agriculture and Environmental Rehabilitation (CO-SAERs) being promoted under the new federalist structure in a number of regions (Gebremedhin B. and D.Peden, 2002). These new organizations have embraced the promotion of small-scale irrigation as their primary mandate and they are channeling millions of Birr each year into such development and construction activities. The focus within these organizations and the overall approach remains engineering oriented encompassing three phases and a changing of institutional players. At the design phase, a combination of regional bodies, the Regional Bureaus for Agriculture, Energy, Water and Mining, and Health, together with the project proponent participate. Once the basic project document is approved, the CO-SAERs or the Cooperating Sponsors take charge and work with the community and concerned Woreda Council, in the construction of the basic infrastructure, headwork, dam or weir and primary canals. After these civil works are completed, the scheme is handed over to the communities concerned and the Regional Bureaus (Agriculture, Energy, Water and Mining, and Health) for the implementation of the irrigation system. Then the community is expected to complete the secondary and tertiary canals and begin to use the system, with the advice and assistance of the Development Agents provided by the Regional Bureau of Agriculture through a Water Users Association created among the user community. The other two bureaus of Water, Energy and Mining and Health are expected to ensure that head works are properly maintained and health concerns are addressed, respectively.

2.2 Current status of small-scale irrigation systems

Irrigation in Ethiopia is classified in to three classes. They are small, medium and large-scale irrigation schemes. Small Scale supplies a total command area of under 200 ha as opposed to medium and large scale, which are 200-3000, and above 3000 ha respectively (MWR, 2001b). The present most frequently cited estimate of small-scale irrigation estimated area is about 65,000 has (MWR, 1998; CSA, 1998; AQUASTAT, 1998; IDD/MOA, 1993 as cited in CRS, 1999)). These Figures are in sharp contrast to the widely cited overall potential for irrigation throughout the country, including small, medium and large-scale irrigation. Tab. 1 provides an overview of the present reference data regarding the scope for small-scale irrigation in Ethiopia.

Tab. 1 The potential area and actual status of small-scale irrigation in Ethiopia

Reference Source	Potential irrigable area (ha)	Actual irrigated area (ha)		Notes/observations
CSA (1998)	---	95/96 84,640	96/97 68,210	Maher (main rainy) season
AQUASTAT (1998)	165,000 – 400,000	63,581		An online database supported by FAO. Rises issue of need for rehabilitation
MWR (1998)	180,000	64,000		Notes that some schemes are not functioning and in need of rehabilitation
Tahal (1998)	-----	40,270		Traditional Schemes only- those without assistance from outside the community
IDD/MOA (1993)	352,000	70,000		Estimate of traditional irrigation without external assistance
FAO (HRDP)	270,000	------		Potential for SSI using both groundwater and surface water sources

Source: programmatic Environmental Assessment of small-scale irrigation in Ethiopia, 1999.

The present levels of total area estimated to be under SSI is currently less than one percent of the total area currently being farmed. A similar analysis could be carried out on the basis of population and small-scale irrigation users.

Small-scale irrigation systems vary in type based on water source and distribution technology. These systems are diversion, spate, spring and storage systems and are defined as follows by (CRS, 1999):

- River diversion systems are off-take systems and are the most common form of irrigation system in Ethiopia. Diversion systems utilize natural river flow, however, regulation of river flow via a permanent structure in the riverbed is also a common practice to increase the off-take. Diversion systems abstract water over a sustained period of time and are able to deliver regular irrigation throughout the cropping regime. A key characteristic of diversion systems is the adequacy of water supply during the dry seasons and the ability to irrigate a dry season crop in addition to providing supplemental irrigation during the rainy seasons.

- Spate systems make use of the occasional flood flows of streams and operate during part of the year and there are two types of spate systems. The first referred as a run-off system, divert flood flows originating in high land areas. The second, most common on foothill sites in arid and semi-arid areas, divert flood flows originating in highland areas. Spate systems have proven difficult to rehabilitate due to difficulty of designing weirs to divert flows that change over a short period of time and which also resist structural damage from flood flows.
- Spring systems use small spring flows. Water is often shared with household and livestock users and stored over night in small reservoirs and emptied daily
- Storage systems are earthen dam that store water for an extended period behind dams. In Ethiopia, storage systems are a recent introduction and pose technical and production challenges. It is important to consider the catchments flow and amount of sediment in designing storage systems. Cropping must be planned according to the amount of water stored and available for irrigation. Typically the irrigable area is much larger during the rainy seasons than during the dry season.
- Lift systems is extracting water from rivers, irrigation canals, reservoirs and wells. Lift systems have lower development costs. Manual or motorized pumps are used.

Irrigated agriculture in the form of spate systems capturing the run-off from the Ethiopian highlands along the Red Sea Coast has been a land-use choice in the Horn of Africa for more than a thousand years (USAID, 1996). These early schemes were the precursors to the small-scale, traditional irrigation schemes, including spate, diversion and very small storage systems, now widely practiced under local community arrangements throughout the country.

2.3 The National Irrigation Policy

The development of the country's irrigation potential is an important part of a major program for the intensification of agriculture launched by the new Federal Government (EPA, 1997). As part of this effort, Water Resources Management Policy to guide water sector development has now been operational. The stated goal of this policy is:

"To enhance and contribute its share in all national efforts towards the attainment of prosperous, healthy and socio-economically developed society with all its human dignity by promoting sustainable management of water resources of the country, without endangering and compromising the capacity of water resources base for regeneration in the services of future generations (MoWR, 1998)." More specifically, the objectives of the policy underline the need for the development, conservation and enhancement, provision of basic necessities, and the allocation of water. These objectives are based on comprehensive and integrated plans and principles that incorporate efficiency of use, equity of access and sustainability of the resources. The policy objectives are also expected to ensure that environmental protection measures are taken into account in the course of studies, planning and implementation and operation of water resources and water resources systems (MWR, 1998)". The policy has also addressed the issue of basins development by giving due emphasis and showing a direction for its inclusion as an integral part of the overall water resources management. The agricultural sector policy and strategy also give special enfaces regarding water development in the country. The national science and technology policy does not specifically address water in its policy framework. However, the policy document contains priority sectors and programs, which emphasize the water sector development.

2.4 Environmental Policy in relation to irrigation

The environmental policy was approved by the council of Ministers in April 1997 (EPA, 1997). It was based on the policy and strategy findings and recommendations of the conservation Strategy for Ethiopia. The overall policy goal is "to improve and enhance the health and quality of life of all Ethiopians and to sustainable social and economic development through the sound management and use of natural, human-made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of the future generations to meet their own needs, (EPA, 1997)."

The National Environment Policy objectives, which are for small-scale irrigation and environment review, are extracted as follows.

- Incorporate the full economic, social and environmental costs and benefits of natural resources development;
- Appropriate and affordable technologies, which use renewable resources efficiently, shall be adopted, adapted, developed and disseminated;
- When a compromise between short-term economic growth and long-term environmental protection is necessary, then development activities shall minimize degrading and polluting impacts on ecological and life support systems;

- Regular and accurate assessment and monitoring of environmental conciliations shall be undertaken;
- To base, where possible, increased agricultural production on improving and intensifying existing farming systems by developing and disseminating technologies which are biologically stable., appropriate under prevailing environmental and socio-economic conditions for farmers, economically viable and environmentally beneficial;
- To ensure that planning for agricultural development incorporates in its economic cost-benefit analysis, the potential costs of soil degradation through erosion and Salinization;
- To promote water conservation in drought-prone and low rainfall areas,
- To ensure that agricultural research and extension have a stronger focus on farming and land-use systems and support an immediate strengthening of effective traditional land management systems.

The Federal Government has also included environmental review as a prerequisite for the approval of new development activities and projects. The Environmental Protection Authority has issued a series of guidelines, including Procedural Guidelines and Sectoral Guidelines (EPA, 1997a) and the EIA Guideline for Agricultural Sector Development Projects (EPA, 1997b). The EIA guide line section 2.3 targets Irrigation and Drainage Projects and suggests a range of issues and sub issues that should be considered in assessing these types of projects. The list of key issues includes: hydrological impacts, water and air quality, soil properties and the effects of soil salinity, and erosion and sedimentation. Responsibility for the assessment of environmental impacts of medium and large-scale irrigation projects will require a full Environmental Impact Statement that will be submitted to the EPA for review and approval. The review and screening of small-scale irrigation is done by Regional Irrigation Desk, The

UN Economic Commission for Africa and Environmental Rehabilitation (SAER) Program and the World Bank-funded Ethiopian Social Rehabilitation and Development Fund (ESRDF)- which are now responsible for funding small-scale irrigation activities throughout the country have developed environmental impact assessment guidelines for their operations.

2.5 Socio economic impact of small-scale irrigation

Irrigation development aims to bring about increased agricultural production and consequently to improve the economic and social well being of the rural population. Properly implemented smallholder irrigation with appropriate technologies may have a considerable potential in improving rural livelihoods, although the viability of such systems becomes questionable when the financial responsibility rests entirely on the community in the absence of institutional support services that enhance market orientation (Kamara et al. 2002; Shah et al. 2002). Given the complex set of constraints facing smallholder producers, providing access to irrigation water by itself is not enough; smallholders also require a broad range of support services (access to inputs, credit, output markets), knowledge of farming and secure land tenure. Achieving economic viability of smallholder irrigation on a market-oriented basis requires access to support services and opportunities for producing high value crops. The issue of smallholder irrigation expansion should focus on institutional linkages, access to markets and other support services that enhance production on a sustainable basis in addition to providing irrigation water and land.

FAO (1997c) pointed out that many Sub-Saharan countries have realized the critical role of irrigation in food production, but a number of constraints have been responsible for a relatively slow rate of irrigation development in this region. The constraints are:

- Relatively high cost of irrigation development
- Inadequate physical infrastructure and markets
- Poor investments in irrigation
- Lack of access to improved irrigation technologies
- Lack of cheap and readily available water supplies

FAO (1997c) further identified the following constraints to be affecting the capacity of farmers to invest and manage irrigation projects:

- Poor resource base of farmers
- Fragmented and small size of land holdings
- Unsecured or lack of land titles
- High interest rates
- Poor transportation and marketing facilities

However, (http://www.fao.org/docrep/X5594E/X5594e00.htm) in the assessment of the smallholder irrigation sub-sector in Zimbabwe found out that smallholder irrigation has brought many successes to farmers. The following observations were made:

- Smallholder farmers are able to grow high value crops both for the local and export markets, thus effectively participating in the mainstream economy.
- In areas of very low rainfall, farmers enjoy producing their own food instead of depending on food handouts from the NGO’s.
- Irrigation development has made it possible for other rural infrastructure to be developed in areas of roads, telephones, schools and clinics.
- Smallholder irrigators developed a commercial mentality.
- Crop yields and farmer incomes gone up manifold.

The report, however, identified a number of constraints, which are hampering smallholder irrigation development in Zimbabwe. Some of them are:

- The high cost of capital investment in irrigation works when one considers that communal farmers are resource poor.
- Rural infrastructure to facilitate input procurement and produce marketing is weakly developed in some areas, for example roads, telecommunications and electricity.
- Lack of reasonably priced appropriate irrigation technology for the smallholders.
- Shortage of human resources at both technician and farmer levels.
- Poor catchments management, which results in siltation of some water bodies.

The successes of smallholder irrigation development are many and varied. Some of these are quantifiable while others are not. Kennedy Muduma (2001), on his study on the impact of socio economic study of small-scale irrigation in Zimbabwe has listed out his findings as follows:

- Smallholder irrigation can be financially and economically viable if it is planned, implemented and managed properly.
- The major determining factors for viability in small-holder irrigation include planning and construction, type of scheme management, type of technology, appropriateness of design, institutional support, cropping programs, availability of markets, marketing strategies, and commitment of the farmers.
- Crop yields and farmer incomes under smallholder irrigation can increase many folds with irrigation.
- Crops unknown to communal farmers can now be grown under irrigation.
- Smallholder irrigators are now able to grow high-value crops both for the local and export markets, thus effectively participating in the mainstream economy.

- In times of severe droughts smallholder irrigation schemes act as a source of food security at the household level.
- Farmers in successful irrigation schemes have acquired physical assets (improved Housing, farm implements, furniture, electrical appliances) and their standard of living has improved substantially.
- Irrigation schemes provide an alternative source of employment to the rural people, thereby discouraging rural to urban migration.

Gebremedhin B. and D Pedon (2000) stated that in Ethiopia, most problems of small-scale irrigated agriculture that hinder the further development of this sub-sector arise from its operational method and not from its construction and design. He pointed out that in Ethiopia irrigation development planning gave emphasis to the agronomic, engineering and technical aspects of water projects, with little consideration to issues of management, beneficiary participation, availability of institutional support services such as credit, extension and input supply, and marketing. Gebremedhin farther stated that the experience of irrigation water development in the last five decades in Ethiopia suggest that several measures need to be taken to support farmer-managed small-scale irrigation projects in Ethiopia. These include enhancing and improving the efficiency of the traditional irrigation systems such as:

- Improving the durability of headwork
- Making simple, cheap and environmentally friendly irrigation technologies such as hand pumps and shallow tube wells available
- Improving market access by building roads, price support and improving product quality
- Developing appropriate extension and credit services, and input supply system

- Enhancing beneficiary participation in governance (establishment of working rules and responsibilities) and management (running the day-to-day operation of projects).

On the study conducted in Tigray in 1998/99, Pender and Gebremedhin B. (2002) found out that small scale irrigation increase the intensity of input use, especially labor, oxen, improved seeds and fertilizer. By promoting increase in use of such inputs, irrigation contributes to increased crop production. Their findings was that the predicted average impact of irrigation, based on the predicted impacts of irrigation on use of inputs, was an 18% increase in crop production relative to rained field plots and the main impact of irrigation on crop production is through promoting increased intensity of farming, rather than through increased productivity of farming practices. With a similar study in the Amhara Region, Benin et al (2002) indicated that irrigation was associated with increased intensification through greater use of fertility-improving technologies (fertilizer and manure), and other purchased inputs (improved seed and pesticides), labor and draft power. Another study by Mintesinot (2002) indicated that irrigation compounded with rain fed cultivation ensures year-round food security, although, off-farm employment during part of the year is a common practice to obtain extra money.

A study conducted by SCF/UK/ (1999) on the North Wello East Plain Food Economy Zone reported that irrigators can plant three times per year and in most cases the production serves as a valuable source of income and the majority of the farms who have irrigation plot have been categorized under rich wealth group in the community.

2.6 Environmental consequences of Small-Scale irrigation

The affected environment pertinent to small-scale irrigation in Ethiopia encompasses a wide range of geographic settings, hydrological characteristics, agro-climatic, topographic situations, cultures and socio-economic conditions. The Ethiopian government currently promotes development, upgrading and rehabilitation of small-scale irrigation schemes in the Awash Basin, based on the diversions of streams and rivers, spate flows of seasonal rivers, use of springs, and construction of the storage reservoirs. Most of the present activities take place in three of the recognized agro-climatic belts of the Ethiopian highlands, namely the Kolla, the Weyna Dega and the Dega belt.

The Catholic Relief Services conducted an environmental assessment of small-scale irrigation in Ethiopia in 1999 and revealed common and recurrent concerns and problems, considered typical of small-scale irrigation environmental issues CRS, 1999). The report provide the basis for a diagnostic of the principal environmental issues and an exanimation of the impacts that need to be avoided or otherwise mitigated in the planning and design of small-scale irrigation. These issues, which affect the sustainability of the schemes and environment, are considered to be the key issues that should be taken into account in making future investments in the sub sector are listed as follows:

- Inefficient use of water
- Soil fertility and quality maintenance problems
- Soil Salinity Problems
- Soil erosion
- Water related disease hazards
- Relation with sustainability of SSI development opportunities and Synergism

- Displacement and Land-use patterns changes and social equity

Inefficient use of water is caused by unlined canals, through the earthen dam structure or from breakages in the canal and faulty use of irrigation water. An inability to control water losses can dramatically change the present existing feasibility issues troubling SSI in Ethiopia.

CRS (1999) has reported that if nutrients are removed more rapidly than are replaced, the system will not be stable., the resources base of the soils will be degraded and crop yield will be reduced. Intensive cropping can lead to deficiencies of the three major elements, nitrogen, phosphorous and potassium and some of the minor or trace elements such as sulphur and zinc. Problems of soil fertility in SSI will undermine the basic premises of any small-scale irrigation development activity. Generally applied as fertilizer can cause water-quality problems. Phosphorous is readily adsorbed in soil particles and as such can be carried in surface run-off. Nitrogen is very soluble and can be present in both surface and foreseeable conditions, the economic and practical constraints on chemical fertilizer and manure usage limit the amounts applied to levels such that water pollution should not be a problem.

Soil salinity problems with irrigated agriculture are well known in Ethiopia, particularly in the large-scale irrigation schemes of the Awash Basin. Salinity is thought to affect more than a third of the world's irrigated agricultural lands (El-Ashry, 1980, as quoted in Tillman, 1881). For irrigated lands in arid and semi arid regions, where salinity problems are most common, even good quality irrigation water (200 ppm soluble salts) can add 0.2 tons per ha of salts with a normal water application of 10, 000 M^3 per ha per year (Massoud, 1977, as quoted in Tillman, 1981). Salinity contribute significantly to that massive tracts of irrigation croplands are going out of production at nearly the same rate as the amount of new irrigated lands are being added. (Biswas et al, 1980, as quoted in Tllman, 1981). Salinization of irrigated lands is mainly caused either by applying saline water or because the soils themselves have appreciable levels of soluble salts. Salinity problems are further exacerbated by conditions that lead to high water tables which impede drainage, stagnation of water in low-lying parcels or depressions in crop fields, regular seepage from higher elevations, leakage from canals or earthen dams or through the excessive application of irrigation water. Because of the serious possibility of large-scale productivity losses associated with salinity and due to the frequency of the problem in Ethiopia, it has the potential to undermine the productivity and achievements of SSI. Treating advanced cases of soil salinity are technically challenging and costly. Where schemes have been mistakenly built in areas with soils having high soluble salts concentrations, the cost of remedial action for successful agriculture may exceed the economic benefits (Tillman, 1981).

Soil erosion is a major problem in the Ethiopian highlands. Smallholder farmers have cropped many of the sites chosen for SSI for decades are degraded and eroded. Attempting to construct SSI on steep slopes will add to the problem, increase the costs of construction and maintenance of the scheme and lead to lower yields although in the past Ethiopian farmers have been dealing with soil and water conservation on their farmlands.

2.7 Water related disease hazards

The primary health risks associated with small-scale irrigation projects relate to water and vector borne diseases. Most of the reported impacts of irrigation development on health consist of water-related diseases. Generally, four groups of diseases are distinguished based on their way of transmission (Cairncross and Feachem 1993) as quoted in E.Boelee, (2002):

- Water-borne or faucal orally transmitted diseases, such as cholera, typhoid and diarrhea
- Water-washed diseases, such as louse-borne infections and infectious eye and skin diseases
- Water-based diseases with an intermediate host living in water, such as guinea worm and schistosomiasis, which causes bilharzias
- Water-related insect-borne parasitic diseases such as river blindness, filariasis and malaria.

Water-washed diseases are widespread in arid and semi-arid regions, where irrigation systems may be the main source of water for all purposes.

Environmental control measures have been applied for ages in many countries till the first half of this century (Takken et al. 1990; Konradsen et al. 2002). But nowadays the health sector has come to rely on environmental management again as a part of integrated disease control approaches (Boelee 2003). Most of the recommendations are focused on preventive measures that can be incorporated into the design of new irrigation systems. In existing irrigation systems, the main options to control vector breeding and water-related diseases lie in maintenance and water management. Boelee farther stated that instead of planning agricultural water systems separately from drinking water supply, the different sectors should work together at national and local level and plan for integrated multi-purpose systems. This would reduce overall investments and contribute significantly to improving the health of rural populations.

The main diseases of importance in the Ethiopian context are malaria, schistosomiasis, water borne disease (gastroenteritis, intestinal parasites, typhoid, etc) and lymphatic filariasis (CRS, 1999). Water contact diseases, such as schistosomiasis, depend on intermediate hosts with transmission occurring when people have contact with effected water. Projects that increase the likelihood of pools of stagnant water provide rich breeding grounds for malaria carrying mosquitoes. Projects which require large numbers of construction workers run the risk of increasing exposure to disease through contaminated potable water and poor sanitation facilities. Irrigation projects increase the amount of stagnant water and, have been associated with the potential to increase the prevalence of malaria (CRS, 1999).

Access to clean potable water in most of Ethiopia is estimated at about 15 percent (MWRPP, 1998) and most people are required to drink water from unprotected sources with resultant high levels of diarrhea disease and intestinal parasites. Water-related diseases transmitted through vectors or intermediate hosts sometimes increase with irrigation development. Canals and drains may create ideal breeding sites for malaria mosquitoes or for snails, (Ghebreyesus et al. 1999) reported that the construction of small dams in Tigray led to increased spread of malaria, even at higher altitudes. Gebreyesus stated that seasonal transmission changed to year-round transmission because of the continuous availability of surface water.

In general, available evidences indicate varying and sometimes contradicting views on the economic viability and socio-economic and environmental impact of smallholder development. Some literature on small scale irrigation has pointed out that small holder irrigation schemes are agriculturally, financially, economically and environmentally viable while others literature argues that such projects are not viable.

3. The Study Area

The Awash Basin covers a total area of 110 000 Km^2 of which 64,000 km^2 comprising its Western Catchments, drains to the main river or its tributaries (Fig. 1). The remaining 46,000 km^2, most of which comprises the so-called Eastern Catchments, drains into a desert area and does not contribute to the main river course. The river Awash emanates at an elevation of about 3000 m in the central Ethiopian Highlands, west of Addis Ababa, west Shewa near Ginchi town and flows northeastwards along the Rift Valley into Afar where it terminates in Lake Abe at an elevation of 250 meters. The main river length is about 1200 km. The Awash Basin has been the most intensively studied river basin in Ethiopia and, because of its strategic location, good access facilities, available land and water resources, is currently the most developed river of Ethiopia in terms of its irrigated agriculture. At the time of the initial basin wide study the irrigated area in the Basin was stated to be 24,000 ha (Halcrow, 1989) and the current irrigated area approximately 69,000 ha (MWR, 2001).

3.1 Geology and Agro climatological classification of the Awash Basin

The two main physiographic components of the Awash Basin are the Ethiopian Plateau and the Rift Valley, widening to the North into the Afar Triangle. A series of fault scraps leads from the plateau to the floor of the Rift Valley, which slops northeast from the elevation of nearly 2000 m at Lake Ziway to less than 400 m where it becomes the Afar Triangle (Halcrow, 1989). Unlike many other Ethiopian rivers the alluvial plains adjacent to the Awash River are relatively wide in parts extending over 25 km. The river has also an elevated formation in the Middle Valley area such that the adjacent lands can be easily irrigated.

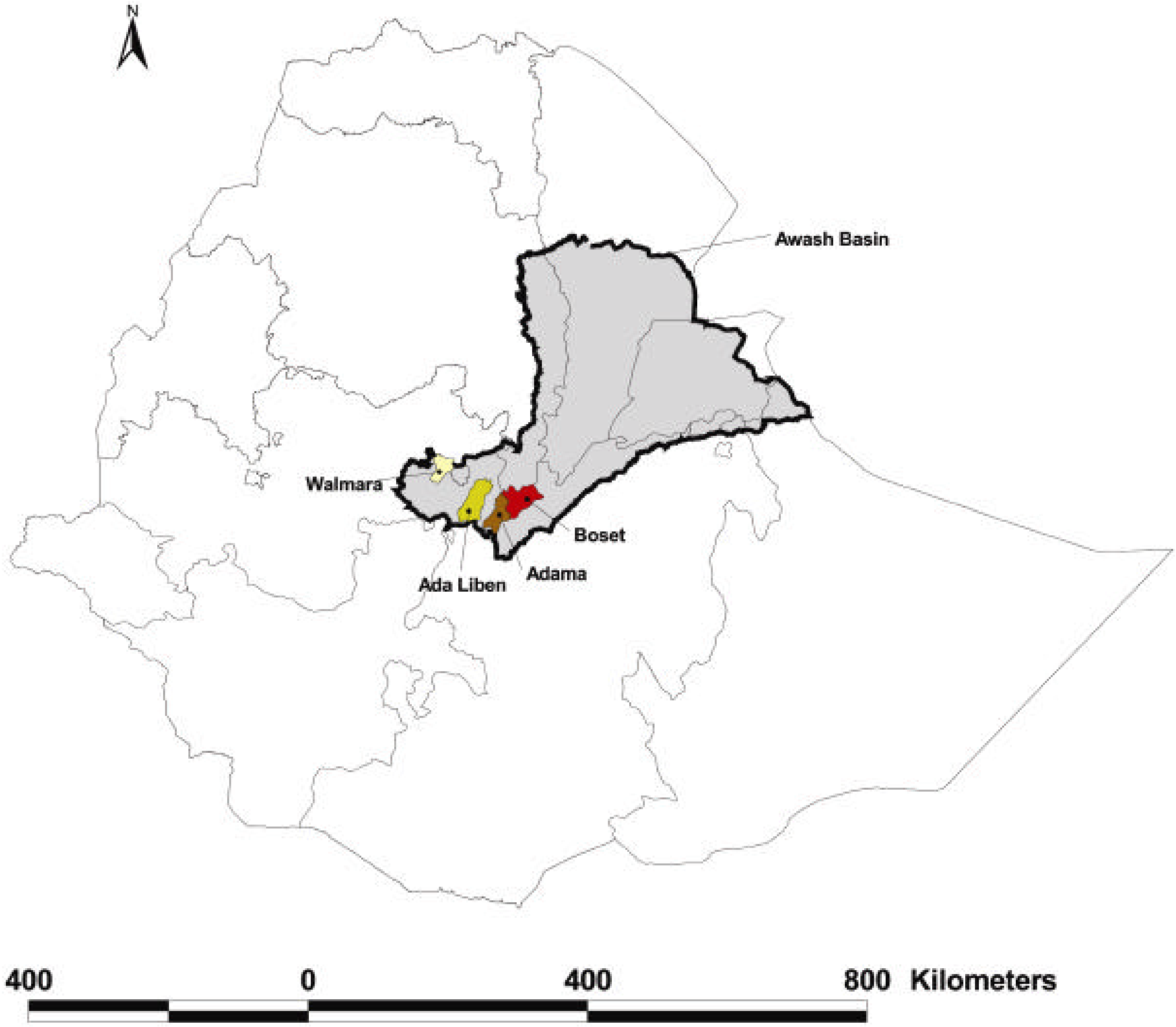

Fig. 1 Map of Awash Basin and study Woredas

The Awash Basin has been divided into five major zones based on physical and socio-economic factors as outlined below by Halcrow in 1989. These are:

- **Uplands –** all lands in the basin above 1500m that area of the Basin with the mean annual rainfall in excess of 800 mm.
- **Upper Valley –** That area of the Basin between Koka reservoir and Awash Station which lies between 1500 m and 1000 m altitude

- **Middle Valley –** That area of the basin between Awash Station and Mile River lying between 1000m and 500 m with a mean annual rainfall variation from about 600 mm to 200 mm.
- **Lower Plains –** These are the deltaic alluvial plains in the Tendaho, Asayita and Dit Bahari areas as well as the terminal lake environs.
- **Eastern Catchments –** this area is of some 47000-km^2 extent and ranges from the Wabi Shebelle watershed at about 2500 m altitudes down to the desert plains, which range from 1000 m down to 300 m.

3.2 Population and Environmental health

The overall population in the Awash Basin was estimated to some 7.6 million in 1989 (Hlcrow, 1989). With an annual growth rate of 2.5%, it is estimated to be about 28.5 million in 2004. The main population centers lie in the Upper Basin and in the Upland areas above 1500 m elevation.

The principal findings of the overview assessment of the environmental health status of the Awash basin carried out by the Environmental Conservation Studies and Research Desk. (EVDSA as cited in Halcrow, 1989) are summarized bellow:

- The health status of the population is generally very low
- Communicable diseases, especially water borne, and nutritional disorders are predominant
- The most prevalent disease is malaria
- There is a general shortage of health staff, and facilities are both inadequate and poorly funded

- There is virtually no systematic monitoring or control mechanism in the Valley
- Most water supply sources are contaminated or unsuitable.
- Sanitary facilities are virtually non-existent with few notable exceptions
- Similarly refuse disposal facilities are absent.

Development projects have induced significant population concentrations and the inadequacy of basic requirements such as water supply, sanitation and health facilities for such groups is a major hazard.

3.3 Climate and water resource

The basin has an extensive resource potential in climate, land and water. With the range in altitude from the Upper Basin areas averaging 2000- 2500 m down to the Lower Plains at an elevation of 300 – 400 m, a series of climatic conditions exist which are suitable for the cultivation of the wide variety of crops. In the upland areas, above 1500 m, the annual rainfall is normally adequate for rain fed cultivation. Below this elevation, the annual rainfall amounts range from about 800 mm down to 200 mm, requiring irrigation to ensure crop growth. The variation in temperature between the irrigated areas of the Upper Valley, at an elevation of 1500 m and the hot desert zone of the Lower Plains, at an elevation of 300 m, permit a wide range of crops to be individually suited to their optimal climatic conditions. The mean annual temperatures range from 20.8 ^{0}C at Koka to 29 ^{0}C at Dubti (NMSA, 1998).

The potentially net irrigable land resource of the Upper and Middle valley and Lower Plains area has been estimated to be in the order of 150,000 ha of which 69,000 ha was irrigated in

1989 (Halcrow, 1989). The present area listed as being under small-scale irrigation is in the order of 65,000 ha, most of which is in the Uplands (MWR, 2001).

The total mean annual surface water resource of the basin is estimated to be in the order of 4900 Mm^3 of which some 3850 Mm^3 is utilizable, the balance being lost in the Gedebassa Swamp area, and elsewhere in the river system. Some 2250 Mm^3 is currently diverted for irrigation in the Upper, Middle and Lower Valley areas. The total percentage of the surface water resource currently used for irrigation is estimated to be 44% (MWR, 2002).

3.4 Irrigation Water Quality

In the Awash Basin there is a progressive increase in the salinity of the water from the Upper valley through the Middle Valley, with the sodium hazard generally remaining is generally observed (Hlcrow, 1989). The quality of the incoming water from the Uplands is generally good and deterioration occurs partly as a result of irrigation return flows, and partly from the contributions of the various relatively saline hot springs such as Sodere and Filwuha both of which contribute water salinity hazard.

In terms of industrial and domestic pollution there is clear evidence of a high level of pollution in the Upper Basin Rivers around Addis Ababa. Water quality in the Upper basin is clearly deteriorating due to high waste disposal of Addis Ababa. These highly polluted streams are used for livestock watering, domestic irrigation, and washing even in some places for drinking.

3.5 Agriculture

The natural fertility of the soils of the Awash Basin is generally high and satisfactory crop growth can be obtained with normal rates of fertilizer application. There are sporadic and in some cases quite extensive, areas where the natural fertility is low and additional fertilizer input are required.

The most important soil erosion processes, which occur in the Awash Basin, are rain splash and sheet wash, gully and wind erosion. All three of these erosion processes occur both in the highlands and in the low lands bellow 1500 m. Sheet wash is the dominant and most widely destructive erosion process. Of the currently irrigated area about 3% is affected by high water table or salinity problems (Halcrow, 1989). Both saline and alkaline soil as well as saline-alkaline can be found in the valley.

Seasonal labor shortages in the Awash Basin hinder efficient farm management. Theses shortages are particularly acute during the critical operation of weeding and harvesting. The effect of inadequate labor availability in preventing farm operations being completed on time is reduced crop productivity, and this is reflected in the existing yield levels. This labor constraint can also seriously limit an improvement in cropping intensity.

Cropping intensities are not high with only limited areas of double cropping. In the Upper valley a high proportion of irrigated land is under perennial crops dominated by sugarcane. Cotton dominates the cropping pattern in the middle Valley of the irrigated land followed by perennial crops like bananas, orange and papaya. Small amounts of vegetables, maize and tobacco are produced. In the lower Valley, cotton is again the dominant crop in the State farm area being as a mono-crop and a rotation crop. On the non-state farmland, maize is the dominant crop followed by the cotton land.

In the 1969's and 1970's, comprehensive reconnaissance and feasibility studies were carried out on Awash Basin by U.S. Bureau of Reclamation (MOA, 1993) and recommended that small-scale irrigation should be greatly encouraged while the large scale irrigation schemes would be coasty. It argued that without a coordinated water development program, there would be no prospects for agricultural development in the basin. On the other hand the Awash River basin attracted a good deal of local and international investments, which were the subject of numerous studies and surveys in the 1960's and 1970's (Dessalegn R., 1986)

In an attempt to contribute a better understanding of the community based irrigation sub-sector in the Awash Basin, a socio-economic performance and environmental impact evaluation was carried out on four selected smallholder irrigation schemes in four different Woreda's called Ada Liben, Adama, Boset and Wolmera (Fig. 2). The selection criteria for the woreda's to be studied took in to account diversity and unique differences within the irrigation schemes. The type and age of scheme, access to irrigation related services; water sources market availability, access to farm inputs, climate variation, was key considerations. The selected schemes vary in size, major crops grown, cropping intensity, type of management and irrigation water acquisition.

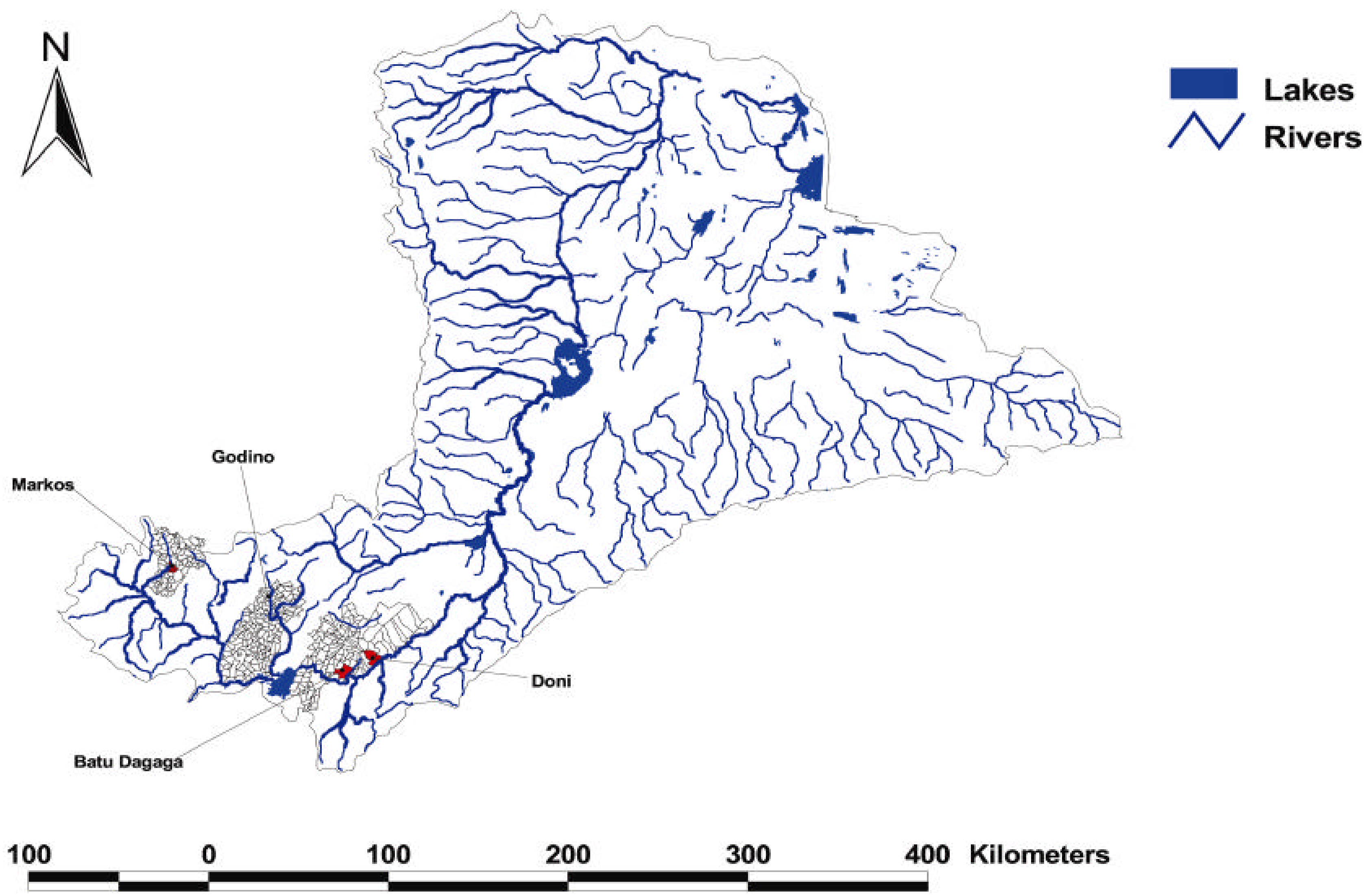

Fig. 2 Map of study schemes

3.6 Description of sample irrigation schemes

3.6.1 Doni irrigation scheme

Doni irrigation scheme is located 08^{o} 89293 N, 039 ^{o} 03129'E at an altitude of 1303 m above sea level, in East Shewa, Boset wereda about 50 km from Nazareth near Tibela State Farm. It is accessible throughout the year and has electric power and telephone facility. The climate is dry hot Kola. The rainfall is erratic and crop failure due to shortage of rainfall is very common. The mean annual rainfall is about 804 mm and cumulative mean monthly temperature ranges from 14 ^{0}C to 35 ^{0}C as shown in Fig. 3.

The source of water for irrigation is Awash River and CARE constructed a distribution canal about 7.3 km in 1994 using gravity diversion.

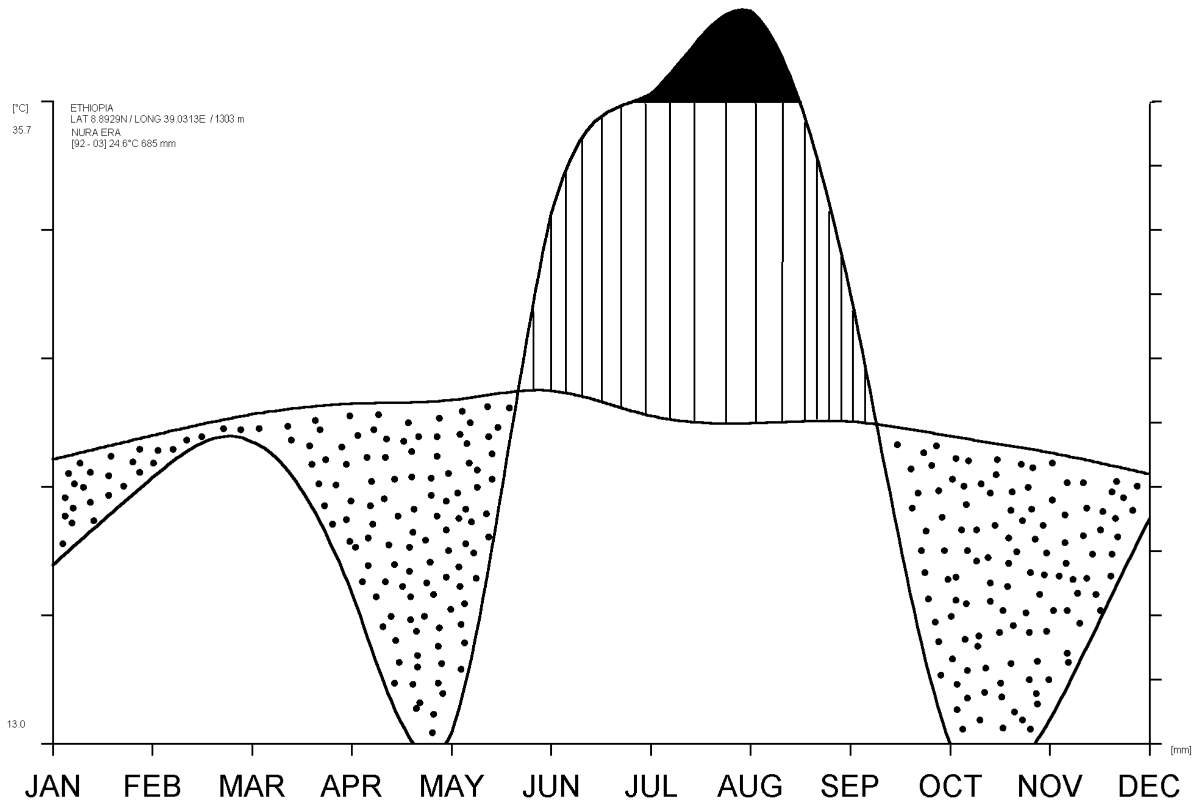

Fig. 3 Cumulative mean monthly rainfall and average temperature of Nura Era State Farm Station, period (1992 to 2003)

During the emperor time (1968), a private investor constructed a low head gravity weir in Awash River and about 3 km long main canal for the scheme then the military regime nationalized the land and distributed to the peasants and were organized under producers cooperative. After a few years, due to the change of government, the land was shared for individual farmers. CARE upgraded the scheme for individual farmers who were organized under water users association. The Doni scheme is located down stream of Wonji sugar state farm and upper stream of all other state farms. The mean discharge is 42.3 m^3 per second and the minimum is 30.5 m^3 per second, which occurs in the month of January. Thus, there is no constraint of water in the scheme.

The scheme has a capacity to irrigate about 250 ha of land, which is classified as flat to rolling. However at present about 85 ha is irrigated. A study has been conducted by World Vision to expand the canal so that the whole land can be irrigated. The area is suitable for conventional surface irrigation methods such as furrow irrigation. However, in the rainy season, the Awash River tops its bank and flood most part of the land. Mot of the area in the peasant association is cultivated using rain fed cropping. Gullies up to 10 meters deep can be observed, showing deep silty loam and sandy loam. The irrigated area elevation varies from sandy to sandy loam and the irrigated area elevation varies from 1240 to 1280 meters above sea level with slope of 0.5% to 4%. The soils are mostly medium textured with weak structures, brown colors and good drainages. The texture ranges from silty loam to sandy loam (OIDA, 2004).

The majority of the populations are Oromos, with few Amharas and other small tribes.

CARE upgraded the scheme with the following objectives as envisaged:

- Assist the government's objectives of attaining food self sufficiency through sustainable small scale irrigation development
- Contribute to the transformation of subsistence agriculture into surplus production for the market.
- Raise levels of nutrition through increased food and cash crop production of farm families
- Strengthen institutional capacity for small-scale irrigation development at community level.
- Integrate irrigated crop production and environmental protection

The dominant rain fed crops of the area are Teff, Maize and Haricot bean and under irrigation; Onion, Tomato, Pepper, Maize and Haricot bean are grown. Most of the produce is sold to whole sellers coming from Addis Ababa. Some buyers also come from Dire Dawa, Gigiga and Djibuti.

Livestock production is an integral part of the crop production supplying traction power in tillage activities and means of transport in the farm. The livestock population in the Peasant association is about 3882 in total comprising 2800 cattle, 1337 sheep and goat and 955 equine. Oxen and Donkey are the main source of traction and transport power respectively. Animal diseases and drought are common in the area and hamper livestock productivity.

Traditional irrigation had started in the project area 30 years ago. Then CARE International in Ethiopia Shewa Project upgraded the traditional irrigation system in 1995. A low head diversion weir equipped with intake gate was constructed across part of the Awash River to divert out irrigation water to the field. The irrigation convergence system and distribution system consists of main canal with a total length of 7.3 km with carrying capacity of 738 liters per second and 18 secondary canals done by CARE and all lateral canals constructed by farmers. The canal is constructed in earth on its entire length except at few locations where cross drains; elevated flumes and retaining walls are built by cement to convey irrigation water across depressions/gullies and unsuitable soil. Furrow irrigation is the main method applied in the order of 30 to 50 meters length. Food For Work (FFW) and community free labor contribution did the construction of the irrigation. The overall project cost was estimated to be 2, 654,963 Birr.

The farmer Water User Association (WUA) is responsible for the water management, operation and maintenance of the irrigation scheme. The management skills of WUA officials involves activities such as organizing groups of farmers for maintenance, resolving conflicts, organizing and delegation of responsibilities for daily distribution of water to the beneficiaries. Operation of the scheme includes keeping the designed types and methods of irrigation, when to irrigate, number of hours to irrigate a particular farm and number of hours water should flow in a given canal. Maintenance includes all works necessary to keep the irrigation system operating satisfactory. Some of the most common maintenance works are gate-greasing, removal of silt from canals and drains, cleaning of vegetation from canals and drains and repairing embankment etc. All farmers in the scheme contribute in cash and labor to the Water Users Association (WUA). The farmers in tertiary units (TU) constitute Water Users Teams (WUT), who organizes the water rotation in their TU. Development Agent assigned in the scheme by irrigation Desk of the Bost Wereda provides technical assistance in operation and maintenance of the irrigation scheme.

Drinking water supply for the domestic human consumption is the critical issue in terms of its quality and impact on human as well as animal health. The only source of drinking water is Awash River. Water borne and water transmitted disease are common in the area.

3.6.2 Batu Degaga Irrigation Scheme

Batu Degaga irrigation scheme is located at an altitude of 1351 m above sea level, latitude 08^{o} 42634' N and longitude of 039^{o} 40945' E in Eastern Shewa zone, Adama Wereda. It is 7 km east of Sodere Resort Center on the road to Tibila State Farm on the right bank of the Awash River.

The area is semi-arid. The mean annual rainfall is between 700 to 760 mm mainly received from June to September followed by a distinct dry spell up to January. The cumulative mean monthly minimum temperature is 10 ^{0}C while the maximum is 35 ^{0}C. The pattern and magnitude of rainfall at Melkas Station over the past 25 years are as shown in Fig. 4 .The soils are generally described as clay loam to sandy clay loam of dark brown to dark reddish brown color. According to the World Vision in Ethiopia Design report (1990), the pH of the soils ranges from 6.7 to 7.3 with sufficient organic matter and phosphorus content. The soil depth ranges from 50 to 100 cm. Major crops grown in the scheme are Onion, Maize sorghum and Soya bean.

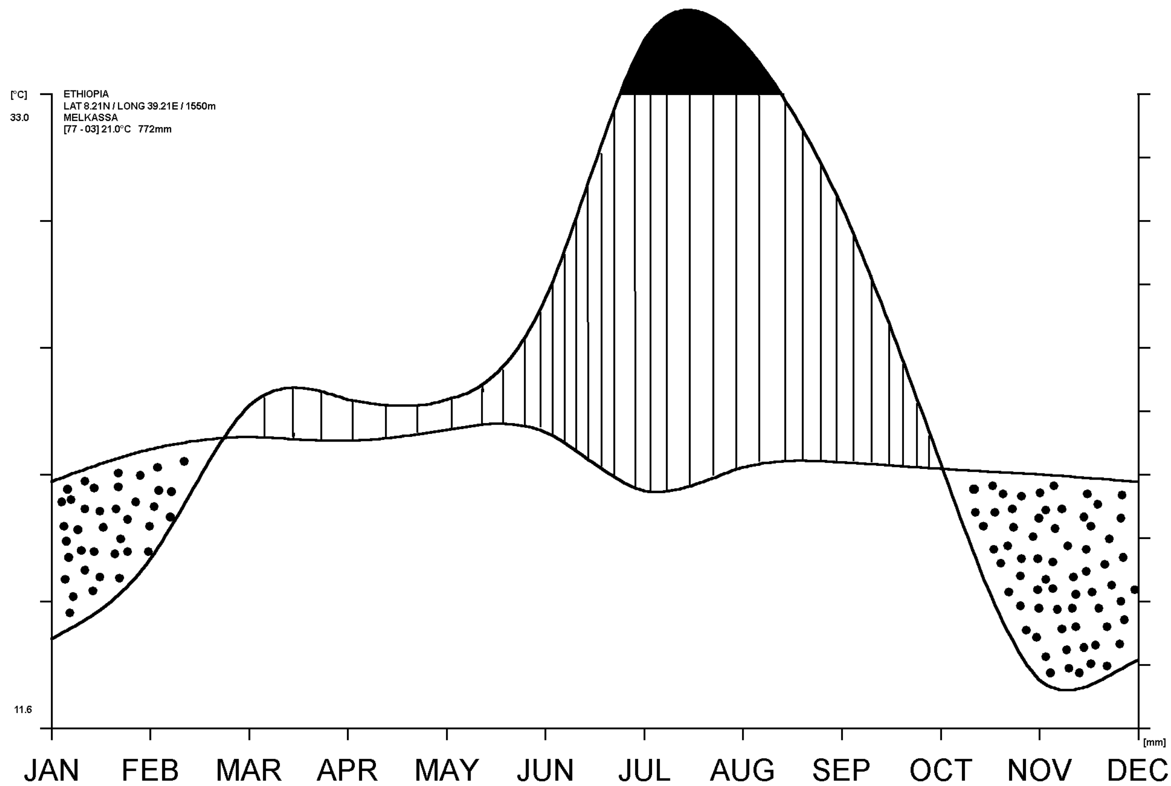

Fig. 4 Cumulative mean monthly rainfall and average temperature of Melkassa Station, period (1977 to 2003)

The only source of water that can be used for irrigation development is the Awash River. When Wenji Sugar state was established, a group of farmers were expelled from their original habitat and resettled at Batu Degaga peasant association. The area is dry and affected by drought occasionally. With the realizations of the problem, World Vision Ethiopia (WVE) intervened and started the irrigation scheme by initial investment of Birr 705,000 in 1992. Three electrical pumps were installed on the Awash River and primary and secondary canals were constructed to divert water from the river. Peak monthly water demand to be diverted from the river is estimated to be 2460 m^3 per ha per month at 12 hours irrigation per day. In farm water application is through furrows parallel to the contour of the area. The total irrigable area covers 140 ha. However, at present 60 ha is irrigated due to the problem of frequent breakdown of pumps. The project beneficiaries are 120 household heads with 0.5 ha irrigable land.

The farmers are organized in Water Users Association and have an executive committee with five members. The committee is responsible for taking care of physical structures such as water gates, canals and other properties of the association, monitoring pump operation, supervising water distribution and other related activities. The executive committee with the support of project staff and from the ministry of agriculture experts also formulated general by-law and detailed rules and regulations. The by-law was approved by the general assembly and is used as an official document of the association. The document contains purpose and objectives of the association, membership criteria, rights and responsibilities of individual members, organizational structure of the association, responsibilities of the general assembly, responsibilities of the executive committee, work team formation, procedures for accounting, financial loan, petty cash utilization, local employment and the formulation of internal rules and regulations. Moreover, for efficient management of the scheme, the irrigated land has been divided in to four blocks and the beneficiaries have been grouped in eight work-teams. Each and every team has elected its own team-leader, accountable to the executive committee in any mater concerning their respective team. To monitor the day-to-day functions of the scheme and minimize misunderstandings that may arise on the use of available resources, a control committee of three members was also formed. Required inputs were provided by WVE at the beginning and an agronomist has been assigned permanently to provide technical supports by Woreda Irrigation Desk.

In 1995, The WVE pulled out from the scheme and the farmers continued production covering the entire electric bill and other expenses from their contribution. In 1998, their crops were damaged by heavy rain followed by low price; they couldn't cover the electric bill and other expenses. Then, in year 2000, the irrigation activity was terminated. After two years, a committee was organized from the Adama Wereda and WVE to study the problem of the scheme. Based on the committee recommendation, WVE settled the outstanding electric bill and covered operational expenses for one year to rehabilitate the scheme. At present, the farmers are covering all the expenses and working with no sign of progress

3.6.3 Godino irrigation scheme

Godino irrigation scheme is located in Oromia Regional State, East Shewa Zone, Ada Liben Woreda at an altitude of 2012 m above sea level, latitude 08^{o} 85474 N and longitude 039^{o} 02063 E about 15 km from Debre Zeit on the road to Chefe Donsa. The area generally lies on the higher altitude. The soils texture of the command area is clay loam and brown in color. The average soil depth is about .65 to 1.05 cm with medium infiltration rate and medium water holding capacity (East Shewa Water, Mineral and Energy Resources Development Department, 1998).

The mean annual rainfall is 816 mm, the highest amount received in July and August. The cumulative mean monthly minimum temperature is 8 ^{0}C while the mean monthly maximum temperature is 25 ^{0}C as shown in Fig. 5. The water source for the irrigation scheme are Belbela-wedecha dams with storage capacity of 27 million m^3 of water. The main source of water for the dams is the runoff of the surrounding catchments area supplying the Wedecha and Belbela streams. The Cuban Civil Mission in collaboration with the Water Resources Development Authority (WRDA) constructed the two storage dams for irrigation purposes in 1980. The protection works, canals, and on farm structures were later constructed by the Ethiopian Water Works Construction Authority (EWWCA) with an objective of irrigating 1600 ha of land area to be used by State Farms.

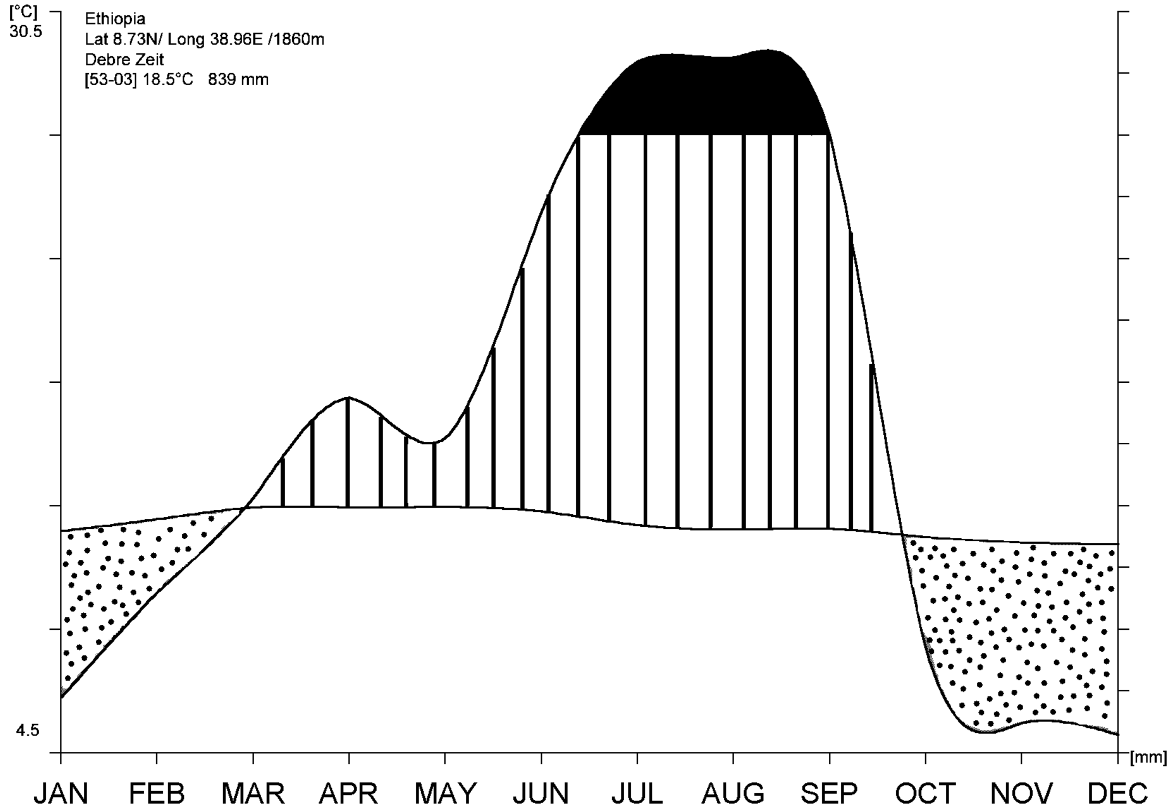

Fig. 5 Cumulative mean monthly rainfall and average temperature of ILRI Debre Zeit , period (1977-1994)

After the fall of the “Derg” regime, however, the irrigation projects of the state owned enterprise and organizations was terminated. Thus, the government started promoting smallholder community based irrigation around the two dams in collaboration with the funding agency (EEC) by constructing gated off takes, lined canals and controlled turnouts from Wedecha dam with a total 708, 000 Birr. Gravitational furrow irrigation is a common practice in the area.

The total population of the Godino peasant association is about 616 household heads out of which 209 are irrigation users. The majority of the people in the peasant association are Oromos with few Amharas.

Crop-livestock production system is dominant which is highly dependant on rain fed agriculture. The dominant rain fed crops grown in the area are wheat, teff, and barley while Onion, cabbage, sugar cane and potato are irrigated crops. Land preparation for most crops is carried out with the traditional plough, using oxen as a source of power for traction assisted by hand tools. Both pesticides and insecticides are largely used for plant protection purposes. In addition, various types of chemicals are used for weed and pest control.

Water Users Committee of the peasant association in collaboration with Woreda Irrigation Desk does the operation of the scheme. The woreda irrigation desk organizes the committee and gives extension services. The maintenance of irrigation structures and other related works are to be performed by Zonal Irrigation Development Authority. A development agent is assigned to the peasant association to give technical assistance in agricultural activities to the farmers.

3.6.4 Markos irrigation scheme

Markos irrigation scheme is located in Oromia Regional State, West Shewa Zone, Welmera Wereda in Berfeta Lemefa peasant association at an altitude of 2076 m above sea level, latitude 09^{o} 03835' and longitude 038^{o} 54862'. It is about 42 km from Addis Ababa on the way to Ambo and is accessible throughout the year. The zonal classification of the scheme is about 12% Dega and 88% Weyina dega. The rainfall in the scheme is bimodal. The average annual rainfall is 1187 mm and about 80% of the annual rainfall is received during the four rainy months June to September. The short rain usually starts in February/March and extends into April. The cumulative mean monthly minimum temperature is 3 ^{0}C and the maximum is to 23 ^{0}C (Fig. 6). On average the minimum temperature does not fall below zero. October to February is normally the coldest months.

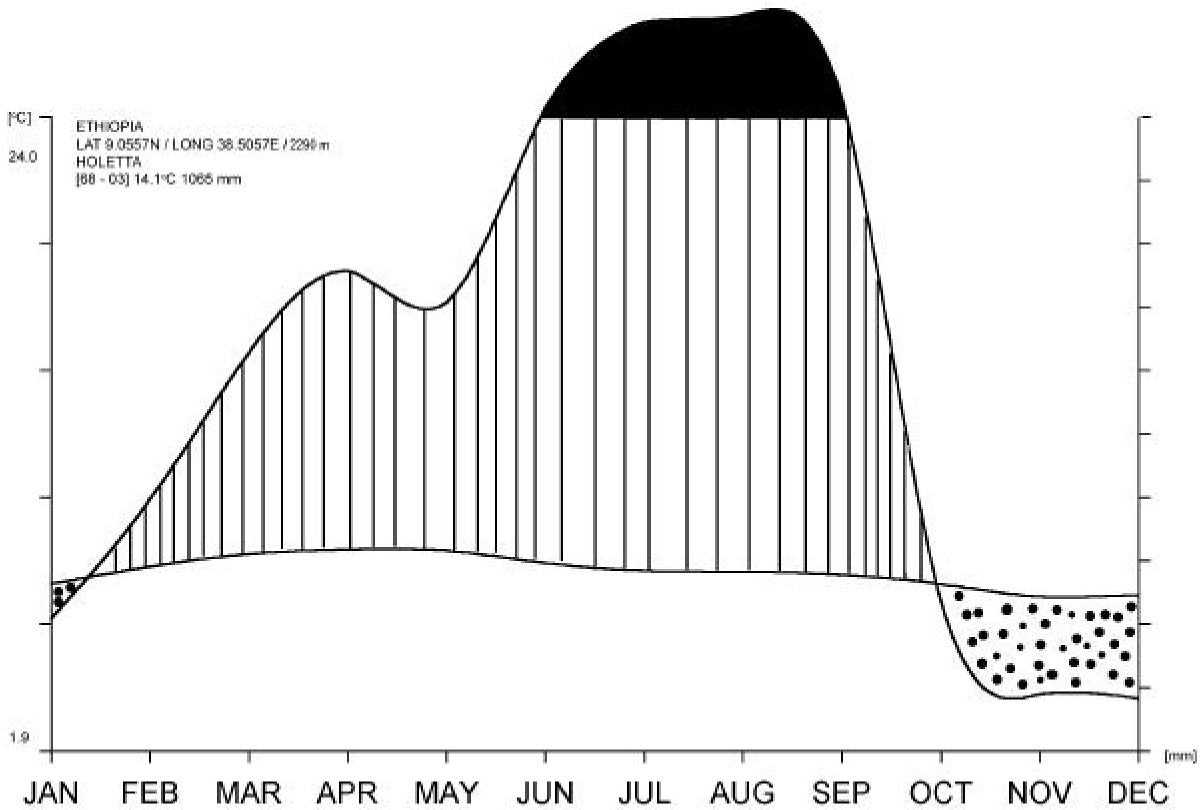

Fig. 6 Cumulative mean monthly rainfall and aver age temperature of Holetta, period (1968-2003)

The total land area of the peasant association is 3299 ha out of which 2010 ha are cultivated. The rest are used as homestead, grazing, forest, shrubs and wasteland. Out of the total cultivated land 130 ha is irrigated. The dominant soil type is vertisols with red soil in the higher altitude. Wheat, teff, horse beans, Barley, millet and rapeseed are grown by rain fed agriculture while potato; Onion carrot and cabbage are grown using irrigation.

Livestock is an integral part of the farming systems and there is an estimated 4885 cattle, 1230 sheep, 940 goats, 930 donkey, 85 horse and 1292 poultry in the peasant association. Feed shortage and sporadic animal disease is common in the scheme. Oxen and Donkeys are the major power source of traction and transportation respectively.

The Markos irrigation scheme is a traditional diversion scheme about 118 years old. The Guntuta River was diverted using earth dam by members labor and financial contribution. The area developed at present is 130 ha with 226 households. Most of the irrigated farms are around homestead area. Water users committee elected by the farmers does the operation of the scheme. However it is not registered by the government and doesn't have legal entity. The committee performs the maintenance of irrigation structures and related works with technical support from Woreda irrigation desk. The gravity water diversion system has no daily operating cost. The irrigation canals and the main canals are maintained every year before the first irrigation season by the farmers labor. There is also casual maintenance of their tertiary unit canals every irrigation time.

4. Results and Discussion

This chapter presents survey results of the four selected small-scale irrigation schemes, namely Doni, Batu Degaga, Godino and Markos. The findings are part of the study aimed at assessing the socio-economic and environmental impact of smallholder irrigation development in the Upper Awash Basin. The analysis was done between farms as well as among schemes. The scheme comparison was done to see the schemes performance since they have deference's in climate, crop type grown and irrigation experience.

4.1 Water sources and irrigation technology types

The two schemes, Batu Degaga and Doni get water from Awash River using diversion channels. Godino gets its water from Wedecha Dam while Markos gets from Markos River using traditional diversion channels. Batu Degaga irrigation scheme uses electric pumps to pump water to the main channel while the rest uses gravity supply. The Markos scheme is traditional and has very long experience of irrigation. The three are up-graded with partially cemented primary and secondary canals.

The water source in the three schemes is reliable except Batu Degaga where an electric motor driven pump pumps the water from Awash River to the main canal and there is frequent breakdown. Markos also faces water shortage in the dry season. The Markos river water amount decreases tremendously especially when the short rains fail in some years. This will restrict the crops they grow using irrigation. There is also a new military center constructed recently up stream, which uses large amount of the water. The water allocation system is very efficient and have avoided dispute among farmers. However, there is water theft during water shortage.

The Wedecha Dam is silting up due to erosion from the surrounding sloppy agricultural fields. Its sustainability is at stake in the long run unless something is done to control the erosion up stream agricultural fields. The government does the maintenance of the dam and primary and the secondary canals of the up-graded schemes. The Wedecha Dam is found inside another Peasant Association. As a result, the up-stream farmers are always complaining and requesting compensation for their lost land. In addition, birds are gathering for water and are damaging their crops. The farmers also mentioned that water borne and water related disease like malaria expanded in the area. Due to siltation, the dam is expanding taking more cultivated land every year.

The schemes studied vary in size. Batu Degaga, Godino, Markos and Doni are 85, 60, 271 and 130 ha respectively. Out of the total cultivated area 5%, 2.4%, 8.04% and 4.02% are irrigated at Doni, Batu Degaga, Godino and Markos respectively. The number of irrigators in Markos is 226 household heads being the highest while Doni household heads are 72 being the lowest in the schemes studied. Female irrigator household heads are few in all the schemes (Tab. 2).

Tab. 2 Scheme size and number of beneficiaries.

Scheme	Sex	No of HH in the Peasant Association	No HH in the Scheme		PA Total Area (ha)	PA Cultivated Area (ha)	Scheme Area (ha)	% of scheme area to cultivated area
			No.	%				
Doni	Male	657	62	9.43	1700	1170	85	5.00
	Female	10	10	100				
	Total	**667**	**72**	**10.8**				
Batu Degaga	Male	894	98	11	2480	1340	60	2.41
	Female	90	22	24.5				
	Total	**984**	**120**	**12.2**				
Godino	Male	534	189	35.4	3369	2210	271	8.04
	Female	82	20	24.4				
	Total	**616**	**209**	**33.9**				
Markos	Male	900	200	37.5	3229	2010	130	4.02
	Female	40	26	31.7				
	Total	**940**	**226**	**36.7**				

Source: Peasant Associations and Development Agents at the scheme, 2004.

4.2 Planning of the irrigation schemes

All the four selected schemes have a long experience in irrigation activities. Batu Degaga farmers were resettled when Wonji Sugar Factory took their land while Doni farmers were farm workers when the scheme was under private farm. Then it was converted to producers cooperative and later to individual farm. Markos and Godino schemes are traditional schemes with long experience. CARE and World Vision Ethiopia upgraded Batu Degaga and Doni schemes with input supply like seed and fertilizer while Godino scheme was up-graded by the regional government to provide farmers with a source of self-subsistence and they didn't actually request for the development of the schemes. The farmers didn't make any financial contributions towards the development of the projects. They only did the infield development.

In Markos scheme, the construction and maintenance of primary and secondary canals is done by the community finance and labor contribution without outside support.

Due to approaches taken by the government and NGO's in schemes development, farmers consider their projects as government and NGO projects. The research believes that if they had participated in the planning process, they would strongly regard the projects as theirs. On the other hand Markos farmers, do contribute and participate in all activities of scheme and have developed a sense of ownership.

Each of the four schemes has water users association (WUA) and groups for water management. They have a system of byelaws to manage the scheme. The water user association of Doni and Batu Degaga are registered by the government and has legal entity while Godino and Markos WUA are not registered. The registered WUA have the right to get inputs and market facilities, credit service etc. from government and NGO's while the non-registered have legal entity problem. The registration is done by cooperative Development Desk at woreda level in collaboration with woreda Irrigation Desk. Woreda Agriculture Desk provides technical advice and inputs like fertilizer and improved seed but these offices are under stuffed and have little budget to give the required assistance even for the registered WUA.

4.3 Labor supply and allocation

The labor needed to operate family farms is characterized by seasonality and the family's work schedule, which is dictated by the agricultural calendar. The availability and type of family labor has also direct relationship to agricultural practices of the smallholder farmer. To study the labor supply by the family, household composition by age, sex and educational status was analyzed. The sample household head farmer's composition by sex is tabulated in Tab. 3 and show that there is significant difference (p-value 0.006) between farm types. This is assumed to be due to the labor-intensive nature of irrigation practices since women have additional responsibility in the house in providing food to the family, look after children and livestock their participation in irrigated practices as a household head is minimal.

Tab. 3 Mean comparison of household heads by sex between farm types.

Dependant variable (Sex)	**Farm type**		**Person Chi-Square**	**df**	**P-value**
	Irrigator	**Non-irrigator**			
Male	112	98	7.47	1	0.006
Female	8	22			

The household composition between farm types is not significant however there is significant difference among the schemes (Tab. 4 and 5). The significant difference in children less than twelve years of age might be due to a better income from the of irrigation farmers tend to have more children. The economically active population within the age group of 18 to 60 didn't show any significant difference between farm types. However, with average family size shown in Tab. 5, the work force that is considered to be with the age group between 12 and 60 is about 76% of the total family members.

Tab. 4 Mean comparison of household composition among schemes.

Dependent variable	Farm type		Significant
	Irrigator	Non-irrigator	
Household size	7.0	6.0	NS
Male household member	3.0	3.0	NS
Female house hold member	4.0	3.0	NS
Household age <12 years	3.0	2.0	*
Age between 12-17 years	2.0	1.0	NS
Age 18-60 years	2.0	2.0	NS
Age >60 years	3.0	3.0	NS
No of illiterate	0.0	1.0	NS
No of read and write	4.0	2.0	NS

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Tab. 5 Mean comparison of household composition between farm types.

Dependent variable	Scheme				Significant
	Doni	Batu Degaga	Godino	Markos	
Household size	6.0a	6.0b	8.0bc	7.0cd	**
Male household member	3.0a	3.0ab	4.0bc	3.0cd	**
Female house hold member	3.0a	3.0b	4.0bc	3.0d	*
Household age <12 years	2.0a	3.0ab	3.0c	2.0cd	**
Age between 12-17 years	2.0	2.0	2.0	2.0	NS
Age 18-60 years	3.0	3.0	3.0	3.0	NS
Age >60 years	0.0	1.0	2.0	2.0	*
No of illiterate	3.0a	4.0ab	4.0c	3.0cd	**
No of read and write	1.0	.1.0	1.0	0.0	NS

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Note: Means within schemes followed by the same letter aren’t significantly different.

Irrigated farms are more labor intensive than non-irrigated once as shown in Tab. 3. The family labor supply is not enough for irrigated farming in most cases while non-irrigated farms have almost enough aggregate labor needed for the farm operation. As a result non-family labor has to be used by irrigator farmers. Labor is both exchanged and hired to overcome labor bottlenecks. Hired labor is most used at transplanting seedlings, weeding and harvesting time. For other activities all physically able members of the household assist in farm work.

The total labor required in man-days for irrigated crops is significantly higher than non-irrigated crops assuming that no quality difference between the labor inputs of the different age and sex groups (Tab. 6). Of this about 60% is supplied by the family and 40% by hired labor for irrigated plot while 88% supplied by the family and 12% by hired and exchange labor for non-irrigated plots. The reality of this reflected in Fig. 7. The study done by Guido (1983) in the Ethiopian highlands found out that the labor requirement in most non-irrigated farms to be about 100 man-days per ha.

Tab. 6 Mean comparison of labor requirement between farms.

Dependent variable	**Farm type**		**Significant**
	Irrigator	**Non-irrigator**	
Family (per ha)	88.0	47.0	**
Hired (per ha)	69.0	29.0	**

NS=non-significant, *=significant; at $p<0.05$; **=significant at $p<0.01$

Fig. 7 Onion transplanting in Batu Degaga. April, 2004.

4.4 Cultivated Landholding and use

The mean cultivated and holding of non-irrigated farms are significantly higher than irrigated plots. However there is no significant difference among the schemes as shown in Tab. 7 and 8. Land holdings are significantly fragmented between farm types in various parcels, sub-divided into different plots however; there is no significant difference between schemes.

Fragmentation arises from the Peasant Association strategy of allocating different land classes equally among its member farmers after the abolition of producer's cooperatives in each scheme. In addition the redistribution of cultivate lands among the family members has also contributed to this phenomena. Fragmentation of cultivated plots has its own positive and negative impacts. It lowers production risks on the other side increases weed infestation from adjacent plots, increases soil erosion and makes grazing difficult. Number of gully on plots was also counted and the comparison shows no difference between farm types while among schemes the difference is significant. This shows that irrigation has no effect on gully formation on plots.

Tab. 7 Mean comparisons of cultivated land holding and other parameters between farm types.

Dependent variable	**Farm type**		**Significant**
	Irrigator	**Non-irrigator**	
Land holding (ha)	0.51	0.81	**
Plot distance (km)	0.80	1.35	**
Water distance from homestead (km)	0.90	2.03	**
Plot no per household	5.00	8.00	**
Gully formation on plot	3.40	5.00	NS

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Tab. 8 Mean comparisons of cultivated landholding and other parameters among schemes.

Dependent variable	**Scheme**				**Significant**
	Doni	**Batu Degaga**	**Godino**	**Markos**	
Cultivated land (ha)	0.68	0.65	0.67	0.57	NS
Plot distance (km)	1.60[a]	1.20[ab]	2.47[bc]	1.54[cd]	**
Water distance from homestead	1.15[a]	2.29[ab]	1.87[bc]	0.79[cd]	**
Plot no	6.60	6.50	7.00	6.80	NS
Gully formation on plot	1.00[a]	2.60[ab]	1.00[bc]	2.50[cd]	**

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Note: Means within schemes followed by the same letter aren’t significantly different.

Plot distances and domestic water source are significant different between farm types and among schemes .In most irrigated farms irrigation water is used for both human and livestock consumption. Since most farmers live near the irrigated plots and irrigation water passes through the villages they don't have to travel long distance like non-irrigators. In all the schemes, irrigated plots are on average 0.08 km from the homestead compared with the non-irrigated plots, which are 1.25 km away.

As observed during the study almost all of irrigated plots are permanently cropped. There is no any fallow land in all the schemes. Permanent pastures are often held in common and are over grazed. There is no any private pasture for grazing animals expect around homestead area and plot boundaries. The majority of farmers in the four schemes cultivate the land by the family inputs. Share cropping and rental systems as shown in Tab. 9 are almost absent in all the three schemes. However, There is significant difference between schemes .In Batu Degaga about 55% and 14% of the farmers give their land for share cropping and rented respectively

Tab. 9 Comparison of tenure systems among irrigator's farmers in each scheme

Dependent variable (Tenure status)	**Schemes**				**Person chi-Square**	**df**	**P-value**
	Doni	**Batu Degaga**	**Godino**	**Markos**			
Household	55	51	95	65	71.143	6	0.000
Share cropping	1	28	3	0			
Rented	2	1	2	3			

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

4.5 Crop production

In all the study area, the main cereals grown vary based on altitude of the schemes. In Godino and Markos, teff, wheat, chickpea, horse bean, potato and barley are grown both with irrigation and rain fed cultivation. Supplemental irrigation by flooding system is common in both schemes. Soya bean, onion, maize, and sorghum are major crops in Doni and Batu Degaga. Teff is the common crop grown in all the schemes. As observed in the study, most farmers plant onion as cash crop. This is because of better price; gives relatively high yield and easily managed by farmers. It also resists water stress and pests.

Comparative yields analysis by crop type couldn't be done because of lack of uniformity and inconsistency in the use crop varieties, seed and seedlings materials. However the major crops grown using irrigation and rain fed practices in the four schemes is presented in Tab. 10. The only crop grown by farm type in the two schemes (Doni and Batu Degaga) is maize. Even with maize, seed variety was not uniform and yields harvest consistency observed in 2002/2003

Tab. 10 Major crops grown and average yield per ha for selected crops during 2002/2003 crop season.

Farmer type	Crop type	Scheme							
		Doni		Datu Degaga		Godino		Markos	
		Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton /ha)	Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)
Irrigator	Onion	0.49	13.18	0.30	1.56	0.22	8.84		
	Maize	0.47	1.84	0.43	2.41				
	Teff	0.56	1.59	0.54	0.87	0.23	0.94	0.34	0.88
	Soya Bean			0.51	1.7				
	Chick Pea					0.23	0.12		
	Horse Bean					0.25	0.75	0.33	0.32
	Wheat					0.27	1.85	0.40	0.76
	Potato					0.15	8.67	0.22	5.95
	Barley							0.23	1.50
	Beet Root					0.20	4.10	0.21	4.47
Non-irrigator	Maize	0.61	0.89	0.52	1.27				
	Soya Bean			0.52	1.19				
	Teff	0.77	0.68	0.78	01.0	0.46	1.00	0.54	0.83
	Chick Pea					0.52	1.04		
	Wheat					0.39	1.31	0.48	1.32
	Horse Bean					0.25	1.00	0.38	1.00
	Barley							0.35	1.16

Source: Survey data, 2004

4.6 Livestock holding and productivity

The most important contribution of livestock to agricultural production in the study area is the use of oxen as drought power for plowing and threshing. Milk, meat and hides from cattle and small ruminants are relatively less important by products, but manure is used as fuel and fertilizer. Sheep in Godino and Markos and goats in Doni and Batu Degaga are kept mainly as a secondary investment and a source of cash in times of need. Donkeys are widely used as transport animals. Poultry are widely kept and used for egg production and home consumption. . Livestock productivity is low for all classes of animals in all the schemes. This is attributed to long periods of nutritional stress and heavy parasite burden. Liver fluke, lungworm and intestinal worm infection are reported by the farmers to be major problems in all the sites. Parasites are transmitted through stagnated water in canals and ditches and waterlogged areas created by uncontrolled irrigation water

The current livestock holding among schemes and between farm types was converted to cash value as shown in Tab. 13 and 14. The analysis highlights that there is no significant difference in livestock holding between irrigators and non-irrigators. However significant difference was reflected among the schemes. Farmers in general stated that there is trend in livestock number reduction among the irrigator farmers. The reason given was that irrigation and livestock production both require more care and are labor intensive. The farmers couldn't afford to run both practices simultaneously efficiently. So, a farmer has to choose one of the activities. The other reason given was feed shortage. Major crops grown in irrigated farms are vegetables, which don't have crop residue for dry season feed while non-irrigators produce cereals, which give straw as a source of feed. Shortage of grazing land is also another problem mentioned by the farmers, which is forcing them to reduce livestock population in irrigated farms. The plots are under crop cover in most of the months in a year

As shown in Tab. 11 and 12, mean oxen power requirement for plowing and threshing was compared between farm types and was found significant for plowing while threshing activity didn't show significant difference

Tab. 11 Mean comparison of animal power required between farm types.

Dependent variable Oxen days /0.25ha	Farm type		Significant
	Irrigator	Non-irrigator	
Plowing	15.1	10.8	**
Threshing	5.9	6.8	NS

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Tab. 12 Mean comparison of animal power required among schemes.

Dependent variable Oxen days /0.25ha	Scheme				Significant
	Doni	Batu Degaga	Godino	Markos	
Plowing	10.6[a]	14.2[ab]	10.8[bc]	14.7[cd]	**
Threshing	13.6[a]	5.4[ab]	6.3[c]	4.3[cd]	**

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Note: Means within schemes followed by the same letter aren't significantly different.

4.7 Asset base and agricultural income of the schemes.

Analysis of farm resource productivity involves not only details of the farms, but also external factors, such as markets and prices of inputs and output, asset base and infrastructure. Productivity is related to the proper choice of technology among those alternatives at the farm. The purpose of this paper is not to study the financial viability of irrigated and non-irrigated farms. However, input output information was collected from the farmers to determine the cash benefits of different agricultural practices. The asset base data was also collected if there is any difference in asset ownership since it has a direct influence on the farm activity significantly. The mean asset value included livestock, farm tools and fixed assets specifically buildings. The analysis as shown in Tab. 13 and 14, the significant difference between farm types is observed in fixed asset ownership. Farm tools and livestock ownership didn't show any significance. However the variation in asset ownership among the schemes was significant for all asset types as shown in Tab. 14.

Tab. 13 Mean comparison of assets ownership between farm types.

Dependent variable	Farm type		Significant
	Irrigator	Non-irrigator	
Farm tools (birr/HH)	427.86	381.23	NS
Livestock (birr/HH)	1104.55	1117.14	NS
Fixed assets (Birr/HH)	4800.11	3481.44	**

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Tab. 14 Mean comparison of assets ownership among schemes.

Dependent variable	Scheme				Significant
	Doni	Batu Degaga	Godino	Markos	
Farm tools (birr/HH)	88.40	488.74	563.87	352.64	**
Livestock (birr/HH)	893.38[a]	1487.50[ab]	1115.52[c]	952[d]	**
Fixed assets (birr/HH)	9182.53[a]	1708.75[ab]	4030.87[bc]	2350.94[d]	**

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Note: Means within schemes followed by the same letter aren't significantly different.

The difference in net farm income between farm types was calculated as shown in Tab. 15. The cost of inputs like fertilizer, pesticide, herbicides and seed were deducted from the gross farm income. The result revealed that the average net farm incomes of irrigation farms in general are higher per ha than the non-irrigated farms. The mean income comparison among schemes also shows a significant difference in all the schemes (Tab. 16).

Tab. 15 Mean comparison of net farm income between farms type in 2002/2003 cropping season.

Dependent variable	Farm type		Significant
	Irrigator	Non-irrigator	
Input cost (Birr/ha)	1418.40	596.07	**
Gross farm income (birr/ha)	5135.61	1868.88	**
Net farm income (birr/ha)	3720.85	1269.98	**

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Tab. 16 Mean comparison of net farm income among schemes for 2002/2003 cropping season.

Dependent variable	Scheme				Significant
	Doni	Batu Degaga	Godino	Markos	
Input cost (Birr/ha)	1314.82[a]	713.43[ab]	1497.74[c]	693.90[cd]	**
Gross farm income (birr/ha)	4826.11[a]	5191.76[ab]	3598.76[bc]	2257.54[cd]	**
Net farm income (birr/ha)	3511.30[a]	4478.33[b]	2110.01[bc]	1563.64[cd]	**

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Note: Means within schemes followed by the same letter aren’t significantly different.

At Markos the net farm income margin between irrigated and non-irrigated is small. This is assumed to be due to the type of crop grown and the price offered for the produce. Potato, which has lower price, is grown in Markos while onion with relatively higher price is grown in Doni and BatuDegaga. In addition it is assumed that the crop type grown, the land fertility, temperature and price of the produce have influenced the yield production. As we have seen from the previous discussions, Markos is at high altitude, where the soil is depleted from long years of cultivation, and where potato grown as a major crop, which is affected, by diseases and low price offers. This show that irrigation in higher altitude where the annual rainfall is more than 1000 mm and with limited crop type and low temperature is not attractive venture among smallholder farmers. The study done by Hailemariam etal (2003) at Gimbichu showed that net margin of wheat was Birr 4752.78 for rain fed agriculture. This shows that irrigation farms in higher altitudes have to shift to other cropping system like fruit production rather than vegetable production.

4.8 Commercial Aspects

In all the schemes, there is no organized marketing system for agricultural product. Yields are sold individually at the prevailing market price at the farm. Buyers come to the field and determine the price. The price variability is high for some crops like onion, tomato, and potato which some times bankrupt the farmers. In some season, prices shoot up and lucky farmers benefit a lot. For example the price of onion in 200/2003 crop season varied from 0.15 Birr to 4.00 Birr per kilo (Tab. 17**)**. The same is true for tomato and potato. The non-irrigated crops price is usually uniform throughout the year with low rate of variability. Due to lack of storage and transport facilities, perishable vegetables are highly sensitive for marketing situation. Vegetables produced are sold at the farm with prices fixed by the buyer in all the schemes. Some farmers tried Addis and Nazareth markets, but the brokers charge and harassment was beyond the farmer's ability. The marketing situation is very critical for perishable products, which are at present grown by most farmers as reflected in Fig. 8. The farmers also produce similar crops at one time creating market competition among them. Therefore, any future intervention in the promotion of cash crop production should consider the issue of marketing and other necessary facilities like price, information, storage, market place, production diversity, consumer preference etc.

Tab. 17 The mean crop prices in the schemes for 2002/2003-crop season

Crop type	**Maximum (Birr/kg)**	**Minimum (Birr/kg)**	**Mean (Birr/kg)**
Onion	4.00	0.15	1.42
Cabbage	2.00	0.30	0.92
Maize	3.00	.27	1.18
Tomato	4.51	0.3	0.87
Carrot	1.80	0.30	0.96
Sorghum	1.40	0.45	0.98
Soya bean	3.00	0.70	1.18
Teff	3.00	1.80	2.28
Chick pea	1.92	0.72	1.22
Horse bean	2.20	0.68	1.81
Wheat	1.80	1.00	1.20
Rough pea	2.60	1.07	1.67
Potato	2.00	0.35	0.78
Barley	2.50	0.25	1.13
Field peas	2.30	0.90	1.80

Source: survey data (2004)

Fig. 8 Looking for transport at Markos scheme about 35 km from Addis Ababa.

4.9 Input supply and credit system

Irrigation farmers use more inputs like fertilizer, improved seed and chemicals (pesticides, herbicides, fungicides) than non-irrigators as the test in Tab. 15 above shows.. However, the availability of these inputs doesn't meet the demand. The government supplies fertilizer and improved seed for non-irrigators and some related model farmers. Private companies supply most of inputs for irrigated farms. Generally, the prices are very high and most farmers don't apply the recommended rate. Sometimes the suppliers adulterate the inputs specially fertilizer, chemical and imported seeds. Inputs are purchased individually from private suppliers and types of chemicals used in all the schemes are listed in Tab. 18.

Tab. 18 Types of chemicals used in the schemes.

Recommended chemical	Pesticide	Insecticide	Herbicide	Fungicide
Endosalphan 35% EC	✓			
Cypermetirin 1% granular	✓			
Endosalphan 3% granular	✓			
Marshal 25% E.C.		✓		
Copper fungicides				✓
Dimethoate 40% E.C.		✓		
Trzine			✓	
Glyposel			✓	
Dalapan			✓	

Source: Woreda MOA in all the schemes. (2004)

Irrigation helps to increase agricultural production. High return depends on the other factors such as adequate usage of fertilizer, labor and improved seed, chemicals through supply of moisture at time of unreliable rainfall. The irrigator farmers use more of the inputs than the non-irrigators as shown in Tab.15 above. This is because nothing is returned to the soil again in general while in particular in irrigated farming the vegetable production and cropping intensity is believed to deplete the soil nutrient requiring more than the non-irrigated plot. However, a farther study is needed to verify the nutrient balance in the system. In addition income from cash crops and increased production enables irrigator farmers to meet the high price of inputs. Fertilizer and chemical utilization are recommended according to the soil, crop climatic condition as well as degree or occurrence of pests and diseases. The general recommendation rate per ha for irrigated plots is shown in Tab. 19. On the other hand the non-irrigators followed a blanket application of 50 kg UREA and 100 kg DAP per ha for cereals.

Tab. 19 Recommended fertilizer and chemical application rate per crop type in the schemes.

Crop type	Fertilizers (kg/ha)			Chemicals (lt or kg/ha)
	DAP	UREA	Manure	
Onion	150-160	150-200	800-400	3.0
Tomato	100-150	150-200	800	3.0
Pepper	50-100	100-150	800	3.0
Cabbage	100-150	150-200	800	3.0
Maize	50-100	50-100	800	3.0
Soya bean				3.0
Sugar cane	100-150	100	800	3.0

Source: Woreda MOA in each scheme (2004).

Credit facilities are non-existent in all schemes. The government provides fertilizer and some improved seed for model farmers who are insignificant in number. In Godino, there is one micro-finance Institute supported by NGO called Gasha who is providing credit for short-term loans (less than one year). The loan amount ranges from Birr 500 to 5000 per person with 13% interest rate and 3% additional tax. The loan is provided in-group not more than ten farmers. The group gives guaranty to cover the loan taken by defaulters. In some schemes merchants provide seed and fertilizer on credit and collect it back in kind. The agreement is that the farmer will sell his produce to the merchant at time of harvest with price fixed by the merchant. This has implication on the income of the farmer since the merchant fixes the price.

4.10 Positive impacts of small-scale irrigation on the environment

Food production is a serious concern for future generation of the country. The long-term development in agriculture is based on the potential of smallholder agriculture. Raising the productivity and incomes of smallholder farmers is the most feasible strategy towards achieving agricultural growth. The major constraints facing these smallholders are persistent droughts and harsh climatic conditions in the areas they live. The high level of inputs (Tab. 15) used in studied irrigation schemes indicates that the farmers have developed a entrepreneurship. The other benefits that can accrue from irrigation development as shown by the study of the four schemes are as follows:

4.10.1 Incomes and Food security

The development of smallholder irrigation schemes can result in high incomes for the smallholder farmers compared with the non-irrigators as shown in Tab. 16. The major area of concern in general among the farming community is the availability of food at household level. However, if the rain fails people are forced to seek support from the government. Smallholder irrigation can lead to availability of food at household level through increased productivity, stable production and increased incomes as shown by the analysis of the four irrigation schemes. All the four schemes offer some form of food security for the farmers and the surrounding communities.

4.10.2 Impact on employment

The development of the rural sector is important to reduce unemployment and reduce the rural to urban migration. Cash crops grown under irrigation have created employment in the field, through forward and backward linkages, and indirectly through multiplier effects. In the field cash crops require more labor input per unit land than non-cash crops and hired labor input tends to be higher for cash than non-cash crops.

4.10.3 Backward and forward linkages

Irrigated farming has created economic backward and forward linkages. Crops, which are grown under irrigation, rely heavily on improved purchased agricultural inputs, which has encouraged the local merchants to supply the farms. This has also increase labor use in the marketing and distribution sectors. Forward linkages occurred since it contributed extra income to the farmers, which enable them to access food. These effects have been reflected in the analysis of the four schemes.

4.11 Major existing environmental constraints in small-scale irrigation

4.11.1 Inefficient use of water

Inefficient use of water was observed in most of the schemes studied specially in Godino and Doni (Fig. 9**)**. Leakage from unlined canals through the earthen dam structure or from breakages of cemented canals system and faulty use of irrigation water were the major problems in the study area. Over using water than is required for satisfactory crop production can lead to inefficient use of fertilizer and over leaching of soils, increase the favorable conditions for pests, and leaves the soils in a more degraded conditions. This is becoming the point of conflict in the water user association in all the schemes. The other problem observed was use of flood irrigation in Godino. Use of extended length of tertiary canals and furrows creates over run of water causing erosion on other fields. This situations calls for a combination of physical and social measurements to control the situation before farther damage is caused.

Fig. 9 Inefficient use of water at Doni scheme

4.11.2 Soil fertility and quality maintenance problems

Irrigation gives farmers the option for second and third season production. As a result of this intensification of agricultural production the quality and fertility of the soils of irrigated plots have been affected. This specifically was observed in Godino and Markos where the land has been cropped for more than 100 years. Farmers stated that with out any fertilizer application their land would not give any yield. The organic fertilizer recently being produced in Addis Ababa is applied in irrigated plots as shown in Fig. 10**.**

Nutrients are removed more rapidly than they are replaced. All crop residue and green by products from vegetable production are removed from the field for livestock feed, fuel, and house construction. The only source of nutrient is use of fertilizer. Few farmers who have livestock apply manure. It is believed that irrigated plots are more exposed to nutrient depletion than the non-irrigated plots given the other factors are similar in both cases. The indication for these phenomena is gradual yield decreases. The farmers in all the schemes witnessed this phenomenon.

Fig. 10 Organic fertilizer applied at Doni

Farmers were asked the field management and care practices by farm type. Their experience and perception extracted from the household survey is tabulated in Tab. 20. Most irrigators practice drainage ditch, stone terrace and fencing more than the non-irrigators. However, in some activities like tree planting, stone clearing from the field, no significant difference was observed between farm types.

Tab. 20 Comparison of cultural practice adopted between farm types

Dependant variable	Farm type		Person Chi-Square	df	P-value
	Irrigator	Non-irrigator			
Erosion on plot					
No problem	89	28	4.016[a]	1	0.134
Mild problem	28	60			
Change in soil fertility					
Highly fertile	64	29	5.978[a]	2	0.050
Moderately fertile	417	334			
Infertile	32	25			
Salinity problem					
No problem	35	15	14.911[a]	2	0.002
Mild problem	18	8			
Severe problem	6	7			
Stone cover					
Low	277	178	11.890[a]	3	0.008
Medium	29	27			
High	1	7			
Very high	0	2			
Stone terrace					
Yes	25	45	14.473	1	0.000
No	485	335			
Drainage ditch					
Yes	136	81	3.382	1	0.066
No	374	217			
Grass strip					
Yes	5	35	34.362	1	0.000
No	505	345			
Clearing stone					
Yes	27	30	2.457	1	0.117
No	483	350			
Planting trees					
Yes	10	14	2.465	1	0.116
No	500	366			
Fence					
Yes	120	65	5.458	1	0.019
No	390	315			

NS=non-significant, *=significant; at $p<0.05$; **=significant at $p<0.01$

4.11.3 Soil salinity problems

The majority of farmers raised salinity problem as minor problem while few farms reported as severe problem in Batu Degaga and Doni schemes as shown in Tab. 20. Salinity problem was observed in Doni and Batu Degaga in some specific plots appearing as identifiable white salt deposits on the soil surface. As a result some farmers have abandoned their fields (Fig.11). This was observed mainly along Awash river bank. Salinization of irrigated land is mainly a problem in most of the state farms in the Awash Basin.

Fig. 11 Salt affected field at Doni

4.11.4 Soil erosion problem

Due to shortage of rainfall dry condition is observed in Doni and Batu degaga irrigation schemes. Wind velocity is very high. The heavy grazing from the pasturalists camels which migrate in the dry season to the area and the livestock owned by non irrigator farmers causes considerable damage to the natural protective vegetation cover of the soil. Thus the soil is exposed to the action of strong wind, causing wind erosion forming rills and gullies.

In Godino and markos, erosion caused by flood irrigation and furrow irrigation along the slope is common problem as observed during the study. Most of the slope of irrigation plots in Godino and Markos are excessive and flood irrigation is practiced specially for supplemental water. Sheet and gully erosion are eating the fields **(**Fig. 10). At Doni and batu Degaga erosion problem is very minimal since the plots are gentle slope however some farmers are affected by flooding when Awash River overflows its bank.

4.11.5 Irrigation water quality

In irrigation water evaluation, emphasis is placed on the chemical and physical characteristics of the irrigation water. Irrigation water contains a mixture of naturally occurring salts. Soils irrigated with this water will contain a similar mix but usually at a higher concentration than in the applied water. The extent to which the salts accumulate in the soil will depend upon the irrigation water quality, irrigation management and the adequacy of drainage. If salt is excessive, yield losses will result. To prevent yield loss, salts in the soil must be controlled at a moderate concentration.

However, during repeated irrigations, the salt in the irrigation water can accumulate in the soil, reducing water availability to the crop. Relatively high sodium or low calcium content of soil or water reduces the rate at which irrigation water enters soil. Certain ions like sodium, chloride, and boron from soil or water accumulate in a sensitive crop to cause crop damage and reduce yields. Excessive nutrients reduce yield or quality depositing on fruit or foliage. Drainage, leaching and changes to more salt tolerant crops are used to avoid the impact of long-term salinity build-up but other cultural practices may also be needed to deal with possible short-term or temporary increases in salinity. To avoid this many cultural practices such as more frequent irrigation, land grading, and timing of fertilization and methods of seeding may be practiced.

To take the appropriate mitigation measures, it is necessary to know the irrigation water quality and its effect on the environment. With this background water samples were collected from each scheme for physical and chemical analysis of the irrigation water. Ethiopian Geological Survey Water Laboratory determined the physical characters, like pH, and Electro-conductivity and concentration of cations, anions and $C0_2$. The results (Tab. 21) compared with the world standard (Annex I and II) and Ethiopian Standard both for human and plant reviled that there is no significant risk of salts and nutrient toxicity problem at present. However, there are some pockets where salinity problem observed in Doni and Batu Degaga schemes. In addation Sodicity is also observed in both schemes. The calculated SAR value is higher than the recommended rate (>9). It is assumed that the hot springs in the basin are dissolving rock salts and adding the concentration of Awash River. For example a farmer has abandoned his plot because of salt accumulation in his field (Fig.11). This needs a farther study on the soil quality to verify the assumption in the schemes.

Tab. 21 Physical and chemical characteristics of irrigation water samples collected from the schemes.

Parmeters	Scheme				
	Markos	**Doni**	**Batu Degaga**	**Godino**	**Significant**
pH	7.70	7.99	7.60	7.57	0.001
Ecw (µs/cm)	248.67	401.33	443.33	362.00	0.000
SAR adj.	2.23^{a}	9.93^{ab}	10.26^{c}	2.78^{cd}	0.000
Bicarbonat (HCO_3) -mg/l	144.33	205.33	222.00	202.67	0.000
Chloride (Cl)- mg/l	6.67	20.00	23.33	8.33	0.065
Sulphate(SO_4)-mg/l	0.93	13.00	11.97	0.90	0.000
Fluoride (F)-mg/l	0.33	2.29	2.19	0.53	0.073
Nitrate (NO_3)-mg/l	1.62	0.04	0.04	3.70	0.000
Sodium (Na)-mg/l	9.50	45.67	48.67	13.83	0.348
Potassium (K)-mg/l	3.13	7.83	10.67	14.03	0.002
Calcium (Ca)-mg/l	26.00	34.33	36.33	38.67	0.030
Magnesium (Mg)-mg/l	10.00	8.00	8.67	10.83	0.384
Boron (HBO_2) mg/l	0.22	0.22	0.57	1.31	0.163
Carbon Dioxide (CO_2)-mg/l	6.00	4.00	10.00	12.00	0.055

NS=non-significant, *=significant; at p<0.05; **=significant at p<0.01

Source: survey data, 2004.

Toxicity normally results when certain ions are taken up with the soil-water and accumulate in the leaves during transpiration. The degree of damage depends upon time, concentration, crop sensitivity and crop water use, and if damage is severe enough, crop yield is reduced. The usual toxic ions in irrigation water are chloride, sodium and boron. Each can cause damage, individually or in combination. The result shows that at Doni and Batu Degaga, Sodium and Boron are within the acceptable range. The most common toxicity is from chloride in the irrigation water. Chloride is not adsorbed or held back by soils rather it is taken up by the crop, and accumulates in the leaves. This problem is not also occurring at present as the value of the result is with in normal range

Nitrogen and phosphorus are two nutrients generally applied as fertilizer, which can cause water-quality problems. Phosphorous is readily adsorbed in soil particles and can be carried in surface run-off. Nitrogen is very soluble and can be present in both surface and sub-surface drainage waters. If excessive quantities are applied, production of several commonly grown crops may be upset because of over-stimulation of growth, delayed maturity or poor quality. The most readily available forms of nitrogen are nitrate and ammonium but nitrate (NO_3 -N) occurs most frequently in irrigation water. The concentration in most surface and groundwater is usually less than 5 mg/l NO_3^-. The laboratory results are within the range. Since nitrogen is present in so many water supplies, it is recommended that the nitrogen content of all irrigation water be monitored in the feature.

The pH is an indicator of the acidity or basicity of water, but it is sometimes a problem by itself. The main use of pH in a water analysis is for detecting abnormal water. The normal pH range for irrigation water is from 6.5 to 8.4. An abnormal value is a warning that the water needs further evaluation while irrigation water with a pH outside the normal range may cause a nutritional imbalance or may contain a toxic ion. The result shows that the pH ranges from7.30 to 8.08 in all the schemes, which is within the accepted range.

Soils containing high levels of exchangeable magnesium are often thought to be troubled with soil infiltration problems. In the entire scheme the value of the analysis was within the recommended range. In magnesium dominated water (ratio of Ca/Mg < 1) the potential effect of sodium may be slightly increased. This was also within the normal range. However, the

SAR (Sodium adsorbition Ratio) calculated from the result show that high value than the recommended rate in batu Degaga and Doni. This causes infilteration rate reduction.

Fluoride analysis shows that at Batu Degaga and Doni the value are in the higher range. However, this has no any immediate effect on human health however care should be taken in the long run. The irrigated water quality analysis showed that there is no immediate concern on the pollution level both for human and plants consumption. However, the soil should be analyzed and the interaction of soil and water in relation to plants growth need farther study.

4.11.6 Irrigation water and Health

Water-borne diseases account for a substantial part of the total incidence of diseases in the rural population. It is directly related to the water use system adapted by the farming community. It is believed that the problem is more sever in irrigated agricultural system where irrigation water is used for human as well animal consumption directly without any treatment. The greatest danger associated with drinking water is contamination by human and animal excrement. Fecal of human as well as animal are left in the open system in the field and around homestead area. Rainfall and direct excretes on the irrigation water and inefficient utilization of irrigation water takes coliform bacteria into water. The Coliform is a family of bacteria common in soils, plants and animals. The coliform family is made up of several groups, one of which is the fecal coliform group, which is found in the intestinal tracts of warm-blooded animals including humans. The presence of fecal coliform in drinking water is evidence that human or animal waste has been present. This may be cause for concern because many diseases can be spread through fecal transmission.

To study the level of pollution of irrigated water samples were collected from the four sites and laboratory analysis on coliform count was done at International Livestock Research Institute (ILRI). The laboratory test for bacteria has two steps. The first step is the analysis for total coliform, which determines if coliform bacteria are present. If the result shows total coliform bacteria, the same sample is checked again, this time to determine whether the coliform bacteria in the water are of fecal origin. This result indicates whether recent animal or human waste has entered the water. The result specifically states whether E.coli bacteria have been detected. However, due to shortage of money and time, only coliform count was conducted. It is clear that the colony count alone is of little value in detecting the presence of fecal pollution since organisms of all types will be counted. However a series of colony counts from a source of water is important indicator of pollution.The result (Tab. 22) shows that all the coliform counts were very high indicating the level of pollution compared with the standard. Their presence should be assumed to be due to fecal pollution unless a non-fecal origin can be proved.

Tab. 22 Total Coliform count of water samples collected from the 4 sites, 2004.

Scheme	Temperature (^{0}C)	pH	Coliform count CFU/ 100ml	Ethiopian Standard[1]		European standards (Counts/ 100ml)	International standards (Counts/ 100ml)
				Recommended limit (Counts/ 100ml)	Maximum allowable limit (Counts/ 100ml)		
Godino-1	21.49	7.77	150	0	0.05	Nil	Nil
Godino-2	22.8	7.57	170				
Markos-1	19.13	7.91	90				
Markos-2	17.2	7.57	20				
Donni-1	21.85	7.91	600				
Donni-2	21.00	7.57	2000				
Batu Degaga-1	21.48	8.47	90				
Batu Degaga-2	22.00	8.29	120				

Source [1] Environmental protection Authority (EPA, 2003)

The highest coliform count was found in Doni whereas the lowest was in Markos. This shows that Doni and Godino are highly contaminated than Markos and Batu Degaga. This may be due to the water passing through the small towns of Doni and Godino where human, animal excretes is left in the open and other wastes are damped to the water. In general, all the schemes irrigation water is polluted considering the international standers, in particular the Ethiopian standards as shown in the above Tab. 21. The coliform count standard is based on an organism that is not in itself pathogenic but merely as an indicator of possible contamination. Generally, disinfected supply should not show coliform organisms per 100ml of distributed water. There should also be no *E.coli.* Again a one-time sample is only an indicator and is difficult to give conclusion without statistically tested result. A farther time series data collection is necessary to see scheme differences.

It was also found out in the study that the design of irrigation systems, which was supposed to avoid stagnant water to prevent negative health impacts of irrigation, was not properly working. This was also aggravated by the inefficient use of water in most of the schemes. Water breaks furrows and ponds in depressions out side the farm. This was observed in Batu Degaga and Doni where the landscape is almost flat and the climate is arid. This has created favorable condition for vector and water borne diseases like Malaria, sischotosmiasis, and lungworms. According to the data collected from Doni public clinic, Malaria, upper respiratory tract infection and parasite were most frequent diseases (Tab. 22). The situation is similar in the other studied schemes.

Tab. 23 No of treated patients affected by different diseases, at Doni public clinic, 2003

No.	Disease type	Number of Treated patients	Treated patients (%)
1	Malaria	2527	60.00
2	Upper respiratory infection	536	12.68
3	Parasites	246	5.58
4	Diarrhea	207	5.00
5	Wounds	194	4.59
6	Anemia	182	4.30
7	Gastritis	90	2.10
8	Sexual transmitted diseases	88	2.08
9	Rheumatic pain	84	1.99
10	Eye diseases	71	1.68
	Total	**4225**	**100**

Source: Doni public clinic, 2004.

The farmers are using the Awash River for human consumption and animal watering with out any treatment. This has increased the incidence of diseases in irrigated areas. Good construction practices are crucial in the implementation of a new irrigation system. Properly laid out fields require less water than poorly prepared lands, as a result avoiding breeding sites formation. Canals with the right elevation, size and slope are not exposed to erosion and can convey water at higher velocities without over flowing. Apart from avoiding favorable situation for development of vectors and intermediate hosts, the location of villages and drinking water supply are important factors. When farmers are working in the field, especially children drink the irrigation water from the near by furrows and ditches. In Godino and Markos the ditches pass through the villages and people and animal drink and clean themselves from the same irrigation water (Fig. 12). One can imagine how intensely the population is exposed to vectors or infested water. For several mosquito and fly species, the flight range is known and when houses are located at a larger distance from the breeding sites, people will be less exposed to possibly fective bites. Cleaning and maintenance of all irrigation infrastructures will reduce the breeding of vectors and intermediate hosts, and improve irrigation performance. In Batu Degaga and Doni adequate facilities should be provided to increase the safe use of irrigation water for other purposes and hence improve health. In both cases, other water uses in irrigation systems could be considered and incorporated.

Fig. 12 Water for household consumption from irrigation water at Godino.

5. Conclusions and Recommendations

Irrigation development aims to bring about increased agricultural production and consequently to improve the economic, social and environmental well being of the rural population. Small-scale irrigation plays a role in meeting the growing demand for food and to achieve long-term food security. The high yields obtained in irrigation and other benefits such as increased incomes, employment creation, food security, are an indication that irrigation can bring sustainable agriculture and economic development without sever effect on the environment.

The study of the four small-scale irrigation schemes in the Awash basin has revealed some factors that are important for the successful implementation of small-scale irrigation schemes. It has come out clearly that irrigation can be comparatively well designed and in a sound technical state but other issues related to land allocation, population pressure, input supply, market situation, health situation can affect the sustainability of irrigation schemes. The most important factor that came out as affecting the viability of the irrigation schemes is soil erosion and nutrient depletion. The nutrient recycling system is disrupted by the agricultural practice followed by the farming community

The system of furrow irrigation, which is practiced in most of the schemes, has higher labor demands and some farmers practice flooding system. This will aggravate erosion especially in sloppy plots.

High electricity and repair and maintenance cost of pumps in Batu Degaga showed that electric powered pumps might be too costly for smallholder farmers. Systems that require less cost like gravity diversion systems should be looked at seriously.

Good irrigation water management is a problem at schemes, if farmers do not pay for water costs. All the three schemes expect Markos don't use water efficiently. The water breaks canals and destroys other farmer fields and the next farmer is also left with out water. This has been a point of conflict in some schemes. Some farmers leave the water to flow out of their field since they have nothing to pay for the water.

Marketing, especially through contract farming, has proven to be a problem for smallholder farmers. Most of the contracts are verbal and dealers at the end usually cheat farmers. The terms are always in favor of the buyers and farmers lack the bargaining power. The study of the four schemes has also shown that in future all smallholder irrigation development should take an integrated rural development approach covering irrigation infrastructure and associated communication and health facilities. This will result in schemes not being robed by transporters because of poor roads, as is happening at present at Markos scheme. Improved communication facilities will ensure that farmers get marketing information timely through such means as telephone. Health facilities should also be near the scheme. For example, Batu Degaga farmers complained that the nearest clinic was 17 km away at Melkasa. Given the fact that irrigation development can be associated with water borne and vector diseases such as malaria, bilharzias and lungworm the need for health facilities and clean potable water should be complementary project of irrigation**.**

The water use system for water allocation within schemes has proven to work efficiently. Upstream farmers, government institute and state farms some times fail to release water for the smallholder scheme downstream during times of shortages. This has occurred in Markos where a newly established military training camp is utilizing big amount the water that is used by the down stream scheme. This tends to affect the performance of Markos scheme negatively during times of water shortages. In Godino, the peasant association where the Wedecha Dam is located is complaining and asking for compensation and this will be point of conflict between up stream dawn stream users. The study showed that there is a need to have water use permit system at Woreda and regional level.

In the analysis of the four schemes it has come out clearly that NGO's and government upgraded or new small-scale irrigation projects are handed over to the farmers with out proper completion of construction and technical training and without proper management establishment. This creates problems at such schemes as farmers remain with the understanding that the government and the NGO are still responsible. It is also important to be transparent and not to threaten people as a way of making them accept a project. These problems were made at Doni and Batu Degaga scheme and farmers always refer to such events. The farmers claim that WVE and CARE at the beginning of the scheme promised them inputs, but this promise up to now has not been effected

It was also observed that lack of technical knowledge among farmers on new technologies and management system. Most farmers are not aware of the interaction and inter linkages between crop rotation, pest management, introduction of new crops, water and vector borne disease and the environment. Teaching farmers on new techniques and scientific findings should be considered along with provision of water for irrigation. It was found out the concept of wealth accumulation is missing among the farming community. Farmers who receive excess income from irrigated cash crop spent more on leisure in near by towns Some farmers are having more than one wife. As a result, infection by HIV-AIDS is increasing at an alarming rate.

A major constraint in irrigation development is the top-down approach by the government and NGO's, which took farm population as beneficiaries rather than stakeholders. Technical experts and administrators make decisions on behalf of the farmer. Farmer's involvement in irrigation planning should be considered from the beginning

The following is a summary of the recommendations that have come out of the study of the four schemes, which are important for the sustainability of smallholder irrigation schemes. These are important for the implementation of viable and sustainable projects.

- Efficient use of irrigation water systems should be practiced to avoid water loss and to control vector breeding and water-related diseases.
- Training in water management, marketing and general crop production is important for new and old irrigation schemes.
- The economics of small-scale irrigation in the Awash Basin is not well understood. Farther economic evaluation of optimal plot size, cropping patterns, technologies, agronomic practices and resources utilized in the irrigation schemes is necessary
- Empowerment of local communities should be given due consideration since they are playing major role in irrigation development in the basin. Awareness of hygienic handling of water should be introduced.

- The NGO's who are involved in irrigation development should come up with a clear, transparent and completed handing over of up-graded or newly developed small-scale irrigation schemes to farmers.
- Rural credit systems should be in place for input supplies and low cost technologies acquirement, which are directly applied to the farm. It is necessary to provide farmers with inputs for the first season, so that they can build a cash flow base and start producing their own seed.
- Institutional support, monitoring and evaluation of irrigation schemes that is done at present by Woreda Irrigation Desk, woreda Agricultural Desk, Woreda Cooperative Development Desk, and NGOs should be enhanced in an organized way.
- It is necessary to plan agricultural water systems as a whole from drinking water to irrigation water supply. The different sectors should work together at national regional and local level and plan for integrated multi-purpose systems. This would reduce overall investments and contribute to welfare of rural populations.
- The establishment of a system of water user fees, which underwrite and reinforce the value of the resource and provide individual motivation for wise use and conservation, should be promoted.
- Training of the development agents and water user association officials is essential to building the local understanding, management capabilities and community responsiveness
- Salinity mitigation measures like selection of salt tolerance crops, leaching and drainage, pre-planting irrigation and seed placement techniques are recommended with a proper training of the technique to the farmers and development agents.

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Annex I

Tab. 1 Guidelines for interpretations of water quality for irrigation[1]

Potential Irrigation Problem				**Units**	**Degree of Restriction on Use**		
					None	**Slight to Moderate**	**Severe**
Salinity (affects crop water availability)[2]							
EC_w				dS/m	< 0.7	0.7 – 3.0	> 3.0
(or)							
TDS				mg/l	< 450	450 – 2000	> 2000
Infiltration (affects infiltration rate of water into the soil. Evaluate using EC_w and SAR together)[3]							
SAR	= 0 – 3	and EC_w	=		> 0.7	0.7 – 0.2	< 0.2
	= 3 – 6		=		> 1.2	1.2 – 0.3	< 0.3
	= 6 – 12		=		> 1.9	1.9 – 0.5	< 0.5
	= 12 – 20		=		> 2.9	2.9 – 1.3	< 1.3
	= 20 – 40		=		> 5.0	5.0 – 2.9	< 2.9
Specific Ion Toxicity (affects sensitive crops)							
	Sodium (Na)[4]						
	surface irrigation			SAR	< 3	3 – 9	> 9
	sprinkler irrigation			me/l	< 3	> 3	
	Chloride (Cl)[4]						
	surface irrigation			me/l	< 4	4 – 10	> 10
	sprinkler irrigation			me/l	< 3	> 3	
	Boron (B)[5]			mg/l	< 0.7	0.7 – 3.0	> 3.0
	Trace Elements (see Tab. 21)						
Miscellaneous Effects (affects susceptible crops)							
	Nitrogen (NO_3 - N)[6]			mg/l	< 5	5 – 30	> 30
	Bicarbonate (HCO_3)						
	(overhead sprinkling only)			me/l	< 1.5	1.5 – 8.5	> 8.5
	pH				Normal Range 6.5 – 8.4		

[1] Adapted from University of California Committee of Consultants 1974.

Annex II

Tab. 2 Laboratory determinations needed to evaluate common irrigation water quality problems

Water parameter	Symbol	Unit[1]	Usual range in irrigation water	
SALINITY				
Salt Content				
Electrical Conductivity	EC_w	dS/m	0 – 3	dS/m
(or)				
Total Dissolved Solids	TDS	mg/l	0 – 2000	mg/l
Cations and Anions				
Calcium	Ca^{++}	me/l	0 – 20	me/l
Magnesium	Mg^{++}	me/l	0 – 5	me/l
Sodium	Na^{+}	me/l	0 – 40	me/l
Carbonate	CO^{--}_3	me/l	0 – .1	me/l
Bicarbonate	HCO_3^{-}	me/l	0 – 10	me/l
Chloride	Cl^{-}	me/l	0 – 30	me/l
Sulphate	SO_4^{--}	me/l	0 – 20	me/l
NUTRIENTS[2]				
Nitrate-Nitrogen	NO_3-N	mg/l	0 – 10	mg/l
Ammonium-Nitrogen	NH_4-N	mg/l	0 – 5	mg/l
Phosphate-Phosphorus	PO_4-P	mg/l	0 – 2	mg/l
Potassium	K^{+}	mg/l	0 – 2	mg/l
MISCELLANEOUS				
Boron	B	mg/l	0 – 2	mg/l
Acid/Basicity	pH	1–14	6.0 – 8.5	
Sodium Adsorption Ratio[3]	SAR	(me/l)[1], [2]	0 – 15	

[1] Adapted from University of California Committee of Consultants 1974.

Annex III

Socio-economic and environmental impact assessment of community based small-scale irrigation in the Upper Awash basin

Household level Questionnaire

Questionnaire Number:____

Date of interview: Day: ___________ Month: _____________Year: ____________

Interviewed by ____

Date checked: Day: ___________ Month: _____________Year: ____________

Checked by: ____

Date entered: Day: ____________ Month: ______________Year: ____________

Entered by: ____

Section 1. General information

Woreda: _______________________________Code: ___________

PA: _______________________________Code: ___________

Scheme: _______________________________Code:___________

Household No: _______________________________

GPS coordinates of residence:

North: ____________ East: _____________ Altitude (m.a.s.l): ______________

Farmer's Name _________________________________ Age ___________________

Farmer's sex ________________Farmer's ethnicity_________________

Farmer's religion_____________________________

How long has the farmer lived in the village______________________

How long has the farmer practiced irrigation (years)__________________

1. Household Composition

1.1 Household composition, education and occupation**.** (Please fill in the codes given after the Tab.)

No	**Name**	**Sex**	**Age (Year)**	**Marital Status**	**Relationship to HH-head**	**Years of schooling**	**Major occupation**	
							Primary	**Secondary**

Variable code:

Sex 1=Male 2=Female

Marital status: 1=Single 2=Married 3=Divorced 4=Widowed 99=NA

Relationship to household head 1= Self 2=Husband 3=Wife 4=Daughter 5=Son 6=Grand child 7=Parent 8=Laborer 9=Sister 10=Brother 11=Step child 12=others

Years of schooling including adult schooling**:** 0=Illiterate 1=1st grade 2=2nd grade 3=3rd grade 4=4th grade etc. 17=Read and write 99=Children under age

Occupation**:** 1=Farmer 2=Trader 3=Housewife 4=Handy craft 5= Construction 6=Weaving 7=Blacksmith 8=Carpentry 9=Student 10=herding 11=Servant (maid) 12=Others (specify) 99=NA

1.2. Household Assets

1.2.1. Number of buildings owned by household: ___________________________

Building No.	Type of roof	Type of floor	Initial cost (Birr)	Year of construction	Present value (Birr)

1.2.2. Assets and investments:

Type of asset	Did you or any member of the household own any of these assets? 1=yes; 0 =no	How many do you have today?	What is the value of the assets today?	What was the value of these assets at time of purchase (Birr)
Ploughs				
Harrows				
Shovels				
Transportation equipment				
Draught animals				
Spike				
Hoe				
Water hose				
Watering can				
Pump (petrol/diesel)				
Knap-sack sprayer				
Bucket				
Borehole				
Others				

1.3. Land owned (allocated to household**)**

Land use	Code	Area	
		Timad/kert	ha
Homestead	1		
Rain fed cultivated	2		
Irrigable cultivated	3		
Fallow	4		
Private pasture	5		
Private tree planting	6		
Others	7		

1.4. Livestock owned**:** number and value owned during the year 2002/2003

Type of animal	**Code**	**Season**		**Remark**
		No	**Value (Birr)**	
Cattle				
Calf				
Young bull				
Heifer				
Cow				
Draft oxen				
Sheep				
Goat				
Horse				
Donkey				
Mule				
Poultry				

Calf = < 1 year, = < 6 months, young bull and heifer = **-**1 year, matured cattle = > 3 years,

1.5. Household Access to Infrastructure and Services

Indicate time taken one way (in minutes) from residence to nearest infrastructure and services

Access to nearest:	**Code**	**Time**		**Source (Select from the list below)**
		Walking	**Vehicle (if appl.)**	
Input supply shop				
Veterinary clinic				
Human clinic or health center				
Crop market				
Livestock market				
School				
Grain mill				
Others (specify)				

Source Code: 1=BOA, 2=Cooperatives, 3= private 4= shop, etc.

1.6. Water Supply

What is your primary source(s) for domestic water use during the wet and dry seasons?

Use	Season	Main water source 1=river 2=stream 3=borehole	How long is the water available (months)	Quality of water 1=good 2=bad 3=average)	How far away is this source of water in kms	How much time does it take to collect water from this source (one way)	How many times in a day do you go to collect water
Human	Wet						
	Dry						
Animal	Wet						
	Dry						

Section 2. Human, economic and social information

2.1. What are the main objectives of using irrigation? (Rank according to importance)

_______ 1=to generate cash income ______2= to produce food for the household ______ 3=produce livestock feed _____________ 4=Others_(specify)___________________

2.2. Did you participate in irrigation association activities? 1=yes, 0=no

2.3. If yes, what are the activities?

1=_______________________________________

2= _______________________________________

3= _______________________________________

99 = NA

2.4. If yes, who participate from the household_______

1=men, 2=women, 3=children , 99=NA

2.5. How many plots do you have? Irrigated plots_______ Non-irrigated plots _________

2.6. Provide the following information for each irrigated plots during 2002/2003:

Question	**Plot 1**	**Plot 2**	**Plot 3**
Approximate size of plot (kert/timad)			
Crop grown			
Distance of plot from house (km)			
For how many years did you use for irrigation			
Who owns the plot? 1=household, 2=share cropping, 3=rented 4=others			
If rented, amount paid (birr)			
Terms of rent 1=monthly, 2=quarterly, 3=yearly			
Have you ever faced flooding? 1=never, 2=occasionally, 3=every year			
How many months do you irrigate the plot in a year?			

2.7. Provide the following information for each non-irrigated plots during 2002/2003:

Question	**Plot 1**	**Plot 2**	**Plot 3**
Approximate size of plot (kert/timad)			
Crop grown			
Distance of plot from house (km)			
For how many years did you use for irrigation			
Who owns the plot? 1=household, 2=share cropping, 3=rented 4=others			
If rented, amount paid (Birr)			
Terms of rent 1=monthly, 2=quarterly, 3=yearly			
Have you ever faced flooding? 1=never, 2=occasionally, 3=every year			
How many months do you irrigate the plot in a year?			

2.8. Have you ever faced any human health problem due to using irrigation? 1=Yes 0=No

2.9. If yes, rank the problems according to importance

1= ________________________________

2= ________________________________

2.10 What are the most important investment activities you require in your community? (Rank according to importance)

1st= ____,

2nd= ____,

3rd= ____,

2.19 Did you produce enough for your household consumption from rain fed and irrigation during 1995/1996? 1=yes; 0=no

2.20 If no, how much of your household food requirement was met from 1995/1996 produce (months)? ____________

2.21 How do you fill the gap between your production and food need?
1= borrow food crops; 2=borrow money; 3= relief assistance; 4= engage in extra off-farm activities to generate income; 5=others, (specify)
____

2.22 Why do you prefer to grow such crops on irrigated plots? (Rank according to importance)

1st= ____

2nd=____

3rd=____

2.23 Are you planning to expand your irrigation activity? 0=no 1=yes

2.24 If yes, when?

1=this yea 2=next year 3=never

2.24 Rank the most important inhibiting factors on your irrigated crops?

	RANK
Water	
Land	
Labour	
Inputs	
Credit	
Marketing	
Crop damage due animals	
Theft	

2.25 What type of land is suitable for irrigation?

1=gentle slope 3=steep slope 5= do not know

2=flat land 4=any land 99=NA

2.26 What type of soil is suitable for irrigation?

1=heavy vertisol 2=light vertisol 3=any vertisol

4=any soil 5=do not know 99=NA

2.27 Have you ever faced any conflict with neighbouring farmers because of using irrigation?

0=no 1=Yes 99=NA

2.28 If yes, what were the problems or sources of the conflict? Rank

1st=____

2nd=____

3rd=_______________________________99=NA

2.29 If yes, what measures were taken to resolve the conflict?

1=____

2=____

3=_________________________________99=NA

2.30 If no measure was taken so far, what solutions do you suggest to resolve such conflicts?

1=____

2=____

3=___________________________________99=NA

2.31. Do you use pesticides for crop protection? 1=yes, 2=no

2.32. If yes, how do you store pesticides?

____

2.33. Do you have protective clothing when you spray pesticides? 1=yes, 2=no

2.34. If yes, describe____

2.35.Do you have ever faced animal disease problem due to using irrigation? 1=yes, 2=no

2.36 If yes, list all animal diseases you faced?

____

2.36**.** Land investment on irrigated plots

2.36.1 Indicate any land investments you have made on your irrigated plots by saying: 1=yes, 0=no

Plot	Stone terrace	Soil bund	Check dam	Drainage ditch	Well	Canal	Grass strip	Clearing stones	Planting trees	Fence	Others specify
Plot1											
Plot2											
Plot3											

2.36.2 If yes, estimate the extent and cost of investment.

Plot no	Investment Type	Labour input				Material input	
		Family		Hired			
		Man days	Birr	Man days	Birr	Type	Cost (Birr)

Section 3. Water management

3.1 What is your irrigation water source?____________________

1=well or borehole 2=stream/river 3=shallow dug-out

4=natural pool/pond 5=other (please specify): _____________________________

3.2 What is the approximate distance of main water source from centre of plot ?
(meter):_____________

3.3 What is the water conveyance method from source to field?

1= ____

2=____

3.4 What is he field application method?

____

3.5 What criteria should be used to decide when to water irrigated crops again?

1= wait until we see signs of wilting on the leaves,

2=check the soil near the roots (morning).

3=When it is dry, we irrigate,

4= irrigate every day

3.6 Does your access to water, limit the area that you cultivate in any part of the year?

0=no, 1=yes

3.7 If yes, indicate the reasons

1=____,

2=____

3= ____

3.8 Do you think your yield is reduced because you cannot apply enough water to your crop?

1=Yes 0=No

3.9 If yes, by how much (specify proportion in percentage) _____________

3.10 Do you use irrigation water for drinking as well?

1=Yes 0=No

3.11 Does the water amount affect your choice of irrigation crops?

1=Yes 0=No

3.12 If yes, which crops do you give priority to grow with irrigation when water is short (rank)

1st= ___________________

2nd=____________________

3rd=____________________

3.13 Do you have irrigation water users association?

0=No 1=Yes 99=NA

3.14 If yes, how was the association formed?

____

99=NA

3.15 Who makes decisions on the sequence of using irrigation water?

1= ____

2= ____

3.16 Do you make any payment for using water for irrigation 0=No 1=Yes

3.17 If yes, how much do you pay? (Birr)_______________

3.18 How do you pay? 1=per month, 2=per year , 3= per plot 4= other
(specify____________________________________

Section 4. Cropping information

4.1. Please list details for agricultural production during the 2002/2003 farming season for each plot

Plot no	Crop type	Plot area	Seed		Season	Irrigated? 1=yes, 0=no	Inputs						Amount harvested		Quantity consumed				Sales	
			Amount	cost (Birr)			Herbicide/pesticide		DAP		Urea		Grain (Kg)	Straw (Kg)	Grain		Straw		Grain Kg)	Straw Kg)
							Amount (kg)	Cost (Birr)	Amount (Kg)	Cost (Birr)	Amount (Kg)	Cost (Birr)			Kg	Cost (Birr)	Kg	Cost (Birr)		

Crop code list: 1=maize; 2=sorghum; 3=groundnuts; 4=soybeans; 5=teff; 6=cotton; 7=chickpea; 8=horse beans; 9=wheat; 10=rough pea; 11=cotton; 12=potato; 13=cabbage; 12=rape; 13=spinach; 14=tomato; 15=onion; 16=pumpkin; 17=carrot; 18=lettuce; 19=sugar cane, 20=others _______________

4.2. Labour input (hours) on plot basis in 2002/2003 for crop production. Plot no. _______________plot type _______

Labour source	Labour type	Field clearing	Ploughing before planting	Planting	Applying manure	Compo sting	Applying fertilizer	Watering	Weeding/h erbicides	Applying pesticide	Harvesting /heaping	Threshing/tra nsporting	Guarding	Other (spcify)
Family labour	Men													
	Women													
	Children													
Hired	Men													
	Women													
	Children													
Exchange labour	Men													
	Women													
	Children													

4.3. Animal power inputs per plot in 2002/2003, Plot no_______________ plot type _______

Source of animal power	Ploughing		Threshing	
	No of oxen days	No of times ploughed	No of oxen days	Number of other animal days
Owned				
Fixed leased				
Borrowed				
Exchanged				
Other (specify)				

4.4 Changes in perception about plot since started using irrigation Please use the codes given on the Tab. beneath

Year	Number of gullies on plot	Average width of gullies (m)	Erosion on plot	Soil depth	Change in soil depth	Soil colour	Soil texture	Soil fertility	Change in soil fertility	Water logging problem?	Salinity problem?	Stone cover

<u>Codes:</u>

Erosion Water-logging Salinity	**Soil depth**	**Change in soil depth**	**Colour**	**Texture**	**Soil fertility**	**Stone cover**
0=no problem	1=deep	1=decreased	1=black	1=clay	1=highly fertile	1=low (0-5%)
1=mild problem	2=medium	2=stayed the same	2=brown	2=loam	2=moderately fertile	2=medium (5-15%)
2=severe problem	3=shallow	3=increased	3=grey	3=sandy	3=infertile	3=high (15-40%)
4=do not know		99=can't tell	4=silt	4=silt		4=very high

4.5. Other sources of income in 1995/1996(include wife where possible)

Source	Code	Who earned	Income (Birr)
Non-farm employment		Men	
		Women	
		Children	
Farm work		Men	
		Women	
		Children	
Food aid (grant)		NA	
Remittance income from family members)		NA	
Hiring out oxen		NA	
Renting/sharecropping out land		NA	
Sale of firewood/charcoal		NA	
Sale of beverages		NA	
Petty trade (net profit)		NA	
Transport service		NA	
Others (specify)		NA	

Section 5. Market information

5.1. What is your most important source of prices information for your agricultural products during the 1995/1996 production year?

1= Radio, 2= Newspaper, 3= Traders at the market, 4=Traders who came to the farm, 5= Fellow farmers, 6=Extension officers, 7=Other sources

5.2 Where do you obtain most of your inputs?

1=Do not use, 2=Input market, 3=Trader at farmstead, 4=Out-growing arrangements, 5=Own retention, 6=Gifts, 7=Other (Specify)

6. Credit system

6.1 Did you use credit when you first started irrigated agriculture? 1= Yes, 0 =No

6.2. If yes, where did you obtain the credit?

1=bank 2= money lender 3=NGO 4=middleman
5=friend 6=relative 7=service cooperative 8=other_______________

6.3. Do you use credit now? 1=yes 0=no

6.4. If yes, where did you obtain the credit?

1=bank 2= money lender 3=NGO 4=middleman
5=friend 6=relative 7=service cooperative 8=other_______________

6.5 If no, Why did you not apply?

1= Not interested, 2= Bank is too far, 3= Interest rate is too high, 4= Defaulted on earlier loan 5= Do not have funds for down payment,

6= Other (Specify)______________________

6.6. What problems have been associated with obtaining credit

1=____

2=____

3=____

6.7 What was the purpose of the loan(s)?

1=Purchase of agricultural inputs, 2=Purchase of livestock, 3=Purchase of equipment, 4=Purchase house construction materials, 5=Other (Specify**)** ____________________

6.8 What kind(s) of collateral/security was required?

1=None, 2=Livestock , 3=House, 4=Group guarantee, 5=Land, 6=Other (Specify)_____________

6.9 Was/were the loan(s) received in cash or in kind?_______

1=Cash, 2=In kind, 3= Both cash and in kind

6.10.For the loan(s) received in cash, what was the total amount received (Birr)?______________________

6.11 For the loan(s) received in kind, what was the total amount received (Birr equivalent)?______________________

6.11 What was (were) the interest rate(s) on the loan(s) received in cash percent)?_______

6.12 For loan(s) received in cash, how much of the debt is still outstanding **B**irr)?_________

7. Agricultural extension services

Agricultural extension services: for each type of advice received, ask the following questions**:**

Type of advice (See code list)	Did you receive any advice of this type during the 1995/1996 seasons? 1=yes; 0=no	What was the most important source of such advice?	How often did you receive advice from this source?	Did you use any of the advice during the last agricultural season? 1=yes; 0=no	If no, Why didn't you use the advice?	Would you like to receive more advice of this type 1=yes; 0=no

Type of advice

1=crop husbandry
2=crop diversification
3=animal husbandry
4=marketing
5=credit
6=conservation farming
7=fruits and vegetables
8=irrigation
9=fish farming
10=household food security
11=farm management
12=farm power
13=post harvest processing
14=storage of farm produce

Source of advice

1=extension officer
2=farmer group
3=field days
4=radio
5=publications
6=marketing agents
7=NGO
8=fellow farmer
9=other specify-----

Frequency of advice receive

1=once a week
2=once a month
3=2 to 3 times a month
4=once in 3 months
5=once a season

Reason for not using the advice

1=irrelevant
2=lack of funds
3=lack of inputs
4=others specify--

THANK YOU VERY MUCH FOR YOUR TIME

TIME TAKEN -----------------------

Annex IV

Socio-economic and environmental impact assessment of small-scale irrigation in the upper awash basin

Peasant Association Level Questionnaire

Questionnaire Number: ____

Date of interview: Day: ___________ Month: ___________ Year: ______________

Interviewed by ____

Date checked: Day: ____________ Month: ___________ Year: ______________

Checked by:____

Date entered: Day: ____________ Month: ___________ Year: ______________

Entered by: ____

Woreda: ______________ Code: __________

PA: ____________________________ Code: __________

Scheme ____________________________ code :__________

PA level survey

1. Reference point in the PA (For example church, school, clinic, etc.- include name):

   Reference point: _________________________________

   GPS coordinates of PA: North: _____________ East: __________
   Altitude (m.a.s.l.): _________

2. Distance and travel time from PA to the woreda town: (indicate the distance and the time to travel from the PA to the woreda town)

	Walking	Pack animals	Vehicle (if applicable)
Distance (Km):	______	__________	_________________
Travel time (minutes)	_____________	______________	______________

3. Distance and travel time from PA to the nearest all weather road.

	Walking	Pack animals	Vehicle .(if applicable)
Distance (Km):	______	__________	_________________
Travel time (minutes)	___________	_____________	_____________

4. Population in the PA:

Description	Population of the PA	Population of the water users association	No. of household Units	Average household size
Male				
Female				
Total				

5. Livestock population in the PA 2002/2003

Livestock types	Cow	Heifer	Calves	Oxen	Bulls	Sheep	Goats	Camels	Donkeys	Mules	Others (specific)
Number											

6. Major Soil types: using the local classification, indicate the major soil types in PA based on abundance.

Soil Type rank	Soil Type	Soil Class	Code
1st			
2nd			
3rd			
4th			

7. Land use: Please give estimated size of area coverage in ha

Land use	Cultivated rain fed	Cultivated irrigated	Homestead	Grazing area	Forest/ Woodlot	Area enclosure	Settlements	Waste land	Other (specify)
Code									
Estimated size (ha)									

9. Land use by crop cultivated in 2003

Description	Price in year		
	1994	1995	1996
DAP (Birr/qt)			
Urea (Birr/qt)			
Pesticide (Birr/lt)			
Herbicide Birr/lt			
Electric charge			
Fuel cost			
Other costs			

10. Input price assessment (Birr)

Crop Type	Irrigated (ha)	Rain fed (ha)	Total size (ha)

11. Seed price assessment (Birr/kg)

Seed type	Price in year		
	1994	1995	1996
Irrigated crops			
Onion			
Cabbage			
Potato			
Garlic			
Red beet			
Carrot			
Soybean			
Paper			
Others			
Rain fed			
Wheat			
Maize			
Teff			
Chick pea			
Others			

12. Feed price assessment

Year	Feed Type					
	Green maize Stover	Dry maize Stover	Teff straw	Bran	Oil seed cakes	Others (specify)
1994						
1995						
1996						

13. What are the major holidays when farmers in your PA do not carry out farm activities by month? Indicate in days.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of days												

14. What is the proportion (%) of different religions of the population in the PA?

Religion	Code	Proportion (%)
Muslim		
Orthodox		
Protestant		
Others		

15. What major natural calamities occurred in your PA in the last three years?

16.What are the prevalent problems encountered in irrigation development?

1=____

2=____

3=____

17. What are health problems previously unknown in the community?

1=____

2=____

3=____

18. What are animal diseases observed in the PA?

1=____

2=____

3=____

19. Is there water lose during transport? 1=Yes, 2=no

20. What are the problems in canal maintenance?

1=____

2=____

3=____

21. What are the human diseases that are caused because of irrigation? (Rank)

1=malaria, __________

2= schistosomiasis , _______

3= diarrhea, _______

4=typhoid, _______

5=worms, _______

6=others (specify)_______________-

22. What are the animal diseases that are caused because of irrigation?

1=____,

2=____

3=____

23. What is the impact of using water for irrigation on the down stream?

1=____

2=____

3=____

24. Do you think the up stream people will be affected by dam construction?

1=yes, 0=no

25. If yes, how are they affected?

1=____

2=____

3=____

26. Do you have communal grazing lands? 1=yes, 0= no

27. What are the problems encountered in marketing products?

1=____

2=____

3=____

28. How old is the irrigation scheme in y=our PA? __________________________

29. What type of delivery system is used from the source?

____

30. How is the management and operation of the scheme undertaken?

____

31. Who is responsible for the diversion weir and ditches maintainase?

____

32. Which institutes are involved in the irrigation scheme?

1=____

2=____

3=____

33. What are the major problems encountered by farmers on this scheme?

1=____

2=____

3=____

34. What are the major problems of the upstream farmers?

1=____

2=____

3=____

35. What are the major problems of the downstream farmers?

1=____

2=____

3=____

36. What are the major benefits of irrigation for your community?

1=____

2=____

3=____

DECLARATION

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

Name: Wagnew Ayalneh

Signature: ....

This thesis has been submitted for examination with our approval as university advisors.

Name	Signature
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Dr. Berhanu Gebremedhin	....
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