

# Best practices and technologies for small scale agricultural water management in Ethiopia

Proceedings of a MoARD/MoWR/USAID/IWMI symposium and exhibition held at Ghion Hotel, Addis Ababa, Ethiopia 7-9 March, 2006





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editors

Awulachew, S. B.; Menker, M.; Abesha, D.; Atnafe, T.; Wondimkun, Y.



Ethiopian Ministry of Water Resources  
P.O.Box 5673, Addis Ababa, Ethiopia



Ethiopian Ministry of Agriculture and Rural Development.  
P.O.Box 62347, Addis Ababa, Ethiopia



United States Agency for International Development  
P.O.Box 20523 Washington, D.C., United States



International Water Management Institute  
P.O.Box 2075, Colombo, Sri Lanka

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MoARD-MoWR-USAID-IWMI symposium and exhibition on best practices and technologies for small scale agricultural water management in Ethiopia, 7-9 March 2006



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## Acronyms and Abbreviations

AAU	Addis Ababa University
ADB	African Development Bank
ADLI	Agricultural Development Led Industrialization
ARARI	Amhara Region Agricultural Research Institute
ARBoA	Amhara Region Bureau of Agriculture
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BoARD	Bureau of Agriculture and Rural Development
BoWRD	Bureau of Water Resource Development
Co-SAERAR	Commission for Sustainable Agriculture and Environmental Rehabilitation in Amhara Region
DECSI	Dedebit Credit and Saving Institution
EIAR	Ethiopian Institute of Agricultural Research
ERHA	Ethiopian Rainwater Association
ESA	Eastern and Southern Africa
ESAT	Ethiopian Society for Appropriate Technology
ESSS	Ethiopian Society of Soil Science
ESTA	Ethiopian Science and Technology Agency
EWRMP	Ethiopian Water Resource Management Policy
EWSS	Ethiopian Water Sector Strategy
FAO	Food and Agriculture Organization of the United Nations
GTZ	German Technical Cooperation
IDE	International Development Enterprise
ILRI	International Livestock Research Institute
IPTRID	International Program for Technology and Research in Irrigation and Drainage
IWMI	International Water Management Institute
KGVDP	Kobo Girana Valley Development Program
MDGs	Millennium Development Goals
MI	Micro Irrigation
MoARD	Ministry of Agriculture and Rural Development
MoWR	Ministry of Water Resources
ORDA	Organization for Rehabilitation and Development in Amhara Region
PRISM	Poverty Reduction through Irrigation and Smallholder Markets
REST	Relief Society of Tigray
RWH	Rain Water Harvesting
SSA	Sub-Saharan Africa
SSI	Small Scale Irrigation

## Acronyms and Abbreviations

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SUN	Sustainable Utilization of Natural Resources for Improved food security program in Tigray
SWHISA	Sustainable Water Harvesting and Institutional Strengthening in Amhara region
SWMnet	Soil and Water Management Network
UNDP	United Nations Development Program
UNECA	United Nations Economic Commission for Africa
USAID	United States Agency for International Development
WUAs	Water Users Associations

## **Acknowledgement**

This proceeding is the result of a three day symposium and exhibition jointly organized by Ministry of Agricultural and Rural Development (MoARD), Ministry of Water Resources (MoWR), United States Agency for International Development (USAID) and International Water Management Institute (IWMI). The financial grant is provided by USAID to IWMI not only to do this work but also for follow up activities related to the output of the symposium recommendations



# Welcome address

## Seleshi B. Awulachew

Head for East Africa and Nile Basin,  
International Water Management Institute (IWMI)

Your Excellency Ato Yacob Yala, State Minister of Ministry of Agriculture and Rural Development  
Your Excellency Mr. William Hammink, Director of USAID in Ethiopia

Dear Participants of the symposium and ladies and gentlemen  
Ladies and Gentlemen:

Allow me to welcome you all to the symposium and exhibition titled **“Best Practices and Technologies for Agricultural Water Management in Ethiopia”**, on behalf of the symposium organizing committee and on behalf of International Water Management Institute.

Allow me also please to provide a background reason why this symposium is organized and to introduce the program

As you all well know, Ethiopia is a country with land area of over 1.1 million km<sup>2</sup> and it is the second most populous country in sub-Saharan Africa (SSA) (and third on the continent of Africa) with estimated population approaching 80 million people. The population growth is estimated at about 2.8% and this then doubles the population almost every quarter of a century. This is a primary challenge that needs to be properly addressed with equivalent economic growth

Majority of the population earn their living from agriculture and most of them are poor. The main economy of Ethiopia dependent on Agriculture, which is mainly dependent on rain fed system, under highly variable rainfall conditions, with progressive degrading natural resources base.

The wider poverty vicious cycle of Ethiopia takes dimensions of population growth → extending agriculture and livestock into less and less favorable land, deforestation to obtain more agricultural land and more energy to meet demand → land and water degradation → damage to ecosystem, poor productivity, food insecurity → increasing poverty → poor health, malnutrition → inability to invest in maintaining or improving (land, water, labour) productivity → further population growth, degradation and deepening poverty. This is a poverty vicious cycle further aggravated by shocks such as war, drought, etc.

How do we break the vicious cycle in to virtuous cycle is a real challenge.

The dominant agricultural system in Ethiopia is small-holder mixed production of cereals and livestock. This dominant small holder agriculture system of Ethiopia is not significantly benefiting from the technologies of water management and irrigation that could significantly reduce the vulnerability of the agricultural system to climatic variability, improve agricultural productivity which could have been a useful entry point to break the vicious cycle. I would say conscious management of agricultural water in wider sense is just beginning.

Majority of the rural dwellers in the country are the ones who are the poorest, with limited access to agricultural technology, limited possibility to diversify agricultural production, having underdeveloped rural infrastructure, and weak access (sometimes lack of access) to agricultural markets and to technological innovations. These issues combined with increasing degradation of the natural resource base, especially in highlands, aggravate the incidence of poverty and food insecurity in rural areas.

The adoption of sustainable water management and irrigation development with strong linkage to private sector and markets together with the necessary institutions and other support condition could provide ample opportunities in terms of coping strategy against climatic externalities. They could enable poverty reduction, wealth creation, growth of economy and reducing the environmental impact of agricultural expansion to marginal land under the rapid population growth. There are considerable experiences within the country, in the region and in the world that could be adapted and replicable to enable usage of appropriate technologies to overcome the stated challenges, fight poverty, protect the livelihood and bring about the desired growth and wealth creation in Ethiopia. In line with these, the United States Agency for International Development (USAID), The Ministry of Agriculture and Rural Development (MoARD) and The Ministry of Water Resources (MoWR) of Ethiopia and International Water Management Institute (IWMI), have initiated and organized these three days joint symposium and exhibition program.

The program addresses key questions such as: what is the reason for limited technology access in terms of agricultural water management? Why promising technologies have not scaled up? What can be done for scaling up? What are the policies and institutional support conditions needing attention for scaling up? How does the private sector strongly involve in the sub-sector? What are the best implementation strategies?

Based on these key questions, the objectives of the symposium are:

- To bring together and share experiences among farmers, government (policy makers, technical experts), NGOs, private sector (small holder and commercial farmers, producers/distributors of technologies for water management and irrigation), international donors and financial institutions and related stake holders that are working around small scale irrigation (SSI), rain water harvesting (RWH) and micro irrigation (MI) technologies;
- To review past and current practice of rain water harvesting, micro irrigation and small scale irrigation technology usage in Ethiopia;
- To carry out focused discussion to explore opportunities and mechanisms through which the uptake of knowledge, application, dissemination and out scaling of SSI, MI and RWH technologies could be enhanced.

The symposium and exhibition themes are subdivided in to:

- Assessment of current practices of small scale –agricultural water management and -irrigation development in Ethiopia
- State of the art and best technologies review in RWH, SSI and MI
- Private sector participation in irrigation development, technologies and equipment development, irrigation management, service provision and agro processing
- Policies and institutional support conditions for small scale irrigation in Ethiopia

The expected outputs of the symposium include:

- Understanding the existing status of SSI, RWH and MI technologies usage, manufacturing, supply/import in the country
- Publishing and documenting resulting information including web document providing information on the best technologies, existing policies, support conditions, constraints and opportunities for up- and out-scaling.
- Information on knowledge gap, framework for future further action research, and priority research and development questions
- Initiation of the private and public sector for active engagement in the sector.

Accordingly, the three days program include (as you may also see it in your program):

- Opening remarks by guest of honors to be followed by
- This morning presentations and discussions on “Assessment of Current Practices of AWM Technologies”

- After having lunch, in the afternoon at 2:00pm we will have the opening of exhibition, and visit through out the afternoon
- In the evening, at 6:00pm we will have cocktail reception for all participants
- Tomorrow we will continue with presentation and discussion on the remaining three major themes
- Towards the end of the day we will formulate groups for group discussions
- On the third day, we will focus on group discussion around three major topics that include technology options, private sector role and policies and institutions
- The discussion groups will present their findings and recommendation on plenary and way forward will be summarized towards the end of the third day. Specifics on the topics of the presentations and discussion topics are provided in the program.

According to our program, I now call H.E. Mr. William Hammink to provide us an opening remark.

Thank you very much.

# About the Symposium and Exhibition

## 1.1 Background

Ethiopia is one of the largest countries in Africa. Covering a land area of 1.13 million km<sup>2</sup>, it is the second most populous country in sub-Saharan Africa (SSA) (and third on the continent) approaching 80 million people. The population has been increasing by about 2.9 % per annum. Population density, and hence population pressure on resources, varies from region to region. Eighty-five percent of the population is rural. The incidence of poverty in the rural areas is higher than in urban areas, 47% and 33% respectively. About 49% of the total population is considered 'under-nourished'. Fifteen to twenty percent of the rural households are female-headed. Average annual per capita income is around 110 USD.

Agriculture is the most dominant economic sector in Ethiopian economy. Most agricultural production in the country is rain fed under highly variable rainfall conditions. There is also progressive degradation of the natural resource base, especially in densely populated and highly vulnerable areas of the highlands, which aggravates the incidence of poverty and food insecurity in these areas. The wider poverty vicious cycle of Ethiopia takes dimensions of population growth → extending agriculture and livestock into less and less favorable land, deforestation to obtain more agricultural land and more energy to meet demand → land and water degradation → damage to ecosystem, poor productivity, food insecurity → deepening poverty → poor health, malnutrition → inability to invest in maintaining or improving (land, water, labour) productivity → further population growth, degradation and deepening poverty. How to reverse this vicious cycle in to virtuous cycle needs a number of measures through good understanding of the most detrimental factors against the most important economic sector.

The Millennium Development Goals (MDGs) pledge, among others, to reduce the number of chronically hungry people by half by 2015. Achieving this goal is a major challenge and requires substantial investment in the smallholder agricultural sector, which is the key occupation for the majority of the poor people in Ethiopia. The country imports about 15% of its food mostly through aid. The government has designed a comprehensive food security strategy that targets the chronically food insecure especially in highly vulnerable areas: marginal and semi-arid areas that are largely moisture deficient, including pastoral areas, with high population pressure.

Ethiopia covers 12 river basins with an annual runoff volume of 122 billion m<sup>3</sup> of water with an estimated 2.6 billion m<sup>3</sup> of ground water potential. This amounts to 1530 m<sup>3</sup> of water per person per year: a relatively large volume. But due to lack of water storage capacity and large spatial and temporal variations in rainfall, there is not enough water for most farmers to produce more than one crop per year with frequent crop failures due to dry spells and droughts. Moreover, there is significant erosion, reducing the productivity of farmland.

There is an endless variability of ways in which water is obtained and used in Ethiopia. These can be categorized for example based on production type as domestic, livestock, rainfed agriculture, supplementary irrigation, and irrigated agriculture of small, medium and large scale.

Considering the agricultural sector, there are four major categories of productive use of water in agriculture: (1) 'rainfed agriculture', (2) 'supplementary irrigation', (3) 'irrigated agriculture', and (4) 'livestock'. Improving water management for agriculture could improve agricultural productivity quite substantially in all the four components. Improving water management in turn requires appropriate adoption and up scaling of technologies and need to establish the necessary market and entrepreneurship for forward and backward linkage, manufacturing and processing of the produces of both technology and agriculture.

In addition to the national agricultural sector led development strategy, there is a water policy for water resources management and a strategy for water resources development. The sub sector policy towards irrigation is to develop the huge irrigated potential for the production of food crops and raw materials needed for agro-industries, on efficient and sustainable basis and without degrading the fertility of the production fields and water resources base. The strategy deals with expansion of irrigated agriculture, water use and production efficiency, sustainable irrigation development and address pertinent problems related to irrigation such as water logging, salinity, etc. Accordingly, the irrigation sector development program stipulates to develop additional 274,612 hectares of land by 2016. According to the current plan and on going projects, this target is exceeded by two fold. Despite these efforts and achievements, it is essential to further upscale the endeavors around this development.

With in the strategies and plans, as explained in above, it is important to consider the entire aspects of agricultural water management including improving agricultural productivity in the rainfed crop, livestock and irrigation sub sectors. It is paramount to tap in to the opportunities that can be obtained from rain water harvesting, surface water and ground watersources for securing production and protecting livelihood. Furthermore, the experiences of use and adoption of rain water harvesting, small scale irrigation and micro irrigation technologies are mixed. The participation of the private sector in the technology generation, manufacturing and usage is limited. The existing policies, institutional arrangement and support conditions need to be understood by various stakeholders.

It is therefore necessary to bring together all the stake holders who are involved in policy and decision making, technology and knowledge generation, knowledge brokering, manufacturing, trading, use of technologies, etc to discuss, exchange knowledge and seek mechanisms through which the technologies could be accessed and the uptakes could be enhanced. The symposium and exhibition event have been therefore geared towards creating the necessary platform to achieve objects pertinent to the above concepts and explained further below.

### **1.2 Aims and descriptions of the symposium and exhibition**

The Federal Ministry of Agriculture and Rural Development (MoARD) of Ethiopia, The Federal Ministry of Water Resources (MoWR) of Ethiopia, The US-Agency for International Development (USAID) and The International Water Management Institute (IWMI) had organized a three days national symposium and exhibition on the title of “*Best Practices and Technologies for Agricultural Water Management in Ethiopia*”. The event took place during March 7<sup>th</sup> -9<sup>th</sup>, 2006 at Ghion Hotel in Addis Ababa.

The objectives of the symposium have been:

- Bring together and share experiences among government (policy makers, technical experts), NGOs, private sector (small holder and commercial farmers, producers/distributors of irrigation equipment), international donors and financial institutions and related stake holders that are working around small scale irrigation (SSI), rain water harvesting (RWH) and micro irrigation (MI) technologies;
- Review past and current practice of rain water harvesting, micro irrigation and small scale irrigation technology usage in Ethiopia;
- Carry out focused discussion to explore opportunities and mechanisms through which the uptake of knowledge, application, and dissemination and out scaling of SSI, MI and RWH technologies could be enhanced.

The main themes of the symposium and exhibition were designed on:

1. *Assessment of current practices of small scale –agricultural water management and -irrigation development in Ethiopia* focusing on assessment on usage of irrigation in Ethiopia; constraints and problems related to irrigation in Ethiopia with focus on SSI, RWH and MI; review of impacts and impediments for uptake and up scaling of technologies in Ethiopia; assessment of impact of irrigation on poverty alleviation, wealth creation and growth of economy
2. *State of the art and best technologies review in RWH, SSI and MI* focusing on recent technologies available for agricultural water management and irrigation in Ethiopia and elsewhere; who are using them? How wide is the distribution? And what need to be done to improve availability? the types of traditional technologies used in Ethiopia; research and piloting, testing, validation and demonstration of technologies; case studies of privately owned irrigation systems using micro irrigation and small scale irrigation technologies
3. *Private sector participation in irrigation development, technologies and equipment development, irrigation management, service provision and agro processing* with emphasis on accessibility and constraints in producing and manufacturing the technologies; case studies of privately owned irrigation technology on import, distribution and manufacturing; the business opportunities and constraints need to be addressed for effective participation of private sector, farmers and farmers groups, cooperatives in irrigation and water management technologies
4. *Policies and institutional and support conditions for small scale irrigation in Ethiopia* with focus on policies related to irrigation and agricultural water management in Ethiopia; institutional and support conditions for agricultural water management; market and market network on small scale irrigation technologies; organizational issues, know how and leadership.

The symposium was attended by federal government institutions, bureaus of the various regions, farmers, the private sector, donors, embassies, UN agencies, international institutions, NGOs, experts outside Ethiopia and the media and press agencies. In total about 130 participants attended the symposium and exhibition.

The symposium and exhibition were addressed by H.E. Mr. William Hamink, USAID Director and officially opened by H.E. Ato Yacob Yalla, State Minister of MoARD. The exhibition was officially opened and the three days event also closed by H.E. Ato Aduana Jebessa.

# Opening address

## **H.E. William Hammink**

USAID Country Director

H.E. Ato Yacob Yalla, State Minister of Agriculture and Rural Development

H.E. Ato Adugna Jebessa, State Minister of Water Resources

Representatives of government agencies, the private sector, financial institutions, non-governmental organizations, international donors and agricultural producers

Ladies and Gentlemen

It is a great pleasure for me as Mission Director of the United States Agency for International Development in Ethiopia to welcome you to this important national symposium/Exhibition where we will discuss a critical issue that could lead to transformational change of Ethiopia's agricultural sector -- irrigation and water management!!

The three day national symposium and exhibition on "Best Practices and Technologies for Agricultural Water Management in Ethiopia" is organized and hosted by the Federal Ministry of Agriculture and Rural development, the Federal Ministry of Water Resources, the International Water management Institute, and The United States Agency for International Development.

The focus of this event is on best technologies and practices for water harvesting, and micro and small-scale irrigation, along with what is required to accelerate the adoption and scaling up of these technologies and practices.

This symposium will bring together the government, NGOs, Private sector, international donors and financial institutions and related stakeholders that are working with small-scale irrigation, rain water harvesting and micro irrigation technologies.

The dominant agricultural system in Ethiopia is small holder farmers providing a mixed production of cereals and livestock under rain-fed conditions.

The degradation of the natural resource base, high population pressure and low level of productivity aggravates the incidence of poverty and food insecurity in most parts of the country.

The small holder agriculture system of Ethiopia is not significantly benefiting from the technologies of water management and irrigation that could significantly reduce the vulnerability of the agricultural system to climatic variability and improve agricultural productivity.

The adoption of sustainable water management and irrigation development could provide ample opportunities in terms of coping strategy, poverty reduction, wealth creation, and growth of the economy.

There are government policies and strategies developed to address most of the problems related to water sector development in Ethiopia.

During this symposium there will be a review of past and current practices of rain water harvesting and small scale irrigation technology used in Ethiopia. Information sharing on the best technologies,



existing policies, support conditions. Constraints and opportunities for accelerating the adoption of best technologies and practices will also be discussed. The discussions will also be significant in identifying and promoting technologies necessary to assist small holder farmers in improving the quality of their lives and in the long run have an impact on the incidence of poverty and food insecurity in Ethiopia.

Given the critical importance of irrigation and water management to achieving Ethiopia's food security, poverty alleviation and economic growth goals, development of an action plan that could serve as a framework for coordinated government, multi-donor and private sector investments and the interventions of other stakeholders should be encouraged.

I look forward to hearing the outcome of the discussions during the symposium

# Opening address

## **H.E. Yacob Yala**

Minister for Ministry of Agriculture and Rural Development

Excellencies,  
Ladies & Gentlemen

It is indeed a great pleasure for me to address this august gathering. I believe that this symposium will provide a platform for participants to understand existing status of small-scale irrigation, identify information on knowledge gap and design strategies for further research and development actions. Allow me once again to take this opportunity to welcome you all to this timely and important symposium.

Excellencies,

Ladies and Gentlemen

Ethiopia has been facing adverse environmental challenges and drought accompanied by famine for more than three decades. The occurrence of drought at increasing shorter intervals resulting in famine, massive starvation and displacement of people has become pronounced and a concern for the nation and the government since the last few decades.

The cumulative effect of drought has resulted in hampering the socio-economic development of the country and thereby leading to widespread poverty and destitution. Hence, the Government of the Federal Democratic Republic of Ethiopia has developed commendable policies, strategies and programs to reverse the situation.

The present challenges of drought, declining agricultural production and the ever increasing population pressure call for turning attention to improved water resources management and small-scale irrigation development to sustain food production at household level in the country.

Excellencies,

Ladies and Gentlemen

Ethiopia has abundant water resources. But these resources have never adequately contributed to the economic and social goal of the nation's population.

Cognizant of this, the Ethiopian Government has developed National Water Sector policy which is an essential overriding policy document for the development and management of the nation's water resources.

Similarly in the realization of the attainment of food security objectives, the Ethiopian Government has committed itself to the promotion of different types of conservation - based rain water harvesting technologies both at household and community level. The primary focus is mitigating water shortages for enhancement of agricultural productivity, which is to be achieved through watershed - based small scale irrigation program. This program is directed at harvesting rainwater, developing springs, and shallow wells and other important soil- storage rainwater harvesting

technologies. Moreover, the exploitation of other sources of water through river diversion, uplifting ground water at small and large scale is also underway.

Excellencies,

Ladies and Gentlemen,

The Government recognizes the important role of water as a catalytic agent of development of agriculture and protection of ecosystems for the ultimate development of Ethiopia's people. Thus, the themes of the symposium are in line with the spirit of the Government's policy, strategies, programs to address poverty reduction in general and food security in particular. It is precisely for this reason that we say this symposium is timely and important in terms of contributing towards the ongoing efforts of water - centered development intervention.

It is, therefore, with a deep satisfaction that I wish to reiterate our appreciation to all those who have been involved in this process.

May I also take this opportunity to express my personal gratitude to the initiators of this symposium namely the United States Agency for International Development (USAID), and International Water Management Institute (IWMI) who were assisted by the Ministry of Agriculture & Rural Development and Ministry of Water Resources.

I believe that they have done a good job in being at a forefront in facilitating this consultative symposium as well as in bringing together all concerned stakeholders to discuss on this timely agenda.

Wishing you success in your deliberations and discussions, I declare that this symposium is officially open.

Thank you



**Assessment of current practices of small scale  
agricultural water management and  
irrigation development in Ethiopia**



# Current Experience on Existing Small Scale Irrigations

Yalew Belete

MoARD

## Abstract

Ethiopia, with an income level and standard of living of the lowest in sub-Saharan Africa, is characterized by wide spread poverty. Agriculture which employs 85% of population is based on rain fed. The agricultural sector is facing severe failures among others due to inadequate rainfall management and drought. Drought is a recurrent phenomenon in the country and recent estimation indicates that on average five up to seven million people are in need of food assistance every year.

On the contrary, the country has a considerable potential of 110-120 billion cubic meter of surface water and 2.6 billion cubic meter of ground water as well as 3.5-4.25 million hectare of irrigable land. Irrespective of this potential and challenging problem very small amount of this is tapped for irrigation.

Recognizing the huge untapped surface resources there has always been attempts to develop these resources since 1960s. After the 1984 drought enormous pressure has been exerted to expand irrigation projects for the sake of coping up with drought and hunger problems.

Currently, in response to the recurrent drought situation the government focused on water centered development with special attention to water harvesting and small scale irrigation schemes.

In spite of previous and ongoing efforts to increase the irrigated area, only about 477 schemes with estimated command areas of about 52,000 hectares have been completed and commissioned to the beneficiaries and successes with these new schemes have been counteracted by poor performance and decline on existing schemes due to among others poor participatory planning and implementation processes, poor design and construction quality, and insufficient attention to O& M.

According to the data obtained from regions, only 361(75%) schemes are fully operational,

the rest of the schemes are either non-functional/abandoned or partially functional. Hence, the productivity and sustainability of the schemes is very low.

This paper, therefore, introduces the existing experiences on planning, construction, operation, maintenance and management of small-scale irrigation schemes. Furthermore, it highlights the functional or utilization status of existing SSI schemes. Finally, the paper also tries to deal with challenges and constraints in small scale irrigation development and discusses key issues and recommendations for the development of the sub-sector.

## 1. Introduction

Agriculture is the dominant sector of the Ethiopian economy and its performance has the major share of the over all GDP growth rate. On average, the sector contributed to 48% of the Ethiopia's GDP between 1995 and 2001. The agriculture sector accounts 90% of the export earning, 70% of raw material inflow into agro-based industries and as a major employer accounting for 85% of the total employment. From this, the crop sub sector accounts 60%, livestock 30% and forestry 10%. However, recent survey data shows that around half of the country's rural population is chronically food insecure.

On the other hand, the country has 110- 122 billion m<sup>3</sup> of annual runoff and ground water potential of about 2.6 billion m<sup>3</sup>. The irrigation potential is also estimated about 3.5-4.25 million hectares. Irrespective of these potentials and the above-mentioned food insecurity gap only a small percent of the potential is currently tapped for irrigation.

Furthermore, drought is a recurrent phenomenon in the country. Recent estimation



indicates that five up to seven million people are in need of food assistance every year.

To overcome the effects of drought and land degradation and thereby improve food insecurity, there is a growing interest in the promotion of water-centered development among which Small-Scale Irrigation and Rainwater Harvesting are the main interventions.

## 2. Existing Experience on Traditional Irrigation Schemes

Schemes initiated, planned, and implemented by beneficiaries themselves with minimum or no technical and financial support from external bodies are known as traditional irrigation schemes. These schemes do not have study and design reports. Most of them are river diversions and surface irrigations (Furrow or free flooding).

The initiation of traditional irrigation schemes development takes centuries back, which is difficult to trace exactly. What is clear is beneficiaries of many traditional schemes trace that they got inherited them from their forefathers. Of course recently the recurrence of drought in the country has increased and intensified the development of these traditional irrigation schemes. Now a days traditional irrigation schemes are common all over Ethiopia.

Traditional irrigation schemes have the advantages of:

- Beneficiaries ownership of the physical infrastructure and the social organizations
- Well known and accepted managing organizations and leaders
- Independence of external support for sustainability
- Labor intensive, but not capital intensive.

However, traditional irrigation schemes suffer from the following limitations:

- Frequent rebuilding of head works, gully crossings and canals requires large amount of labor & risk of injury or even death every year;
- Very low conveyance efficiency because head works and canals leak significantly;
- Inability to cross wide gullies
- No irrigation water regulatory and distribution structures;
- Erosion of canals on command areas;
- Don't have study & design reports and difficult to trace back their history
- Limited command area due to inefficient diversion and very low irrigation efficiencies

To develop these schemes farmers organize themselves into associations. With the recognition of Kebele Officials, beneficiary farmers start to construct traditional irrigations schemes, and there was no technical as well as financial input from outside. Materials used for construction of headwork are fully local. Namely-stone, soil and wood.

The schemes range in size from less than 20ha - 100 ha. The farm size of these schemes per family head varies from 0.25 to 0.5 ha. The beneficiaries of these schemes are well organized and effectively operate their schemes. The organizations of beneficiaries (water users) are long existed to manage these traditional schemes. It is those farmers, who know and respect each other very well, form these associations and are committed to cooperate and achieve their common goal. Such typical associations comprise up to 200 user members.

Some of these traditional irrigation schemes are hundreds of years old. This indicates that such long lasting has given them good experience to manage their schemes. Irrespective of this experience, during rainy season since their abstraction is made up of weak soil, stone and wood it can't tolerate the maximum flood coming. Therefore, the flood always takes their diversion weir away during rainy season. Because of this they construct new earthen weir every year.

Since most of these schemes are long lasting, most of the areas of these schemes are covered

by permanent crops like coffee, sugar cane, banana, chat etc

On traditional irrigation schemes, supervision of water distribution is carried out by the leaders of their association (usually called father of water). In fact, each association is categorized into groups for maintenance of the scheme as well as water distribution. Based on this, each group is scheduled as to when to irrigate. Irrespective of the area and type of crop irrigated, time allocated is similar.

The members of traditional irrigation schemes' associations don't have conflict on water, what usually occurs are the upstream and down stream users' conflict between different associations. On their farms there is no structure in which flow is controlled as well as distributed. Because of this their canals get eroded usually. This is the case where traditional irrigations are well established. There are also some traditional irrigation schemes, which are temporary. That is to say, they are working in some years and not in others.

Head work and canal maintenance of traditional irrigation schemes is usually carried out once at the beginning of the year. Additional maintenance within the year is not commonly practiced

In almost all traditional irrigation schemes, farmers carry out all operation and maintenance as well as organization and management. They get little support from development agents.

According to the data obtained from regions, farmers on average develop more than 1200 traditional irrigation schemes with a command area of about 280,000 hectares national wide on annual basis on their exclusive efforts.

### **3. Existing Experience on Modern Small-Scale Irrigation Schemes**

These are generally considered to be command areas of about 200 ha or less. Modern SSI schemes are planned, designed and constructed by the government or other external body for the benefit of the farmers with minimum

contribution (about 10% of the investment cost) in terms of labor and/or local materials or no contribution by the beneficiaries. Gravity surface irrigation predominates with low irrigation efficiency, probably less than 30-40%. Few micro-earth dam and pump schemes exist due to relatively high cost.

These schemes have been expanded after the 1984 drought, which affected the country. The objective is to achieve food security & improve livelihood of farmers.

Since then, even though the pace is slow due to different factors, the schemes expansion has been on progress as water centered development is on the prime agenda of the government.

In terms of water source and abstraction methods the major models of modern SSI schemes currently used are:

- River + diversion weir
- River + micro-earth dam
- Spring + diversion weir
- River + pump
- Lake + pump
- Well + pump

River plus diversion weir is the most commonly used modern SSI model in almost all regions. This model has the following advantages:

- Relatively simple to study, design, construct and operate
- Cost per hectare is relatively low
- Sedimentation and seepage problems are minimal

Therefore the river plus diversion weir schemes are more successful as compared to others. As a result, currently regions are turning to and giving high emphasis to this model. However, this model has the following limitations:

- Can be applied only in rivers which are permanent and have a considerable discharge
- Water harvesting in rainy seasons is not possible so that irrigation water shortages during long dry seasons

- commands very limited area due to limited discharge

The other commonly used model is river plus micro-earth dam. This model has the following advantages:

- Water harvesting during the rainy season to use in the dry season
- appropriate in areas where there are no perennial rivers
- Increased command area due to harvested water

The limitations of this model are:

- Investment cost per hectare is relatively high
- Needs relatively highly qualified professionals & heavy machineries
- Increased risk of seepage and sedimentation problems
- environmental impacts such as submergence of productive lands & infrastructure
- Health hazards such as malaria & other water born diseases

Having all these advantages and disadvantages regions are planning & implementing this model.

The pump models are also being implemented even though the operation and maintenance works are difficult to farmers. They require skilled manpower and relatively high cost for proper operation and maintenance. Availability and access to spare parts is also an other problem. Well plus pump model is being piloted at Kobo Gerana valley (Amhara region) & some private farms and found promising.

Planning of modern small scale irrigation schemes is carried out in the following three steps:

1. Project Formulation & identification.
2. Reconnaissance
3. Feasibility study & design

Modern small scale irrigation schemes are being conceived either in the office from the topo maps/ aerial photos or by demands from

the farmers. Following the steps required the scheme would be prepared for implementation. Depending on the availability of budget, with some contribution of labour by the beneficiary farmers, schemes can be constructed and made ready for use. The constructed and completed schemes are usually handed over to WUAs for managements, and maintenance. In almost the majority of existing schemes water users association have been supposed to be established before the construction of schemes have been started.

In a lot of schemes constructed by NGOs, schemes are not well studied and designed. Because of this, after construction there is a shortage of water. There are also several schemes where NGOs constructed only headworks and leave the development of irrigated land. In some cases where proper study has not been carried out, conflict between traditional and modern schemes users arises.

In most of irrigation schemes watershed developments have not been considered. This has resulted in reduction of rivers discharges, silting of head works as well as canals, which highly affect the water management capacity of schemes.

Concerning management of SSI schemes, there is no clear responsibility between the implementing agencies as well as beneficiary communities on completed irrigation schemes. Redistribution of land is one of the impediments on the efficiency of some schemes. There is limited supply of agricultural inputs and credit service on SSI. There is no production plan on SSI, which severely affects the production market of SSI schemes. There is poor marketing service. In general it is possible to say that there is no extension service wherever small-scale irrigations are implemented.

There is also no adequate research undertaking at federal and regional centers on the sub sector and hence improved technologies on irrigated agriculture are not available.

In some cases due to budget constraint some SSI schemes were under designed. In others, schemes are not completed in accordance with

their design and those implemented some times lack quality, which in turn affect the water management of the scheme.

In areas where food aid and donation has become part of life, it is handicapping farmers to strategically anticipate to it as one of their livelihood options. Therefore, they hesitate to accept any development including irrigation due to dependency syndrome.

There is also lack of experience in basic irrigation water management, how to improve efficiency of irrigation water use as well as skill on improved and diversified irrigation agronomic practices. Poor land management leads to high levels of erosion, poor infiltration of rainfall and inadequate fertility management.

Finally limited management capacity to initiate maintenance practices for sustainable running of the schemes by farmers and limited capacity of experts involved in irrigation development in terms of study, design, construction, operation and maintenance of irrigation infrastructure highly suppressed the development of small-scale irrigation.

#### **4. Institutional Arrangements**

Prior to the establishment of regional governments, small scale irrigation schemes has been organized and coordinated at the central level. Then in 1992 the whole responsibilities of small-scale irrigation has been transferred to the regions where by several schemes have been developed so far.

The institutional set up of regions to implement these schemes varies from region to region. In Tigray, Amhara and Southern region study, design and construction of small-scale irrigation schemes are under taken by Water Resource Bureaus, and operation and maintenance (Agricultural Extension) being implemented by Bureaus of Agriculture and Rural Development. In Oromia, all the irrigation activities (study, design, construction as well as its extension) are carried out by Oromia Irrigation Development Authority (OIDA). Currently; regions are undertaking a structural reform that construction works are to be carried out by governmental enterprises and private

contractors. Besides these major regional government bodies, several donors, non-governmental organizations and community organizations are currently involved in the planning, designing and construction of small scale irrigations.

At scheme level, there are three types of SSI scheme managing organizations:

- Traditional Organizations (TOs)
- Water Users associations (WUAs)
- Irrigation Cooperatives (ICs)

In some of SSI schemes, the different social organizations with in an irrigation scheme exist side by side. In many schemes WUAs exist along side ICs, the member ship of which also comprises only some of the water users.

Traditional water management organizations, which exist in almost all of the schemes with a history of traditional irrigation, have tended to be ignored. WUAs are usually set up initially to mobilize the community to participate in the construction work. Once construction has been completed, the focus is to the irrigation cooperatives. Lack of policy support to WUAs and traditional water fathers threatens to under mine sustainability as the irrigation cooperatives are not expected to operate and maintain the scheme and manage water distribution.

#### **5. Utilization and Operational Status of Existing Modern SSI Schemes**

Development of small scale irrigation has been continuing by the regional Bureaus & NGOs. In the previous decades, a number of SSI schemes have been constructed, completed and commissioned to the beneficiaries. However, getting updated and actual data is being difficult. As a result the number and command area of completed & commissioned SSI schemes is not accurately known. This is due to lack of exhaustive investigations and lack of institutional memory due to frequent restructuring and changing of mandates. Further more, operational and utilization status of existing SSI schemes is even more difficult to trace.

There are various data and information regarding these issues. However, according to the data obtained from regions in 2004 and 2005, the total number of completed and commissioned modern SSI schemes to date are more than 477, with an estimated command area of 52,247 ha. Of the above figure, a minimum of 59(13%) schemes with command area of 5,136 ha. have been completely abandoned and out of production. Further more about 57(12%) schemes with a command area of 7,092 ha are reported partially functional or under utilized and seeking for major and minor maintenances.

Structural failures (Seepage, sedimentation of head works and canals, demolition of head works, breaching of canals, etc), shortage of water, lack of proper operation and maintenance, lack of awareness and skill of the beneficiaries are some of the problems observed in most of the schemes.

Productivity and sustainability of SSI schemes is also affected by lack of participatory planning process (beneficiaries, all stakeholders), lack of proper attention to social organizations, lack of post-construction support to beneficiaries, absence of access to market and poor watershed management.

The complexity of modern irrigation development makes the task more challenging. The attempt to move subsistence agriculture to intensive, diversified, and commercialized agriculture involves many changes of mind set up, infrastructures, institutional arrangements and practices.

## **6. Key Issues and Recommendations**

Lessons learned from previous experiences indicate that the following issues are corner stones to successful planning, implementation and sustainability of irrigation projects:

### **Adoption of Participatory Approach**

Full participation of beneficiaries and involvement of all stakeholders in the planning, study & design and construction of the schemes needs to be improved for better performance.

### **Combating Dependency Syndrome**

Dependency is one of the major factors that affect productivity of irrigation schemes. In some areas farmers believe that they can't live without food aid. Hence, they are reluctant to accept any development interventions including irrigation because of the fear that they will lose the aid. Hence, continuous awareness creation and attitudinal change forums are relevant to avert dependency syndromes.

### **Integrated/ Multidisciplinary Approach**

It is a common practice for more emphasis to be placed on physical construction than operation and management. It is also true that an irrigation scheme is not appreciated in the context of the entire catchments in which it exists. A shift from a single discipline approach to multi-disciplinary approach is crucial for sustainability & balanced emphasis is required among the different disciplines & components in irrigated agriculture. An irrigation schemes should not be treated as an isolated entity.

### **Watershed Based Water Resources Planning & Development**

This is important from the view point of water resources planning, assessment of soil and water conservation requirements, and the prevention of conflicts among users. Catchments water balance studies should be under taken to determine the potentials we have. Scheme based approach should be replaced by watershed approach.

### **Watershed Management**

It is worth considering watershed management as a prerequisite to scheme development. Wherever, irrigation is proposed it should encompass upstream catchments management/treatment as the major component as it protects sedimentation and flood hazards and improves the hydrology of the watershed.

Adequate support to establishment and strengthening of relevant institutions

Frequent restructuring and changing of mandates highly affect the development of irrigated agriculture in the country. Therefore,

rectification of mandates, responsibilities, and accountability of governmental institutions involved in the development of irrigated agriculture based on current experiences is highly important for sustainability.

### **Establishing Basic Database Centers**

Designing and constructing an irrigation scheme based on inadequate basic data leads to a failure. Hence, institutions working on the survey of basic data need to be strengthened and database centers should be established in all areas that can be easily accessed by all stakeholders.

### **Availability and Access to Market**

Access to market and market information needs to be improved in all irrigation schemes to enable beneficiaries to sell their products. Expansion of preservation and storage technologies as well as agro-processing industries in rural areas is crucial for sustainability.

### **Sufficient Emphasis to Agricultural Extension**

SSI operation and management is complex because it requires shifting from subsistence to more intensive, diversified, higher input & group farming systems. Therefore, intensive training in operation & maintenance of structures, water management, input application and the like is critical for sustainability. Besides, establishment of demonstration and trial plots, timely availability of inputs and assignment of qualified personnel at woreda & scheme level are important measures to be addressed.

### **Adequate Emphasis to Social Organizations for Irrigation Water Management**

In most of the modern SSI Schemes traditional Water management organizations tend to be ignored in the establishment of WUAS and irrigation cooperatives. This threatens the viability of the modern organizations is disempowering. The cooperatives promotion bureaus are only on interested in the promotion of irrigation cooperatives WUAs do not have a

legal status and policy support to enable them to operate a bank account and access credit Neither WUAs nor ICS fully represents the water users farming with in the command areas.

### **Adequate Emphasis to Post Construction Maintenance & Repair Works**

Government should take responsibility for post construction, maintenance and repair when this lies beyond the capacity of the farmers. There should be a clear and transparent planning procedures and allocation of adequate budget for major (head work, main canal) and emergency maintenance works. Long term support is a necessity not an option for sustainability.

### **Establishment of Cost Recovery Mechanisms**

A cost recovery mechanism should be established to strengthen investment capacities. This can be a long term strategy as irrigation development is in its infant stage in the country. Funding and implementation of O&M through Collection and management of water Charges is an essential component and guidelines need to be developed to ensure that irrigation water is affordable and meets the demands of O&M and also discourages over use of water.

Hence, as a short term strategy beneficiaries should contribute and collect money which can be used for operation and maintenance of irrigation schemes.

### **Adequate Training**

There is a knowledge and skill gap in the study, design, construction, operation and management of irrigation schemes. A number of schemes have been failed due to poor study, design and construction qualities as well as low capacity of agricultural extension services.

There is also lack of experience in basic irrigation water management, how to improve efficiency of irrigation as well as knowledge on improved and diversifised irrigation technologies. Hence, long-term and short term training of experts is mandatory for the development of the sub-sector. Further more, periodic training in the field of irrigation water

management, operation and maintenance, improved agronomic practices and marketing to irrigators & experts are highly recommended for sustainability and improve productivity.

Further more establishment and strengthening of relevant research institutions is necessary for the provision of improved irrigation technologies.



# Household Water Harvesting and Small Scale Irrigation Schemes in Amhara Region

Yacob Wondimkun and Melaku Tefera

SWHISA Project Bahirdar, Ethiopia

wyacob@yahoo.com

## Abstract

Many schemes, both Household Water Harvesting (HHWH) and Small Scale Irrigation (SSI) Schemes, have been developed in Amhara Region. In the year 2004, Regional Irrigation Land and Water Resource Inventory was undertaken by Amhara National Regional State (ANRS) to collect basic information for future planning and management of the schemes.

A total of 14,976 HHWHS were counted, 13,028 (87%) of which were based on run-off harvesting and 1,948 (13%) hand dug wells. 82% of the schemes were constructed in 2003 while only 1.2% before this period. 22 % of the structures were found to be functional, 70% not functional and the rest were destroyed. Harvested water has been used for different purposes: 35.6 % for irrigation only, 31.4 % for other purposes (water supply, cleaning and construction) and 33 % for both purposes. The total area irrigated using the functional structures in the dry and wet season was found to be only 51.4 and 25.9 ha, respectively. Water from these functional structures were used to provide supplementary irrigation to an average area of only 216 m<sup>2</sup> in the dry season and/or 290m<sup>2</sup> in the wet season.

A total number 6,219 SSIs were counted, of which 311 (5%) were modern and 5908 (95%) were traditional. A total of 8063 ha was irrigated by the modern schemes during the dry season, which put the modern irrigation at a rate of 80% of the planned area. This was only about 1.4 % of the potential irrigable area of Amhara Region. Irrigated area of most of the beneficiaries ranged between 0.125- 0.25ha, benefiting more than 330,000 households and 1.9 million people. Use of modern inputs was seldom and minimal, with fertilizer rate of not more than 0.013 q/ha. Flooding and furrow were the most common methods of irrigation

used. Irrigation intervals were dangerously too long and hardly met.

Lessons learnt from HHWHS and SSI schemes in the region includes that these schemes have problems encompassing technical, social and environmental issues. The major problems with HHWH schemes were design, construction and operation related where as with SSI schemes operation was the most important problem. As a result, crop yield and income were low. It is important that the whole process of planning and management of these schemes are based on full participation of the communities so that the schemes are eventually owned and sustainably managed by the farmers and operated at their full potential providing maximum benefits to the farmers.

## 1. Introduction

Amhara national regional state is one of the largest regions in Ethiopia. It occupies a territory extended within a geographical coordinate between 9<sup>o</sup> 29` - 14<sup>o</sup> 0` N latitude and 36<sup>o</sup> 20` – 40<sup>o</sup> 20` E longitude. The total area of the region is estimated to be 170152 km<sup>2</sup> with ten administrative zones, 106 rural *woredas*, 12 urban administrations and 3231 *kebeles*.

The region is endowed with four river basins with net potential area of 0.57 million hectares. Modern small-scale irrigation development in the country as well in the region began after the establishment of the irrigation development department within the MoA at the end of 1984. Since 1995, CO-SAERAR was mandated to undertake the same; however, in both cases the progress was slow. Moreover; most of the modern schemes were poorly operated, managed and under-capacity. At tradition

schemes peasant farmers were utilizing irrigation schemes date back to the last century.

Lately in 2003, in the national/regional food security program, one of the strategies envisaged was the introduction of small-scale water harvesting systems. As a result there was big attempt to introduce small-scale irrigation and HHWS in all parts of the region. A number of different structures were built all over the region. The number of structures built in the same year outstripped those built before.

To identify/ know the size and distribution of the structures in the year 2005, the Bureau of Water Resources Development (BoWRD) undertook regional irrigation land and water resource inventory study. The result of this inventory study is adapted to evaluate the current operational status of both irrigation and HHWH schemes. It also helped to develop water resource data base of the region for future planning.

### 1.1 Household Water Harvesting Structures

In the region a total of 14976 HHWH structures were counted, about 87% (13, 028) and 13% (1948) were found to be Runoff Harvesting Structures (RHS) and Hand Dug Wells (HDW) respectively. The highest proportion of the structures was found in Weyna dega agro climatic zone. 13192 structures were in moisture deficit and 1784 structures were in moisture sufficient woredas of the region.

The geometric shape of the structures were found to be Hemispherical, Dome shaped, Trapezoidal, Cylindrical, Rectangular and others; Hemispherical and Cylindrical were the dominant geometric shapes of the structures. The materials used to construct the structures include cement, plastic and earth. The dominant material used was earth

Different organizations have participated directly/indirectly in the construction of RHS. Organizations participated were summarized in groups; government, community, government

**Table 1. Water harvesting structures by agro-ecology zones**

Area / struc.	Dega	WD	Kolla	Total
<b>Runoff Struc.</b>	<b>2643</b>	<b>6465</b>	<b>3920</b>	<b>13028</b>
<b>Hand dug well</b>	<b>663</b>	<b>1042</b>	<b>243</b>	<b>1948</b>
<b>Regiona l total</b>	<b>3306</b>	<b>7507</b>	<b>4163</b>	<b>14976</b>

WD= Weyna Dega

+community, non-governmental organizations and private. Government and private agencies constructed the highest 62% and the least 5.2% of the structures respectively. Among the government-constructed structures, most of the structures were found to be earthen, followed by cement and plastic membrane.

The status of the structures showed that those constructed before 2003 were found to be more functional compared to those constructed in succeeding years (2003 and 2004). The highest number of structures was constructed in 2004 (82%). Of the total RHS 2794 (22%) were found to be functioning, 8783 (70%) not functioning and the rest 964 (8%) were destroyed. WH structures used to supplement crop production in the dry and wet season were found to be 2382 and 896, supplementary irrigated 51.3 and 26 ha of land, respectively

The crops cultivated include root crops (48%) followed by vegetables and cereals. The use of modern inputs was minimal with 6.8%, 0.5% and 0.2% of the HHs utilized animal manure, Urea and DAP fertilizers, respectively. HHs utilized one or more of the different methods of water application to supplement crop growth and save it from total failure. Drip application accounted the highest (43%), followed by furrow method (26%). The harvested water has been used for different purposes: crop development only, other purposes (cleaning, construction, and livestock drinking) and both purposes with 36%, 31% and 33%, respectively.

**Table 2. Geometric shape of RHS & Construction material used**

Geometric shape	Construction Materials		
	Cement	Plastic Sheet	Earth
Hemispherical	2753	177	5778
Dome	360	12	165
Trapezoidal	163	933	603
Cylinder	173	5	894
Rectangular	49	24	442
Others	43	1	116
<b>Total</b>	<b>3541</b>	<b>1152</b>	<b>7998</b>

Major problems observed in HHWH structures include the following:

- **Design and construction related:** poor awareness of the technology, poor implementation procedures (use of standard design, site selection problems and poor construction management)
- **Operation related :** shortage of water, water lifting problems, shallow depth of irrigation water application, poor crop selection and cropping pattern problems with time and method of irrigation and limited experience in irrigation extension
- **Maintenance related:** tearing of plastic sheets, silt up of structures, etc.
- **Environmental related:** malaria, hazard to human & animals, stinging water, etc.

In general, yield level of crops supplementary irrigated through harvested water was found to be low compared to irrigated and rain fed crop yield levels. Yield level of these crops was established and found that cereals, vegetables and root crops averaged 15, 101 and 89 qt/ha, respectively.

**Table 3. WH structures and irrigated area by season**

Area/ Season	Water harvesting Structures						Irrigated area (ha)
	Type/Number			Used for irrigation			
	HDW	RHS	Total	HDW	RHS	Total	
Moisture Deficit	1434	11758	13192				55.5
• DS				331	1682	2013	40.8
• WS				73	689	762	14.7
Moisture surplus	514	1270	1784				21.8
• DS				170	199	369	10.6
• WS				33	101	134	11.2
Region Total	1948	13028	14976				77.3
• DS				501	1881	2382	51.4
• WS				106	790	896	25.9

HDW = Hand dug well; RHS = Runoff harvesting structures; DS = Dry season; WS = Wet season

## 2. Small Scale Irrigation

### 2.1 Irrigation Schemes by Type and Irrigated Area

Irrigation schemes are classified in two as modern and traditional. A total of 6219 schemes were counted, 5% (311) and 95% (5908) were found to be modern and traditional schemes, respectively. Of the total irrigated land area (76,131 ha) at dry season, the share of modern and traditional schemes was found to be 10.6% (8063 ha) and 89.4% (68068 ha), and at the wet season out of supplementary irrigated (14178.5 ha) it was 8.1% (1154.5 ha) and 91.9% (13024 ha), respectively. Thus there was large difference in size of the total irrigated land area between modern and traditional schemes at both seasons. The share of moisture deficit and moisture sufficient *woredas* in both schemes at dry and wet season was found to be 38.8% (29555.8 ha) & 61.2% (46574.6 ha) and 18% (2494 ha) & 82% (11684 ha), respectively. A total of 334,824 HHs and 1,930,249 families have been benefiting from irrigation.

Modern schemes were found operating under capacity from the planned 10036.8 ha to be

irrigated in both seasons only 80% (8063 ha) was covered under crops at dry season the rest was kept fallow, at the wet season 14.3 % (1154.6 ha) supplemented and 73.4 % (5920.86 ha) was under rain-fed crops. The area left uncultivated (987.5ha) was kept fallow by virtue of some reasons. In the same case the cropping intensity was estimated to be 150.5%. At traditional schemes, a cropping intensity of 179% was observed the balance left uncultivated in the wet season due to water logging problems. Ample possibilities exist to expand irrigation in the region. A total of 223597.33 ha of potential land was estimated which 55.6% (124367.5 ha) at moisture deficit and 44.4% (99229.8 ha) at moisture sufficient areas.

At modern schemes, during dry season, the root crops took up the highest coverage of the cropped land at 33.7% (2720.8 ha) followed by vegetables 27.7 % (2237 ha). Similarly, at traditional schemes root crops took up the highest 37.6% (25598 ha) followed by vegetables 27% (18351 ha). At the wet season at modern and traditional schemes vegetables took up the higher 21% (241 ha) and 30.7% (3993.6 ha), respectively.

**Table 4. Irrigation Schemes by type of structure**

Area	Type of structure / No. of structure					total
	diver.	dam	pump	pond	h/dug	
MD	2334	8	26	26	25	2419 (40%)
Modern	105	8	26	9	12	160
Tradition.	2229	-	-	17	13	2259
MS	3520	2	98	16	164	3800 (60%)
Modern	49	2	98	1	1	151
Tradition.	3471	-	-	15	163	3649
Region	5854	10	124	42	189	6219
Modern	154	10	124	1	13	311
Tradition.	5700	-	-	30	176	5908

MD = Moisture Deficient; MS = Moisture Sufficient

**Table 5. Land use pattern at irrigation schemes**

Area	Planned (ha)	Season / irrigated area (ha)					Expansion Potential (ha)
		Dry season		Wet season		Rainfed (ha)	
		Irrigated (ha)	Fallow (ha)	Irrigated (ha)	Fallow (ha)		
Region Total	78104	76131	1974	14178	15106	46846	223597
Modern Scheme	10037	8063	1974	1154	987	5921	19669
Traditional Scheme	68067	68067	-	13024	14118	40925	208928

**Table 6. Fertilizer application rate**

Season/ Region Total		Amount Applied (qt/ha)					
			Cereals	Vegetables	Root	Pulses	Fruits
Dry Season	Inorganic Fertilizer	DAP	0.013	0.013	0.015	-	-
		Urea	0.005	0.023	0.012	-	0.167
	Organic Fertilizer	Compost	0.015	0.010	0.598	-	0.927
Manure		1.181	1.058	1.169	0.015	0.931	
Wet Season	Inorganic Fertilizer	DAP	0.014	-	0.004	-	-
		Urea	0.012	-	0.002	-	-
	Organic Fertilizer	Compost	0.019	-	0.002	-	-
		Manure	1.023	-	0.120	-	0.060

## 2.2 Fertilized Irrigated Cropland Areas

In irrigation schemes data on rate of application of natural and chemical fertilizers were collected. As shown in Table 5, chemical fertilizers DAP and Urea were applied at dry & wet season at modern schemes for cereals at the rate of 0.013 & 0.005 qt/ha for dry and 0.014 & 0.012 qt/ha for wet seasons respectively. At traditional schemes 0.29 & 0.17 qt/ha and 0.175 & 0.25 qt/ha in the order mentioned. At modern schemes for the same crop organic fertilizer, compost and manure were applied at the rate of 0.015 & 1.2 qt/ha for dry and 0.02 & 1.02 qt/ha for wet season. Where as, at traditional schemes at dry & wet season the rate applied was found to be 0.64 & 4.6 and 0.6 & 3.23 qt/ha, respectively.

## 2.3 Irrigation Schemes and Oxen Possession Pattern

The significant contribution of cattle to crop farming is draught power. In modern schemes, HHs possessing two oxen was found to be the highest (42.56%) and those with no ox were (17.26%), where as at traditional schemes 45.49% of the HHs possesses two oxen and those with no ox were found to be 13.34%. In the region one can infer that oxen possession is uneven and is found to be problem to accomplish farming activities on time. HHs with no and one ox employed other means to plough their farm. Of the various means the most commonly employed by modern scheme HHs with no ox was use of hand tools 38 % and

crop sharing 32%, at traditional schemes use of crop sharing was 32.7% and hand tools 29.1%. Those with one ox at modern scheme used mekenajo<sup>1</sup> 90% and hand tools 3.9%, where as at traditional schemes mekenajo accounted 82.9% and hand tools 5.4%.

## 2.4 Extension Services under Irrigation Schemes

The extension support services provided to modern and traditional scheme HHs was found to be not satisfactory to rely upon. Irrigation packages were not properly provided and the support was not found to be complete to enhance the yield of growing crops. In both schemes HHs to DA ratio was not narrow.

In the region the frequency of DA's visit of irrigation HHs was assessed once in a week, once in two weeks, once in a month and once in more than a month. At modern schemes it was found to be 49.4 %, 22 %, 15.4% and 13 % where as, at traditional scheme it was found to be 32.2%, 33.3 %, 20.5% and 14 %, respectively.

## 2.5 Water Management Related Problems

Poor water management and inadequate drainage invariably increase water logging and salinity accompanied by health hazards like malaria. The most serious environmental hazard caused by irrigation schemes with water management problems were salinization and the loss of valuable land because of it. In the region, at modern schemes water logging, mild salinity and malaria were found to be problems accounting 29.7%, 12.5% and 40.6% of the participating HHs, where as, at traditional schemes it was found to be 23.9%, 8.2% and 44.6%, respectively.

## 2.6 Major Constraints of Irrigation Schemes

The performance of irrigated schemes is far below expectation. Attempt has been made to

<sup>1</sup> Pairing of oxen with other HH having single ox or extra ox

rank the major constraints of irrigated schemes from the most severe problems to the least (1 to 8). Insufficient water supply and availability was found to be the 1<sup>st</sup> constraint in both

**Table 7. Frequency of development agents visit of HH**

Frequency of Visit	HHs, %	Total HHs responded
Once in a week	15.4	1755
Once in Two Weeks	22.1	1755
Once in a Month	49.4	1755
Once in more than a Month	13.1	1755

schemes. Input supply & marketing problems were the 2<sup>nd</sup> at modern and the 3<sup>rd</sup> at traditional schemes. Maintenance was the 3<sup>rd</sup> at modern schemes and the 2<sup>nd</sup> at traditional schemes

## 2.7 Crop Yield under Irrigation

Crop production under irrigation is characterized by low yield level. Attributed to the traditional water management practices, limited use of modern inputs and the depletion of soil fertility. Regional yield level of irrigated crops is low; at the dry and wet season average yield level of crops was found to be 68 and 37 qt, respectively.

## 3. Current Trends and Lessons Learnt

Improvement in planning process  
 Shift to ground water abstraction  
 Change of geometry of HH water harvesting structures  
 Improvement in volume of structures

### Lessons Learnt

- Lessons learnt include
- The need to improve, study, design and construction
  - Lack of adequate design skills

- Formal Trainings should incorporate solution to local needs
- Improve knowledge and skill of practitioners
- Implementation should follow scheme based approach

### **Organization of O & M Activities**

Organization of operation and maintenance activities includes:

- Organization of irrigation agency: refers to the organization of agencies working on irrigation; like BoWRD, BoARD, etc.
- Organization of the farmers: refers to the organization of farmers in WUA's and irrigation cooperatives.

**Operation:** irrigation operation at scheme includes the following activities: planning of cropping pattern & irrigation demand, daily operation, monitoring, evaluation, timely supply of inputs and necessary materials, use of on farm research and demonstration, provision of strong & appropriate extension system, credit & marketing services and Training

### **Maintenance**

Maintenance is required to keep the schemes at top operation at all time; obtain the longest life and greatest use of the system through adequate maintenance; achieve the above two at lowest possible cost

Major maintenance activities:

- Identification of needs
- Costing of needs
- Categorization and prioritization of requirements
- Implementation of maintenance
- Supervision and inspection of works done

### **Marketing**

- Irrigation season versus rainfed season
- Inadequate input and credit supply
- Poor marketing infrastructure
- Poor marketing institutions (weak Water User's Association (WUA)) and lack of Irrigation Cooperatives

### **Irrigation institutions**

The major bottlenecks related to institutions include:

- Institutional mandates and linkages
- Stability of institutions
- Irrigation fees and related costs
- The necessity to establish regional water data base

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# Small Holder Farmers' Experience on Pressurized Irrigation Systems in Kobo Valley

**Adinew Abate**

Kobo Girana Valley Development Program Office, North Wollo, Ethiopia  
kagvdp@ethionet.et

## 1. Introduction

The problem of food security had long been in a priori importance in Ethiopia. The problems of land degradation, population pressure, low productivity in agriculture, improper utilization of resources, poor infrastructure, absence or poor level of adoption of technological innovations, etc., contribute to food insecurity in the country. The situation in the Amhara National Regional State as well as in Kobo Girana Valley is not different from the national situation.

Kobo Girana Valley Development Program Office (KGVDP) is located in North Wollo Zone of the Amhara National Regional State and covers Kobo, Gubalafto & Habru woredas of the Zone. It was established in 1999 by the Amhara National Regional State with the goal of ensuring sustainable food security and improving the livelihood of the people in the area.

The program has been implementing integrated rural development projects, which include crop husbandry, livestock resources development, natural resources development and irrigation infrastructure development over a period of 25 years. The development of irrigation systems in the valley is increasingly coming to be the core activity of the program implementation. It started implementing pressurized irrigation systems from ground water source and two of the pilot systems are implemented to date.

In this paper, the experience of KGVDP in the implementation and management of irrigation

systems with specific reference to pilot pressurized systems is presented. The existing situation, the potentials, constraints and proposed solutions are presented.

## 2. Irrigation Infrastructure Development

Kobo Girana Valley Constitutes five distinct sub basins, viz., the kobo sub basin, Alewuha sub basin, Chereti sub basin, Gelana sub basin, and Hara sub basin. Despite the available potential of water resources, the valley generally is considered to be drought prone area.

Based on the study document for KGVDP, the area has a potential of producing 156.2 million cubic meter surface water yield and 113 million cubic meter underground water yield, which totals 269.12 million cubic meter water yield per annum.

On these basis, the study proposed irrigation developments to irrigate an area of 5665 ha by using the sub-surface water source and about 3600 ha by using the underground water source, which altogether goes to 9265 ha of land by the end of the project, which is subject to revisions and detailed studies during implementation.

With regards to the underground water resource use, the study on KGVDP proposed the development of 90-130 bore holes each producing an average of 30 liters per second. A review study in 2003, on the other hand, proposed the development of about 63 bore holes, which have an average discharge of 50 lit/sec. Based on the second proposal, an area of



**Table 1. Profile of Implemented Pilot Projects in KGVDP.**

<i>Item</i>	<i>Unit</i>	<i>Pilot Projects</i>			<i>Total</i>
		HG-1†	WG-1	HE-I§	
Area	ha	34	41	5.7	80.7
Drip	ha	24	25	---	49.0
Sprinkler	ha	10	16	5.7	31.7
Beneficiary HH	No	163	124	8	295
Female	No	16	19	1	36
Male	No	147	105	7	259

† HG-1, Hormat Golina no. 1; § HE-I, Hormat Ethio Israel

2520-3150 ha can be irrigated using these boreholes and 12,000-15,000 house holds can benefit from these sources.

### 3. Performance of Pilot Projects

Since the commencement of the program, KGVDP has drilled 27 boreholes of which 21 are productive wells and 6 are test wells. Among the 21 productive wells, 4 wells are pilot wells and the installation of infrastructure on the two of these pilot wells are completed and considered as pilot projects. Until the end of 2005 only these pilot projects started proper crop production. By the beginning of 2006, pressurized systems infrastructures on additional six wells were in place to irrigate about 330 ha.

#### 3.1. Profile of Pilot Projects

Prior to the implementation of pilot pressurized irrigation systems by KGVDP, a similar 5.7 ha pressurized irrigation system was installed by Amhara Regional Bureau of Agriculture (ARBoA) in cooperation with the government of Israel, and successive extension support was given by KGVDP. The positive effect of this system for the subsequent extension work was enormous. Including this system, the profile of the three pilot projects is given above.

#### 3.2. Production Patterns and Input Use

A crop plan document is prepared for each project and the crops cultivated by the systems are onion, tomato, pepper, maize, haricot bean, groundnut and cotton. Major Crops used to be produced in the area before project implementations were teff, maize, and sorghum. Although the yields were better than the conventional production levels, productivity of crops in the systems were not up to the standards of commercial productivity levels.

As regards to input use, farmers don't use the required amount of inputs, especially fertilizer and pesticide, as per the recommended rates. Major costs are seed, fuel and electricity charges.

#### 3.3. Product Marketing and Income from the Systems

Products are normally handled in an ordinary manner and sold to private traders, military camps and to Ambasel Trading House (in case of cotton & Haricot Bean). Marketing constitutes the major aspect of problems in irrigated agricultural production.

From the potential point of view, the systems are not efficiently operating. As a result, income gained from the system by farmers is not to the expected level as compared to commercial farms. Even at the existing operational efficiency, however, the farmers

significantly benefited from the system. The harvests showed that a net income of Birr 7500-12000 per hectare per season was gained depending the strength of the farm operators.

### **3.4. Successful Achievements**

The successful achievement in the area with respect to the promotion of pressurized irrigation system is the change in attitude of farmers on the effectiveness of the system. From the beginning, farmers were suspicious on the suitability of the system and its capacity to satisfy crop water requirements. But later, the farmers proved the potential and the capacity of the system. Moreover, it was found out that, it is possible for the farmers to manage the system technically.

The system is economically feasible even at current farmers' level of practice and farmers who exercised recommended practices gain good income. Even though the life of the introduced practices is not long enough to perceive a significant change in the life style of the beneficiaries, farmers from the Ethio-Israel project, which operated for about eight years have gained substantial benefits and their life style is changed positively.

Although it is early to talk about the sustainability of the system at farmers' level, today beneficiary farmers of Hormat Golina No-1 infrastructure have started to maintain their system and replenish spare parts. The beneficiaries of the Ethio-Israel project, which was established before the commencement of KGVP, proved proper sustainability of such a system at farmers' level. They replenish all their spare part demand as long as they are available in the market.

### **3.5. Adoption Challenges**

The challenge in the promotion of irrigation development is not easy in the area as well as in other parts of the region. As the technology is new and sophisticated, the challenges with pressurized irrigation systems are worse than others. Some of the issues are raised below.

#### **3.5.1. Land Tenure Related Issues**

The nature of farmland distribution is uneven and fragmented. Whilst some farmers have about a hectare or more of land in the system, who might be unable to manage it properly, some other interested on the system have no access and they may get the access by renting (20-33% rented). Another problem related to land is the inconformity of the shape and size of the actual farm with the requirement of the system. While the system needs rectangular shape at a definite size, the farms of individual farmers are irregular and two to three farm plots fall in one system plot and one farm plot falls in two to four system plots.

These situations lead to great conflict of interest among farmers. When such interest conflict arose and individual farmers become stumbling block to the smooth implementation of the system, land administration policy is expected to react promptly and find solution. The reaction and solution the policy element, however, is slow and process oriented, even for solutions and measures within their by-laws.

#### **3.5.2. Institutional Weakness of Farmers' Organizations**

Although the weakness is not entirely attributed to the farmers, there exists a great lack of leadership commitment in the farmers' organizations. Influenced by socio-cultural situations, they used to loosen their own bylaws.

#### **3.5.3. Dependency Attitude of Farmers**

These infrastructures are installed by the government and sponsoring organizations. The dependency attitude of beneficiaries for support in operation and maintenance is enormous. Covering fuel, electric cost is a major operation cost where beneficiaries tend to receive especially at the beginning of the system. Shortage of capital, lack of confidence on outputs, experience different forms of subsidies and sometimes presence of different forms of subsidy in the neighboring woredas are some of the reasons for their dependency attitude.

### **3.5.4. Poor Integration among Stakeholders**

The integration and commitment of concerned bureaucratic bodies towards the promotion of irrigation extension, cooperatives establishment and strengthening, and supports in their respective tasks is weak and not to expected level.

### **3.5.5. Limited coordination in backward and forward linkages**

The importance of availability and timely delivery of inputs and market outlet for farm produce is not questionable. The availability of inputs is limited and sometimes completely not available for some types of seeds. The absence of strong institutionalized market integration on farm products contributes to the fall of productivity and a shift to conventional cropping pattern.

and electric charge is critically needed; preferential electric tariff treatment for small holder farmers' irrigation systems should also be sought;

4. Ensure the availability of spare parts or substitutes during installation
5. Whilst it needs a special attention for effectiveness, the concern on irrigation at all levels is not to the demand. It is therefore essential to strengthening extension and institutional coordination as well as the backward and forward linkages of the agricultural production system.

## **4. Concluding Remarks**

The implementation of these pressurized irrigation systems showed that the system is applicable at smallholder farmers' level with a strengthened multidimensional effort. Despite the need to undertake enhanced institutionalized multidimensional effort for the effectiveness of the system, the concern on irrigation at all levels is not to the demand. In order to improve irrigation management in the respect, the following ideas are forwarded.

1. As the system needs homogeneity, social mobilization and organization works should be finalized first;
2. Disparity is created & widens in access to irrigable land and in the management capacity of land as new land is irrigated. Hence, as new irrigable land is addressed, land related problems/issues have to be considered critically and the policy has to incorporate absorbing mechanisms (Long term Planning)
3. Ensuring the availability of credit access for the first production season for fuel

# Farmers' Testimony about Agricultural Water Management Technologies in use in Amhara National Regional State

**Abdul Hussien and Adinew Molla<sup>1</sup>**

Amhara National Regional State

Mr. Adinew Molla from Kobo Woreda and Mr. Abdul Hussien from Bati Woreda of Amahara National Regional State were requested to share their experience regarding the agricultural water management technologies and practices they are using during the symposium and their response is presented as follows.

Mr Adinew is living in area which is susceptible to drought. He has to work hard every day in order to produce the required food for his family. After the Ethio-Israel company introduced pressurized irrigation system in his area his life has changed tremendously. He grows and sells different vegetables and gets good profit. He has now 40, 000 birr deposited in a bank and he also upgraded his house. He said "improved technology has helped us a lot in changing our life". He also passed his gratitude to Kobo Girana Irrigation Project for the support it has been providing to him and his fellow farmers. However he mentioned some of the problems which hindered him from attaining more profit from his irrigated land. These are;

1. Limited market access
2. Absence of spare part for Israeli made pumps in the area which led him to travel to Addis Ababa for maintenance purpose which cost him more than 2600 Birr.
3. The ever increasing fuel cost for pumping

On the other hand Mr. Abdul from Bati Woreda of Amhara National Regional State practices small scale irrigation using runoff harvesting. He constructed a pond by himself and he is now using it to grow papaya, mango, mandarin, tomato, chat and carrot as main crops.

Moreover he has a plan to excavate another water harvesting pond in order to increase the size of his irrigation farm to two hectares. He said that he already prepared construction materials required for his anticipated water harvesting pond.

Mr. Abdu reported that because of the water harvesting structures he managed to buy a pump for his irrigated field. He also mentioned that because of his success twelve households in his village are already organized to irrigate their farm using water harvesting.

Mr. Abdu nevertheless indicated that the evaporation rate from his water harvesting pond is too much and it subsequently reduced the water available for irrigation use later and requested assistance in controlling and minimizing this loss. He also requested technical assistance as the technology is new and there is limited know-how in the area<sup>1</sup>

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<sup>1</sup> Farmers from Kobo and Bati Woredas of Amhara National Regional State who practice small scale agricultural water management technologies

# Improved Agricultural Water Management: Assessment of Constraints and Opportunities for Agricultural Development in Ethiopia<sup>1</sup>

Seleshi B. Awulachew

International Water Management Institute (IWMI)

s.bekele@cgiar.org

## Abstract

Ethiopia is one of the largest countries in Africa, having the second largest population in Sub-Saharan Africa, but it is also one of the poorest. However, most of the areas used by settlement are extremely degraded, per capita land availability is dwindled and productivities of land and labor are reduced. It has tremendous land and water resources, particularly in low lands and river valleys, but these areas are not extensively utilized. This paper is dealing with key constraints and challenges in terms of water management in improving agricultural productivity. The country has had mixed experiences with promoting irrigation and other modern agricultural technologies. Promoting small-scale irrigation (SSI) and rainwater harvesting are central to Ethiopia's new policy and strategy on agricultural and rural development. This paper also deals with an assessment of the impacts of these interventions, identifies further opportunities and constraints. In some regions, there is evidence that irrigation has created some positive impacts: better opportunity for production, better income, reduction of risks and hence generated benefits for poor rural communities. Despite successes, there are a number of failures that need attention. There is a general perception in all regions of Ethiopia that the current trend of low performance of some of the small-scale irrigation schemes is related to flawed project design and lack of adequate community consultation during project planning. Since small proportion of the potential is used and most of the SSI programs are currently in the planning stages, and are yet to be implemented, these conclusions should be seen as providing a unique opportunity to learn from these drawbacks. If ignored, well-intended efforts of governments and NGOs are likely to continue falling short of their intended impacts.

## 1. Introduction

Ethiopia is one of the largest countries in Africa. Covering a land area of 1.13 million km<sup>2</sup>, it is the second most populous country in sub-Saharan Africa (SSA) (and third on the continent) population approaching 80 million and 85% dependent on agriculture and live in rural areas. Agriculture employs 80% of the labour force and accounts 50% of the GDP. It has a surface area of about 1.127 Million km<sup>2</sup>, of which 1,119,683 km<sup>2</sup> land and 7,444 km<sup>2</sup> water area. The country has a land boundary length of 5311km. Ethiopia in the horn of Africa has special features because of its topography, geology and climate, Awulachew, S. B. (2001). The per capita income is only about \$100 per year. The average population increase is at about 2.4 % annually<sup>1</sup>.

Ethiopia's topography can be broadly grouped into uplifted central highlands, tapering into peripheral lowlands that also include the Rift Valley. Most of the country consists of high plateaus and mountain ranges with precipitous edges dissected by numerous streams in the center, and rolling plains all along the periphery (Mati, 2004). The lowlands are relatively hot, with annual rainfall varying between less than 200 to 800 mm and average temperatures of 25° C. The climate in the highlands above 1800 m is mild and annual rainfall ranges from 800 to 2200 mm, with a mean annual temperature of 15° C. The highlands above 1500 m altitude constitute 43% of the country and accommodate 88% of the human population, over 65% of the livestock, comprise 90% of the cultivated land and nearly 100% of the industrial forest cover (Bekele-Tesemma, 2001). The dry lands occupy

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<sup>1</sup> The study was conducted with financial support of Canadian International Development Agency, CIDA

about 70% of the total landmass and 45% of the arable land. They are characterized by a highly fragile natural resource base; soils are often coarse-textured, sandy, and inherently low in organic matter and water-holding capacity, making them easily susceptible to both wind and water erosion. Crops can suffer from moisture stress and drought even during normal rainfall seasons. Farm productivity has declined substantially and farmers find themselves sliding into poverty (Georgis, 1999).

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

On the other hand, Ethiopia covers 12 river basins with an annual runoff volume of 122 billion m<sup>3</sup> of water with an estimated 2.6 billion m<sup>3</sup> of ground water potential. This amounts to 1743 m<sup>3</sup> of water per person per year: a relatively large volume. But due to lack of water storage capacity and large spatial and temporal variations in rainfall, there is not enough water for most farmers to produce more than one crop per year with frequent crop failures due to dry spells and droughts. Moreover, there is significant erosion, reducing the productivity of farmland.

Agriculture is by far the dominant sector. Most of Ethiopia's cultivated land is under rainfed agriculture. Less than 40% of the arable area (13.2 million ha, or 12% of the total land area) is currently under cultivation (ADB, 2003). There is progressive degradation of the natural resource base, especially in highly vulnerable areas of the highlands, which aggravates the incidence of poverty and food insecurity in rural areas. Ethiopia imports about 15% of its food. The government has designed a comprehensive food security strategy that targets the chronically food insecure especially in highly vulnerable areas: marginal and semi-arid areas that are largely moisture deficient,

including pastoral areas, with high population pressure. If such measures can be effectively and sustainably implemented can make significant difference.

## **2. Existing Situation in Ethiopia**

### **2.1 The Poverty Vicious Cycle**

The current situation in rural Ethiopia is a "vicious cycle" that includes the following dimensions: population growth → extending agriculture and livestock into less and less favorable land, deforestation to obtain energy and more agricultural land → land and water degradation → poor productivity, food insecurity → poverty → poor health, malnutrition → inability to invest in maintaining or improving land productivity → further degradation, etc. How to transform this "vicious cycle" in to a "virtuous cycle" is the key question that needs to be addressed.

### **2.2 Agricultural Water Management Problems and Investment Opportunity**

#### **2.2.1 Key agricultural water management problems**

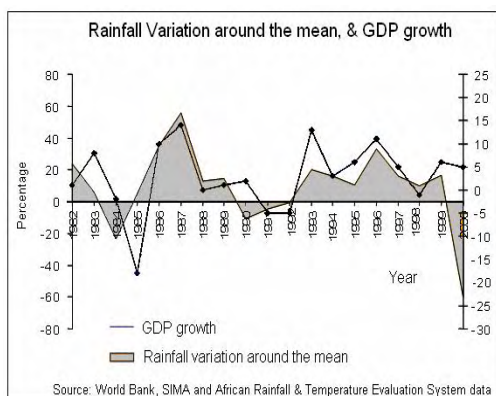
The major problems associated with managing agricultural water include:

- a. Long dry spells (leading to crop failures)
- b. Drought (three major droughts in 30 years)
- c. Very low productivity of agriculture, where by productivity mainly comes through agricultural land expansion compared to intensification or improving productivity
- d. Large water resources potential but with spatial and temporal variability
- e. Unused due to lack of infrastructure, lack of investment capital, transboundary nature of the rivers → stagnation to increase production and productivity using water resources
- f. Other problems related to supporting institutions, water use rights, management, etc

Some of these problems are discussed below

### 2.2.2 Extreme hydrological variability, dry spells and droughts

Poor management of agricultural water leaves almost all part of the country highly susceptible to rainfall variability which depicts itself in terms of prolonged dry spells and droughts. The prolonged dry spells, may not be pronounced in wide areas in a given year. However, it could cause significant harm to production and productivity of agriculture. On the other hand, drought that occurs in a given period or year could show clear impact on the total agricultural produce that could also be pronounced through gross domestic product and gross national product. The figure shown below shows the relationship of rainfall variability and GDP for Sub-Saharan Africa. The Figure shows such impact of the 1984 drought, which has devastated Ethiopia. On the other hand although floods have local impact, the impact of excess rain is having strong positive relevance to GDP.



**Figure 1: GDP and GDP relation to rainfall variability in SSA**

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

improve productivity of agricultural sustainable economic development.

### 2.2.3 Low productivity, limiting mechanisms to cope with shocks

The recent history of Ethiopia shows that the country has failed to adequately feed itself. Food deficit and famine occurrences in the country is claimed to be as a result of the erratic nature of rainfall or drought. Ethiopia has faced three large-scale drought induced food shortage and famine in recent times (i.e. in 1972/73, 1983/84, 2002/03), which claimed thousands of lives (See Figure 2 below based on Ethiopia calendar). In 2002/03 about 15 million people (over 20% of the total population) were under food aid need. Both number of population and proportion of population affected by drought and flood are with increasing trend. Figure 3 shows the drought and disaster affected population and proportion.

The trends of agricultural growth in Ethiopia are heavily reliant on expansion of agricultural land (extensification) and limited intensification through irrigation. In the period 1980-2001, the annual production increase for cereal, pulses and oil seeds as it is disaggregated in to productivity increase due to increase in land area and yield are found in Table 1.

**Table 1: Average cereal yield growth for the period 1980-2001**

	Type of crop		
	Cereal	Pulses	Oil seeds
Average annual production growth	0.74	0.6	0.48
Growth attributed to land expansion	0.57	0.45	0.38
Growth attributed to yield increase	0.17	0.15	0.1

This shows that 1) production growth, which is at average annual value of 0.61% mainly comes from cultivated land growth at 0.47% and productivity growth of 0.14% respectively. 2) The average population of growth of Ethiopia is

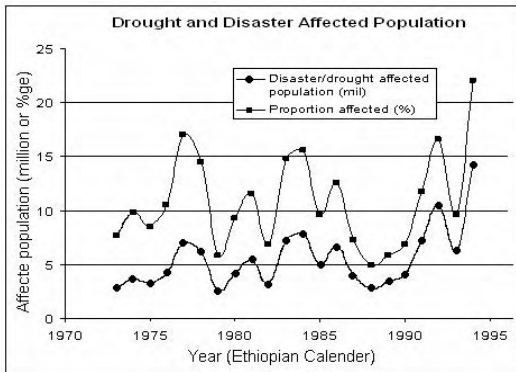


Figure 2: Drought and Disaster Affected Population in Ethiopia<sup>2</sup>

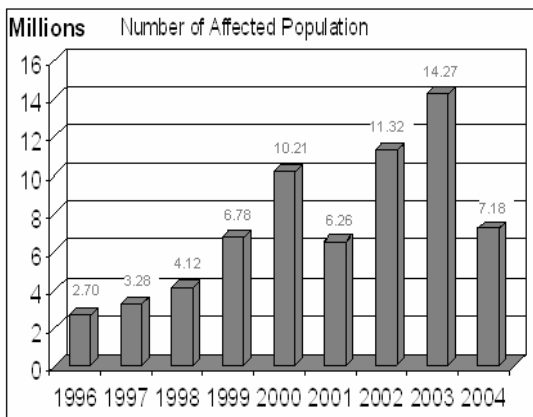


Figure 3: Drought and Disaster Affected Populations during the last decade

growing at approximately 2.1% in the same period, and the result shows production growth is way below population growth 3) Given that majority of the population live in highland and marginal areas, the former pushes agriculture to encroach more and more to less productive, highly vulnerable to degradation and high gradient marginal land. However, the recent reports of government sources show that particularly after the 2002/2003 drought, productivity of agriculture has increased, with noticeable magnitude of over 6%.

<sup>2</sup> Ethiopian calendar is according to Gregorian Calendar, 2006 August corresponds to 1998 in Ethiopia, and new year occurs in September

## 2.2.4 Large Water Potential and Low Infrastructure

Figure 4 shows the potentials of water resources availability and the hydrological variability of major rivers in Ethiopia, which is also a depiction of the rainfall variability. These water resources potentials are not utilized to lack of water control and management infrastructure. Figure 5 illustrates the comparative per capita water availability of various countries in the world including Ethiopia. It is clear that the annual per capacity water storage availability in Ethiopia is just 38m<sup>3</sup>, compared to say Brazil which has got 3,386m<sup>3</sup> or North America which is at 5,961 m<sup>3</sup>. The major storage is yet in non agricultural sectors such as hydropower and urban water supply

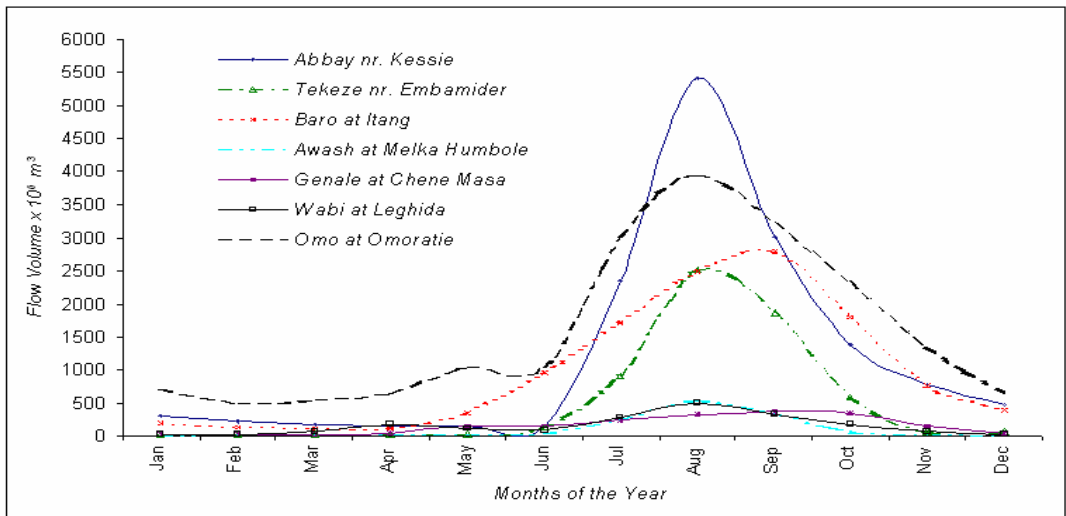
## 2.3 Improved AWM and Investment Opportunities in Ethiopia

### 2.3.1 Investment Opportunities

Rural Ethiopia exhibits a huge variation along a number of social and economic dimensions: ethnic group, religion, and economic status are just three. After infrastructure development such as roads, investments in irrigation emerge as key factor triggering rural upliftment Moreover, the multiplier effects of investments in agricultural intensification, for example for irrigation, are considerable (Hussain and Hanjra 2004). Studies reveal that for each dollar invested in agriculture, the value of economic activity in forward and backward linkages including input supply, trade, export, and processing adds another two dollars return. However, for these benefits to be realized especially in the African smallholder context, smallholder irrigation must satisfy the following conditions (Shah et al., 2002):

- Irrigation must hold out a promise of making significant improvement in the livelihoods and food security situation of the irrigation farmers, i.e., it must be central in their livelihood strategies, and a large proportion of household income must come from irrigation (this relates to optimal plot sizes, crop choices, etc. that enhance viable production);



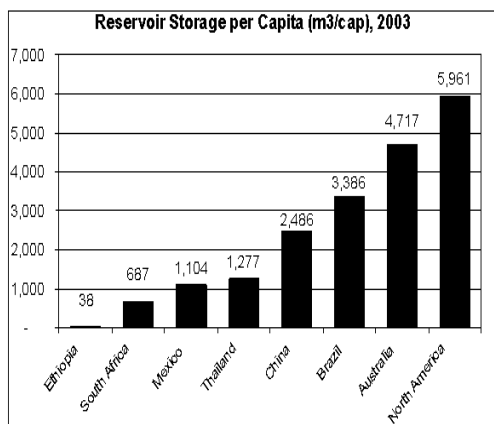


**Figure 4: The Water Resources Potential & Variability of Major Rivers in Ethiopia**

- The cost of sustainable farmer management of the schemes (including infrastructure, technology, water user associations, etc.) must be an acceptably small proportion of the income derived from irrigation, i.e., benefit cost ratios must give incentives that facilitate rational production decisions;
- The schemes must have a certain level of access to institutional support services, including access to inputs, output markets, credit, extension, institutional framework defining and enforcing secured and use rights to land and water
- 

### 2.3.2 Irrigation in Ethiopia

Irrigation is one means by which agricultural production can be increased to meet the growing food demands. Increasing demand can be met in three ways: increasing agricultural yield, increasing the area of arable land, and increasing cropping intensity (number of crops per year). Expansion of the area under cultivation is a finite option especially due to the marginal and vulnerable characteristic of large parts of the country’s land. Increasing yields in both rainfed and irrigated agriculture and cropping intensity in irrigated areas through various methods and technologies are viable options for achieving food security in Ethiopia. If the problem is failure of production as a result of natural causes such as dry-spell, drought, etc., agricultural production can be stabilized and increased by providing for irrigation and retaining more rainwater for in situ utilization by plants.



**Figure 5. Per Capita Stored Water Availability of Ethiopia and Selected Countries of the World**

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

and unpredictable natural factors (unpredictable climate). Ethiopia has also to combine these with enhancing water availability for production and expansion of irrigation that can lead to security in terms of getting a reliable harvest as well as intensification of cropping (producing more than ones per year). This should be combined with improved partitioning, storage and soil water-retention capacity to increase plant water availability, and use of rainwater to overcome erratic rainfall especially in the relatively higher rainfall areas of highland Ethiopia. There are also important other ways to reduce risk for farmers (social, economic, spatial diversity) and for the government (trade, buffer, pricing).

The estimates of the irrigation potential of Ethiopia vary from one source to the other, due to lack of standard or agreed criteria for estimating irrigation potential in the country. The earlier reports for example according to World Bank (1973) as cited in Rahmato (1999) show the irrigation potential at the lowest 1.0 and 1.5 million hectares, and the highest according to Tilahun & Paulos (2004), on the order of 4.3 million hectares. Table 1 provides the distribution according to the latter. Thus, the above variation in estimates calls for accurate review of the irrigation potential of the country.

Similarly, there is no consistent inventory with regard to the developed irrigation of the country. In 1990, BCEOM (1998) estimated a total of 161,000 ha of irrigated agriculture for the country as a whole, of which 64,000 ha was in small-scale schemes, 97,000 ha in medium and large-scale schemes, and approximately 38,000 ha as being under implementation. Tilahun & Paulos (2004) report that the traditional irrigation schemes alone cover 138,339 ha, and that 48,074 ha are under modern small scale irrigation, 61,057 ha under modern large and medium scale schemes, with the aggregated sum of irrigated agriculture at 247,470. From the latter, it can be seen that small-scale irrigation contributes 75% of the irrigation (74.2% traditional and 25.8% modern small scale). Given the current household level irrigation expansion through traditional schemes and water harvesting, it is also possible that the total sum of actual irrigation development could be over 250,000 ha. One of

the limiting factors of irrigation potential is water abstraction. The Ethiopian hydrographical network often shows deep and narrow gorges that make water abstraction costs extremely high. However, construction of multipurpose dams for irrigation, hydropower and flood control may help reduce the per hectare cost of development.

Ethiopia indeed has significant irrigation potential assessed both from available land and water resources potential. Irrespective of the lack of knowing what is the accurate potential and what has been developed, and despite efforts of the government to expand irrigation specially on SSI, MI and RWH, the country has not achieved sufficient irrigated agriculture to overcome the problems of food insecurity and extreme rural poverty, as well as to create economic dynamism in the country.

### **Large and Medium Scale Irrigation**

Irrigation projects in Ethiopia are identified as large-scale irrigation if the size of command area is greater than 3,000 ha, medium scale if it falls in the range of 200 to 3,000 ha, and small scale if it is covering less than 200ha. The categorization in this document is based on the size of land irrigated. In addition to the above classification according to MOWR (2002), the new classification developed by Lempérière also includes the dimensions of time and management. This system distinguishes between four different types of irrigation schemes in Ethiopia: traditional, modern communal, modern private and public. More details on the different types can be found in Werfring et al. (2004: in press). The existing irrigation scheme development based on Regions is shown in Table 2.

Although the number of large and medium scale irrigation projects has remained stagnant in the last decade, in the new water sector development program, these types of irrigation schemes are considered important. Figure 6 provides information on the targeted development of irrigation schemes in Ethiopia. The development of large-scale schemes is useful as they are associated to useful infrastructure development, create job opportunities, and contribute to agricultural growth and to the macro economy.

Parallel to the water sector development program, there are considerable efforts to develop master plans for the various river basins such as Abay, Tekeze, Wabishebelle. In fact comprehensive master plans for five basins are already developed. Through these master plan studies, a number of medium and large-scale irrigation projects are identified. The challenge is to transform these master plans into practice through undertaking feasibility studies, design and construction, operation and maintenance in a sustainable and profitable way.

Even with its limited capital for investment, Ethiopia needs to consider the opportunities that large and medium scale schemes provide as mechanisms of food security and fighting poverty. Many countries have developed irrigation schemes as public investment (e.g., India, China, Egypt, USA) and some are still developing irrigation through the allocation of public and government resources (e.g., Turkey, Brazil). Though not always designed as pro-poor interventions, large-scale irrigation

**Table 2: Existing Irrigation Schemes by Region (Source: Tilahun & Paulos, 2004).**

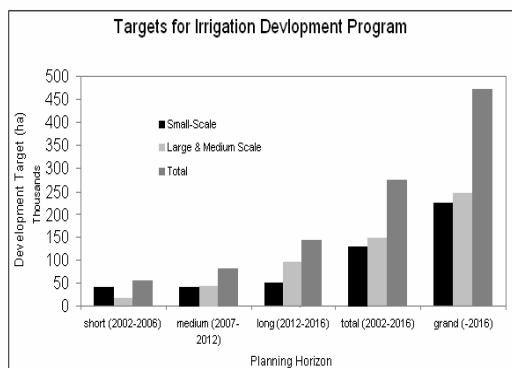
Region	Irrigable Potential	Current Irrigation Activities		
		Traditional	Modern Irrigation	
			Small	Medium & Large
Oromia	1,350,000	56,807	17,690	31,981
Amhara	500,000	64,035	5,752	-
SNNP	700,000	2,000	11,577	6,076
Tigray	300,000	2,607	10,000	-
Afar	163,554	2,440	-	21,000
Ben Shangul				
Gumuz	121,177	400	200	-
Gambella	600,000	46	70	-
Somali	500,000	8,200	1,800	2,000
Hareri	19,200	812	125	-
Dire Dawa	2,000	640	860	-
Addis Ababa	526	352	-	-
<b>Total</b>	<b>4,256,457</b>	<b>138,339</b>	<b>48,074</b>	<b>61,057</b>

schemes in Asia have been shown to have positive poverty impacts (Hussain, 2004). The Government could also consider other models found in for example China and build large public schemes at its expense, and then contract out the operation and maintenance (O&M) and even agricultural services to private firms; and promote farmer-based WUAs or coops at secondary canal levels to do the O&M at that level.

#### **Small Scale Irrigation Schemes**

The small-scale irrigation schemes in Ethiopia are understood to include traditional small scale up to 100 ha and modern communal schemes up to 200 ha (MoWR 2002). However, we also see a 'traditional' spate irrigation scheme in, for instance Tigray, of up to 400 ha. Traditionally farmers have built small-scale schemes on their

own initiative, sometimes with government technical and material support. They manage them through their own users' association or committees (MoWR 2002). The farm size varies between 0.25 ha and 0.5 ha. Water user associations have long existed to manage traditional schemes. They are generally well organized and effectively operated by farmers who know each other and are committed to cooperating closely to achieve common goals. Typical associations comprise up to 200 users who share a main canal or a branch canal. They may be grouped into several teams of 20 to 30 farmers each. Such associations handle construction, water allocation, operation and maintenance functions.



**Figure 6: Irrigation Development Targets (data based on MoWR, 2002)<sup>3</sup>**

The Federal or Regional Government normally constructs small-scale modern schemes. Such schemes have been expanded after the catastrophic drought in 1973 to achieve food security and better peasants' livelihoods by producing cash crops. Such schemes involve dams and the diversion of streams and rivers. The constructed and completed schemes of such types are usually "handed over" to WUAs for management, operation and maintenance with the support of personnel from Regional Bureaus. See section 4 for further discussion.

### Micro Irrigation

Micro irrigation is not understood in the same sense in all regions of Ethiopia. Sometimes the term is used for small-sized schemes of less than 1 hectare developed at household level, such as rainwater harvesting schemes. Others consider micro irrigation in relation to the technology and refer to drip irrigation schemes. In this report, we use "micro irrigation" to refer to individualized small-scale technologies for lifting, conveying and applying irrigation water. It therefore includes treadle and small power pumps to lift water, and a variety of irrigation application technologies such as small bucket and drip systems, and small sprinkler systems. In general, the advantages of this category of technologies are: 1) they can be adopted and used by individual farmers, i.e., are not depending on collective action by groups; 2)

they are of relatively low cost in terms of their capital and operating costs (per farm, not necessarily per hectare) and therefore are potentially affordable by small farmers; 3) they are often highly efficient in use of water (high water productivity) while also improving crop quality and reducing labor costs; and 4) they can be distributed by private firms through markets, i.e., are not dependent on being provided by government institutions. This category is sometimes referred to as "Affordable Micro Irrigation Technology, AMIT" (ITC et al., 2003) to distinguish it from commercially available 'high-tech' irrigation application technologies such as pressurized drip systems.

In Ethiopia, some private entrepreneurs producing high value crops are using the latter types of conventional 'high-tech' micro irrigation systems. All of the mushrooming flower farms (around Sebeta Hollota areas in the Oromia Region) and to some extent others such as vegetable farms (e.g., Genesis Farm in Debre Zeit, Oromia Region) are using these conventional imported irrigation technologies on relatively large holdings.

The use of micro irrigation, for example under current efforts of water harvesting in Ethiopia where the harvested volume of water is small, is appropriate from the point of view of conserving water. The use of micro irrigation by poor farmers has hardly begun in Ethiopia. Its introduction is a recent phenomenon, with some attempts to utilize this concept by NGOs (such as World Vision in the South, SNV in Wello Area) and universities such as Arba Minch University (AMU) and Mekelle University (MU).

It is appropriate and timely to consider introducing the wide range of technologies developed elsewhere such as in India and Kenya, so farmers can make their own selection. For example, farmers in India in 2002 could buy four types of kits: bucket kit, drum kit, customized kit and micro sprinkler. According to ITC et al. (2003), the prices of different types of kits ranged from Rs 225 (US \$5) for bucket kits to Rs 3,000 (US \$63) for tank kits. Individual farmers directly purchase these kits.

<sup>3</sup> Note that grand is total existing plus the planned schemes

In Ethiopia there are also local manufacturers such as Selam and Wolita Rural Development Center that are trying to manufacture and promote treadle pumps. Treadle pumps and small power pumps could provide an opportunity to lift water stored from harvested rain in underground tanks or shallow ground water wells. This type of technology could be also imported and adapted for up scaling.

It should be understood that adding 'only' water to the soil increases the rate with which the crop removes plant nutrients, and when these are not replenished by chemical or organic fertilizer, the soil degrades, reducing production capacity even faster than if no water were added. In other words, a plant nutrient replacement strategy must be part of any irrigation strategy. Market-driven profitable agriculture provides farmers incentives to invest in soil fertility.

### **Rainwater Harvesting**

The term rainwater harvesting (RWH) is used in different ways and thus no universal classification has been adopted (Ngigi, 2003). According to Critchley and Siegert (1991), water harvesting in its broadest sense is defined as the "collection of runoff for its productive use." Runoff may be harvested from roofs and ground surfaces as well as from intermittent or ephemeral watercourses. A wide variety of water harvesting techniques for many different applications is known. Productive uses include the provision of water for home garden application, livestock water, concentration of runoff for crops, fodder and tree production and less frequently water supply for fish and duck ponds.

An excellent overview on land and water conservation technologies and small to medium scale irrigation in Ethiopia is presented by WOCAT (<http://www.fao.org/ag/agl/agll/wocat/wocatqt.asp>). It lists 7 technologies specific for Ethiopia, while many others from other countries apply in some areas. Oweis et al. (1999) reviewed water harvesting methods used in winter rainfall areas (>100 mm per year) and in summer rainfall areas (>250 mm). They give an excellent overview of the theory of catching, concentrating and storing of water, and how this relates to rainfall characteristics, landscape and

crop demands. The principles have been known and applied for millennia. Practical designs are given, yet the authors note that recent attempts to encourage more farmers in semi-arid zones are often disappointing, and give the following reasons: (i) people often do not understand the principles and get inadequate training, (ii) transaction costs are high, (iii) outside institutions are often needed to get started, (iv) too little focus on 'risk' and how to handle it, and (v) cooperation with different people (i.e., not worked with before) is difficult. The fact that many farmers in semi-arid regions do not own the land they farm is another reason why investments in water harvesting are low. Not mentioned in the review but likely also a cause of slow uptake is that many of the farmers in semi-arid regions have more experience of being a herdsman than being a cultivator. Kunze (2000) showed that although profitability of water harvesting can be significant at the field level, it might still be negligible if only applied to a small part of the farm.

RWH systems are generally categorized into two categories: a) in-situ water conservation practices, small basins, pits, bunds/ridges, and b) runoff based systems (catchment and/or storage). The storage system is usually used in supplemental irrigation. The in-situ systems, which enhance soil infiltration and water holding capacity, have dominated over storage schemes in Ethiopia until recently. Despite the additional costs involved in storage schemes, the recent trend shows there is a relatively high degree of adoption. Surface runoff from small catchments and roadside ditches is collected and stored in farm ponds holding an average of about 60m<sup>3</sup> of water. This storage is not significant in volume and thus is usually used for supplementary irrigation of vegetables. The use of these systems can be extended to crop fields and larger plot sizes can be warranted through larger sizes of storage combined with efficient water application methods such as low-pressure drip irrigation methods.

Hence, rainwater harvesting is a useful mechanism to overcome the recurrent erratic rainfall and dry spell conditions which often result in crop failures in Ethiopia. There is a need to effectively promote promising RWH

technologies and systems; to incorporate and integrate land users' knowledge and innovations; and to build capacity of the land-users to assimilate, adopt and adapt various technologies. We address this in the following sections.

### 3. Main Gaps to promote SSI, MI and RWH in Ethiopia

The following lists are key constraints, knowledge gaps and broad research needs in effectively implementing the technologies of small scale irrigation, micro irrigation and rain water harvesting in Ethiopia (for details, see IWMI 2004):

#### Main Constraints

- Lack of or inadequacy of baseline studies, data and information on potentials of different areas for the development of water resources
- Poor technology choice
- Low yields
- Property rights
- Too small landholdings
- Conflicts in water use and use rights
- Marketing and market access
- Dependency syndrome
- Institutional arrangements and instability
- lack of training to handle technologies; lack of extension services
- lack of start-up capital or access to credit to initiate venture
- poor linkage between research and extension in the area of irrigation water management

#### Main knowledge gaps

- Faulty design
- Lack of knowledge on use of modern irrigation technology
- Poor water management
- Poor land management
- Poor input utilization
- Poor management capacity
- Lack of information and database
- Lack of post-harvest technology and management

#### Future Opportunities

- High water potential
- High commitment of the Ethiopia government, donors and NGOs to support irrigation management and development activity
- Opportunity for implementing multiple use water systems (MUS), with regions coordinating sub-activities. Effective utilization of scheme infrastructure through diversification of uses to meet various needs for water such as domestic, irrigation, livestock and hygiene is the most important.
- Opportunities for improving knowledge of policy makers, planners, designers, contractors and development agencies through education, training, dialogues and participation
- Opportunities for more gender-equitable investments, targeting poor women, through for example MUS and micro irrigation

#### Research Needs

These research needs specific to this paper can be grouped into the following broad categories:

- *Policy research* – strategic policy research to enhance the improvement of national level policies and processes, and to enhance the realization of broader poverty and food security impacts of smallholder irrigation interventions at national, regional and local (community and household) levels.
- *Socio-economic and market research* – research on marketing and market information so that farmers can produce targeted crops using irrigation was a general issue in all regions; market surveys and analysis so that farmers can produce according to market requirements; input supply arrangements during irrigation period; research on how to successfully upgrade traditional schemes into modern ones, including organizational issues related to WUA formation; benefit-cost analysis for alternative irrigation technologies taking into account affordability, accessibility, maintenance and sustainability.

- *Institutional research* – research to establish clear and effective policies to minimize conflicts between upstream and downstream water users (raised as an issue in Amhara); problems of institutional arrangements in regional structures was acknowledged as relevant in all regions except Oromia; research on property rights regarding access to land and water was emphasized, particularly clear definition of rights to water to minimize conflicts between traditional irrigator and those on modern small scale scales.

## 4. Conclusion

Promotion of water related technologies in Ethiopia, at small and large scales, makes good sense for a number of reasons, and there are basically good opportunities for both. Large scale irrigation schemes and technologies are relatively well known and the government has already plans to promote these systems actively. Some types of small scale technologies, especially micro irrigation technologies, however, are still relatively new in Ethiopia. Yet they have the potential of enabling supplementary irrigation for millions of people and to achieve household food security through home garden micro irrigation, and modest wealth for emerging commercial farmers. The relatively simple equipment needed can be produced locally, hence promoting off farm employment, and better post harvest stimulate the same indirect benefits. Since small scale technologies are also particularly effective in expanding the source of domestic water and for home gardens; therefore they are a key to empowering women. There are examples of successful financing mechanisms for poor farmers to adopt small scale technologies, including self financing and micro-loans.

To carry out such a program, activities must build on the ongoing projects by GOs, NGOs, CBOs and farmer organizations, and on their experiences. This includes learning from other counties, building research and extension capacity in Ethiopia, participatory implementation of household and communal water use systems for domestic and productive uses, and refining the methods for implementation through evaluation,

demonstration and learning sites. It must also include development of the legal framework for land and water and related service providers. Research needs to accompany the implementation process to allow acceleration of up- and out-scaling, and to continually adjust recommendations to local conditions and to development in materials and knowledge. To prepare for such an expansion, capacity building and awareness promotion must be addressed from the beginning. If the implementation program is successful, significant local demand for small-scale equipment will develop. The creation of local supply chains of these equipments and other agricultural inputs, including fertilizers, is crucial.

If the implementation project is really successful, significantly larger volumes of vegetables and other food items will be produced. Markets for these products need to be identified, and producers should be connected to them. These explorations should be initiated in an early stage.

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**State of the art and best technologies review in  
rainwater harvesting, small scale irrigation  
& micro irrigation**



# Review of Agricultural Water Management Technologies and Practices

Regassa Namara, Seleshi B. Awulachew and Douglas J. Merrey

IWMI

r.namara@cgiar.org

## Abstract

Low average rainfall that is seasonal, highly variable in time and space, and increasingly unreliable is the major impediment to farm households increasing their production of food, cash crops, and livestock products in Ethiopia. The impacts of this unreliable and inadequate water supply are compounded by many other problems both natural (for example poor soil fertility), and human-created (for example lack of support services and infrastructure). Improving the reliability of water supply for agriculture is therefore a necessary though not sufficient condition for reducing poverty and malnutrition and generating faster agricultural growth. There is reasonable though not conclusive evidence that some of the agricultural water management technologies reviewed in this study, under the right conditions, do lead to substantial improvements in households' food security and incomes, and that they do so in a cost-effective manner. But the tremendous diversity of conditions in Ethiopia must be acknowledged. Even within districts, there is such diversity in soils, micro-climate, cultures, and access to markets that what works on one farm may not be appropriate next door. This means there is no possibility of generalizing, no cook book approaches or sure-fire universal panaceas that will work everywhere. Following from the diversity of Ethiopia, it is no surprise that there are no cases of successful massive scaling up and out of specific agricultural water management technologies and practices. Adoption, adaptation, or rejection decisions are a function of many factors including lack of information or access, lack of fit between the technologies on offer and the capacities and needs of households, inefficient promotion strategies, flawed assumptions about households' needs and capacities and the real costs and benefits from their perspectives, ineffective targeting, lack of capacity to manage projects offering a large array of small-scale technologies to

thousands of poor households, and lack of credit.

## 1. Introduction

Due to progress in agriculture, globally there is enough food supply that can satisfy the needs of the world's growing population and projections indicate no global food shortage in the forthcoming decades. Investments in water resources have effectively contributed to this success of modern agriculture. However, these successes are yet to be achieved particularly in many of the sub-Saharan African countries including Ethiopia. Lack of reliable access to agricultural water undermines the food security and poverty reduction objectives of the region. Without guaranteed access to reliable water, the farmers, the main actors in the food security and poverty reduction battle, lack the motivation to adopt other productivity enhancing inputs such as fertilizers, high yielding varieties, herbicides, etc, which are the bases for the green revolution of the type that had been observed in Asia and Latin America.

The vast majority of the rural poor rely on rain-fed land for their survival, making them vulnerable to the highly variable and unpredictable rainfall. Some authorities suggest this variability may be increasing. Even in years having "normal" rainfall, a period of ten to fifteen days with no rain at a critical stage in crop growth can spell disaster for thousands, even millions, of poor farmers. Periodic drought and famine are the result in many regions of Ethiopia, which is hard hit by what seem to be increasingly frequent and devastating droughts, floods and famines. In addition to the hunger and starvation that ensues, the results are drastically reduced economic growth rates, serious impacts on the nutritional status of

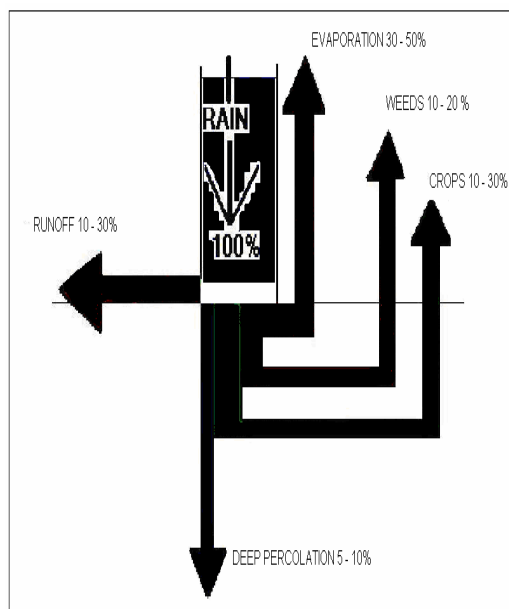
children, compounding of the already serious impacts of malaria, HIV/AIDS and other diseases, and reduced resilience to face the next drought period.

Investment in Agricultural Water Management (AWM) is often identified as one of the possible responses to this problem, and has had considerable success in Asia in terms of achieving national as well as local food security, reducing poverty, and stimulating agricultural growth (IWMI/ADB 2005). In Ethiopia, AWM investments never kept pace with those in Asia for many reasons, such that today, of all the major developing regions Ethiopia has one of the lowest percentages of cropped area irrigated (FAO 2002). Many analysts believe future increases in food supplies and economic prosperity for the rural poor in the Ethiopia will mainly come from improved agricultural water management. Access to water will allow the intensification of agricultural production systems. In light of this, researchers, policy makers, NGOs, and farmers are increasingly experimenting with and promoting various innovative agricultural water management technologies and practices. It is believed that making widely available relatively low-cost AWM technologies can make a major contribution (e.g., Falkenmark and Rockström 2004; Polak 2005). There is evidence from Asia, for example that the introduction of treadle pumps has lifted millions of people out of poverty (Shah et al. 2000). Throughout India private firms and NGOs are promoting a large variety of highly cost effective agricultural water management technologies whose uptake and impacts are indeed impressive (e.g., Shah and Keller 2002; Namara et al. 2005).

This paper summarizes suitable innovative agricultural water management techniques and approaches that may be applicable to Ethiopia in combating the effects of dry spells and/or droughts based on experiences from other regions in Africa and Asia. First, the definition of Agricultural Water Management is provided based on the concept of rainfall partitioning at the field level. Second, the paper provides examples AWM technologies by categories and finally some conclusions and recommendations are made.

## 2. Agricultural Water Management

Figure 1 gives an indication of the partitioning of rainfall into different water flow components in rain-fed agriculture (Rockstrom 2000). Soil evaporation accounts for 30-50% of rainfall. Surface run-off is often reported to account for 10-30% of rainfall. The characteristics in dry lands of frequent, large and intensive rainfall, results in significant deep percolation amounting to some 10-30% of rainfall. The result is that productive green water flow as transpiration in general is reported to account for merely 5-10% of rainfall. The rest, between 70-90% of rainfall is lost from cropping systems as non-productive green water flow (soil evaporation) and as blue water flow (deep percolation and surface run-off).



**Figure1. Partitioning of rainfall at field level**

The figure provides a conceptual diagram illustrating the potential for improving the productivity of rainfall: if unproductive evaporation, runoff and consumption by weeds are reduced, there will be more water available for the crop. Hence: the need for agricultural water management interventions.

The term “agricultural water management” is a broad term covering an increasingly wide range of technologies and practices available for

improving water and land management. It is now a commonly accepted term to cover the range of technologies and practices whose objective is to ensure that adequate water is available in the root zone of crops when needed. It therefore includes capture and storage (in dams, in groundwater) as well as drainage of any water used for agriculture (crops, livestock, fish); lifting and transporting water from where it is captured to where it is used for agricultural production or removing excess water from where agriculture is practiced; and in-field application and management of water, including land management practices that affect water availability to crops (Merrey et al. 2006). In-field application and management of water and land is the common denominator, regardless of the source of the water, and is a critical element of all agriculture. Therefore “AWM” is critical to successful agricultural production.

### 3. Some examples of AWM

#### 3.1 Technologies for Water Control and Storage

##### **In situ soil and water conservation technologies**

Soil and water conservation (SWC) refers to activities that reduce water and nutrient losses and maximize their availability in the root zone of crops: rainwater and therefore nutrients are conserved where it falls, in-situ. This distinguishes SWC from rainwater harvesting (RWH), which seeks to transfer run-off water from a “catchment” to the desired field or a storage structure (Mati 2006). RWH includes a range of micro-catchment systems, earthen bunds and other structures to capture and store run-off from elsewhere (hence, ex- situ) for use when needed. As Mati (2006) notes, the line between SWC and RWH technologies is very thin.

A recent large-scale assessment (286 interventions in 57 poor countries covering 37 million ha and 12.6 million farms) shows that “resource-conserving agriculture”— including among others rainwater harvesting,

conservation agriculture, and integration of livestock and aquaculture into farming systems—has led to an average crop yield increase of 79%, and very high water productivity gains (Pretty et al. 2005). The water productivity gains ranged from 70% to 100% for rainfed cereals, legumes and roots and tubers. This work supports experimental, theoretical and practical work by Rockström (e.g., Rockström et al. 2003; Falkenmark and Rockström 2004), Hatibu and Mahoo (eds.2000), Ngigi (2003) and others that demonstrates a doubling of rainfed crop yields in the semi-arid tropical regions of SSA is possible with currently known technologies for improving water and nutrient management. Mati (2006) provides a good source on experiences with a large number of RWH and SWC technologies in eastern and southern Africa.

Water and soil nutrient management are critical to successful agriculture. Soil nutrients are being mined in Ethiopia, leading to declining yields; but with the high cost and sometimes non-availability of fertilizers, Ethiopia has one of the lowest per ha use of fertilizer in the world. Yet there are a large number of both indigenous and introduced technologies and practices that can help maintain and enhance soil nutrients. SWC therefore includes techniques like terracing, ditches, stone and vegetative bunds, mulching, conservation tillage and more broadly “conservation agriculture.” What specific techniques or combination of techniques is appropriate depends on local climate, soil, social and economic and other factors. Below, we provide a more detailed discussion of techniques that come under the heading of “conservation agriculture.”

#### **Conservation Agriculture**

FAO suggest a definition for conservation agriculture as:

Involving a process to maximize ground cover by retention of crop residues and to reduce tillage to the absolute minimum while exploiting the use of proper crop rotations and rational application of inputs (fertilizers and pesticides) to achieve a sustainable and

profitable production strategy for a defined production system.

In practical terms, examples of conservation agriculture techniques include the following:

- Ripping only the planting line using a tractor or animal-drawn 'rippertine', rather than normal plowing;
- Tied ridges, for holding water and facilitating infiltration in low rainfall areas (there are a variety of types of ridges);
- Mulching using both crop residue and material from non-cultivated areas, for holding water, returning nutrients to the soil, and in some cases reducing the temperature of the soils;
- Assuming hand-hoe farming: a variety of techniques referred to as pot holing, pitting, trenching (ridges and furrows);
- Where erosion control is important, various techniques such as contour ridges, storm drains, grass strips, etc. and
- Agroforestry and green manure or cover crops, many of which contribute to nitrogen fixation.

Conservation agriculture has not developed in Ethiopia and Africa in general as rapidly as its proponents wish. There are many reasons: low soil fertility combined with unreliable rainfall make agriculture risky and limited access to markets make it unprofitable; and traditional communal land tenure systems which limit land use rights to the growing season discourage investment in for example green manure or cover crops. Further, the very diversity of agricultural environments and economic conditions make selection of appropriate mixes of cost effective and appropriate technologies rather difficult. The situation is compounded by the lack of clear policy and institutional support. Although in the long run conservation agriculture is expected to save labor, during the transitional stage, i.e., the first 1-5 years, labor costs are often higher. Conservation agriculture is a long-term investment in improved soil fertility and water holding capacity, but initially the returns compared to the costs may discourage many small farmers. In some agroecological areas, soils are predominantly clay having very low infiltration rates. In such cases the depth of water infiltration is very

small and water may remain (ponding) at the soil surface or in the upper layer of the soil profile if ridges are tied or pits are made.

Minimum or no tillage technologies, which are forms of conservation agriculture, are seen as ultimately labor saving while improving household food security and incomes. Daka (2006) says that in Zambia micro-basins prepared by hand hoes to capture and store rainfall lead to a doubling of maize yields to 3 tons/ha. This performance has led to accelerated adoption such that small farmers cultivating an estimated 200,000 ha of rainfed land have adopted such conservation technologies. They have the additional advantage of allowing precision planting and fertilizer applications. It makes use of tools and implements such as the jab planter and the animal drawn ripper or no-tillage planter, in combination with agronomic practices that have the potential to suppress weeds through soil cover and introduction of cover crops form a set of possibilities (SWMG 2005). Minimum tillage reduces labor requirements especially in peak seasons for land preparation and weeding, and potentially contributes to household food security by making more efficient use of rainwater and increasing soil fertility through the introduction of nitrogen fixing cover crops. Minimum tillage reduces expenditure on hiring farm power services and purchase of fertilizers, whilst generating additional revenue through the production of fodder and cash cover crops, and reduces production costs by reduced use of expensive fuel.

In Namibia, the Agronomic Board promotes conservation tillage, especially in the form of planting pits dug with a hoe (de Lange 2006); the main cost to the farmer is her own labor in the first year, but the Board claims this work can be spread over a long time period in small steps, and the work load diminishes in subsequent years through fewer weeds and higher yields. In East Africa such systems are usually used for special crops like banana and fruit trees; their use for maize as in Zambia and Namibia is considered novel.

There is a rather large menu of technologies and practices, and these can be packaged to create synergies among them and to adapt them to

specific contexts. For example, combining various types of reduced tillage systems or pits with mulch, combining contour ridges or basins with mulch seems to provide very positive results. Several researchers emphasize the critical importance of combining water and soil nutrient management (Twomlow and O'Neill 2003; Stroosnijder 2003) indeed water conservation without combining with nutrient management often leads to no positive impact. This also suggests the importance of paying attention to agronomy and soils as well as water technology and markets.

### **Ex-situ water harvesting and storage**

There are a variety of technologies for harvesting rainwater from roads, foot-paths and household compounds. Many of these water run-off harvesting systems have been developed by farmers themselves, for example those capturing "sheet and rill" runoff generated by compacted surfaces like roads, paths and household compounds. Water is harvested and directed either directly onto cropped fields, or into various types of natural or man-made storage structures (see fig 2).

In this section we provide examples of small storage dams, shallow wells and boreholes, roof top water harvesting, and above- and below-ground storage tanks.

### **Small storage dams and tanks**

A large variety of storage technologies are in use around Eastern and Southern Africa. We discuss here a few types that require minimal engineering.

#### **Charco dam**

Mati (2006) describes charco dams as small excavated pits or ponds constructed in relatively flat topography, and requiring minimal engineering. They are generally about 3 m in depth, and take advantage of areas where water collects naturally. They are used for multiple purposes including livestock water and to supply domestic water to villages and small towns. The technology can serve up to 500 households or 4,000 livestock units in semi-arid areas (SWMG 2005). Local communities are



**Figure 2. Road runoff harvesting into a channel for banana production, Arabaminch, Ethiopia, 2006**

responsible for the management of the dams.

The village communities participate in the planning and construction of the dams and are responsible for their operation and management. Normally the village governments form dam management committees with responsibilities of operation and maintenance of the dams. Additionally the committees are expected to come up with by-laws and measures that are acceptable and implementable by the local communities within the catchment areas of the dams.

### **Rooftop rainwater harvesting and above ground storage tanks**

Harvesting rainwater from roofs of buildings usually combined with either storage or, with drip irrigation kits are also increasingly common in Eastern Africa (Mati 2006). Despite relatively high rainfall, the level of activity in rainwater harvesting in Ethiopia is very low and isolated until quite recently. The most common type of rainwater harvesting is the traditional one, where families catch water falling from rooftops in drums of 200-210 liters capacity for short term use. The technology is quite novel in its formal state but it has existed for a long time. A similar type of system involves the use of gutters on buildings like schools and

hospitals. Though with limited application, the system referred to as 'institutional rainwater harvesting' is quite effective and uses ferrocement tanks, which collect rainwater from roof tops via gutters. The collected water is used by the concerned communal institutions.

While the collection of rainwater by a single household may not be significant in the larger scheme of things, the impact of thousands or even millions of household rainwater storage tanks can be enormous. The main components in a simple roof water collection system are the tank itself, the materials and the degree of sophistication of the whole system largely depends on the initial capital investment. Some cost effective systems involve cisterns made with ferrocement. In some cases, the harvested rainwater may be filtered. In other cases, the rainwater may be disinfected. Storage structures for roof catchments include surface tanks like ferrocement tanks and commercially available plastic tanks. Drip kits are promoted by some NGOs in combination with rooftop water harvesting, but the need for gutters and a collector tank is seen as raising the cost significantly.

### **Underground tanks to catch surface run-off**

Underground rainwater tanks are a cheaper alternative than above-ground tanks because construction costs less; however it is then necessary to lift the water. Another problem is higher likelihood of contamination and sedimentation. The main problem, however, is lack of expertise at local level to design and construct underground tanks that are safe and functional (Mati 2006). Nevertheless, underground rainwater storage tanks (cisterns) are being aggressively promoted by several African governments, for example Ethiopia, and material on designs is available through Southern and Eastern Africa Rainwater Network (<http://www.searnet.org>).

In South Africa, underground tanks are currently being promoted to enable food insecure households to become more resilient against hunger. With an average rainfall of 450mm/year, the increased run-off available from the homestead yard, adjacent roads and

fields as compared to rooftops, is an important potential water source. In hilly areas it is possible to channel surface run-off into above-ground tanks, but otherwise, underground tanks (cisterns) are preferred.

A wide range of building materials can be used, with the most popular currently being self-made cement-blocks and ferrocement. Rammed earth is being investigated as an affordable alternative, while geofabric with a bitumen coating has also been tried. A variety of plastic linings are being investigated for their durability and ease of installation and maintenance by households. They are said to be already in use in parts of Kenya because they are easy to construct and more affordable (Mati 2006). However, this depends greatly on the types of plastic available in any particular country. In South Africa, nine types of plastic lining are currently being investigated to identify the most suitable for specific applications.

Clearly, there is a large range of potential small scale technologies for capturing water and directing it either onto crops or into storage facilities for later use. Many of them are quite low-cost and easily constructed by local people from local materials, with minimal technical assistance; and many of them provide water that can be used for many purposes, not just agriculture. As with other small-scale technologies, combining different ones to capture, store, and apply water is often synergistic: a small amount of water captured and stored can be used very productively and with minimal labor cost by combining with drip kits or treadle pumps. But adaptation to local conditions, with poor farmers empowered to make their own decisions rather than being passive recipients is critical to success.

### **Groundwater**

#### **Hand dug shallow wells**

In many parts of SSA, shallow wells are constructed in valley bottoms and equipped with pumps or other manual technologies. The water is used for human use, livestock and some supplementary irrigation during dry spells. These are largely privately constructed.



### Boreholes

In many SSA countries, small-bore wells (boreholes) are drilled and equipped to supply community water for domestic use and animal watering. However, in dry areas, the development of community food gardens has been based almost exclusively on borehole water. Boreholes for food production are mostly equipped with diesel or electric-powered pumps. Electric pumps are preferred, because both the operation costs and the maintenance requirements and costs are less than those for diesel motors. In Ethiopia, livestock herders and remote rural communities are highly dependent on borehole water, which is often their only water source. Some regions in Ethiopia have developed effective programs for the provision of water supply based on boreholes.

### Diversion systems

Often referred to as off-take systems, diversion systems are probably the most common form of irrigation system in Ethiopia. Diversion systems often utilize natural river flow; however, regulation of river flow via a permanent structure in the river bed 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.

## 3.2 Technologies for Water Lifting and Conveyance

### Treadle pumps

Treadle pumps are a potentially high-return, high-impact AWM intervention. More specifically, they are especially appropriate where there is a water source close to the surface (less than 6 meters) and close to the field to be irrigated (less than 200 meters), and they will be especially profitable when farmers have access to markets where they can sell high-value fruits and vegetables. They can be used for supplementary irrigation during dry spells, though this is not commonly found.

There is evidence that in many circumstances they can benefit very poor people and women, but this often depends on the local culture and social structure. Treadle pumps are also versatile—they can be used for many purposes where water needs to be lifted; they are not limited to irrigation (See Figure 3 for sample models of treadle pumps in different countries of Africa).

The successful programs to promote treadle pumps have paid considerable attention to the manufacture, sales, and after-sales service of treadle pumps, and to training farmers in their use. It is quite likely that the additional attention to helping farmers link effectively to output markets further enhances their positive economic impacts. Providing packages that combine treadle pumps with water-efficient application technologies such as low-cost drip systems can further enhance the returns, especially where either water is scarce, or labor shortage limits the capacity to pump.

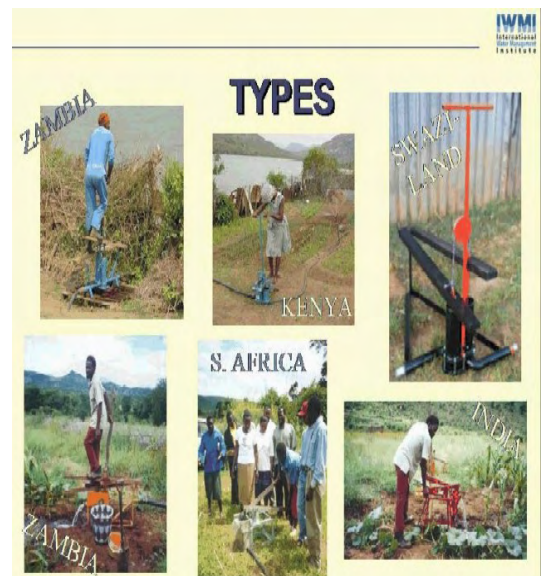


Figure 3. Different types of treadle pumps

### Motorized pumps

Low-cost motorized pumps have had a big impact in Asia, but in Africa there is far less experience except in West Africa, especially Nigeria. Impediments to their rapid uptake include:

- In most countries, they are either not available or are too expensive;
- Lack of scale means that the input supply market (spare parts, maintenance expertise) is weak;
- Relatively high fuel prices and rural electrification is not wide spread; and
- Limited markets for high value produce.

For all the reasons given above, it is likely there are limited opportunities for poor farmers to make profitable use of motorized pumps, particularly if promoted on individual basis. Communal ownership and operation may be feasible and may have substantial poverty reducing impacts.

### 3.3 Field Application Technologies

#### Drip irrigation systems

Drip irrigation enables the farmer to make use of limited amounts of water and fertilizer which can be applied together with the irrigation water to grow high value crops. Drip irrigation allows precise application of small amounts of water directly to the root zone. In terms of Figure 1 on rainfall partitioning, it reduces losses from evaporation, weeds, runoff and percolation. Drip irrigation is popularly viewed as one of the most water efficient types of irrigation, but Laker (2006) warns that in large areas the soils are not suitable for drip irrigation, notably coarse sands and severely crusting soils.

Conventional drip irrigation systems typically cost US\$ 5,000–10,000 per hectare or more, installed in East and Southern Africa. Recent advances have introduced some adaptations that make them accessible to small-scale farmers. Simple drip irrigation systems are now available which would cost a farmer US\$ 15 to cover 15 m<sup>2</sup>, or US\$ 200–400 for a bigger system covering 500 m<sup>2</sup> (Sijali, 2001; Sijali and Okumu 2002, 2003)<sup>1</sup>.

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<sup>1</sup> The reader is referred to Sijali's excellent handbook (2001), with diagrams of layouts and functions of virtually every type of bucket and drum drip kits available in Eastern and Southern Africa.

While there are numerous individual farmers in Africa who have benefited from low-cost bucket and drum drip kits, there is no evidence of successful implementation on a larger scale. This is in contrast to South Asia, where there has been considerable success, both in terms of market-driven systems aimed at relatively better-off farmers, and in terms of targeting poor farmers. The technology is potentially very beneficial and profitable to poor small farmers but only under certain conditions. These include:

- Dry area or growing season when there is a high premium on maximizing productivity of water; they are not likely to be attractive in relatively wet areas.
- A reliable water source close to the garden to be irrigated.
- Soils are suitable for drip irrigation or are sufficiently ameliorated to ensure their suitability.
- Effective program for promotion (social marketing), training, technical support, provision of spare parts, and targeting to people who can really benefit.
- They must save labor, especially small kits for poor families whose labor supply is a constraint.
- Robust but simple technology, which is affordable and easy to maintain and operate.
- Access to output markets for higher value fruits and vegetables.

#### Clay pot (sub-surface irrigation), also called 'pitcher' irrigation

This is a low-cost indigenous sub-surface drip system achieved by use of unglazed fired clay pots that remain micro-porous and are molded by hand by rural women. There also exist molding machines that can mass produce clay pots with specifications of porosity and firing temperature to eliminate possibility of shrinking and swelling of clay which may lead to cracking. The clay pots are buried in the ground with their necks appearing above ground in a row at specific plant intervals. Plants are planted adjacent to the pot on either side and the pots filled with water and covered with a clay lid to avoid direct evaporation of water and

rodents drinking the water (See figure 4). Using the principle of moisture potential, water oozes out of the pot from its high water potential to wet the surrounding soil outside the pot where the soil water potential is low. The water is instantaneously taken up by the crop from its root zone around the clay pot. The pots are made of locally available clay with optimum properties of strength (to resist crushing), permeability (to exude water into the soil at an approximately steady rate), and size (to hold enough water for at least one day's supply). Such use of soil-embedded porous jars is one of the oldest continuous irrigation methods that probably originated in the Far East and North Africa.



**Figure 4. Clay pot/sub-surface irrigation**

This is a very suitable technology for poor rural women as they make the pots for sale (income generation), and because it is less labor intensive than most alternatives, it has high labor returns and suits people disadvantaged by physical handicaps or HIV/AIDS. Water as well as fertilizer productivity is also very high. Clay pots have a lot of potential for backyard vegetable and flower production even in urban areas. In a wet period, they can also be used for drainage by emptying the pots as water infiltrates back in from saturated soil.

It has been well established that irrigation intervals between 7-14 days and water saving between 50% and 70% are achievable, resulting

in yield increases between 30% and 45% over conventional flood furrow and basin irrigation systems. This indicates a high potential for labor saving while irrigating. Crops that prosper under this system include tomatoes, rape leaf vegetable, cauliflower, maize, beans and fruit trees. This was achieved at far higher water productivity than conventional irrigation.

The potential of clay-pot irrigation has not been fully exploited by farmers in the eastern and southern Africa region, even though the technology is suitable for small-scale farmers. The value of the clay pot or pitcher irrigation is confirmed by several authors from across the globe (Bainbridge 2002).

There are numerous advantages to using buried clay pot irrigation. First, pots are not as sensitive to clogging as drip emitters, although they may clog over time (after 3-4 seasons) and require renewal by reheating the pots. Second, the system does not require a pressurized water system, which is difficult to establish and maintain at remote sites. Third, animals are less likely to damage or clog buried pots than aboveground drip systems. Fourth, by selecting lids that collect rainfall, any precipitation that does fall can be conserved and used. Finally, buried pots are more robust than drip systems because they do not rely on continuous supplies of power or water to operate.

We conclude that clay pot irrigation is a cost effective and easy-to-implement alternative to bucket and drip irrigation kits. The pots can be manufactured locally and therefore create employment for poor people (often women), and can be used by poor women and men to irrigate vegetables and fruit trees cost effectively. They are appropriate wherever water is scarce, or where obtaining water is expensive, putting a premium on water conservation.

### **Sprinkler Systems**

Sprinkler Irrigation is a method of applying irrigation water which is similar to rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air and irrigated entire soil surface through spray heads so that it breaks up into small water

drops which fall to the ground. Sprinklers provide efficient coverage for small to large areas and are suitable for use on all types of crops. It is also adaptable to nearly all irrigable soils since sprinklers are available in a wide range of discharge capacity. Micro and Mini sprinkler kits are available in sizes from 100 to 1000 m<sup>2</sup>. Systems more than 1000 m<sup>2</sup> can be customized to suit specific requirements. Micro-sprinklers are spaced at 3m x 3m mini-sprinklers are spaced at 6m x 6m in order to produce uniform wetting. Micro-sprinklers require 5 m to 10 m operating pressure whereas mini-sprinkler requires 10 to 15 meters of operating pressure. Micro and Mini sprinklers can be shifted from one place to other to cover larger areas and thus are potentially useful for small scale farmers with varying land holdings.

#### 4. Concluding Remarks

- Low average rainfall that is seasonal, highly variable in time and space, and increasingly unreliable is the major impediment to farm households increasing their production of food, cash crops, and livestock products in Ethiopia. The impacts of this unreliable and inadequate water supply are compounded by many other problems natural (for example poor soil fertility) and human- created (for example lack of support services and infrastructure). Improving the reliability of water supply for agriculture is therefore a necessary though not sufficient condition for reducing poverty and malnutrition and generating faster agricultural growth.
- AWM technologies and practices are complementary in nature. For instance, while the water lifting technologies, diversion and storage systems are means of accessing water from a source, the application technologies are means of efficiently using the accessed water. This combination has to be appreciated in any future investment planning, particularly given the scarcity of water.
- It is important also to note that some of the technologies and practices have been known to the farmers for many years or are indigenous, but the extent of their use or adoption is low. This may reflect their highly location-specific nature.
- The literature on agricultural water management is usually crop-biased while the livestock production sector constitutes a vital livelihood system of the rural people in Ethiopia and elsewhere. A lot of innovative water management systems for livestock production systems that warrant further consideration are available.
- There is reasonable though not conclusive evidence that some of the AWM technologies reviewed in this study, under the right conditions, do lead to substantial improvements in households' food security and incomes, and that they do so in a cost-effective manner. This is especially true for treadle pumps, but there is enough case study and anecdotal evidence to suggest that the statement also applies to low-cost drip kits, clay pot irrigation, conservation farming practices that integrate nutrient and water management, and a variety of in-situ and ex-situ water harvesting and storage technologies.
- There are many actors and many projects involved in studying and (especially) promoting a large number of different AWM technologies and practices in Ethiopia. However, there has been little or systematic analysis of their effectiveness, impacts and sustainability, or attempts to understand what strategies work and why, and what does not work and why. Undoubtedly the same mistakes are being repeated needlessly. While a multiplicity of effective local and international NGOs is to be encouraged, it would be useful to find out systematically what are the main strengths and weaknesses (comparative advantages) of each, and develop mechanisms for better coordination and sharing of experiences and lessons learned.
- The tremendous diversity of conditions in Ethiopia must be acknowledged. Even within districts, there is such diversity in soils, micro- climate, cultures, and access to markets that what works on one farm may not be appropriate next door. This means there is no possibility of generalizing, no cook book approaches or sure-fire universal panaceas that will work everywhere. Unfortunately, it appears that there are cases where AWM technologies not really appropriate to local conditions

- and needs are promoted (and rejected). Further, there has been a failure to take an integrated approach, in several senses: recognition of the multiplicity of household water needs given the diversity of livelihoods (for example integration of livestock, crops, brick making, etc.); recognition of the potential synergies of integrating AWM technologies, for example combining treadle pumps with efficient application technologies with soil conservation practices; integrating water and nutrient management; and pursuing implementation strategies that integrate attention to support services (inputs), attention to production processes, and to outcomes on the demand side in terms of both household food security and nutrition and access to well-functioning markets.
- Following from the diversity of Ethiopia, it is no surprise that there are no cases of successful massive scaling up and out of specific AWM technologies and practices. Adoption, adaptation, or rejection decisions are a function of many factors including lack of information or access, lack of fit between the technologies on offer and the capacities and needs of households, inefficient promotion strategies, flawed assumptions about households' needs and capacities and the real costs and benefits from their perspectives (for example the assumption of surplus labor availability), ineffective targeting, lack of capacity to manage projects offering a large array of small-scale technologies to thousands of poor households, and lack of credit.
  - In many regions in southern Africa where there is a water source no more than 6 meters below the surface or 200 m away from where the water is needed, treadle pump offer a potentially high-return and high-impact intervention. The pumped water can be used for many domestic and productive purposes, not only irrigation. The evidence from Malawi, Tanzania and Zambia demonstrates the potentially very high impact on food security and incomes.
  - Like low-cost drip irrigation kits, although so far clay pot irrigation has not been implemented on any scale, we believe this is also a low-cost technology that can result in a very high level of water and labor productivity.
  - The term “conservation agriculture” covers a large range of in-situ water and land management technologies and practices, some of which require large initial investments to implement. But some of the practices described under this heading are relatively low-cost, with very high potential returns. The critical issue is that many interventions have failed to address the necessity of integrating water and nutrient management: adding water by itself can actually lead to more rapid depletion of nutrients, while soil nutrients cannot be efficiently used by plants without water. Because of the complexity and diversity of most Ethiopian farming systems, there is no monolithic package of conservation agriculture technologies; rather farmers need to be supported and assisted to try new ideas and combinations of practices that work under their conditions.
  - As with in-situ water and land management practices, there is a wide range of low- cost and easy-to-construct ex-situ water harvesting and storage practices that under specific conditions are effective and can have large impacts on food security and livelihoods. As is the case for others, adaptation to local conditions with poor people empowered to make their own decisions rather than being passive recipients is critical to success.
  - Following from the observations above regarding the diversity of conditions and situations and the fact that no single AWM technology or practice can be a panacea, we strongly recommend that supporting the creativity of the user is essential if people are going to improve their food security and escape from poverty. Therefore, participatory approaches that encourage and support creativity and innovation, for example by offering choices and menus that can be adapted and combined as needed, participatory approaches that empower users to make their own decisions, and provision of support services that reduce risk and makes available resources that are not otherwise at hand.

- While supporting the need to invest in major water (and indeed other) infrastructure at a far greater scale than seen so far in Ethiopia, we strongly recommend scaling up investments in AWM technologies and practices because it offers a relatively faster and more cost-effective way to achieve the MDGs than for example major irrigation investments. Many AWM technologies are far less expensive per household than formal irrigation, their benefits begin immediately upon acquisition, and they are not plagued by all the management problems, transaction costs and negative externalities often characterizing formal irrigation. Of course, for poor people living in areas where there is no adequate source of water, infrastructural development is necessary to bring water close to the people in need.
- AWM technologies are “divisible”; i.e., can be used by individuals or small groups directly. They also lend themselves to provision by the private sector, unlike large water infrastructure projects with large public good and common property characteristics. Therefore, we recommend that governments examine how to make their policies more conducive to encouraging private sector firms to manufacture, supply, and even experiment and innovate AWM technologies.
- We recommend that NGOs and governments currently promoting AWM technologies as part of their relief efforts move away from short term relief to long-term development. We have found cases where well-meaning provision of technologies like bucket and drip kits has had no impact, because of the lack of longer term service provision and training. This is not a good use of scarce resources. It is clear that the most successful programs are those that take a longer term integrated perspective toward creating the conditions conducive to sustainability.
- Finally, we strongly recommend more investment in monitoring, impact assessment, pilot testing of innovations, and sharing the lessons learned widely among government agencies, investors, donors, private firms and farmers. Creating “learning alliances” among interested partners to collaborate in these endeavors is one effective way to achieve this.

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# Best Practices and Technologies for Agricultural Water Management

S. S. Magar

Dr. Balasaheb Sawant Konkan Agricultural University, Dapoli, India.  
ssmagar@yahoo.co.in

Water is one of the largest renewable natural resources but fresh water is expected to emerge as a key constraint to future agricultural growth. Globally and more particularly for many developing countries including India, Ethiopia, changing water availability and quality pose complex problems and management options are not easy. The changing situation comes partly from increasing demands such as population, industry and domestic requirements partly from consequences of climatic change. The demand for water has grown annually by 2.4 per cent. The present water stress (about 28%) of many countries is expected to be about 50% due to population growth and industry development. Indian statistics shows that per capita availability has come down from 5300 m<sup>3</sup> in the year 1955 to 1967 m<sup>3</sup> in 1997, which is projected to further decrease to 1500 m<sup>3</sup> by 2025 with wide inter-basin variations. Environmental scientists have categorically notified the critical water availability per capita to the extent of 1000 m<sup>3</sup> per annum (Selvarajan *et al* 2004); Water Availability Index (WAI) and Water Stress Levels (WSL) are reported in Table-1.

**Table 1: Standards of Critical Water Stress Levels (Mitra A.P, 2004)**

(WAI) M <sup>3</sup> /capita/annum	Water Stress Level (WSL)
>1700	Satisfactory
1000-1700	Water stress
500 - 1000	Water scarcity
< 500	Water Storage

WAI=Water Availability Index

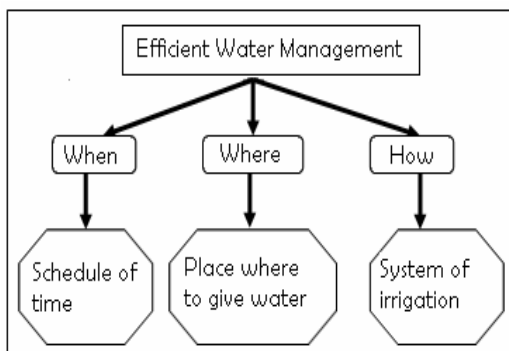
On the background of 6.0 Billion World population with geographic river basin water availability variation, the best water management practices with location specific technology are now inevitable for sustainable rural and agricultural development.

Rainfed agricultural lands are low in productivity and sustainability and are more prone to risk as compared to those in irrigated areas. This can be obviated to some extent by expanding irrigated areas through improving water management practices and enhancing water use patterns. Presently, the problem facing the country is not the development of water resources, but the management of the developed water resources in a sustainable manner. The bulk of agricultural land could be brought under irrigation provided that efficient water management practices including micro-irrigation would be adopted by the farmers.

The best practices and technology for agricultural water management refer to application of optimum water quantity scheduled at right time with highest water application efficiency. The application of too little water is an obvious waste as it fails to produce the desired production. Excessive flooding of the land is however likely to be still more harmful as it tends to saturate the soil for long time, inhibit aeration, leach nutrients, induce greater evaporation and subsequent salinization. Therefore, apart from wasting water, excessive irrigation contributes to its own demise by the twin scourges of water logging and soil salinization. The best irrigation methods are designated to apply a small measured volume of water at desired frequent intervals to where the roots are concentrated. The aim is to reduce fluctuations in the moisture content of the root zones

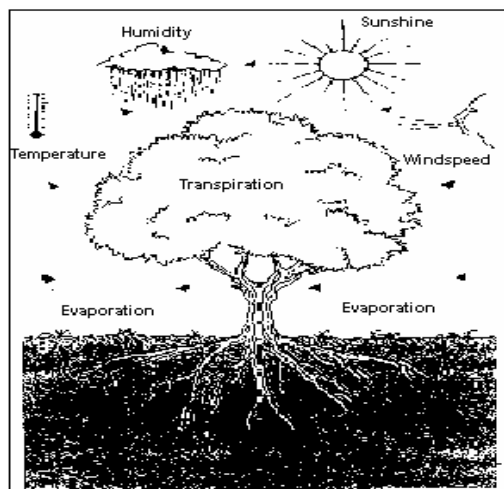
without subjecting the crop either to oxygen stress or water stress.

Moreover, irrigation system should convey water to the field in concrete line channels so as to avoid seepage losses or preferably in closed conduits that avoids pollution. The objective of water management is to provide a suitable moisture environment to crops to obtain maximum yield with high water use efficiency. It is integrated process of diversion, conveyance, regulation, measurement, distribution time and requisite quantity of water. Efficient water management is depicted in a simple manner in Figure 1.



**Figure 1. Efficient Water Management**

The basic principles of irrigation water management could be summarized in a simple relationship of soil-water plant atmosphere continuum (SPAC) (Fig. 2). Moreover, 'Management Allowable water Deficit' (MAD) estimated based on pertinent physico-chemical properties (FC, PWP & AM) and soil moisture stress resistance of a crop are important parameters for selecting best practice of agricultural water management. Other soil parameters of infiltration rate, hydraulic conductivity, slope, advance and recession of water front and opportunity time, etc. are also important parameters in maintaining optimum MAD. In brief, root zone soil layer should be kept at about field capacity maintaining optimum level of soil moisture, aeration and microbial load.



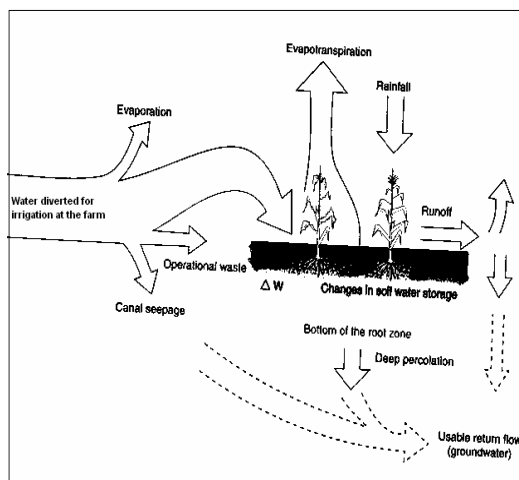
**Figure 2. Soil Plant Atmosphere Continuum**

The term water use efficiency is categorically used to analyze the best water management practices. Irrigation scientists have developed high precision technologies for achieving greater efficiencies such as 'conveyance efficiency', 'on farm application efficiency' or 'field application efficiency'. Finally, all the above indices of efficiency may be combined in a single concept, the overall agronomic efficiency of water use,  $Fag$ .

$$Fag = P/u$$

Where P = Crop production (unit dry mass or marketable produce)  
 u = Unit volume of water

The quantity of water applied in each irrigation is divided in several parts such as runoff (R), deep percolation loss (DP), evaporation from soil surface and transpiration from leaves (ET), evaporation during conveyance and application (EP), etc. The total water budget in between two irrigation rotations is depicted in fig.3. The modern technology is developed to improve water use efficiency (WUE) focused on conservation of water and enhancement of maximum quality marketable agricultural produce in terms of economics. However, soil is the media which needs to be given top priority for its assessment related to international classification to maintain its health.



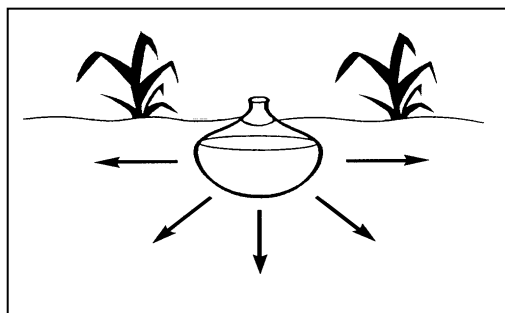
**Figure 3. Hydrological parameters and water budget between two successive irrigations**

The agricultural water management practices are classified under surface, sprinkler, micro-irrigation (Drip) and subsurface irrigation. Each and every irrigation practice has got its merit, demerit and limitations depending upon water availability cropping pattern, water quality, soil types, topography, climate & socio-economic status of the farmers. It is emphatically pointed out that irrigation system that may prove most appropriate in one country or region may not be suited in other country or region due to specific local physical conditions and cropping pattern. The economic background and government support to the farmers are also major factors. The large rotating wheel type sprinklers are common in California which rarely used in practice in other developing countries. Human factors include labor and management, training and skills are need to be given due consideration. Moreover labor cost, capital and energy availability, etc. are coupled with the expected returns. The modern irrigation methods (sprinkler and micro irrigation) are efficiently used in developed countries, but various alternatives with respect to their possible applicability in developing countries particularly in Africa need to be given special attention. The scientists are confident that low cost best practices with high WUE could be brought into practice provided that HRD component and farmers training are planned systematically.

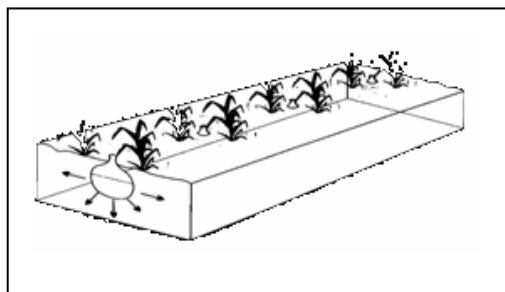
The definition of 'HELPFUL Irrigation' is very innovative from FAO Development series 2 as it denotes: High frequency (H), Efficiency (E), low volume (L), partial area (P), Farm (F), Unit (U) and Low cost (L). (Hillel Daniel (1997). How could be the farmers be brought into this ideal system? It is necessary to categories the situation for selecting best combination of HELPFUL Irrigation.

### CASE STUDY- 1.

Water scarcity area, Poor Socio-economic status, Untrained HR, cheap labor availability, Limited economic support from Government sector. Soil climate and topography. Here also profitable cropping pattern is possible. Best irrigation practice & technology will be the Pitcher irrigation system which is depicted in fig. 4 and fig. 5.



**Figure 4. Pitcher Irrigation Method**



**Figure 5. Pitcher Irrigation Method**

Following parameters are considered for its efficient design and operation:

- Preferably clayey - clay loam texture soil type.
- Estimation of Net irrigation requirement in terms of LPD.

- Water application - daily or alternate day (high frequency).
- Reuse of pitchers for subsequent crops is possible.
- Use of liquid fertilizers through pitcher is possible.
- Broad Base Furrow (BBF) technique is very effective.
- Excellent SPAC relations are maintained throughout crop growth period.
- Rotational volumetric water supply system, conjunctive water use, possible land development with precise slope > 0.6%, mostly cash crops and cropping pattern with 200% intensity.
- The border or Ridge and furrow irrigation layouts are preferred with specific length, breadth, slope and discharge.
- The infiltration rate is also playing important role in achieving high water application efficiency.

The results of pitcher irrigation system on cotton crop at MPKV, Rahuri (M.S.) India, are reported in Table 2. However, filling of pitcher or jars with high frequency is the major limitation, which could be solved by arranging limited water conveyance PVC pipeline.

**Table 2: Detail of irrigation, WUE and meteorological parameters under different irrigation methods**

Particulars	Drip	Furrow	Drip *	Pitcher
Gross irrigation (cm)	43.14	89.53	43.14	31.38
WUE (kg/ha-cm)	64.32	25.12	49.96	63.47
Water saving (cm)	46.3	-	46.4	58.15
Water saving (%)	42.87	-	42.87	64.95
Yield (q/ha)	31.36	22.49	31.10	19.92

\* Fertilizer through tank

### CASE STUDY - 2

Optimum Water availability, command area of irrigation project, surface flow irrigation, middle class socio-economic status, soil, climate and cropping pattern favorable. Farmers are innovative and ready to accept new changes.

Good irrigation practice will be the surface irrigation with border or ridges and furrow irrigation layout:

These parameters are designed in such way that advancement of water without soil erosion and recession of water flow with high infiltration rate would be precisely adopted. The sufficient opportunity time is obtained so that soil moisture deficit in effective root zone is met out with minimum deep percolation losses at head and tail reach portions of border or furrow. The details of water applied with WUE are shown in Table 3 A and B. However, under no circumstances field application efficiency exceeds 60% and the deep percolation losses to the extent of about 10% are inevitable.

### CASE STUDY - 3

Precision Technology of Sprinkler Irrigation - Any soil type, cash crop focused cropping pattern, assured water and energy supply, skill oriented, better socio-economic conditions. Sprinkler irrigation system parameters are indicated below:

- Limited field layout or sometime leveled field.
- Beneficial for hilly areas with variable topography, high frequency water application based on crop tolerance for soil moisture and MAD
- High energy requirement
- Prone to wind velocity drifting.
- Uniformity coefficient about 80%
- Water saving to the extent of 30-40% as compared to traditional system.
- Increase in the yield to the extent of 10-20% as compared to surface method

**Table 3: Comparative studies on different irrigation methods****(A) Effect of methods of irrigation on the dry pod yield of groundnut**

Treatments	Yield (q/ha)			Increase in yield over border (%)
	1985	1986	Pooled	
Border	18.32	18.29	18.31	--
Check basin	18.99	18.75	18.87	--
Sprinkler	22.42	21.87	22.15	20.97
S.E. ±			0.08	
C.D. at 5%			0.21	

**(B) Yield of red dry Chilli, water expense and water use efficiency as influenced by methods of irrigation for Chilli (Pooled Mean)**

Methods of irrigation	Yield of dry Chilli (q/ha)	Water applied (cm)	WUE (kg/ha-cm)
Furrow	17.15	39.00	44.27
Sprinkler	20.91	26.00	81.12
S.E. ±	0.35	--	--
C.D. at 5%	1.0	--	--

- High initial investment and capital cost solid and rotating systems.
- Shifting movable types are available.
- Design operation and maintenance are key parameters.
- Farmers have to be skillful and knowledgeable

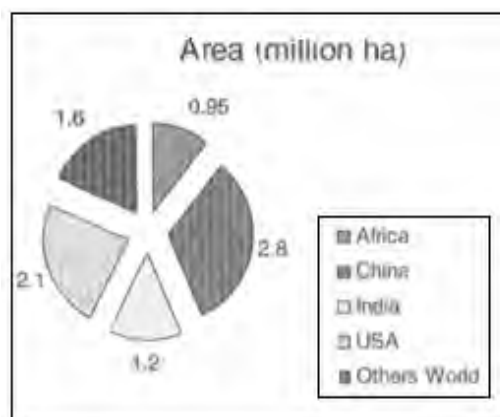
The details of results obtained in India for sprinkler irrigation systems with its economic parameters are reported in Table 3 A and B. However, experiences in India show that sprinkler growth is steady and micro irrigation system is being accepted and adopted by farmers on larger scale.

**CASE STUDY - 4**

Modern Technique of Micro Irrigation or Drip/Trickle Irrigation- This is the best world wide accepted modern technique in water management system. It has got wide range acceptability under variable soil, crop and climatic conditions. From the recent past as share of water for agriculture is declining, the judicious use of every drop of water is gaining attention. And spread and use of micro irrigation has become need of the hour. Extent of the micro irrigation in the world is depicted in Figure 6.

The details parameters are as follows:

- Any water resource with optimum quality.
- High frequency (daily or alternate day)
- Low pressure (about 1 to 2 Kg/cm<sup>2</sup>)

**Figure 6. Micro- irrigation spread in the world**

- Estimation of daily water requirement based on Pan evaporimeter data in terms of litres/day/plant (LPD)
- Solid system - network of LDPE pipes provided with specific type of emitters.
- Assured energy supply is necessary but its requirement is low.
- Very high Uniformity Coefficient > 95%
- Design, operation and maintenance skills

**Table 4. Results of Studies on Micro-irrigation by Plasticulture Development Centre**

Crop	Yield (Q/ha)		Irrigation (cm)		WUE (q/ha/cm)		Advantage of MI (%)	
	Surface	Drip	Surface	Drip	Surface	Drip	Surface	Drip
Beet	5.70	8.90	86.00	18.00	0.07	0.50	79.10	56.10
Bitter Gourd	32.00	43.00	76.00	33.00	0.42	1.30	56.60	34.40
Brinjal	91.00	148.00	168.00	64.00	0.55	2.30	61.90	62.60
Broccoli	140.00	195.00	70.00	60.00	2.00	3.25	14.30	39.30
Cauliflower	171.00	274.00	27.00	18.00	6.30	15.20	33.30	60.20
Chilli	42.30	60.90	109.00	41.70	0.39	1.50	61.70	44.00
Cucumber	155.00	225.00	54.00	24.00	2.90	9.40	55.60	45.20
Lady's finger	100.00	113.10	53.50	8.60	1.87	13.20	84.00	13.10
Onion	284.00	342.00	52.00	26.00	5.50	13.20	50.00	20.40
Potato	172.00	291.00	60.00	27.50	2.90	106.6	54.20	69.20
Radish	10.50	11.90	46.00	11.00	0.23	1.10	76.10	13.30
Sweet potato	42.40	58.90	63.00	25.00	0.67	2.40	60.30	38.90
Tomato	61.80	88.70	49.80	10.70	1.24	8.28	78.50	43.50
Banana	575.00	875.00	176.00	97.00	3.27	9.00	45.00	52.20
Grapes	264.00	325.00	53.00	28.00	5.00	11.60	47.20	23.10
Papaya	130.00	230.00	228.00	73.00	0.60	3.20	67.90	76.90
Pomegranate	34.00	67.00	21.00	16.00	1.62	4.20	23.80	97.00
Water melon	82.10	504.00	72.00	25.00	5.90	20.20	65.30	51.39

WUE = Water Use Efficiency; MI = Micro Irrigation

- Initial cost is high but quality and quantity of production are assured.
- Saving in Water is greater than 60%
- Increase in yield is greater than 60 - 70 %
- Spot application of water hence inter culturing expenses are minimum.
- Application of liquid fertilizer is possible
- Severe limitations of emitter clogging, water filtration, ground water quality physical impurities in water, local salt accumulation, etc.
- very high initial cost - Life is also limited drip material prone to physical injuries, careful handling
- Availability of Technical Manpower for maintenance.

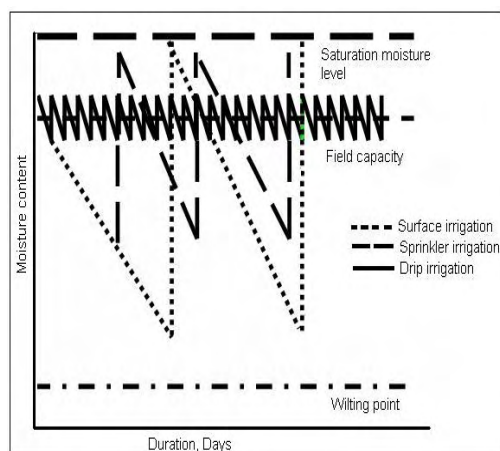
program. The details of research findings are given in Table 4. These research findings are confirmed to water saving and increased in the yield of several cash crops including vulnerable crops like sugarcane and cotton and low spaced vegetable cash crops. Water use efficiency with micro-irrigation for major crops is given in Table 5.

Selection of most appropriate method in given circumstances is a major task of water manager. This depends upon crop response to various level of moisture stress. Moisture availability in relation with field capacity and wilting point for crops under different methods of irrigation are depicted in Figure. 7

Exhaustive research has been done by several institutes in several countries. India is not exception to that international research

**Table 5. Water use efficiency with micro irrigation (INCID, 1994)**

Crop	Yield increase (%)	Water saving (%)	Increasing use efficiency (%)
Banana	52	45	176
Chilly	45	63	291
Grape	23	48	136
Sweet Lime	50	61	289
Pomegranate	45	45	176
Tomato	50	31	119
Water Melon	88	36	195

**Figure 7. Moisture availability at various moisture stress levels for different methods of irrigations**

## Conclusion

Micro-irrigation coupled with Biotechnology, value addition, Information Technology and Watershed based approach of development will bring paradigm shift in agriculture as knowledge based profession. Latter will have wide spread and sustainable impact on enhanced agriculture production and productivity. The micro-irrigation technology will act as catalyst for evergreen revolution with precision farming. Sustainability, productivity, profitability and equity will

become reality in every farmer's field with better water, fertilizer, energy, environment and human efficiency.

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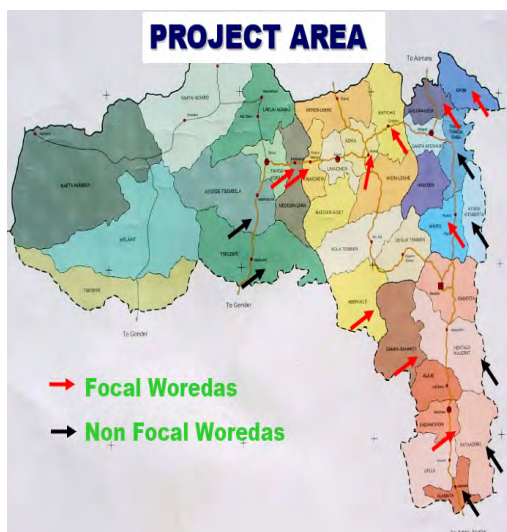
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# From Soil and Water Conservation to Small Scale Irrigation

**Chris T. Annen**

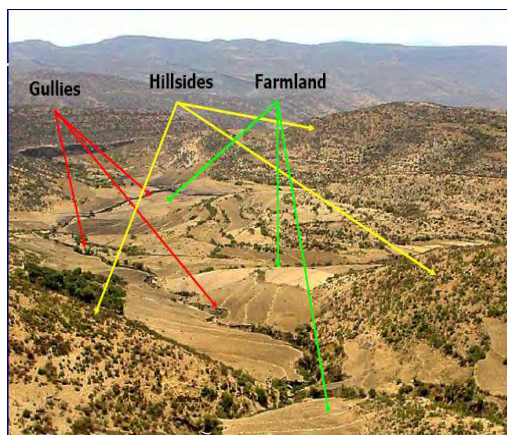
GTZ/SUN Tigray  
gtasuutg@ethionet.et

The project was implemented in Tigray region on the location shown on figure 1.



**Figure 1. Location of the project area**

The project intervention areas were watersheds as shown in figure 2



**Figure 2. Project Intervention Areas: Watersheds**

The major stakeholders involved in this project were Bureau of Agriculture and Rural Development as implementing agency, Tigray Food Security Coordination Office for regional coordination and administration, GTZ Sustainable Utilization of Natural Resources for technical support

## Project Objective

The objective of the project was to improve food security by sustainable utilization of natural resources

## Approaches

The approaches employed by the project were:

- Adoption, Testing and Development of innovative food security relevant watershed management techniques
- Action-oriented community engagement and participation
- Recognizing and Realizing potentials and short term benefits for farmers
- Integration of indigenous knowledge and
- Farmer to farmer experience exchange.

### A. Managing Water in Hillsides

#### A.1 Traditional Sediment Storage Dams

One of the selected and applied watershed management techniques was traditional sediment storage dam (figure 3)





Figure 3. Traditional sediment storage dams

### A.2 Semi-Circle Terraces

Semi circle terraces were also tested and it is found out that they have the following advantages and disadvantages:



Figure 4. Semi circle terraces on hillsides

### Advantages of Semi Circle Terraces

- Effective soil conservation and water harvesting structures
- Short –term benefits
- Can render unproductive hillsides into intensively cultivated units with supplementary irrigation
- Individual user rights can be applied
- Can provide income for land less farmers

### Disadvantages of SCTs

- Need to be protected from livestock and wild animals (Baboons, Porcupines, and Rodents)
- Require skill, training
- Are Labor Intensive?
- Require a nearby water source for optimum productivity (ponds, springs)
- Establishment of individual user right in most cases causes user right disputes

### Future Design of Semi-Circle Terraces

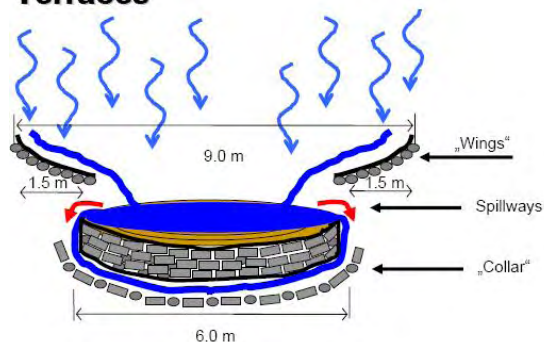


Figure 5. Proposed future design of semi-circle terraces

## B. Harvesting Gully Water

The other watershed management techniques tested were those which are used to harvest gully runoff. These are biophysical gully treatment, gully runoff harvesting using serial ponds and river bank cultivation. Benefits and shortcomings these methods are:

## B. 1 Biophysical Gully Treatment

### Advantages of Biophysical Gully treatment

- Effective gully erosion control
- Direct short-term benefit (forage biomass)
- Effective ground water recharge
  - Drinking water supply
  - Small-scale irrigation

### Disadvantages of Biophysical Gully treatment.

- Labor intensive physical gully treatment
- Requires reshaping of gully walls
  - Loss of arable land or pasture
- Requires livestock exclusion
- Necessity to establish clear cut user rights
- Likely to cause user right disputes



Figure 6. Biophysical gully treatment

## B.2 Gully Water Harvesting with Serial Ponds

### Advantage of Serial Ponds

- Effective ground water recharge
- Drinking water Supply
- SSI from hand dug wells

### Disadvantages of Serial Ponds

- Labor intensive, costly pond construction work
- Large ponds occupy land
- Increased risk of Malaria

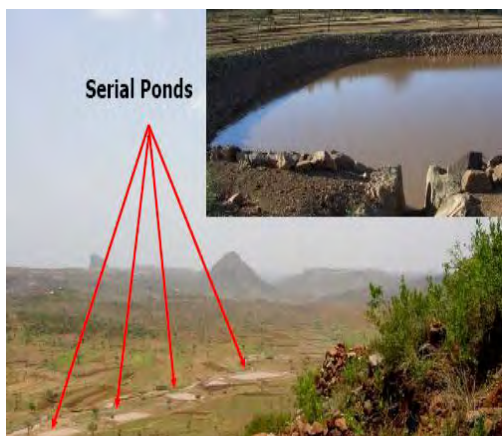


Figure 7. Gully runoff harvesting using serial ponds

## B.3 Riverbank cultivation



Figure 8. Riverbank cultivation

## C. Managing Water on Farmland

Techniques which are tested to manage water on farmland include soil bunds, ponds for micro scale irrigation and trench bund

### C.1 Soil Bunds- An Ecological Niche for Development

#### Advantages of Soil Bund cultivation

- Can provide short-term benefits to farmers (Bee forage, oilseed)
- Does not compete with arable production



- Low labor input
- Can provide an incentive to farmers to maintain soil bunds and trench bunds

### **Disadvantages of Soil Bund Cultivation**

- Most farmers are not familiar with sunflower
- More awareness creation is needed
- Weeding, thinning out is essential
- Sunflower can be susceptible to pests
- No oil extraction device available
- Short cycle Sunflower (non hybrid) is not yet available



Figure 9. Soil bunds integrated with sunflower

### **C.2 Pond Construction for Micro-Scale Irrigation**

#### **Advantages of Pond construction**

- Short-term benefits (household income and nutrition)
- Community skill development
- No User right disputes on individual farmland

#### **Disadvantages of pond construction**

- Labor intensive construction of ponds
- Requires livestock exclusion or fencing
- Requires skilled masons
- Requires external inputs (cement, plastic sheeting)
- Increases household labor input
- Increases risk of Malaria



Figure 10 Ponds for Micro-scale irrigation

### **C.3 Trench Bund**

#### **Advantages of Trench Bund Cultivation**

- Effective combination of runoff water harvesting with supplementary irrigation (ponds, hand dug wells, springs)
- Does not compete with arable production
- Can increase household income and improve household nutrition within three years
- Can provide an incentive to farmers to maintain trench bunds
- No user right disputes on individual farmland

#### **Disadvantages of Trench Bund Cultivation**

- Requires livestock exclusion on farmland
- May require protection from rodents (Baskets) during the first two years
- Requires supplementary irrigation (ponds, springs and hand dug wells)
- Increases household labor input (supplementary irrigation, weeding, harvesting, marketing etc)

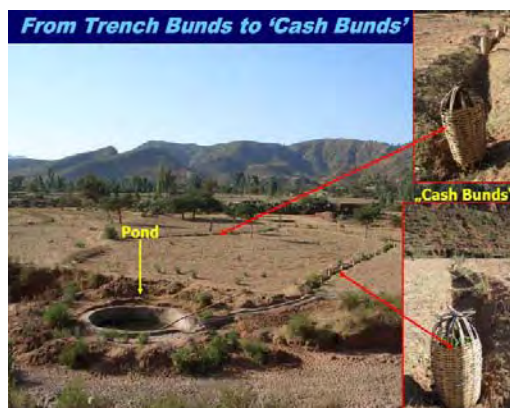


Figure 11. Cash bunds

### D. Hand –Dug Wells for SSI

Another water management technique for small scale irrigation is Hand dug well. Its economic viability can be calculated as follows:

#### Economic Viability:

Example: 1ha irrigation by 3 HDWs  
 -Construction. Cost (3 HDWs): Birr 10'1667  
 Estimated annual net crop return: Birr 40'000  
 Irrigation cost: Birr 6'940  
 Net profit: Birr 33'060  
 1st year cost/benefit ratio: 1:3.3  
 Operational lifetime: 15 years  
 15-years cost /benefit ration: 1:49

Note:

Irrigation cost will reduce considerably once farmers are able to purchase their own pump  
 Income of rainfed crop is not considered

#### Advantages of Hand Dug Wells

- Considerable improvements of household economy and nutrition within six months
- Skill development (crop diversification, irrigation agronomy, marketing)

#### Disadvantages of Hand Dug Wells

- Requires livestock exclusion on farmland or fencing
- Considerable increase in household labor input
- Requires external inputs (pumps, seeds)

- Requires substantial skill development (irrigation agronomy, soil fertility management, crop protection and marketing)
- Risk of over utilizing groundwater reserves
- Increased risk of Malaria
- Risk of loss of livestock and human due to drowning incidences



Figure 12. Hand dug wells and small scale irrigation

### E. Gravity Drip Irrigation

#### Advantages of Gravity Drip Irrigation

- Improvements of household economy
- High irrigation water efficiency
- Can be applied with small water sources (Not less than 250 m3 per annum / 500m2)
- Can prevent over utilization of groundwater reserves

- Skill development (crop diversification, irrigation agronomy, soil fertility management, marketing)

### **Disadvantages of Gravity Drip Irrigation**

- Requires livestock exclusion on farmland or fencing
- Increase in household labor input
- Relatively high investment for external inputs (drip system, pumps barrels, seeds) on a small unit of land
- Requires good marketing of cash crops to recover investment
- Drip lines need to be replaced after 5-7 years
- Requires substantial skill development (irrigation agronomy, soil fertility management, crop protection and marketing)



Figure 13. Crop production using gravity drip irrigation

### **Disadvantages of Indigenous irrigation schemes**

- Requires livestock exclusion on farmland or fencing
- Increase in household labor input
- Low irrigation water efficiency
- Low productivity
- Not recognized by agriculture extension service

## **F. Indigenous Irrigation Schemes**

### **F.1 Traditional Stream Diversions and crossings**

#### **Advantages of Indigenous irrigation schemes**

- Communal irrigation schemes strengthen community self help capacity
- Low cost, low input technology
- Increased food security and household income

# Simple and Low-Cost Drip Irrigation System: An alternative approach to raise household farm productivity

Mekonen Ayana, Fassil Eshetu and Kassa Tadele

Arba Minch University  
meko\_amu@yahoo.com

## Abstract

It is estimated that more than 90% of the food supply in Ethiopia comes from low productivity rainfed small-holder agriculture. Hence, rainfall or access to irrigation water is the most determinant factor affecting the food self-sufficiency at household level and national food supply. Not only limited access to water has impeded the productivity of farming system but also lack of appropriate means of utilizing the available water more productively. In the history of irrigation, drip irrigation method has proven to be the most efficient technology that helps to irrigate the plants and not the 'soil'. However, the technology in its conventional design is expensive and can not be afforded by the poor. Raising the productivity of smallholders under Ethiopian condition requires a new approach to the design of simple and affordable irrigation systems. This paper describes the experiences with simple and low-cost drip irrigation system (bucket, clay pot drip irrigations) developed at Arba Minch University and successfully used by the farmers around Arba Minch. The simplicity and availability of the accessories of the system on the local market with reasonable price and the ease of assembling makes it appropriate and affordable to the poor farmers. It is also proposed to spread the technology to other parts of the country with the aim to increase smallholder farm productivity and ensuring food self-sufficiency at household level.

Keywords: drip irrigation, affordability, smallholder, productivity

## 1. Introduction

Huge proportion of the population (more than 85%) in Ethiopia is engaged in less productive agricultural activities. This low productivity rain-fed small-holder agriculture is the main source of food supply in the country. With this

regard, unreliable distribution of rainfall represents critical constraint to food production and is the major cause for food self-insufficiency and famine in the country. Under these conditions, implementation of irrigation is considered as the only means to sustain food production.

Appropriate methods of water lifting and distribution are the most important aspects that determine the efficiency and success of an irrigation system. Also in terms of cost, the water diversion, conveyance and distribution systems are the most expensive parts of modern irrigation network. The distribution of modern irrigation development in Ethiopia is mainly concentrated along the plane of perennial rivers. Neither the poor smallholders have the capacity to install the expensive modern irrigation system nor can the already implemented and planned large, medium and small scale irrigation schemes benefit the majority of the poor. From the perspectives of poor farmers alternative methods such as low-cost smallholder irrigation technologies are vital and attractive.

Experiences from other developing countries show that coupling of low-cost irrigation technologies with water conservation and harvesting technologies allows better control and management of limited water resources and results in much higher returns to farmers. Small-scale, low-cost irrigation systems that can be easily afforded and managed by poor farmers contribute significantly to the endeavors of ensuring food self-sufficiency at household level.

## 2. Background

Efficient use of scarce water has gained attention during the recent years as key to crop production in arid and semiarid regions. Drip irrigation is widely recognized as one of the most efficient methods of applying water to crops. Rather than irrigating the entire field surface as with other methods with drip irrigation water can be delivered precisely to the root zones. There are reports indicating that drip irrigation brings about water savings of about 50% and reduced labour. However, the conventional drip systems are expensive and cannot be afforded by smallholder poor farmers. To solve this problem a number of innovative options have been developed in different parts of the world (references in Isaya V.S., 2001 and in Postel S. et. al., 2001). The aims of these innovations are being to improve the distribution and application of water. Attempts have been made to make them as simple as possible so that they can be manufactured at lower cost and operated and maintained easily.

Low-cost irrigation systems attempt to retain the benefits of conventional systems whilst removing the factors preventing their uptake by poor smallholders: purchase cost, the requirement of a pressurized supply, the associated pumping costs and complexity of operation and maintenance (FAO, 2001). Low-cost smallholder drip irrigation system can be grouped into bucket and drum drip irrigation kits (Isaya V.S., 2001).

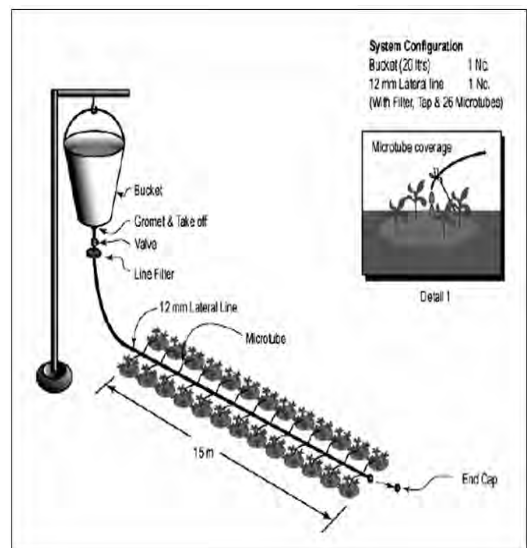
### Irrigation kits

In bucket kit drip irrigation, water flows into the drip lines from a bucket reservoir placed 0.5-1m above the ground to provide the required water pressure. Starting from 1995, International Development Enterprises (IDE) is an international NGO that has developed a variety of low-cost drip irrigation kits that are appropriately sized and affordable for smallholders (Isaya V.S., 2001). The kits operate under low pressure (up to 2m) and are successfully used for the production of fruits and vegetable as well as other row crops. The kits are expandable so that farmers can start small and scale-up as their capacity and

experiences grow. The capacities of the kits vary from 20-liter bucket that can irrigate 20m<sup>2</sup> to customized system covering about 1000m<sup>2</sup>.

### Bucket kits

Each comprises a 20 liter bucket installed on a pole at shoulder height. The bucket is fitted with a 15m lateral line from which 26 micro-tubes extend (Figure 1). By placing the tubes midway between parallel crop rows it is possible to irrigate four crops per tube. Depending upon the type of the crop and growing stage, the buckets need to be filled two to four times a day. Each bucket kit irrigates more than 100 individual plants over an area of 25m<sup>2</sup>. This technology helps the family not only to save water but also labour and time required to irrigate the garden which otherwise done by women.

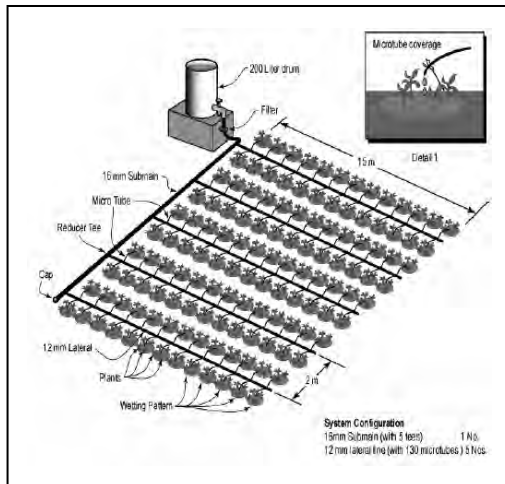


**Figure 1. Schematics of a Bucket Kit System (Postel, S. et. al., 2001)**

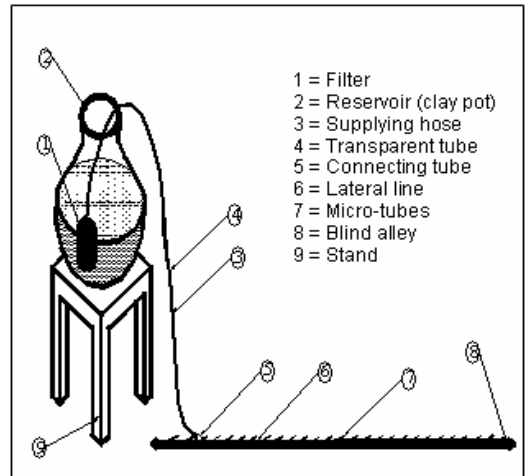
### Drum Kits

These systems consists of a 200-liter drum from which up to five lateral extend. It operates also under a low pressure head of water (0.5-5 m). The higher the drum is placed the greater the area that can be irrigated. Each lateral line is 15 meters long and fitted with 26 micro-tubes allowing each drum kit to irrigate 125 m<sup>2</sup> plots (Figure 2).





**Figure 2. Schematic of a Drum Kit, micro-tube (Postel, S. et. al., 2001)**



**Figure 3. Low pressure drip irrigation system (Fassil, E. et. al., 2003)**

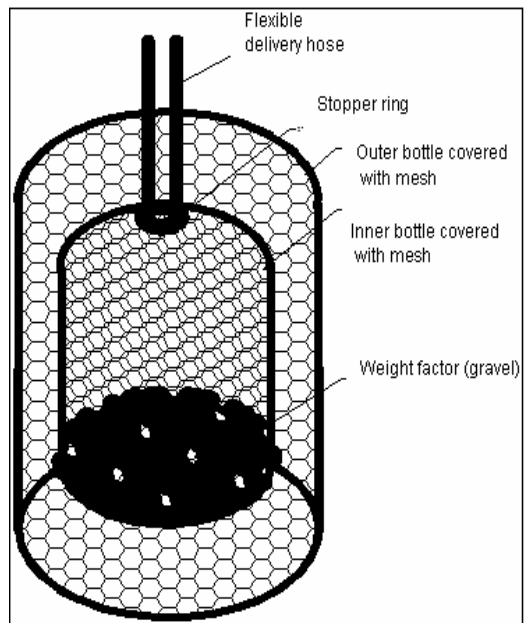
Examples of different drum systems such as the KARI drum system from Kenya, the Waggon Wheel system from South Africa, the Family system, Plastro and Micro-Tal systems from Israel and the IDE drum used in India are presented by Isaya V.S. (2001).

In all of these systems attempt is made to take the advantage of the benefits of drip irrigation method without requiring expensive central pressurized water system. The accessories of the systems are mostly developed and manufactured in Israel. Each bucket kit is delivered with instructions on how to assemble it, operate and manage it.

### 3. Low-pressure Micro-tube Drip Irrigation

#### 3.1. Description of the system

Fassil, E. et. al., (2004) has developed a Low-Pressure Drip Irrigation System. It consists of bucket or locally made clay pot and accessories as shown in Figure 3. The main feature of this system is that all the accessories are available on the local market for reasonable price and can easily be assembled by local farmers with little training and without or with little back-up support. The pots placed at 0.9 m above the surface



**Figure 4. Arrangements of filter components**

can supply water to a lateral line which is 15 m long and 16 mm diameter. On a lateral line there are about 28 micro-tubes spaced at 0.5m (spacing of most vegetables) that allow water to drip on the soil. The water enters into a 4.5mm supply hose after passing through a filter arrangement. Filtering of water from coarse materials and impurities is accomplished by outer fine mesh and perforated double plastic bottles inside the mesh (Figure 4). After

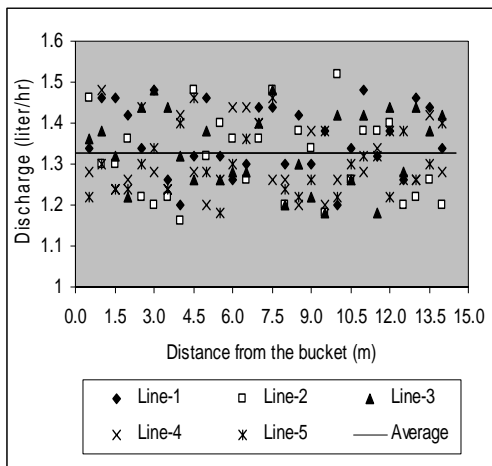


detaching the hose at transparent tube and mouth sucking the flow of water in to the supply hose can be initiated. Immediately after making sure that the water is in continuous flow in to the flexible delivery hose, the hose can be reconnected.

### 3.2. Test Results

#### 3.2.1. Dripper Discharge

The capacity of the system to distribute the required amount of water to the plant is determined by the discharges of the drippers. To know the discharge of each dripper and the uniformity of its distribution a catch can test was conducted. The results of the experiment are presented in Tables 3.1 and 3.2 and Figures 5 and 6. As can be seen from Figure 5, the discharges of all drippers are scattered around the average discharge line along the entire distance. It can be said that all drippers along the lateral line release water at almost a uniform rate..



**Figure 5. Discharge of drippers along five lateral lines (28 drippers on each lateral line located at 0.5m distance along the line)**

No significant differences in water distribution rate has been observed between drippers at the head, middle and tail of lateral line. Uniformity in water distribution is maintained throughout the system

There is no significant difference between the average discharges of all lateral lines. Both standard deviation and coefficient of variation

are very low, i.e., 0.08 to 0.1 and 0.06 to 0.08 respectively. The overall average dripper discharge is 1.326 liter/hour. This multiplied by 28 drippers is 37.12liter/hour which is the capacity of one lateral line. A 15 meter lateral line with its 28 drippers over 0.50 meter wide bed can irrigate an area of 7.5 m<sup>2</sup>.

#### 3.2.2. Uniformity parameters

##### Distribution Uniformity (DU)

For a uniform growth of the plant uniform application of water along the lateral line is essential so that each part of the irrigated area receives the same amount of water. However, as the water flows from one end of the lateral line to the other, there will be head loss which results in uneven distributions of discharge from the outlets over the lateral lines. Irrigation system needs to be carefully designed so that the variation in discharge is minimized.

The commonly used measures of uniformity are Distribution uniformity and uniformity coefficient. DU is a measure of a dripper's ability to apply water uniformly over the surface. A completely uniform application would have a DU of 100%. The more unevenly the system distributes water, the smaller the DU value. DU can be estimated as

$$DU (\%) = \frac{q_{lowest\ 25\%}}{\bar{q}}$$

Where,  $q_{lowest\ 25\%}$  = average of the lowest quarter discharge

$\bar{q}$  = average discharge of all drippers

**Table 3.1 Statistical parameters of catch can test**

	Line 1	Line 2	Line 3	Line 4	Line 5	average
Average discharge (l/h)	1.361	1.314	1.337	1.311	1.305	1.326
SD	0.083	0.101	0.092	0.083	0.075	0.087
CV	0.061	0.077	0.069	0.063	0.057	0.066

**Coefficient of Uniformity (CU)**

CU as proposed by J.E. Christansen (1942) is widely used to estimate the uniformity of water distribution in sprinkler irrigation. It has been applied to all types of irrigation systems. In drip irrigation it is also known as Emission uniformity (EU).

$$CU = 1 - \frac{\left( \sum |q_i - \bar{q}| \right)}{n \bar{q}}$$

Where,

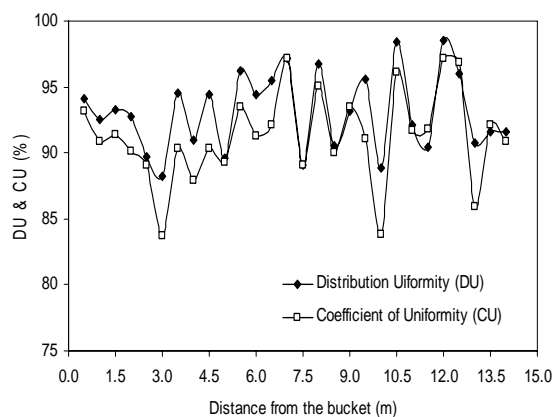
- $q_i$  = dripper discharge
- $\bar{q}$  = average discharge
- $n$  = number of drippers

The results of DU and CU along the lateral lines are presented in Figure 6. The curves of both parameters of uniformity measures show similar trend with DU lying above that of DC. As can be seen the system have been observed to have consistently DU and CU above 89 % and 84 % respectively.

The results of water distribution uniformity of five sample lateral lines are calculated and given in the table 3.2. In average over the laterals the distribution uniformity is 92% while the coefficient of uniformity is 90% which signify an even distribution of water throughout the system.

**Table 3.2. Summary of Uniformity Parameters**

Lateral lines	Uniformity parameter (%)	
	DU	CU
1	92.1	90.1
2	90.9	88.5
3	91.0	88.9
4	93.7	90.3
5	93.5	91.9
Average	92.24	89.94

**Figure 6. Distribution Uniformity and Coefficient of Uniformity along the Lateral Line**

### 3.3. Wetting Pattern

The wetting pattern under a dripper varies according to the texture of the soil. In soils of capillary suction the horizontal and vertical infiltration will be similar and the wetting pattern will be approximate to a hemisphere. In coarse soil, with low capillary suction, the wetting pattern will be more elongated with a higher vertical movement.

Water flowing from dripper is distributed in the soil by gravity and capillary forces creating the counter lines. The exact shape of the wetted volume and moisture distribution depend on the soil texture, initial soil moisture, and to some degree on the rate of water application.

The moisture distribution patterns of the drippers after irrigation have been determined using gravimetric method. The results are presented in Figure 5 and 6. The results of dripper 2, 14 and 28 which are located respectively 1m, 7m and 14 m away from the bucket/ reservoir. Constant moisture content below 45 cm depth shows initial water content. Water application has brought about change in

water content only in 45 cm soil layer (0-45cm) at the time of sampling. For some extent, further redistribution of water in vertical direction may take place between the wetted zone and the underlying dry soil. The distribution patters coincide with typical wetting pattern of soil under drip irrigation system.

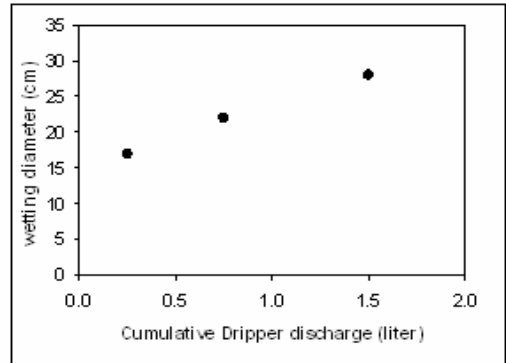


Figure 7. Relationship between dripper discharge and surface wetting

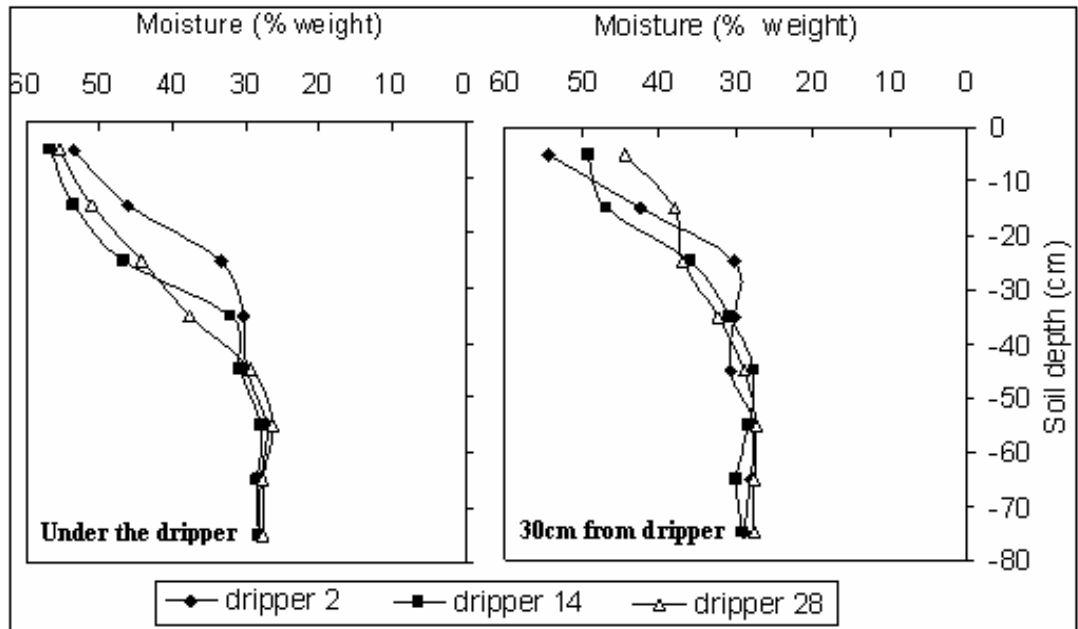


Figure 8. Moisture distribution patterns under different drippers located at different distances from bucket (dripper 2, 14 and 28 are located at 1.0, 7.0 and 14.0 m away from the water source/ bucket respectively)

Figure 8 shows that more uniform moisture distribution pattern over the entire lateral line can be obtained when the moisture distribution of the adjacent drippers overlaps. For closely spaced vegetables the dripper distances are also close to each other so that the wetting patterns overlap and create continuous moisture zone along the row/ lateral.

Moisture content in 30 cm from the dripper is higher than in 15 cm. Under single dripper the wetting front starts directly from the center of the dripper and advance both vertically and laterally (figure 7). In the practice series of drippers are arranged one after the other so that the wetting patterns of neighboring drippers overlap and produce more moist areas. This moisture distribution characteristic supply crops planted between the drippers with more water than those crops planted under the drippers.

At water application rate of 1.326liter/hour the surface wetting front will take about one hour to overlap with wetting front of the neighboring dripper. Figure 7 shows how the surface wetting advances with volume of water applied. This characteristic of moisture distribution is of course, as described above, the function of soil physical properties.

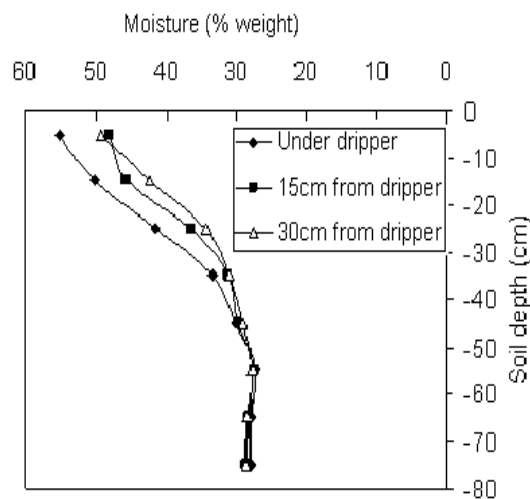


Figure 9. Average lateral and vertical moisture distribution patterns

## Summary

Under the present condition, whereby water harvesting at householder level is widely practiced in Ethiopia with the aim to fight against poverty and food self-insufficiency, appropriate means of producing food out of water is an important issue that deserves attention. Low-cost drip irrigation systems can support such endeavors as they can save and supply water to the plant more efficiently and afforded by the poor farmers. When operated properly wastage of water can be minimized with increased water productivity. In addition to its simplicity, low-pressure micro tube drip irrigation system extremely save the precious water and labour needed to water plants each plant every time. Moreover, vegetables watered with low-pressure micro-tubes drip irrigation system have higher yields.

Experiences from Arba Minch shows that a single low-cost drip irrigation system of 60 -70 birr initial cost can supply family with fresh vegetable for home consumption. Figure 10 shows the cumulative harvest of fresh tomato from one row (0.5m × 15m) irrigated by one lateral line of the drip system. With the adoption of the system, a family has harvested every three days over more than one month which was enough for the family. Increasing the number of laterals or rows will increase the opportunity to produce more for local market and get more income.

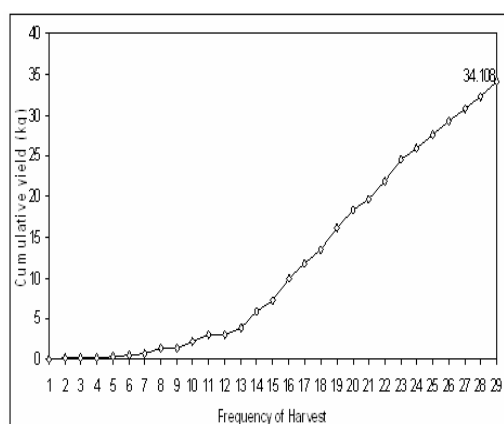


Figure 10. Cumulative harvest of tomato from field of a lateral line

The system has the water supply capacity of  $1.326 \text{ liter/h/dripper} \times 28$  (total number of drippers) = 37.12 liter/hour. Satisfying the water requirement of the crop, which is the function of climatic condition, crop type and growth stage, is possible through adjusting time of application. Suppose the peak water requirement of tomato growing on 7.5 square meter bed is 5mm/day. The total daily water requirement is equal to 37.5 liter/day. If the tomatoes are to be irrigated every day by the lateral that drips 37.12 liter/hour, the operating time would be

$$\frac{(37.5 \text{ liter / day}) \times \text{day}}{37.12 \text{ liter / hour}} = 1.0 \text{ hour}$$

However, the capacity of the bucket is 20 liter so that the farmer needs to fill the bucket two times a day to meet the water requirement of tomato in this case.

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**Accessibility & private sector participation in  
irrigation development, technologies &  
equipment**





# Private –public Partnership and Technological Imperatives for Irrigation Development

**Alemayehu Mengiste**

Agritec System P.L.C, Addis Ababa, Ethiopia  
agrsys@ethionet.et

## **Abstract**

In irrigated agriculture, water taken up by crops is partly or totally provided through human intervention. Irrigation water is withdrawn from a water source (river, lake or aquifer) and led to the field through an appropriate conveyance infrastructure.

There is a marked difference in yield response and water requirements between irrigated and non-irrigated agriculture. Irrigated crops produce better yield than rain fed crops because of their higher water consumption even if those rain fed crops get optimal inputs.

Experience shows that rain fed agriculture have been unable to meet the food requirement of the Ethiopian population. The present annual per capita consumption of cereals and pulses in the country is 163kg compared to UNICEF standard of 240kg and that of the average for developing countries of 230kg (2100 Calories). Even though considerable increase in production can be attained through intensification of the rain fed agriculture, it is bound to fall short of the ever increasing population.

The terms “drip”, “trickle” and “sprinkler” irrigation, common in many parts of the world in the last 15 years have been emphasized by the term “micro irrigation”, “low volume irrigation”. Micro irrigation includes all methods of frequent water application, in small flow rates, on or below the soil surface.

This is probably the promising technology choice in terms of water management, fertilizer application, crop protection & increased yield. Considering the need to cop up with growing demands, the choice of appropriate technology is eminent. The technology choice is mainly dictated by the cropping pattern, the level of sophistication & the operational capacity of end users, the optimum combination of efficiency in

water use and cost effective operation and maintenance.

The terms “drip”, “trickle” and “sprinkler” irrigation, common in many quarters in the last 15 years have been supplanted by the term “micro irrigation”, recently adopted by the American Society of Agricultural Engineers. Micro irrigation includes all methods of frequent water application, in small flow rates, on or below the soil surfaces.

Regarding irrigation development areas of cooperation between the private and public sector could be mainly in a)technology choice and adaptation b)financing and resource mobilization c)rural entrepreneurship and private sector development.

Micro irrigation systems have many potential advantages when compared with other irrigation methods. These are mainly: use of smaller flow rate, controlled application of chemicals, use of saline water, improved quality of crop, adaptation to any topography.

## **1. Irrigation and Current Crop Production System of Ethiopia**

### **1.1. General**

In irrigated agriculture, water taken up by crops is partly or totally provided through human intervention. Irrigation water is withdrawn from a water source (river, lake or aquifer) and led to the field through an appropriate conveyance infrastructure. To satisfy their water requirements, irrigated crops benefit both from more or less unreliable natural rainfall and from irrigation water. Irrigation provides a powerful management tool against the vagaries of rainfall, and makes it economically attractive to grow high-yielding seed varieties and to apply adequate plant nutrition as well as pest

control and other inputs, thus giving room for a boost in yields (FAO, 1996). Irrigation is crucial to the country's food supplies.

### 1.2. Yield Response

There is a marked difference in yield response and water requirements between irrigated and non-irrigated agriculture. Irrigated crops produce better yield than rain fed crops because of their higher water consumption even if those rain fed crops get optimal inputs. The water consumption for rain fed agriculture stops at 5,500 m<sup>3</sup>/ha as it is impossible for 'typical' rain fed crops to consume more water. The corresponding yield is estimated to be 5000kg/ha. Whereas the irrigation crops water consumption could go up to 6500m<sup>3</sup> /ha with a corresponding yield of over 7500kg/ha.

### 1.3. Food Balance

Experience shows that rain fed agriculture have been unable to meet the food requirement of the Ethiopian population (See table 1). The present annual per capita consumption of cereals and pulses in the country is 163kg compared to

UNICEF standard of 240kg and that of the average for developing countries of 230kg (2100 Calories). Even though considerable increase in production can be attained through intensification of the rain fed agriculture, it is bound to fall short of the ever increasing population. Table 1 with a five years interval shows the required growth of irrigated agriculture in Ethiopia. It can be seen from the table that although the production from rain fed agriculture is expected to grow still additional production is required to meet the demands, which has to come from the irrigation sub-sector. In order to achieve this nearly 1.5 million hectares and nearly all of the 3.5 million hectares must be developed by 2020 and 2040 respectively.

## 2. Private-Public Partnership for Irrigation Development

### 2.1. General

In present day agricultural production system, irrigation is effectively used to compensate for permanent water deficit & to smoothen climate variations mainly caused

**Table 1. Required food crop production & irrigation land**

Year	1995	2000	2005	2010	2015	2020
Population ('000)	53,277	60,965	70,297	82,689	96,806	113,234
Annual Per Capita						
Food Consumption(KG)	150	160	170	180	190	200
Total Requirement of Cereals (MT)	7.99	9.7544	11.95	14.88	18.39	22.64
Production from rain fed Cultivation(MT)	7.491	7.99	8.49	8.99	9.99	10.99
Balance Production from irrig. Agriculture(MT)	0.50	1.7644	3.46	5.89	8.40	11.65
Production rate for irrig. Agriculture(t/Ha)	6.5	7	7.25	7.5	7.75	8
Required area under irrig Agriculture (Mha)	0.07	0.25	0.47	0.78	1.08	1.45

Source: - The 1984 population & Housing Census of Ethiopia; Analytical Report at National level, Addis Ababa, Dec.1991

due to precipitation. Irrigated agriculture in Ethiopia from the point of view of technology can be categorized into traditional, modern-community owned, modern-private, and modern-public. The traditional farms are mainly characterized by enormous water loss, uncontrolled water application, backward crop husbandry, etc. However, the modern ones are better in relative terms but still having less than 45 % irrigation efficiency, particularly those that are under surface irrigation. Today there are very few but not exceeding an aggregate of some 3000ha under low volume (drip & sprinkler) modern irrigation systems. This is probably the promising technology choice in terms of water management, fertilizer application, crop protection & increased yield. Considering the need to cop up with growing demands, the choice of appropriate technology is eminent. The technology choice is mainly dictated by the cropping pattern, the level of sophistication & the operational capacity of end users, the optimum combination of efficiency in water use and cost effective operation and maintenance.

## **2.2. Technological Choice and Research**

Apart from the formal higher learning institutions of the country, to date there is no center for irrigation technology choice & adaptation. This has immensely contributed to the stagnation of the backward irrigation technology we are utilizing. Therefore the establishment of a center for technology choice & adaptation is fundamental to the growth of irrigation development in the county. Adaptation of best practices from elsewhere in the country or from abroad could not be conducted using original scientific research, which is time taking & expensive but by employing adoptive research.

The utilization of new technologies & farming practices of irrigation development would greatly benefit from adoptive research. It can also stimulate sustained growth & spread of & improved technologies. As water is becoming more critical for agricultural production, it has also more competing use & therefore efficiency of water use will be of prime concern as irrigation development widens.

## **2.3. Financing Irrigation Schemes and Resource Mobilization**

The issue of financing is critical particularly when irrigation development is considered, since irrigation is finance intensive based on the technology chosen & the scale of intervention. The shining success in terms of food self sufficiency of India & China, the two mostly populated nations of our world, stems mainly from their use of appropriate planning & implementation together with suitable technology of irrigation including massive mobilization of their people and indigenous resources (both finance & human resource).

## **2.4. Rural Entrepreneurship and Private Sector**

The rural economy needs to be diversified from the mono tuned crop-livestock production system into other economic activities that are either agricultural based or in trade, service & rural industry. The introduction of irrigation yields the opportunity for diversified business activities. As income increases due to surplus production of irrigation, there will be increased demand for non - farm products & services. Hence, the private sector will be involved to handle these business activities. As these activities require financial & institutional support, the role of the government will be to enhance the rural business areas, facilitate or avail capital in a form of credit or incentive & guide in running the businesses and in general develop rural entrepreneurship & private sector participation.

## **3. Technological Imperatives for Irrigation Development**

### **3.1. General**

The terms “drip”, “trickle” and “sprinkler” irrigation, common in many quarters in the last 15 years have been supplanted by the term “low volume irrigation” or “micro irrigation” as recently adopted by the American Society of Agricultural Engineers. Low volume irrigation includes all methods of frequent water application, in small flow rates, on or below the soil surface. Ideally, the volume of water is

applied directly to the root zone in quantities that approach the consumptive use of the plants.

### 3.2. Components of a micro Irrigation System

In micro or low volume irrigation systems, water is distributed using an extensive hydraulic pipe network that conveys water from its source to the plant. Outflow from the irrigation system occurs through emitters placed along the water delivery (lateral) pipes in the form of droplets, tiny streams or miniature sprays. The emitters can be placed either on or below the soil surface.

Emitters can vary from sophisticated, constant-flow-rate at variable pressure types of devices (pressure compensating emitters) to very small, simple orifices. A large number of different types of emitters have been developed in attempts to find a perfect one. The main objective is to assure uniformity of water distribution. It is essential that the discharge from the emitter be uniform and that it not change significantly with small pressure variations in the system. At the same time the emitter should be constructed in such a way that it does not clog very easily (figure 1).

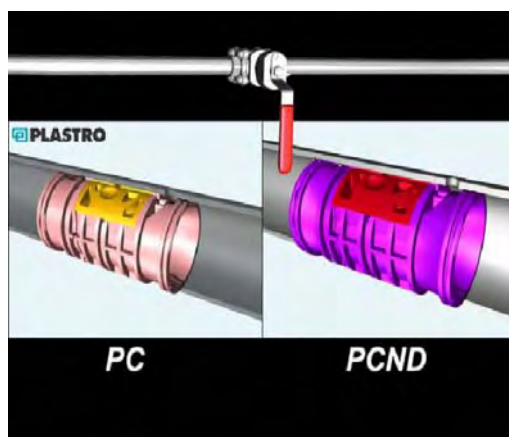


Figure 1. Plastro emitters (PC and PCND types)

### 3.3. Wetting Patterns under Micro Irrigation

Due to the manner in which water is applied in a micro irrigation system, only a portion of the

soil surface and root zone of the total field is wetted. Water flowing from the emitter is distributed in the soil by gravity and capillary forces creating the contour lines. The exact shape of the wetted volume and moisture distribution will depend on the soil texture, initial soil moisture, and to some degree, on the rate of water application (figure 2)



Figure 2. Typical wetting pattern of drip irrigation system

## 4. Consideration for Selecting the Most Appropriate Irrigation Application

### 4.1. General

Micro irrigation systems have many potential advantages when compared with other irrigation methods. Most of them are related to the low rates of water application.

Irrigation water requirements can be smaller with micro irrigation when compared with other irrigation methods. This is due to irrigation of a smaller portion of the soil volume, decreased evaporation from the soil surface, and the reduction or elimination of the runoff.

### 4.2. Smaller Flow Rates

Since the rate of water application in micro irrigation systems is significantly lower than in other systems, smaller sources of water can be used for irrigation of the same acreage. The

delivery pipes, the pump, and other components of the system can be smaller and therefore more economical.

### **4.3. Application of Chemicals**

Micro irrigation system allow for a high level of control of chemical applications. The plants can be supplied with the exact amount of fertilizer required at a given time. Since they are applied directly to the root zone a reduction in the total amount of fertilizer used is possible.

Other chemicals, such as herbicides, insecticides, fungicides, nematicides, growth regulators and carbon dioxide can be efficiently applied through micro irrigation systems to improve crop production.

### **4.4. Water Sources with High Salt Content**

A significant advantage of micro irrigation is that water with relatively high salt content can be used by the system. For optimum plant growth a certain range of total water potential in the root zone must be maintained. The potential defines how difficult it is for a plant to extract water from the soil. Large negative numbers are characteristic of very dry soils with low total water potentials while potentials near zero reflect soils near saturation.

### **4.5. Improved Quality of the Crop**

Micro irrigated plants are supplied very frequently with small amounts of water and the stress due to the moisture fluctuation in the root zone is reduced to the minimum, often resulting in larger and better quality yield. In arid climates, or during dry seasons, the harvest time can be controlled by proper water management.

### **4.6. Adaptation to Any Topography**

Micro irrigation systems can operate efficiently on hilly terrain if appropriately designed and managed. Well managed micro irrigation system will not create runoff even on hilly terrain.

### **4.7. Additional Advantages of Micro – Irrigation Systems**

During dry seasons or in arid climates disease and insect damage can be reduced in micro irrigation system since the foliage of the plant is not wetted. With a small portion of soil surface being watered, field operations can be continued during irrigation. The water distribution is not affected by the wind for drip irrigation. However, wind can have some effect on jet spray patterns.

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# The Adoption of Micro Irrigation Technologies (Private Sector Participation in Irrigation Development)

## The KickStart Experience

**John Kinaga**

Kickstart International, Nairobi, Kenya

john.kiuaga@kickstart.org

### Abstract

The paper covers the threat to human survival as water becomes scarce and the need to food and other basic requirements becomes a priority for the smallholder farmers who constitute about 75% of the population of many African countries.

The Africa people though seen as poor in reference to their capital base are potential investors seeking for opportunities that would assist them create a sustainable business enterprise to generate wealth and job creation. The farmers have access to land, water and adequate skills. What they lack is the right business choice and the right appropriate affordable technology.

The paper address how KickStart, an International Social Enterprise not-for profit organization which was established in 1991 in Kenya has transformed the lives of more than 200,000 people in Africa get out of poverty and how they have started their own business enterprises. The mission of the organization is to promote sustainable economic growth and employment creation by developing and promoting technologies that can be used by dynamic entrepreneurs to establish and run profitable small-scale business enterprises. The different technologies are discussed and how they operate to benefit the smallholder farmers.

The paper discusses the strategy on how the organization operates and its current impacts in Africa. A case study that tells the beneficiaries' story has been given to highlight how the micro irrigation technologies have changed peoples' lives. The paper discusses how the technologies are made accessible to the end users and how they are maintained.

The paper also discusses the private sector business model and the financial implication on how to set up such a Promotion Program in Ethiopia or any other African Country for Micro irrigation technologies. In conclusion the paper will indicate the parameters for a successful promotion program in any new country and the sustainability of the Private Sector business model.

### 1. Background

Kenya is predominantly agricultural country. It occupies a total area of 569,000 sq km, with an estimated population of 32 million of which 80% of the population stays in the rural areas where it is engaged in agricultural production.

The Agricultural sector is the backbone of the economy contributing over 50% to the GDP. Majority of the rural households (70%) rely directly on the agriculture sector for their livelihoods. About 18% of the total area is classified as medium and high potential area for agriculture production with an annual rainfall of between 750 and 2000mm. The rest of the country, about 80% is classified as arid and semi arid land with limited potential for agricultural production without some form of irrigation.

Due to the growing population pressure, agricultural activities are been pushed into the arid and semi arid regions where farming with out supplementing natural rain is not profitable.

Poverty in Kenya continues to be a big challenge to the Government with about 50% of the population classified as poor (living below a dollar a day). Currently, about 10 million Kenyans are considered to be chronically food insecure. It is also estimated that about 2 million people require food relief annually though the number fluctuate to be 4 million in times of drought. These occur mostly in the arid and semi arid areas where rainfall is mostly unreliable.

Achieving food security has been hampered by several factors; the major one being over-reliance on rain fed agriculture. Agricultural production in the country is predominantly rainfall dependent. It is estimated that about 16% of the total land area can support rain fed agriculture. Population pressure has also pushed people to the arid and semi arid areas, which receive erratic rainfall. Productivity in the high and medium potential areas has also declined.

Irrigated Agriculture will continue to contribute significantly to the development of agricultural production especially in the arid and semi arid areas of the country and can contribute towards attainment of food security. The government should strive to create a conducive environment for investment in irrigation especially by the smallholder farmers.

The Kenya Government has prioritized irrigation development as the key strategy to revitalize agriculture. Smallholder farmers are not such poor people, as many outsiders would want to be believed, they have land, water, time and adequate skills. If only they have access to the right technology and support for their investment they would be self reliant in food production, with sufficient surplus for local and international market to meet their basic daily needs like better health services, education, shelter and other social amenities.

In the dry areas of the country the threat to human survival is evident as water becomes scarce and the need to food and other basic requirements becomes a priority for the smallholder farmers who constitute about 75-80% of the population of many African countries.

In Kenya the government has not invested adequately in water storage facilities hence arid and semi arid areas are adversely affected by drought that affects their survival. In end of 2005 and early 2006, about 3-4 million people were affected by drought and hundreds of livestock died.

Africans though seen as poor in reference to their capital base, are potential investors seeking for opportunities that would assist them create a sustainable business enterprise to generate wealth and job creation. The farmers have access to land, water and adequate skills. What they lack is the right business choice and the right appropriate affordable technology.

It is in this background that KickStart programs operate in Kenya, Tanzania and Mali.

## 2. Introduction

KickStart is a Not-for-Profit International Social Enterprise founded in Kenya in 1991. In 2000 the Tanzanian program was started while Mali was opened in 2004. Since 1996 KickStart started promoting the Money Maker series of treadle pumps. Although the three aforementioned countries actively run social marketing programs, KickStart technologies especially the Money Maker pumps have been supplied to 16 African countries.

### 2.1. Mission

KickStart's mission is to eradicate poverty by fostering sustainable economic growth and employment in developing countries. Operating more like a business than a nonprofit organization, we accomplish this mission by designing, manufacturing, and marketing equipment that is purchased and used by poor people to establish profitable small-scale enterprises.

Our most successful product line is a series of foot-operated manual irrigation pumps. Because 80% of the poverty in sub-Saharan Africa is in rural, agrarian areas, irrigation is a particularly effective way to increase incomes. With a \$33 to \$95 KickStart pump, an African farmer can grow and sell produce, earning enough additional income to move from poverty

towards middle class. Our irrigation pumps illustrate that economic and social sustainability are achieved when people have the means to provide for themselves.

## 2.2. Our Beliefs

KickStart believes that:

- Self-motivated entrepreneurs are the most effective agents of change in economies in transition
- Such entrepreneurs are able to raise small amounts of capital (\$50-\$1000) required to start new micro-enterprises
- These entrepreneurs have the capacity and skills to manage the day to day affairs of a small business

But that they face two challenges:

1. Business Choice: It is difficult for them to identify viable new enterprise opportunities.
2. Access to Technology: They cannot easily access or develop the technologies needed for these enterprises to function

KickStart sees poor people as potential entrepreneurs who have:

- The drive and desire to get ahead,
- Land, time and labor to invest,
- The ability to borrow or save a small amount of money to start a business.

KickStart also believes that the millions of people who live at the so-called 'Base of the Pyramid' in Africa should not be considered as a problem waiting to be solved. We see them as an opportunity waiting to happen. These people comprise a massive reserve of human and social capital, of energy and intellect, and of skills and knowledge, with millions of hectares of under-utilized land at their disposal. Although cash-poor at this point in the economic development of their countries and regions, they are ready to invest their wealth of non-financial assets into any endeavor that promises a worthwhile economic and social return. They simply need practical ways of using these qualities. For a very large proportion of this huge rural population the answer is irrigation.

However, the appropriate, low-cost capital equipment required to start such a business is unavailable. Private sector companies have difficulty making money in rural areas of the developing world because of the excessive marketing costs to reach poor rural buyers. While marketing low-cost consumer products such as soda and shampoo is difficult in these markets, selling high-cost capital goods is simply cost prohibitive for private companies.

## 2.3. Strategy

KickStart addresses this need using a six-step methodology:

1. Research markets to identify highly profitable new small business opportunities that greatly enhance the productivity of rural Africans' primary assets – land, labor and entrepreneurial drive
2. Design the required low-cost capital equipment
3. Train private manufacturers to mass produce the designed product
4. Develop a private sector supply chain to deliver the equipment whereby every partner in the chain is profitable
5. Mass-market the equipment to rural Africans. We subsidize the development and promotion of new products until they are as well known as other income generating products in Africa, such as bicycles and sewing machines
6. Carry out continuous sales and impact monitoring to evaluate progress toward set goals. Our state-of-the-art Impact Monitoring Unit measures the impacts of our program and continually searches for improvements.

After creating a "critical mass" of sales and awareness, we cease our marketing subsidies and leave in place a fully sustainable supply chain and growing demand.



This strategic process ensures:

- The highest impact is achieved in the shortest time possible
- A cost effective program is achieved
- A self sustainable income generating process and
- A scaleable or replicable process to other areas

## 2.4. The Choice of Technologies

KickStart recognizes that the sort of impact achieved to date depends intimately on getting the right product at the right quality in the right place at the right price through promotional awareness. Equally it recognizes that there are a number of useful products that it cannot promote because they do not have mass market potential. The criteria for selecting a technology to promote are based, ideally, on the following:

- It must be a very profitable business model that allows entrepreneurs/investors to recover their costs in 3 – 6 months
- The technology must be affordable to very poor investors (our guideline is that its price be less than 3 month's gross disposable income)
- The technology must have mass production and mass market potential (i.e. tens of thousands of potential investor MSEs)
- The technology must be inherently capable of distribution through existing private-sector market channels
- The technology must be capable of increasing target-group family income by at least 100%
- The technology must be sufficiently durable to last at least two years without major maintenance
- The technology must use the local available raw materials
- The technology must operate efficiently enough to be competitive with other alternatives
- Operation of the technology must be simple
- The technology must be environmental friendly

KickStart places great value on these criteria because experience has shown that without being affordable, capable of widespread use and capable of radically increasing family income, even the best technology will not be bought by very many people. KickStart also recognizes that a number of promising technologies may be excluded by this process, but believes that its concern to offer a high benefit-cost payoff requires fairly close adherence.

KickStart has developed a number of technologies beside the MoneyMaker pumps.

- An Action-Pack Block Press compresses a mixture of soil with small quantities of cement (usually at a ratio of 18:1) to produce blocks that are stronger than concrete blocks. A 50kg bag of cement can produce between 90-110 stabilized soil blocks.
- The "Mafuta Mali" Oil Press is a manual press that press oilseeds like sunflower and simsim to make nutritious cold pressed cholesterol-free cooking oil.
- The MoneyMaker Hay baler makes it possible to run a bailing business and ensure an abundant supply of livestock fodder.
- The Super MoneyMaker pump is the fast moving irrigation pump in the market today. We also expect the new MoneyMaker Hip pump to revolutionize the irrigation sector especially for the very poor small-scale farmers due to its affordability.

## 2.5. Impacts.

Smallholder irrigation in Africa is highly valued by its users. The average holding size varies between 0.2ha to 1.0ha. Studies carried out by International Program for Technology and Research in Irrigation and Drainage (IPTRID) indicated that irrigated agriculture contributes about 25-80% of total family income annually

KickStart impact studies have found that the net annual income from irrigation per family using the Money Maker pumps ranges from \$800 to \$1,000. In December 2005 there were 55,080 irrigation pumps that had been purchased in Kenya, Tanzania and Mali. These irrigation

pumps have contributed into the development of 37,535 enterprises and created household income of \$37.9 million annually with an employment of 44,343 jobs (both family and waged jobs). This new wealth has helped nearly 200,000 people out of poverty. An additional 600 to 800 pumps are being purchased every month, adding further investment into irrigated agriculture in these countries.

A further indication of benefits from irrigation is the establishment of small-scale businesses within the vicinity of nearby village markets, thus creating employment. This has led to improved access to better education, health, housing and welfare services to the farming communities. This is all achieved through individual farmer's initiatives to accelerate their own socio-economic growth. Figure 1 show the trend for the adoption of the irrigation technology in the three countries where KickStart has marketing programs.

Nationally, irrigation development brings about economic growth by generating export crops, reducing imports, increasing food security and saving the country the much-needed foreign exchange. Additionally in each country pump

dealers are opened all over the country to sell the products. In Kenya alone over 260

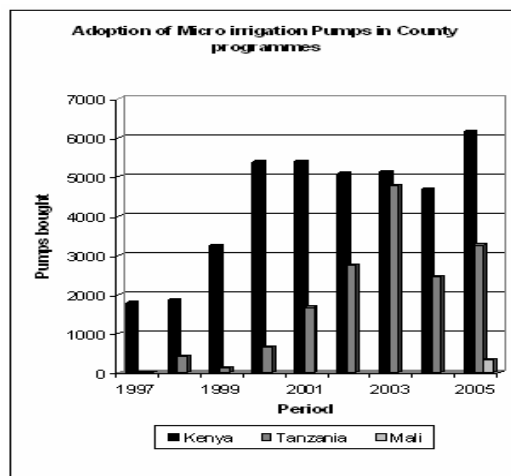


Figure 1. Adoption trend of irrigation technologies

retailers/dealers have been opened, making the irrigation pumps accessible to the rural farmers. Tanzania had 100 dealers while Mali had 44 dealers by December 2005.

Table 1- Characteristics of MoneyMaker pumps

Specification	Super MoneyMaker	MoneyMaker Plus	MoneyMaker Hip Pump
Max. Suction Depth	23ft (7m)	23ft (7m)	20ft (6m)
Max. Pumping height	46ft (14m)	46ft (14m)	43ft (13m)
Push water on flat distance	656ft (200m)	656ft (200m)	656ft (200m)
Irrigation Capacity	2 acres	1 acre	¾ acre
No. of sprinklers powered	5	3	2
Weight	21kgs	11kgs	4.5kgs
Guarantee	1yr	1yr	6 months
Cost (March 2006)	\$95	\$54	\$33

### 2.5.1. The Micro Picture- Samuel Ndungu's Testimony

Samuel Mburu Ndungu from Kamahuha Location of Maragua district in Central Kenya lives with his wife and 6 boys and 1 girl. They live in a plot of less than 1 acre. Initially Samuel used to be a hawker in Nairobi where he was selling fruits and roasted maize. Although he was making a substantial amount of money, he realized he was spending all of it buying food for his family back at home after meeting his needs at the city. He made no savings and was living from hand to mouth. He decided to try irrigation farming by growing vegetables for household use and for sale as the family farm was near a stream. He became an out grower for Frigoken (a French beans exporting & processing co.) by planting 1kg seeds of French beans and later increased to 2Kgs. He started making Ksh 10,000 (\$ 135) in one crop cycle. After a few crop cycles he started selling through a middleman, but things were not any better. That is when I started selling to another out grower company, the Everest. By this time, I had bought a cow and a goat. In 2003 he approached Everest, a fresh produce exporting firm to whom he was selling his produce for a credit facility to buy the Money Maker pumps which he had heard about from the local radio and had seen various demonstrations. He had identified the pump as a toll that would transform his irrigation business. Although he never got a credit facility he did not give up but approached the KickStart Promotion Assistant at the local retail shop who introduces him to the Dealer. The dealer to lend him the pump after he paid a deposit of Ksh.2,000 (\$27) and made a written commitment to repay the balance.

In the last two years Samuel has:

- Increased the area under irrigation by renting land from other people.
- He grows French beans throughout the year
- He plant a new crop after every 2 weeks
- His income is never less than Ksh 100,000/- (\$1,350) a year.
- He has built a house for his three older boys.
- He had added another cow, and in total now have 7 goats.
- He has been able to pay school fees for his children one in local polytechnic and pays

an annual fee of Ksh 9,600/- (\$130), the second one in local secondary school paying a fee of Ksh 11,000/- (\$150) and the third child who is pursuing an electrical wiring course at a cost of Ksh 10,000/- (\$135).

- He has bought the three children each a bicycle to ease their traveling. The rest of the children are in primary school, while one is still at home.
- He recently bought a motorized pump, which cost him Ksh 28,000/-(\$378) to enable him irrigate his increased 5 acre farm which he now plants 16kgs of French beans.
- He has already paid a deposit of Ksh 40,000 (\$540) for the purchase of an acre of land at a cost of Ksh.80,000 (\$1,080) in the neighborhood.

“I am very happy with KickStart work. It has made it possible for me to make a major difference to my family. I pray for them and their supporters to always get some more to help many more who are suffering the way I used to. I am sending out an appeal to KickStart supporters and would be supporters to extend their support to this organization since the MoneyMaker pump has made a major difference to my life”

The pump can irrigate up to 2 acres. In practice we have found the average area actually irrigated is 0.3 hectare (0.7acres).

### 2.5.2 Export to other countries.

KickStart's micro irrigation pumps are now being used in 17 African countries besides countries like Haiti and Philippines, USA, and Yemen. Figure 2 shows the exportation of pumps to some countries who imported about 100 pumps.

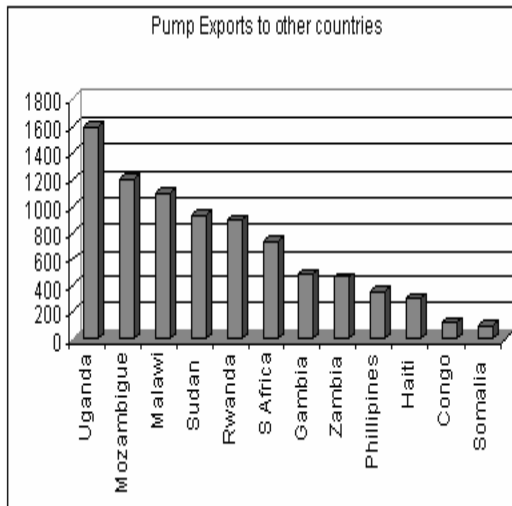


Figure 2. Countries with importation of about 100 pumps

### 3. The Business Private Sector Value Chain

KickStart’s operation follows the classic private sector business chain approach in which every player in the commercial chain between raw material supplier and final investor/consumer of the finished product profits from their activity.

KickStart introduces the product to the manufacturers and to the market. The principal goal is to create increased confidence amongst the manufacturers, Retailers and Buyers. In the introduction of any new product neither manufacturers nor retailers are ready to invest in making or selling the technology because it is an unproven product. KickStart’s interventions are, then, principally designed to reduce perceived levels of risk without distorting the pricing structure that is needed for long-term sustainability. KickStart works directly with manufacturers and retailers and indirectly with end-users, who benefit from the KickStart-backed guarantees and are made aware of the technology through public media and below the line promotion activities. KickStart offers consignment credit to the retailers or wholesalers initially and after the product has penetrated the market, sales are made on agreed terms of credit while KickStart pays the manufacturer all its suppliers. Figures 3 and 4

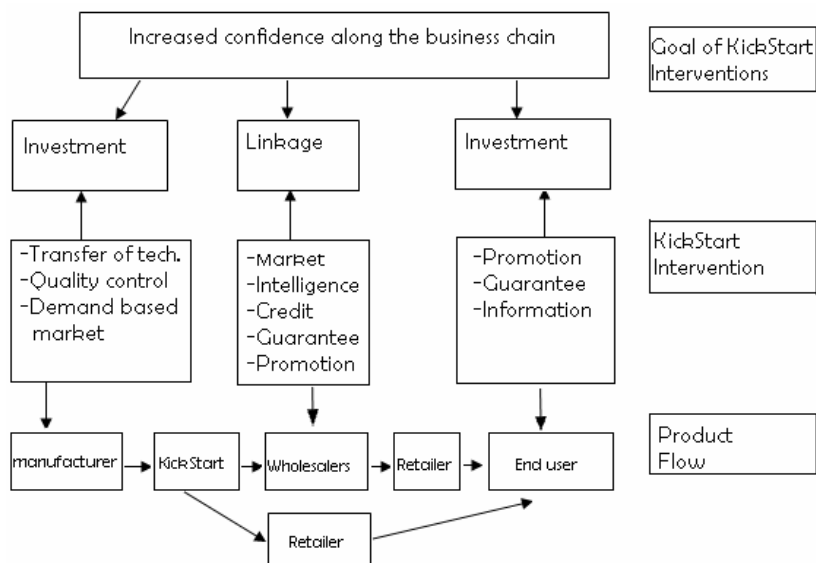
shows the private sector distribution value chain.

The business chain is important as a brand new product will not sell in the market for the simple reason that people cannot be interested in something they do not know about. So the development of a new market for a new product requires a major and expensive effort to launch the product, and sustain a spirited marketing campaign for as long as it takes for the product to find a place in the market. This is where a big challenge lies.

In the business chain, KickStart’s principal intervention is in the area of research & development (or product development) and in creating awareness/developing the market for the product. For this to happen, financial support is needed to carry out these two vital intervention areas. This is where donor financing is spent. All the private players in the business chain make profits from the outset, thus ensuring a sustainable delivery system from the beginning which can be expanded in future as demand and sales rise. Figure 4, describes the KickStart private sector business value chain showing the areas of donor subsidy to KickStart to develop and mass market the technologies.

#### 3.1. Marketing Development and Costs

Market development describes the strategy for accelerating product uptake in the market, which is considered from a national (and sometimes international) perspective. This involves mass media, storefront and marketplace demonstrations, billboards, Leaflets etc. The rationale for this investment is that once there is a critical mass of users - a process which can take years - it becomes unnecessary to maintain as the technologies create their own demonstration effect



**Figure 3. Product introduction to the private sector business chain from manufacturers to wholesalers and retailers.**

No new technology will establish itself in the market without mass-market development and a well distribution chain from the manufacturer to the end users. Marketing and promotion of a technology to rural areas is a very costly exercise and needs to be sustained over a long period of time in order to reach a critical mass of people, and achieve a tipping point, where the need to maintain such an intensive demand creation and marketing program diminishes. Our tipping point is defined as the point where twenty percent of the potential market acquires the technology. KickStart is approaching this Tipping Point in Kenya, (perhaps 3 to 5 years

away) but is only half way there in Tanzania, while still at the very beginning in Mali.

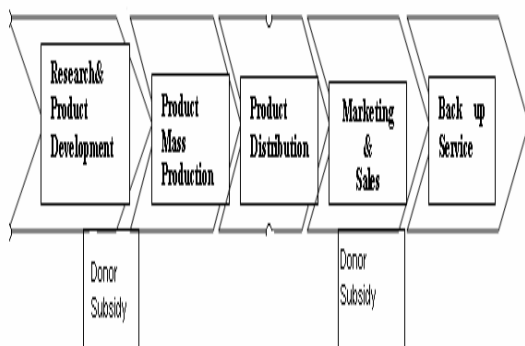
To market pumps in East Africa, KickStart has had to spend the following “Marketing Cost per Pump”

- In 2000 \$242 per pump
- In 2002 \$206 per pump
- In 2005 \$125 per pump

So the trend is clear. As awareness builds and demand and sales rise, the ‘per-unit’ cost of sales diminishes.

### 3.2. Reliability/Quality Guarantee

A crucial element of KickStart’s marketing is to ensure that the pump is absolutely reliable, durable, easy to operate, and requires almost zero maintenance. Every KickStart pump carries a 12-month, no-questions-asked guarantee of free repair or complete replacement in the event that the user has any trouble with it. This is a vitally important part of the product offer. When introducing a new technology for the first time, people will set their standards and expectations by the first examples they see. Unhappily in many parts of Africa, substandard, poorly made and troublesome treadle pumps have been distributed and promoted. This has negatively affected public perceptions of treadle pumps, as



**Figure 4. Private Sector Business Value Chain**

affected public perceptions of treadle pumps, as many farmers have been disappointed by these badly made pumps. And bad news travels faster than good news.

#### **4. Proposal for Financial Marketing Program to Government (S) and Development Partners**

The role of the governments is to create an enabling environment that would encourage investment to create:

- New business enterprises to increase incomes
- New employment
- Improved food security
- Better nutrition leading to better health
- Gender equity
- Industrial development
- Increased exports among others

KickStart has over the years developed irrigation technologies that are currently being used in many African countries. These are proven technologies that are transforming the lives of thousand of people. KickStart offers its experience and specialized expertise in setting up a marketing and promotion program that benefits the farmers through the private sector business chain that is sustainable and cost effective in the long run.

Let us assume that a farmer invests \$120 in a pump and its accessories and KickStart spends about \$150 to set up the private sector distribution chain as well as promote and market the pump. From KickStart findings, one Super MoneyMaker pump practically irrigates on average 0.3ha. The investment cost for irrigating one hectare would be \$900. This is a very reasonable cost compared to many planned irrigation schemes. We have the track record, capacity and core competencies needed to virtually guarantee that with \$1.5 to 2.0 million funding support, we can achieve the following in two years:

- By ensuring 10,000 pumps are put into productive use, 10,000 Base of the Pyramid (BOP) Investors will mobilize at least \$ 1.2m from their own resources to purchase and use manual micro irrigation technologies

- Over 50% of these MSEs will be run by women
- At least 3,000 additional hectares will be put under irrigation
- Over \$8million in new profits will be generated by these small farms, annually boosting local economies assuming an average income of \$800 per user. In three years period the farmers would generate \$24m.
- At least 10,000 new waged jobs will be created
- An entire national industry comprising a private sector supply chain of local distribution, marketing and sale of these technologies will be in place and growing fast as the demand rises.
- With continued support for KickStart's technology and market development program these figures can grow year on year by 15% - 25%

The total cost of the program for the two years would be \$2.7million incurred by both KickStart to get the program running and by farmers in purchasing the pumps while the accrued income benefits to the farmers would be \$16m or \$24m in 3 years, the expected life span of the pump. The farmers would continue to reap more benefits for another 2-3 years as experience has shown that these pumps can last for 5 years before replacement.

#### **5. CONCLUSION**

It is evident that micro irrigation has helped thousands of farmers from poverty. The smallholder irrigation farmers are potential investors seeking opportunities to:

- Attain Food Security
- Create Wealth
- Generate Employment Opportunities

Although our rural farmers may be lacking in financial resources they have non-financial resources they can utilize to improve their livelihood. They have:

- Land
- Water
- Time
- Adequate Skills

What the farmers need is an enabling environment in which they are given opportunities in which they can operate to create their own sustainable economic development rather than relying on handouts and relief food. Smallholder irrigation is the key to this investment that creates food security, increased household income and employment.

To ensure a successful promotion and marketing program in any country the following parameters are important:

- IMPACTS-The highest impact is achieved in the shortest time possible
- COST EFFECTIVE-A cost effective program is achieved
- SUSTAINABILITY- A self sustainable income generating process and
- REPLICABILITY- A scaleable or replicable process to other areas is achieved.

# Green Water Re-capitalization for Optimizing Agricultural Productivity in Eastern & Southern Africa

**Bancy M. Mati & Nuhu H. Hatibu**

Soil & Water Management Network of ASARECA (SWMnet)

b.mati@cgiar.org

## Abstract

Failure to “manage” water has been identified as the major problem associated with poor agricultural productivity in Eastern and Southern Africa (ESA) region. Out of a total of 38 million ha of cultivated farmlands in the region, 18 million have been identified as suitable for managed water systems (usually irrigation and drainage) but only 3 million have been developed. The problems of insufficient management of water for agriculture are affecting mostly smallholder land users (farmers, pastoralists), who form about 85% of the total rural poor in the region. The most vulnerable zones being: the arid, semi-arid and dry sub-humid areas, which occupy about 69% of the land area in the region. Here, climate-induced risks to crop and livestock production persist, resulting in very poor yields, usually less than 1 t ha<sup>-1</sup> of grain staples, and increasingly crop/pasture failures and thus food insecurity, famines and poverty. Agricultural drought is usually the real problem rather than meteorological drought, caused by the failure to make use of available rainfall optimally. Even in the well-endowed wetter areas of the ESA, high poverty (54%) among smallholder farmers persists, while land degradation is also a common problem.

The place of agricultural water management to alleviate food insecurity and poverty among smallholder producers in Africa has been well articulated in various documents and forms core tenets of the Millennium Development Goals and NEPAD’s CAADP. That water, and in particular rainfall, is the premier resource associated with vulnerability among smallholder farmers is well known, including the fact that the main limitation is that the water is not distributed spatially and temporary in such a way as to make it naturally available to farmers whenever they need it. What is needed, therefore, is identification of more innovative and deliberate actions, to optimize on the

utilization of all forms of water, especially rainfall, which is water at its purest form. In the past, sectorized approaches that encouraged channeling of resources, research and extension messages in such a way that the different components of water management compete rather than complement each other have not served farmers well. In addition, much of the targeted effort and investment on water for agriculture has previously gone to developing the use of “blue flows” such as rivers and lakes at great cost, while ignoring the vast potential of the “green” flows, which includes rainwater re-capitalization. It has been argued that over 90% of irrigation water in the ESA region is used to compensate for losses and/or inefficiencies in the management and utilization of rainfall. This paper therefore advocates for the green water paradigm, i.e. the deliberate actions towards institutionalizing the management and utilization of water held as green flows (harnessing rainfall, its storage and utilization, reduction of evaporative losses, optimization of soil moisture and water stored in green biomass). It calls for increased investment in holistic management of water for agriculture, with a view to enhancing agricultural productivity and environmental services especially in fragile ecosystems.

## Introduction

The Eastern and Southern Africa (ESA) region has certain common features in terms of natural biophysical and socio-economic conditions that make it possible to treat the region as a block. The 21 countries (the data quoted here excludes the Democratic Republic of Congo, Sudan, Djibouti and Somalia) of the ESA have a total population of about 350 million, of which about 260 million (73%) live in rural areas. The ESA has one of the highest poverty rates in the world, averaging 56% in the rural areas. About



85% of the rural poor people derive their livelihoods from small scale agriculture (IFAD, 2002). In general, low agricultural productivity and rural poverty are most evident in arid, semi-arid and sub-humid areas, which occupy 69% of the land area in the ESA (FAO, 1999). In the past, poor harvests, food insecurity and famines were confined to the Horn of Africa countries, especially Ethiopia, Kenya and Somalia, but more recently, several countries from southern Africa have joined the list of those depending on relief food. For instance, the FAO estimated in February 2006 that 11 million people in East Africa were on the brink of starvation due to drought affecting Ethiopia, Kenya and Somalia, and some parts of Eritrea, Djibouti, Tanzania, Burundi, southern Sudan, Uganda and Rwanda due to failure of the short rains in 2005. Thus cattle, sheep, goats, wildlife and even camels died, some people had died and for instance, 70% of cattle in Wajir District of Kenya died. In some districts, not only food aid but also relief water was necessary to alleviate suffering. In most parts of the Eastern and Southern Africa (ESA) region, the most pressing constraint to smallholder agriculture may not be access to land, as much as access to water for crops and livestock (IFAD 2002). Thus the optimal management of water for agriculture forms an entry point towards alleviating suffering and improving livelihoods for smallholder producers in the region.

Agricultural water management (AWM) is not necessary new in the ESA. Rather, there is the question of how much targeted actions are applied as opposed to allowing natural phenomena to run their own course. The main problem is that the region has seen declining crop yields and recurrent crop failures associated with 'drought', yet the real problem lies not with the amount of rainfall received, but with inappropriate management of the water. Moreover, subsistence-based agronomic practices have resulted in the "mining" of the natural resource base in the process of crop production and livestock husbandry due to the need to produce more from the static and declining land areas. Since land is inelastic, innovative ways that allow higher productivity will have to be adopted to meet the growing food gap. For instance, at global scales (World Bank 2005), it has been recommended that over

40% of the extra food required to meet the growing food demands by 2025 will have to come from intensified rainfed farming, for which improved water management is essential. Within the sub-Saharan Africa region, 75% of the agricultural growth required by 2030 will have to come from intensification (62% from yield increases, 13% from higher crop intensities) rather than extensification of agriculture (FAO, 2000). It has been argued that smallholder agriculture may be the major cause of, and potential solution for poverty reduction and economic growth in Africa (DFID, 2002). In this respect, management of water under smallholder agriculture is the target of the Millennium Development Goals on hunger (Sanchez et al, 2005), and is seen as one way of increasing food security and reducing poverty among poor people in SSA.



**Figure 1. Eastern and Southern Africa Region showing additional countries in IMAWESA**

It has been estimated that this will require developments in water for agriculture by at least 10% of the potential, targeting improvements by 25% in water productivity of irrigated agriculture alone by the year 2015 (Donkor, 2003). Both rainfed and fully irrigated systems are expected to contribute to these improvements.

## Biophysical factors and agricultural productivity in the ESA

The ESA region (Figure 1) broadly covers 25 countries in eastern, central and southern Africa to include Angola, Botswana, Burundi, Comoros, Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Rwanda, Seychelles, South Africa, Somalia, Sudan Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. In this paper, the data provided (IFAD 2002) excludes the Democratic Republic of Congo, Djibouti, Sudan, and Somalia. The ESA is a diverse region and compared to other tropical and sub-tropical regions of the world, the natural resource base for agriculture is relatively marginal. Mean annual rainfall ranges from less than 100 mm in desert zones to over 1500 in humid mountainous areas (FAO, 1993). In addition, the soils are generally highly weathered, easily erodible and having little organic matter contents. With about 36% of the land area in the ESA being desert, arid or semi-arid, poor resource base and climatic variability have been blamed for the declining agricultural productivity and rural poverty. Furthermore, the dry sub-humid climate zones include vast savannahs at varying altitudes, where rainfed cereal production dominates. At altitudes 1000 m or more, the savannahs provide relatively cool temperatures (for the tropics) allowing

maize-based mixed farming systems. These take large tracts of Angola, Kenya, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia and Zimbabwe. About 32% of the region's poor people live in these maize-based systems. It is here that declining soil fertility and poor investments in inputs and machinery, and lack of targeted agricultural water management have seen agricultural production plunge down to subsistence levels. The high-rainfall and potentially highly productive areas include more than half of Uganda and Rwanda, and quite large areas in Ethiopia, Kenya and Madagascar, covering about 31% of the total land area. However, even with the high production potential, poverty prevalence in these zones is quite high, and about 54% of the region's poor live here.

Climatic variability resulting in prolonged dry spells and sometimes droughts is associated with poor agricultural productivity on the ESA. Even then, climate and natural resource base are not entirely to blame for the poor status of agricultural production by smallholder farmers. It has been shown that agricultural productivity within the same geographical region, same crop, same climate, remains much lower under smallholder agriculture as compared to on-station research and large-scale farms (Falkenmark and Rockström 2003; SIWI, 2002).

**Table 1 Agro-climatic zones and rural population in Eastern and Southern Africa (FAO databases)\***

Climate Zone	Area km <sup>2</sup> (million)	Population (million)	Share of area	Share of population
Arid & semi-arid	3.7	36	38%	14%
Dry sub-humid	3.0	76	31%	30%
Moist sub-humid & humid	2.9	148	31%	56%
Total	9.6	260	100%	100%

\* Urban population and areas are excluded

For instance, in Zambia, the gross national average of maize yield on smallholder farms is about 1.3 t ha<sup>-1</sup>, but farmers with slightly larger holdings and good managerial skills obtain 4.5 t ha<sup>-1</sup>. In comparison, trials with highbrid varieties, fertilizers and timely planting and under the same rainfed systems yield 9 - 13 t ha<sup>-1</sup> (IFAD, 2002). Similarly, in western Kenya, maize yields under research yield over 6 t ha<sup>-1</sup> compared to less than 1 t ha<sup>-1</sup> recorded under smallholder farms and 0.5 t ha<sup>-1</sup> for beans (Mati and Mutunga, 2005). It has been stated that low crop productivity is affected more by management aspects (of water, soils, agronomy) than by natural resource base (Place et al, 2005). Moreover, this difference shows widest gaps in areas prone to climatic variability, especially semi-arid and sub-humid areas where agricultural production cannot solely depend on the natural endowments of the land. Tackling the natural limitations to production will require access to information about technologies and approaches through which smallholders themselves can establish profitable operations, optimizing the impact of their investments, particularly labor, which is the more available resource.

### **Green Water re-capitalization and AWM**

Green water is the portion of rainfall that finds its way back to the atmosphere, through both direct evaporation and evapotranspiration. In terms of benefit to agriculture and therefore livelihoods, green water is a water resource, usually stored as soil moisture generated from direct rainfall infiltration, before it vaporizes as evapotranspiration from plants. Green water can therefore be partitioned as (i) Green water flows, which is the total evapo-transpiration from soil moisture, (ii) Productive green flow, which is the transpiration of plants of beneficial use to people, and (iii) non-productive green flow which is direct evaporation flows from water bodies and soil surface. The balance of the rainfall therefore forms blue water which can be partitioned as (i) blue water flow, which is the surface runoff and base flow, and (ii) blue water resource, which is water stored as groundwater, lakes, reservoirs, wetlands and other bodies (Fallenmark, 1995). The importance of green water flows to agricultural

productivity is linked to the fact that plant biomass is created when water is taken up from the soil, and utilized in evapotranspiration.

The green water paradigm requires an understanding that water is rarely truly scarce, but the main problem is that losses and extreme variability. Therefore, maximizing rainfall storages and infiltration as well as water uptake capacity of plants is the key to unlocking existing potentials. The reduction of non-beneficial green flows are important components of green water re-capitalization. In addition, there is need for attention to scale interactions of water functions, such as water and livelihoods, land use and degradation, carbon sequestration and water services provided through land management.

In its ultimate form, green water re-capitalization is achieved through holistic agricultural water management (AWM). Agricultural water management has been defined (FAO, 1995) as “any kind of human action that influences the natural flow of water to farmers’ crops, or any form of agriculture that takes advantage of naturally rising or falling water levels for crop production”. Thus, AWM is a broad term encompassing irrigation, drainage, water harvesting, water conservation, utilization of high water tables, as well as control of unnecessary evaporation, reduction of seepage losses, improving efficiency in water application, conveyance and utilization, and all aspects where water benefits the crop, livestock and ecosystems. “Management of agricultural water” is a better term describing the deliberate human actions, which ensure optimization of all types of water resource use for agricultural production. AWM ultimately leads back to green water re-capitalization. At the regional scale, AWM is visualized to be achievable through the following actions: (i) Working towards food security and virtual water trade, (ii) water resource development to meet competing demands (noting that rainfall is water), (iii) strategic and integrated public investments in holistic approaches to agricultural water, (iv) response to climate variability, including short-term shocks such as prolonged dry spells, (v), linking farmers to markets, enabling AWM contribute to poverty reduction, (vi) making every crop, high value,

(vii) opportunities pull rather than push by potential, and (viii) managing water wisely (integrated approaches for crop, livestock and ecosystems). Thus, since agriculture is about producing plant biomass, then AWM should enable production of more useful biomass per mm of water depleted which with appropriate market linkages should lead to higher net per drop. As most of the irrigation water in the ESA is used to compensate for losses in conveyance, application, and/or inefficiencies in the management and utilization of rainfall, managing rainwater is the missing link to optimizing productivity of green water.

### **Importance of green water re-capitalization in the ESA**

Even with the physical presence of semi-arid zones, the untapped potential for green water re-capitalization and ultimately holistic agricultural water management in the ESA is enormous. There are about 38 million ha in the low income countries of the region classified as cultivated lands (Table 2). The total potential for targeted AWM in these countries is about 18 million ha, of which only 3 million ha are already under some form of water management (IFAD, 2002). Of these, about 2 million ha are under irrigation with full or partial control, while the remaining 1 million ha are under traditional wetland and valley bottom management systems. Madagascar, with about 1 million ha under full or partially controlled irrigation, accounts for about 50% of the total land area under controlled irrigation in the region. The share of irrigation in the other countries is less than 5%. For instance, aggregate annual runoff in Ethiopia is estimated at 122 billion cu m and ground water potential as 2.6 billion cu m (IFAD, 2002). However, only 5% of the irrigation potential is utilized, accounting for 3% of total food crop production, while a similarly small fraction of the runoff potential is utilized. It should be noted that in characterizing land as suitable or not for AWM, the estimates are based on the availability of land and water, usually available “blue” flows. It and does not take account of

possible sources and the huge potential for green flows, such as road runoff harvesting, flood harvesting from surfaces, and rarely includes ground water potential.

Thus, substantial potential for targeted water management remains largely unknown and thus un-developed in the ESA region.

Another important aspect is the role of rainfed agriculture, which is the dominant form of crop production in the ESA region and is set to remain so in the foreseeable future. With the exception of Madagascar, Mauritius and Swaziland, rainfed agriculture accounts for over 95% of all croplands in each of the countries of the ESA (World Bank, 1999). However, while the potential for improving production and income from rainfed systems is considerable, there are risks associated with rainfed agriculture that must be mitigated with targeted interventions. The most vulnerable people to climate-related disasters are poor smallholder farmers, especially those in marginal rainfall areas. This is partly due to their inability to access cutting edge knowledge, afford inputs or utilize appropriate machinery and technologies that can mitigate natural disadvantages. In particular, there is need for alternative approaches to the development and maintenance of small-holder water management systems and major increases in investment in exploitation of the irrigation potential.

Agricultural productivity in the ESA could be improved further, through the integrated management of the water under rainfed systems, which includes some level of irrigated agriculture. In the past, sectorized approaches to both rainfed and/or irrigated agriculture have promoted initiatives like soil and water conservation (SWC) or rainwater harvesting (RWH) with some level of success. Examples of these are scattered throughout the region and have formed the foundation of many development projects with agriculture and land

**Table 2: Cultivated area and water management potential ('000 ha) (FAO 1995)**

<b>Country</b>	<b>Cultivated area</b>	<b>Total potential for water mgt.</b>	<b>Area of controlled irrigation</b>	<b>Area under other water mgt.</b>	<b>Total water managed area</b>	<b>Remaining potential</b>
Angola	2 900	6 700	75	350	425	6 275
Burundi	800	185	14	60	74	111
Comoros	78	0	0	Na	0	0
Eritrea	439	Na	28	Na	28	Na
Ethiopia	6 000	3 637	190	Na	190	3 447
Kenya	3 738	352	67	6	73	279
Lesotho	209	13	3	Na	3	10
Madagascar	2 580	1 500	1 087	Na	1 087	413
Malawi	2 106	162	28	62	90	72
Mozambique	3 600	3 300	107	Na	107	3 193
Rwanda	825	160	4	156	160	0
Tanzania	6 300	828	150	Na	150	678
Uganda	5 028	202	10	Na	10	192
Zambia	1 030	520	46	100	146	374
Zimbabwe	2 750	331	117	20	137	194
<b>Total</b>	<b>38,382</b>	<b>17,890</b>	<b>1,926</b>	<b>754</b>	<b>2,680</b>	<b>15,210</b>

Na = Not available

management on their agendas (Reij et al., 1996; Lundgren, 1993; Hurni and Tato, 1992; WOCAT, 1997). In particular RWH systems have been applied over wide range of conditions in areas where average annual rainfall is insufficient to meet the crop water requirement, with seasonal rainfall as low as 100 to 350 mm (Oweis et al., 2001; SIWI, 2000). Indigenous and innovative technologies in SWC, RWH and soil nutrient management abound in the ESA (Mulengera, 1998; Reij and Waters-Bayer, 2001, Mati, 2005, Negassi et al., 2000; Hamilton, 1997; Hatibu and Mahoo, 2000). Most of these technologies are also easily replicable. In addition, successful cases of smallholder water management have been documented in which farmers have overcome different kinds of obstacles, not only to achieve food self sufficiency, but also increase their incomes and move out of poverty (Mati and Penning de Vries, 2005; Penning de Vries et al, 2005). However, there has been little common meeting ground between what is perceived as “rainfed” with “irrigated” agriculture. The focus should be how to reduce poor people’s vulnerability to climatic variability, especially water risks associated with both floods and droughts, including both agricultural and meteorological droughts (Sally et al, 2003). The challenge is how to deal with declining crop yields and recurrent crop failures associated with ‘drought’, yet the real problem lies not with the amount of rain that is received, but inappropriate management of the water. Neither water nor know-how hinders success. The real gaps are in policy, awareness, and capacity and institution building. Policy and legal frameworks for fair and reliable allocation of water, surface and groundwater to a range of users and to the environment.

### **Impact of Policies**

Several questions have been asked regarding the role of policy and legal framework in the ESA region (IFAD, 2000). Such questions as government policies with regard to water rights, cost recovery on water supplied for agriculture to the poor, the roles of private and public sectors, risk management, environmental legislation, incentives for conservation etc. To date, these questions still demand answers. Even then, all the countries in the ESA have

policies that touch on water, environment, agriculture, natural resources, rural development and macro-economic policies (OED 2003, FAO 2003). Most of the policies focus more on drinking water with little mention of agricultural water management succinctly. Rather, the policies are split between irrigation, drainage, flood control, water harvesting, soil and water conservation disjointedly. Since most of the countries in the ESA are in the process of formulating and implementing various components of their PRSPs, contemporary policies on AWM in most countries of the ESA are either in draft stages or not well tested to allow for balanced critique of their efficacy. An analyses of both existing and proposed policies across the countries of the ESA can be summarized as follows (OED 2003, FAO 2003; FDRE, 2002; IMAWESA, 2006; Government of Malawi, 2002; URT, 2001; Government of Kenya, 1999); most of the policies tackle (i) the development of water resources on equitable and sustainable basis, (ii) allocation and apportionment of water resources based on comprehensive and integrated plans, (iii) management and mitigation of droughts and floods, (iv) efficient allocation, redistribution, transfer, storage and use of water resources (v) adherence to optimum allocation principles that incorporate efficiency of use, equity of access, and sustainability of resource, and (vi) conservation and protection of water resources and aquatic environment on sustainable basis.

There is therefore a need to overcome several obstacles in these policies due to overlapping jurisdictions, laws and regulations that sometimes contract each other. In addition, it is sometimes not clear as to who should enforce what regulation. Other obstacles include an unjustifiably large body of legislation, incompatibility between customary law and national law, lack of an agreed position on key policy issues such as in areas of land tenure, appropriate methods of tackling land degradation and an agreed position on the question of the harmonization of legal and administrative approaches to AWM. Of great interest is whether or not policies that address AWM tacitly are to be found in the national plans, legislations and programmes. There is also the question of the role of regional and

international policies in affecting actions at national and local levels. However, good policies are necessary for successful promotion of land husbandry, but they are not sufficient in themselves to bring about sustainably productive local resource management. Policy simply provides a framework and gives farmers the latitude to manage their resources for the long run. It is just a first step towards local resource management for sustainable production. National AWM policies should cover land tenure, equity, rights to natural resources and the legal framework for land and water management.. Policy reform is therefore necessary to address agricultural water management in all its components. There efforts from various quarters, as with the IMAWESA project.

### **Contribution of the IMAWESA project**

The Improved Management of Agricultural Water in Eastern and Southern Africa (IMAWESA), is a three-year project supported by the International Fund for Agricultural Development (IFAD), through the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) in partnership with the International Crops Research for Semi-Arid Tropics (ICRISAT) and being implemented by Soil and Water Management Network of ASARECA (SWMnet). IMAWESA operates indirectly in all 25 countries of the ESA for the knowledge management component, and directly in 15 countries, which includes Burundi, Eritrea, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Swaziland, Tanzania and Uganda, and including the Democratic Republic of Congo and Sudan. The overall goal of the project is to enable poor producers in Eastern, Central and Southern Africa to increase their incomes through improved management of agricultural water. In order to achieve this goal, the purpose of the project is to enhance the development impact of public and private investments in smallholder agricultural water management. The project has four planned outputs which include:

- Enhancing engagement in policy dialogue relative to smallholder

management of agricultural water within the ESA region,

- Enhanced understanding of key issues, in order to contribute to guiding future investments in management of agricultural water actions in the region
- Capacity strengthening for program management and implementation for management of agricultural water in the region, and
- Developing a robust knowledge management approach to ensure more systematic capture, synthesis, exchange and eventual utilization of experiences and lessons relative to management of agricultural water with emphasis on linking and networking those with experiences and expertise at both implementation and planning levels into a community of individuals and organizations, which will share knowledge and learn from each other, during and beyond the project period.

Though project implementation has just started in January 2006, IMAWESA had a six-month inception phase during which a baseline study of policies, policy makers and policy making processes associated with AWM in the ESA. In addition, IMAWESA has been documenting key stakeholders (managers and implementers of program and projects, researchers, policy makers, extension workers, the media) who influence decision on AWM in the ESA region. Preliminary findings have revealed major gaps to be filled by further research, as well as the fact that there is quite a good but varied human resource capacity for targeted AWM action in the region. The major problem is that of poor interaction, knowledge management and weak linkages between and across the various stakeholders, within their countries and across the region. IMAWESA intends to catalyze action, first through policy dialogue, capacity strengthening, communication and knowledge sharing, and hopefully development of viable communities of practice in AWM in the ESA.

### **Conclusions**

The concept of green water management is not new, even to the ESA region. The green water

paradigm involves activities which optimize the management and utilization of water held as green flows such as rainwater harvesting, storage and utilization, reduction of water losses by evaporation, enhanced storage of water as soil moisture and in green biomass. However, what is new is the need to raise enough consciousness about its importance, so as to influence the knowledge, attitudes and practices of all stakeholders to its immense potential impacts on agricultural productivity in the region. The difference between green water re-capitalization and conventional forms of AWM is that green water directly affects plant biomass production, which is the essence of all agriculture, including livestock production. Even though the ESA region is on average water scarce, the green water potential that has not been fully utilized, yet it is capable of closing the gap between food deficits and food security, as well as alleviating suffering resulting from crop failures caused by climatic variability. The paper thus advocates for increased focus on the “green water” component which comprises 57% of rainfall flows in the ESA. It has been pointed out that the prevailing policies in most of the countries in the ESA are not succinctly sensitive to AWM, but are fragmented between ministries and departments. Sometimes the policies contradict each other. There is therefore need for targeted policy reform to address agricultural water management, more succinctly. The technological options are available and the main challenge is to put knowledge into practice.

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# **Integrating Agro Enterprise Approach and Small-Scale Irrigation: Experiences of CRS/Ethiopia in Water Development and Management**

**Legesse Dadi and Bekele Abaire**

Catholic Relief Services/Ethiopia

legsseda@crsethiopia.org.et

## **Abstract**

This paper highlights CRS/Ethiopia's experiences in small-scale irrigation development and management and how an agro enterprise approach is integrated to small scale irrigation to make irrigation schemes profitable and sustainable. CRS/Ethiopia implements its development interventions in an integrated manner and small scale irrigation is one of the components of the integrated watershed management approach. The type of small-scale irrigation developed or to be developed depends on availability and type of water sources, topography of an area and investment required. CRS/Ethiopia and its partners developed and promoted shallow well lift irrigation, river diversion and direct motorized pumping from rivers. In areas where rivers, springs and under ground water is not accessible, water harvesting structures were developed to serve as sources of irrigation. Motorized water pumps and treadle pumps are used to lift water from shallow wells and rivers. In areas where volume of water is limited and spring and streams flow at bottom of a valley, storage structures are built on high elevation places. Water is pumped to the storage structure using motorized water pumps and then transported to irrigation fields by gravity flow. Spate irrigation system is also practiced in Dire Dawa areas. Beneficiaries participate in identification, construction and maintenance of small scale irrigation scheme through contribution of labor and provision of locally available materials such as stone, sand and gravels. It is believed that such participation enhance empowerment of the community and sustainability of the irrigation scheme. One of the possible reasons why some small scale irrigation schemes are not successful is that production on this scheme may not respond to market needs. CRS/Ethiopia and its partners are

making an effort to address this problem through supporting farmers respond to market demand. In areas where small-scale irrigations were developed, market opportunity identifications were carried out and based on the results of market study tomato, potato and onions were selected and promoted on irrigation schemes. Relevant government institutions were involved in market opportunity identification. CRS/Ethiopia and its partners encourage farmers to get organized into agro enterprise groups and play facilitation role in connecting farmer groups to market actors. Water user associations were organized and assumed responsibility to manage the irrigation water. Water user associations perform water management functions and may also engaged in purchase of inputs and marketing of outputs.

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## Introduction

Among many other factors availability and access to water is a crucial constraint limiting agricultural productivity and growth in the semi-arid and arid parts of the country. The semi-arid and arid areas account for more than 63% of the country and expanding because of climatic changes. Recurring drought is one of the root causes of the food insecurity situation in the country. A number of climatic induced shocks occurred in the past has eroded the meager assets of rural population and exposed them to malnutrition, hunger, food insecurity and in some cases for migration. As a result of recurring drought, on average, 6.2 million people required external support during the period from 1995 to 2000. A host of factors contributed to the growing problem of drought, vulnerability and food insecurity. A major challenge in moisture stress areas is how to reverse the effect of drought and ensure adequate food supply for the rapidly growing population without degrading the limited natural resources.

Ethiopia's agriculture is characterized by smallholder farming and production exclusively depends on rainfall and productivity on smallholder farm is low. Development of the agricultural sector is central to combating hunger, food insecurity, reducing poverty and generating growth (Mekuria, 2003). The low input agriculture widely practiced by millions of smallholders in the country hinder the agricultural sector to meet desired objectives. The amount of rainfall received in semi-arid part of the country is insufficient and erratic in nature. This put agriculture production and the life of people depending on agriculture at risk.

Despite large water potential and irrigable land, irrigation technologies have not been exploited. Very insignificant number of smallholder practice irrigated agriculture. Among ranges of options for increasing agricultural production in Ethiopia, particularly in semi-arid and arid areas, application of irrigation and efficient use of water resource deserve great attention. Smallholder farmers have limited access to irrigation technologies due to lack of awareness, know-how and access to capital for irrigation development.

Catholic Relief Service/Ethiopia has adopted small-scale irrigation as one of its strategies in supporting the poor and disadvantaged groups to support themselves. This strategy goes with Ethiopia's food security strategy and water sector strategy in tackling drought through use of small-scale irrigation. The strategy emphasizes efficient allocation, transfer, storage and efficient use of water resources (SDPRP, 2002).

## CRS approach in rural long term development interventions

CRS/Ethiopia is a faith based humanitarian organization. It was established in 1943 after the Second World War. It started its operation in Ethiopia in 1958 and assists persons on the basis of need, not creed, race or nationality. The organization's strategic goal is to reduce the overwhelming poverty in Ethiopia by promoting food security and strengthening civil society (APSA, 2004). CRS/Ethiopia works with eight local church, partners as well as three secular partners, other NGOs, different government offices and donors. CRS/Ethiopia developed expertise in managing large food aid dating back to the 1984 drought. It also developed expertise in agricultural recovery from disaster and long term development programs particularly in agriculture, natural resources management, water and sanitation and health.

Basically CRS/Ethiopia's agriculture, natural resources management, water and sanitation interventions build on four pillars and implemented in integrated manner in a way to reinforce each other in addressing poverty and food insecurity problem. The overall approach is based on an integrated watershed management (IWM) framework, which looks to integrate sectoral activities (agriculture, natural resource management, health & nutrition, water and sanitation) within a given watershed in order to maximize impact on household food security of rural families living in extreme poverty (DAP document 2003).

CRS/Ethiopia long term rural development interventions are aimed at increased crop production and productivity, improved soil and

water conservation, improved livestock feed management, sustainable and productive land-use planning, improved potable water resource development, improved family health, increased and diversified household income and strengthened stakeholder partnerships.

### **Types Irrigation Schemes Promoted by CRS**

CRS/Ethiopia and its partners develop and promote different types of small scale irrigation. Type of small scale irrigation schemes developed and promoted depends on sources of available water, topography of the area and investment required to establish the scheme. The range of irrigation developed by CRS includes:

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#### **Shallow well lift irrigation scheme**

Ground water is widely used for irrigation in India, Pakistan, Sri Lanka and other Asian countries (Merry, 1997). This is rarely practiced in Ethiopia because of weak infrastructure development, limited capital and lack of awareness. More recently CRS/Ethiopia and its implementing partners started developing and promoting use of ground water in areas where this is technically possible and financially feasible. These types of schemes were developed in areas where ground water is found close to surface (within a shallow depth of 3-8 meters) and water is lifted to surface either with treadle or motorized pumps. Once the water is lifted to surfaces it may directly transported through canal and crops irrigated using furrow irrigation. The second option is that water is pumped to water storage structure and transported to different fields by gravity flow and water application is done using furrow irrigation method. More recently use of sprinklers demonstrated to farmers and its

technical feasibility and cost comparison with other methods is being tested.



**Figure 1. Water storage constructed at high elevation at Goro Gutu woreda, East Haraghe Zone**

#### **River diversion**

This is a system applied in areas where streams/rivers flow on a surface and costs for partly blocking and raising the stream bed level for easy conveyance of the water through intake structure is reasonable and affordable. Water is transported to irrigated field through gravity flow.

#### **Direct pumping from rivers**

Such practice is put in use along rivers/stream flowing on surface and suitable for pumping.

#### **Spring development**

In most cases springs are found at the foot of a hill. In such case water is pumped to storage structures constructed at high elevation areas. From storage structure water is transported to irrigation fields by gravity flow. In cases where command area is below the spring points water is transported to irrigation field by gravity flow and furrow or basin irrigation methods are used for irrigating crop.

#### **Spate irrigation system**

This is a system where flood-water is diverted to crop field and used for irrigation. The method is applied in cases where irrigated fields

are located at lower part of watershed and rainfall is received at upper part of a watershed. Such system is practiced in Dire Dawa Administration Council. Under this system farmers have limited control over the water. They only make use of opportunity of using passing by water



**Figure 2. Construction of diversion weir and main canal at Harbu small-scale irrigation**

### **Drip irrigation**

In areas where rivers, springs and under ground water is not accessible, rain water harvesting structures were developed to serve as sources of irrigation. Drip irrigation was promoted along with the development of water harvesting structures. CRS/Ethiopia supports farmers to access drip irrigation kits and train them on how to use drip irrigation kits.

### **Multiple use of water**

CRS/Ethiopia promotes multiple use of water, where productive use of water is an important component of water development schemes. Spill over water from drinking water points and water from wells are used for vegetable garden production. Under this intervention, women, children other disadvantage group who efficiently manage and make efficient use of limited water are supported.



**Figure 3. Canal reinforced by cemented wall to reduce water loss, at Metta woreda, East Haraghe Zone**

### **Beneficiaries' participation in small-scale irrigation development**

CRS/Ethiopia, beneficiaries participate in the construction of scheme through contribution of labor and locally available materials such as stone, sand and gravels. Maintenance of small-scale irrigation scheme is a routine work, which must be done to keep an irrigation scheme working properly.



**Figure 4. Community sensitization before project Implementation**



Beneficiaries are responsible for undertaking maintenance works such as canal and drain clearing, repairing farm structures and lubricating pumps and pump accessories. Once construction is completed farmers started using the scheme, CRS/Ethiopia handover the scheme to the community to allow them fully manage it by their own.

### **Irrigation water management**

The major bottlenecks for sustainability of small-scale irrigation project are profitability, water management and infrastructure maintenance. CRS/Ethiopia and its implementing partners organize and involve beneficiaries in management of schemes from the initiation of small-scale irrigation development. It also engages relevant authorities who oversee and provide technical support after the project is terminated and a scheme is handed over to the community. The whole responsibility of managing small-scale irrigation lay with beneficiaries.

For effective water management water user associations (WUA) consisting of all farmers owning land within command area are established. WUAs formulate and apply rule and regulations (by-law) in managing irrigation scheme. A general assembly of WUA elects committee members responsible for allocation of time when each individual member irrigates his fields. The WUA engage in avoiding disputes among the beneficiaries that may arise due to inappropriate water utilization. The association is also responsible for coordinating maintenance, facilitation of extension activities, collection of maintenance fee<sup>1</sup> and manage savings for future investment and replacement tools. They may facilitate land exchange/lease/sharecropping<sup>2</sup> among members or other interested household who have insufficient or no labor to manage irrigated land. Committee members serve the

association on voluntarily basis and there is no extra allocation of time or payment for the service rendered. In case of schemes where traditional irrigation is rehabilitated and upgraded, irrigation water management builds on indigenous water management practice of the area.

In schemes where pumps are used to lift water, pump care takers are identified and trained. Pump care takers are responsible for operating and undertaking simple maintenance works. Such individuals are compensated by WUA for their extra services they provide for WUA members.

A supportive policy and legal environment is crucial for the sustainability WUA (Merrey, 1997). Most of the WUAs established are legally registered with respective Cooperative Promotion Offices and they have legal status. They are in position to sue or sued for disputes may occur during the business interaction with other market actors. Some WUA joined farmer cooperative unions and are able to access inputs or output markets through the farmer cooperative unions.

CRS/Ethiopia and its implementing partners train WUA members in irrigation water management and conservation, roles and responsibility of groups, how to apply by-laws, vegetables production and seedling raising techniques, record keeping, financial management and marketing aspect. It arranges exchange visits to share experiences and learn from successes and failures of others. CRS/Ethiopia also facilitates and provides technical supports to WUA to enable them access inputs and new technologies.

### **Sustainability of small-scale irrigation scheme**

Community participation is critical all along the way from project identification to implementation for sustainability of small-scale irrigation scheme. Small-scale irrigation is sustainable if voices of beneficiaries are heard and their interests incorporated in the design, and they participate in construction,

<sup>1</sup> A case was observed where beneficiaries pay water fee at Harbu, South Wollo

<sup>2</sup> At Harbu, South Wollo Zone, small-scale irrigation scheme, 26 farmers have plots in the command area. These farmers have leased out part of their irrigated land and the number of beneficiaries increased to 73.

management and operation of the scheme. Contribution for operating cost and setting aside for expansion and replacement costs show beneficiaries commitment. In kind- labor, stone, gravel- contribution by beneficiaries also reflects commitment. Such participation and commitments are important in enhancing sustainability of the scheme beyond the project life as it creates more interest and empower them in deciding on their future better life.

One of the possible reasons why some small-scale irrigation schemes are not successful is that farmers may lack know-how of management of irrigated production; and production on this scheme may not respond to market needs. CRS/Ethiopia and its partners are making an effort to overcome this problem through training farmers on technical aspects of irrigated agriculture and advising and supporting farmers respond to what market demands.

This is to underline that CRS/Ethiopia and its implementing partners do not focus only on production aspects. They give due attention to where, how product produced on irrigation schemes are marketed. Efforts are made to link production with market in order to increase income of beneficiaries. It is our conviction that such effort has great impact on sustainability of irrigation scheme.

### **Agro-enterprise development**

The agro enterprise development strategy is developed by CIAT to address the entrepreneurial development needs of institutions that support rural communities. The approach is aimed at developing and strengthening mechanisms that link small-scale farmers to local, regional, national and global markets. The concept of agro enterprise development entails the process of working with smallholder producer to design and set up new income generating opportunity that take into account the process from production to consumption. The approach provides a means of developing new business opportunities for rural communities and integrating subsistence farmers into market led agriculture. This approach advocates production decision

governed by the market. It provides method of addressing poverty and opportunity to find ways of stimulating demand for technical and social innovations and helps to identify areas that require support from research, finance and local policy (CIAT undated).

CRS/Ethiopia entered into an innovative Agro enterprise Learning Alliance in 2002 with International Center for Tropical Agriculture (CIAT) to strengthen its market-led agriculture interventions. It also established learning alliance with the national agricultural research system particularly with Malkassa Agricultural Research Center and Haramaya University. CRS/Ethiopia implements the agro enterprise development approach in all of its development interventions to improve income of its beneficiaries. Territories, market opportunities and market chains were identified. High value vegetables such as potato, onion, tomato and cabbage were identified to be produced on irrigated fields.

CRS/Ethiopia and its implementing partners are helping smallholder producers organized into self help groups to access and evaluate new



**Figure 5. Types of vegetables and fruits produced on irrigation scheme and vegetable garden**



technologies, acquire or produce needed inputs such as seed and engage in collective marketing. In all small-scale irrigation made operational interested self help groups were organized and started producing for the market.

In all small-scale irrigation developed by CRS/Ethiopia WUAs have multiple functions. As their names implies they are responsible for irrigation water management: allocation, handling of disputes, management of and collection of maintenance fees. They are also agro-enterprise groups who make joint decisions to produce and market an enterprise that has market demand. The association facilitates access to different business development services (extension, research-technologies, credit etc.). The association also identifies and facilitating linkage with buyers arranges transport facilities. The last function of the association is not well developed yet. At present, few WUAs engaged in procurement of agriculture inputs like seed fertilizer pesticide and marketing of agricultural products

One possible way to make small-scale irrigation profitable and sustainable is through connecting users to market. CRS/Ethiopia took an initiative to link farmers with different market actors and business service providers. CRS/Ethiopia and its implementing partners play facilitation role in linking farmers to market. To date linkage has been created with private traders, cooperative unions and exporters for onion, tomato, and potato producers. These producers are supplying products to domestic and international markets. For instances potato and onion producing irrigation water user groups in East Haraghe supply their produce through cooperatives and private traders to exporter who export these commodities to Djibouti market. There are areas where potato and onion production target domestic market. CRS/Ethiopia and its partners undertake market study and identify market opportunities and constraints in the market chain. In collaboration with national and international institutions CRS/Ethiopia and its partners train and advise farmers to produce quality product that market needs.



**Figure 6. Sorting and packaging of potato for market Karsa wored , East Haraghe Zone**

### **Impact small-scale irrigation scheme coupled with AE approach**

Despite a number of constraints, there are evidences that underscore improvement in the income of farmers who practice irrigated agriculture. Small-scale irrigation beneficiaries participated in agro enterprise development has raised their income. For instance, in kersa wereda, East Hararge zone 80 farmers were organized into four sub-groups and produced potatoes and onions using irrigation scheme developed through financial and technical supports of CRS/Ethiopia. Members of this group earned an income ranging from 3,000 to 11,525 birr/household. The farmer who earned a gross benefit of 11,525 had spent about 2500 birr for fuel. Similarly, in Dugda Bora woreda, East Shewa Zone, beneficiaries who produced tomatoes and onions, using irrigation, obtained income ranging from 3000-7000 Birr/household. In Adama woredas of East Shewa zone, 40 farmers organized into group are able to generated income of 600 to 5300 birr per household per one production season. As shown in Table 2 irrigation user have obtained gross income ranging from 250 to 7486 birr per household per one production season.

Some of the beneficiaries constructed a corrugated roofed house, and invested on productive assets such as farm tools, inputs and

livestock (oxen, cows and goats). They claim that their life have changed and able to feed their family and afford to send their children to school.

### Conclusions

Application of irrigation technology depends on access to water resource from surface (rivers, dams, ponds etc.) and ground water. Moreover, irrigation technologies require large investment that can not be readily made available by individual household or group of household unless the groups get access to financial sources. Irrigation schemes also require group action and formation of group call for dedication and commitment from the side of members.

CRS/Ethiopia experience shows that coupled with agro-enterprise development, small-scale irrigation based production have great impact

on changing, for good, the lives of the poor and disadvantaged groups. Involving beneficiaries in the design and implementation of small scale irrigation scheme contributes towards sustainability of those schemes.

Small-scale irrigations contribute a lot in changing the life of people practice them. This has been documented by humanitarian and government institutions. Given the size and growing rural population this will not take us no where, if we operate at the current pace. A way forward away from food crisis in Ethiopia lay with increased use of irrigation. We should examine scope of our interventions also look far beyond the small-scale irrigation which is more suitable on the highland to large scale schemes in vast and under exploited land and water in the lowland areas.

**Table 2. Income obtained from harvest of vegetable and others for a single season (Water Action progress report, 2005)**

<i>Crop</i>	<i>No. of beneficiaries</i>	<i>Area (ha)</i>	<i>Yield/ha (qt)</i>	<i>Average income/hh (birr)</i>	<i>Total income (birr)</i>
Tomato	29	3.5	150	2716	78,750
Onion	7	3.5	75	7486	52,400
Pepper	43	2.0	10	465	20,000
Cabbage	2	.683	120	250	500

Possible ways of expanding small scale irrigation

- Focus on simple and low cost small scale irrigation type (mainly on drip and sprinkler)
- Encourage and promote group action
- Availability of credit and ease of access
- Sustained extension support
- Institutional capacity building- training for farmers and other market actors
- Commitment of government in providing technical and financial support

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**Policies and institutional support conditions  
for small scale irrigation in Ethiopia**



# Irrigation Policies, Strategies and Institutional Support Conditions in Ethiopia

Solomon Cherre

MoWR

[solomoncherrie@yahoo.com](mailto:solomoncherrie@yahoo.com)

## 1. Background

### 1.1. Water Resources of Ethiopia

Ethiopia is endowed with abundant water resources. A large number of rivers flowing on either side of the rift valley form a drainage network that covers most of the country. Most of the rivers that carry the water resources, however, end up in neighboring countries hence making them international or Trans boundary Rivers.

The total surface water resources of Ethiopia, coming from the country's twelve river basins, are estimated to be in the order of 122 billion cubic meters per year. With regard to ground water resources, the true potential of the Country is not yet known, however it is widely reported that Ethiopia possesses a ground water potential of approximately 2.6<sup>1</sup> billion cubic meters. Around 60% of the water resources flow into the Nile River system. However, the amount may be decreasing gradually because Ethiopia, in common with neighboring countries, has experienced apparent long-term changes in climate with an overall decrease in annual rainfall and a higher frequency of droughts since about 1970, accelerating a longer-term downward trend in average rainfall by 5% since 1912.

### 1.2. Agriculture sector

Agriculture is the dominant sector of the Ethiopian economy and its performance is the major determinant of overall GDP growth rate.

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<sup>1</sup>Ethiopian Water Sector Development program, 2001

On the average, the sector contributed about 48% of Ethiopia's GDP between 1995 and 1999. It equally accounted for 90% of export earnings, which consists mainly of coffee, hides and skins, pulses and oilseeds and 70% of raw material inflow into agro-based industries during the period. The agricultural sector is also the major employer, accounting for 85% of total employment. The crop sub-sector accounts 60% of the sector output, livestock and forestry constitutes 30% & 10% respectively. Peasant farms at household level are the backbone of the sector, cultivating about 96% of the cropped area and producing 90% to 94% of all cereals, pulses and oilseeds.

Rain fed agriculture provides the largest proportion of the total production. However, over the past few decades, irrigated agriculture has become more important. At present some 197,000 ha of land is under irrigation, the majority being in the Awash Valley. Around 68,800<sup>1</sup> ha were established, initially by private entrepreneurs and then by the government as State farms, principally growing cotton, citrus fruits and vegetable.

### 1.3. Irrigation sub sector

Irrigated agriculture started in Ethiopia in the 1960 with the objective of producing industrial crops (sugar and cotton) on large-scale basis. Local farmers however, had already been practicing irrigation by diverting water from rivers in the dry season for the production of subsistence food crops. Productivity of rain-fed farming has dropped, and the agricultural sector is now unable to provide the basic requirement to the farming people. Traditional farming practices, environmental degradation, lack of external agro-inputs, effect to recurrent drought, and high population pressure have aggravated

the present food insecurity in Ethiopia. This implies the need of launching irrigation projects development based on acute objectives of increasing crop yield, improving the living standard of the people and to provide impact on the environment.

Currently government gives emphasis to develop the sub-sector to fully tap its potentials by assisting and supporting farmers to improve irrigation management practices and the promotion of modern irrigation systems. Currently, irrigated agriculture produces less than 3 percent of the total food production of the Country. Ethiopia's experience in large-scale irrigation development and management is in state enterprises, mainly growing industrial crops like cotton and sugar cane. The experience in modern small-scale irrigation (SSI) development and management started in the 1970s by the Ministry of Agriculture (MoA), in response to major droughts, which caused wide spread crop failures and consequent starvation. The sector could be used to reduce family risks that are associated with crop failures resulting from droughts.

Traditional small-scale irrigation schemes (SSIs) have also existed for perhaps several hundred years, mostly developed by feudal landlords, notably in Hararge, Shewa and Gojam. These developments were usually no more than a few hectares in area and diverted water from streams, often only to provide supplementary irrigation. (Supplementary irrigation consists of irrigation during dry spells in the wet seasons; this is in contrary to normal irrigation, which is concentrate in the dry season). Over the past few decades many of these schemes have expanded as skills developed, irrigating areas of fifty or more hectares. The diversion structures are constructed of wood, stones, and grass sods. They are often washed away during high river flows and have to be remade each year. It is estimated that there are approximately 72,000 ha of land being irrigated by traditional means; the majority situated in Oromiya (41,500 ha), 12,500 ha in the Amhara NRS, 8,900 in the SNNPRS and the remainder in the other regional state.

Based up on the various river basin master plans and land and water resources survey, the

aggregate maximum irrigation potential of Ethiopia (small, medium and large scale) have been estimated 3.7 million hectares. Out of this estimate only 197,000<sup>1</sup> hectares of land under irrigation.

## **2. Institutional framework**

### **2.1. Ministry of Water Resources**

Ministry of Water Resources is charged with aspects of water sector policy, planning, water resources regulation, development and use, and implementation of medium and large-scale irrigation. It also has the responsibility of building the capacity of regions regarding water resource development, and preparation of plans for the proper utilization of water resources. It coordinates projects that involve more than one region, or those that involve international procurement. The MoWR will render the implementation of the project by establishing a project coordination office (PCU).

Under the economic policy of the Government, the private sector can play a pivotal role in the development of irrigated agriculture. The International and Local None Governmental Organizations also play a significant role in study, design and development of small-scale irrigation schemes in different regions,

### **2.2. Local Government Administration**

Administratively, the Ethiopian Federation is divided into eight self-governing regional states. The regions are further divided into zones, woredas (districts) and kebeles. The regional self-governments have legislative, executive and judicial powers in respect of all matters within their geographical boundaries, except for such matters as defense, foreign policy, economic policy etc. The Regional Council (RC) is the legislative organ of the regional state and is constituted by members elected in accordance with electoral law. It is the repository of overall political power

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<sup>1</sup> Ethiopian Water Sector Development program, 2001



regarding the internal affairs of the region. The President heads the Regional Council.

Regional Bureaus in each region are established, which are responsible directly to the regional executive authorities. These Bureaus are almost replicas of the Federal Ministries. Thus there are Bureaus in charge of agriculture, health, water, social affairs, planning and economic development, mines and energy, transport and communication, works and urban development, trade and industry, tourism. Each bureau is responsible in relation to its area of activity mainly for: (i) the preparation, and upon approval, implementation of plans and budget; (ii) ensuring the implementation of laws, regulations and directives; (iii) undertaking studies and research, collecting and compiling statistical data, and transmitting it to the concerned federal organ.

### 2.3. Water Resources Management Policy

In 1998, the MoWR issued the Ethiopian Water Resources Management Policy (WRMP), which sets guidelines for water resources planning, development and management. The Fundamental principles pertaining to the formulation of the policy are:

- Water is the natural endowment commonly owned by all the people of Ethiopia.
- As far as conditions permit, every Ethiopian citizen shall have access to sufficient water of acceptable quality to satisfy human needs.
- In order to significantly contribute to development, water will be recognized both as an economic and social good.
- Water resources development shall be underpinned on rural-centered, decentralized management, participatory as well as integrated framework.
- Management of water resources shall ensure social equity, economic efficiency, systems' reliability and sustainability norms.
- Promotion of the participation and community management of all stakeholders and user communities, particularly women's participation in the relevant aspects of water resources management.

- The policy deals with water supply and sanitation, irrigation, hydropower, inland water transport, aquatic resources, water for tourism and recreation sub sectors. The overall goal of the policy is: to enhance and promote all national efforts towards the efficient, equitable and optimum utilization of the available water resources of the country for significant socio-economic development on sustainable basis. The specific objectives of the policy are to: Promote the development of the water resources of the country for economic and social benefits of the people, on equitable and sustainable basis;
- Allocate and apportion the water, based on comprehensive and integrated plans and optimum allocation principles that incorporate efficiency of use, equity of access, and sustainability of resources;
- Manage and combat drought as well as other drought associated impacts, and disasters through efficient allocation, redistribution, transfer, storage and efficient use of water resources; and
- Conserve, protect and enhance water resources and the overall aquatic environment on sustainable basis. The WRMP recognizes and adopts the hydrologic boundary or "basin" is the fundamental planning unit and water resource domain.
- To develop and enhance small and large scale irrigated agriculture and grazing lands for food self sufficiency at the household level and for food export.

### 2.4. Irrigation Policy

Irrigation is one of the sub sectors included in the Ethiopian water resources Management Policy (EWRMP). The overall objective of the irrigation policy is to develop the huge irrigated potential for the production of food crops and raw materials needed for agro-industries, on efficient and sustainable basis and without degrading the fertility of the production fields and water resources base. The policy sets the following detailed objectives:

- Development and enhancement of small scale irrigated agriculture and grazing lands for food self-sufficiency at household level
- Development and enhancement of small, medium and large-scale irrigated agriculture for food security and food self-sufficiency at national level including export earnings and to satisfy local agro-industrial demand.

- Promotion of irrigation study, planning and implementation on economically viable, socially equitable, technically efficient, environmentally sound basis as well as development of sustainable, productive and affordable irrigation farms.
- Promotion of water use efficiency, control wastage, protection of irrigation structures and appropriate drainage systems.
- Ensuring that small-scale, medium-scale and large-scale irrigation potential projects are studied and designed to stage ready for immediate implementation by private and/or the government at any time.

The above objectives are consistent with the objectives of Ethiopian Agricultural Development–Led Industrialization (ADLI) economic development strategy. The ADLI strategy is essentially based on initially fostering the rapid development of small holder’s agriculture, including irrigated agriculture with a view to creating demands for industrial goods and thereby fuelling the growth of industry. Thus ADLI meant to create the foundation for a virtuous cycle of mutual and parallel growth of the agricultural and industrial sectors.

## 2.5. Water Sector Strategy

To translate the national water management policy into action the Ministry of Water Resources has issued Ethiopian Water Sector Strategy (EWSS) in 2001. The strategy sets the road map as how to make meaningful contribution towards:

- Improving the living standard and general socio-economic well being of the Ethiopian people
- Realizing food self -sufficiency and food security in the country
- Extending water supply and sanitation coverage to large segment of the society, thus achieving improved environmental health conditions
- Generating additional hydropower
- Enhancing the contribution of water resources in attaining national development priorities
- Promoting the principles of integrated water resources management

By doing so, the strategy will be able to make meaningful contributions towards achieving a broader national development objectives of poverty alleviation and sustainable human resources development.

## 2.6. Irrigation development strategy

The irrigation development strategy is one of the sub-sectors dealt in the water sector strategy. The principal objective of the irrigation development strategy is to exploit the agricultural production potential of the country to achieve food self sufficiency at the national level, including export earnings, and to satisfy the raw material demand of local industries, but without degrading the fertility and productivity of country’s land and water resources base. More specific objectives of the strategy are:

- Expand irrigated agriculture
- Improve irrigation water-use efficiency and thus the agricultural production efficiency
- Develop irrigation systems that are technically and financially sustainable
- Address water logging problems in irrigated area

## 2.7. Main Elements of the Irrigation Strategy

### Technical and Engineering aspects

1. Initiate the planning and implementation of a comprehensive, well coordinated and targeted-irrigation development program
2. Design appropriate irrigation schemes by taking into account the physical conditions, hydraulic characteristics, irrigation engineering, management capacity of users, and detailed agronomic and agricultural considerations.
3. Implement measures to secure long-term viability and sustainability of irrigation schemes.
4. Adopt improved and affordable systems and tools for water harvesting and pumping, for reducing seepage losses in canals, for water control, storage and retention systems and measurement structures.

5. Undertake measures to improve water conveyance efficiency, especially the irrigation water use efficiency by implementing agronomic, engineering, demand management, and economic measures based on detailed studies and analysis of these measures.
6. Develop standards, guidelines, manuals and procedures for the sustainable operation and maintenance of irrigated schemes and systems, while ensuring their successful application, monitoring and improvement
7. Develop and promote simple designs and standards for construction and operation and maintenance of irrigated schemes.
8. Establish water allocation and priority setting criteria, as well as fair and transparent management system.
9. Pursue integrated planning approach in the development and implementation of irrigation projects.
10. Consider development of groundwater resources as supplementary means of irrigation in drought-prone areas, where rainfall duration is less than the length of growing season, as it is the only insurance against crop failure.
11. Develop necessary technical guidelines and standards for mechanisms, systems, materials and technologies to be used for improving water use efficiency in small, medium and large scale agriculture, so as to avoid both shortage (stress) and excesses (loss).
12. Give emphasis to water harvesting methods for small-scale irrigation development in areas where wet season runoff can be stored and used for crop production.
13. Create conditions conducive to the implementation/construction of medium and large-scale irrigation schemes.
14. Give appropriate consideration to past performance and technical capacity while selecting contractors and consultants for implementation/construction of irrigation projects because, in general the list bidder principle had not proven successful in construction works.
15. Implement a sequential framework for project authorization for the planning (studies and design), implementation and management phases. Analyze and outline the operation and maintenance as well as management requirements with respect to the beneficiary skills, and availability of materials, budgets and technical capacities.

### **Financial and Economic Aspects**

1. Make higher budgetary allocations from the government sources for the implementation of short, medium and long-term irrigation development plan.
2. Share irrigation development costs with other sectors like power, road, health, education and agriculture, etc.
3. Establish and implement norms and procedures for financial sustainability and viability of irrigation schemes. For this purpose, implement a stage-by-stage cost recovery transition procedure (initial grace period; operation and maintenance costs borne by the beneficiaries from the beginning; cover cost of minor structures beyond the primary off takes; finally total cost of the scheme are to be recovered). Medium and large-scale irrigation development schemes are generally considered to operate on full cost recovery principles, although a transition procedure may be justified to stimulate development of the region.
4. Establish users' fee according to the related level of cropping patterns and farm level profits, scheme efficiency, and in simple and clear cost recovery system. Ensure that the water charges and fees are timely collected for efficient operation of the service rendering institution. Sustain the functioning of the irrigation systems through their regular operation and maintenance and gradual upgrading of the operation and maintenance capacities of the local beneficiaries.
5. Implement a price stabilization mechanism to protect the producers against market risks. Facilitate producers in rationalizing their production choice by providing updated production and marketing information. Discourage import of agricultural products to protect local producers through strict enforcement of standards, quality control and high import taxation. Increasing agricultural production efficiency will be the key to bring local production costs comparable to the international prices.
6. Extend credit facilities and bank loans for development of irrigation projects, especially small-scale irrigation schemes to be executed by local community groups. Provide incentives to encourage private sector investment in the irrigation schemes.

7. Mobilize financial resources from external sources for undertaking the development of medium and large-scale irrigation schemes.

### **Institution Aspects**

1. Strengthen institutional and regulatory frameworks at the federal and regional levels by undertaking assessment of the existing institutional capacities with respect to the regulatory and implementation roles and responsibilities so as to develop the appropriate institutional structures for the implementation and management of irrigated agriculture. Make efforts to avoid overlap of duties and responsibilities among the institutions within the sector.
2. Reactivate and reinforce the role of federal government and regional states in the development of small, medium and large-scale irrigation schemes. This involves, inter alia, undertaking of activities related to rehabilitation and upgrading of existing schemes, upgrading of previous studies and designs, and implementation of the new schemes.
3. Enhance greater participation of the regional states and federal government in the development of large-scale irrigated schemes and farms in high water potential basins where there is low population density. Since large and medium scale irrigation areas are more in the low lands, the conflict arising from resettlement and loss of grazing land will be of prime concern. In such cases, compensation measures such as provision of irrigated pasture and livestock watering facilities may be considered.
4. Ensure operational sustainability of small-scale irrigation schemes by establishing operation and maintenance departments within the regional bureaus; description of operation and maintenance requirements for these schemes; identification of means to meet these requirements; preparation of operation and maintenance manuals; and strengthening the capacities of beneficiaries before handing over the schemes to them. In this regard, ensure transitional period during which the capacity of the beneficiaries is to be ascertained with an objective to identify and remedy difficulties and problems. Provide training to farmers using pilot level demonstration schemes, experience sharing programs, and research and study tours to improve water use efficiency and product quality.
5. Establish self-financing autonomous public institutions to undertake operation and maintenance activities of large-scale

irrigation schemes. Involve major stakeholders in the board of directors of these institutions. Make these institutions responsible for all aspects related to irrigation water management in the area.

6. Encourage the participation of private sector, especially for the operation and maintenance and management phases of medium and large-scale irrigation schemes. Towards this aim:
  - a) Devise and implement incentive systems such as tax holidays, longer grace periods of repayment, duty free import of construction and farm equipment, and provision of main infrastructure, etc.
  - b) Launch business promotion campaigns and forums
  - c) Facilitate co-operative or joint venture arrangements with the potential investors
  - d) Make approval procedures simple and easy, such as the 'one stop shop' principle, and
  - e) Distribute up to date information regarding investment possibilities in the irrigation sub-sector to local as well as foreign investors.

### **Capacity Building Aspect**

1. Equip the institutions involved in project implementation with the available modern know-how in the fields of project study, design, construction and operation and management. Facilitate the transfer and adaptation of modern technology in irrigation development and secure basis to sustain technological base.
2. Strengthen technical capacities of national/regional/zonal/woreda level offices in: project planning, design, implementation, operation and maintenance, information management, monitoring and evaluation, and other aspects related to irrigation management. Towards this aim:
  - a) Expose the national staff to higher level training
  - b) Implement targeted training programs
  - c) Encourage research and development activities
  - d) Execute skill transfer programs through on the job training, and
  - e) Link national institutions to regional and international network
3. Strengthen contract administration and management capacity of the clients and

national consultants to improve and upgrade the operational efficiency of existing and planned schemes.

4. Develop and strengthen information management capacities. In this regard, improve the adequacy, reliability and accessibility of existing databases at the national and regional levels (especially with regard to data on potential irrigable land, water resources availability, water use patterns, crop water requirements, farming systems, and irrigation efficiency) to carry out water management analysis and to determine potential to increase agricultural production.
5. Strengthen the existing technological base to improve the productivity and efficiency of irrigated agriculture. Take appropriate measures to sustain this technological base and to ensure that its expansion (either through local production or imports from external sources) complements the existing base and confers with the development needs of the sector.

### **Social Aspects**

1. Integrate irrigation development activities within country's socio-economic development plans, particularly within the Agricultural Development Led Industrialization (ADLI) Strategy, based on the two pronged approach of (a) strategic planning for achieving socio-economic development goals, namely through feasibility studies and designs for potential projects, and (b) Participatory driven approach for promoting efficiency and sustainability.
2. Institute decentralized and grassroots user based management of irrigation systems, taking into account the special needs of rural women in particular, during the planning, implementation/construction, operation, management and monitoring phases. Enable the local community to benefit from the irrigation schemes in terms of provision of social services, job opportunities and prevention of adverse social effects.
3. Assign priority to those irrigation projects, which are of multiple-purpose in nature and would contribute towards ensuring food security, provision of irrigated pasture in areas where cattle grazing and watering is a problem, increasing household incomes, and enhancing regional development.
4. Establish and strengthen the Water Users Associations or Irrigation Co-operation in

each scheme on a voluntary basis. Encourage and promote the role of women in these community-based structures. Provide training to the women to assume greater role in the functioning of these community-based structures. Make these structures focal point for development and management of irrigation schemes.

5. Promote partnership building between relevant government institutions, NGOs and local communities at different levels for the provision of bulk water storage, flood control and transfer schemes in particular;
  - a) Mobilize local community groups and assign them greater role in the planning, construction, and operation and maintenance of small scale irrigation schemes;
  - b) Involve local people in the project cycle of irrigation schemes, as well as settlers in the decision-making process; and
  - c) Institute conflict resolution mechanisms based on traditional approaches and cultural practices.
6. Make use, to a maximum extent possible, of local materials and resources in the construction of small-scale irrigation schemes since these lead to reduction in construction costs and help in avoiding delays in procurement.

### **Environmental Aspects**

1. Conduct appropriate Environmental Impact assessment (EIA) studies for the irrigation schemes, including the implementation of remedial measures, based on the National Conservation Strategy and Environmental Guidelines;
2. Establish guidelines for maintaining irrigation water quality;
3. Establish drainage parameters/requirements, and integrate appropriate drainage facilities in all irrigated agricultural development schemes;
4. Consider technical and technological options, which avoid the prevalence of breeding ground for vectors; minimize loss of forests; reduce seepage; and protect erosion, siltation, salinisation and pollution.

### **2.8. Irrigation Development Program**

The irrigation sub-sector program is one of the sub-sector programs incorporated in water sector development program. The overall objectives of the program are:

1. To improve the food security and food self-sufficiency status of the country, both at national and household levels;
2. To improve the nutritional status and general welfare of the population;
3. To contribute to the supply of adequate raw material inputs for industries;
4. To build national and regional capacities for planning, implementation and operation of irrigation projects;
5. To exploit untapped land and water resources for sustainable irrigated agriculture;
6. To reduce dependence on rain-fed agriculture and attendant vagaries of the Ethiopian climate;
7. To improve rural employment through increased cropping intensity; and
8. To improve land productivity through double cropping

Within a period of 15 years, the Irrigation Programs aims to develop a total area of 274,612 ha of land, bringing the total area under irrigation to 471,862 ha by the end of the Program period in 2016.

### ON GOING IRRIGATION PROJECTS IN THE MOWR

The ministry of water resources is undertaking a number of irrigation projects located in different regions. They constitute approximately a total area of 510603 ha. Most of these projects are envisaged to be completed and ready for production before the end of the irrigation program-planning period in 2016. This about twofold the area planned to be developed in the irrigation development program.

**Table 2. List of On-Going Irrigation Projects**

Name of the projects	Irrigable area (ha)	Type of work	Status	Detail description
Kessem Tendaho	90000	C	Under construction	
Koga irrigation and watershed	6200	C	Under construction	
World Bank financed irrigation	177998	IS	Under study	Megech = 31821 ha, Ribb= 199925 ha, Ange=26563, Negesso=2300ha, Upper Beles=53700ha, & Angereb=23000 ha
Awash river flood and watershed mgt	-	FS	Under study	
IFAD SCP-II/AFD Gumera Irrigation	3340 23000	SC FSD	Under study and construction Under study	IFAD/French Govt Financed
Lake Tana shore irrigation	37000	FSD	Expecting financial and technical proposal from VVWDSE	Gilgel Abay, North-west, South-west, North-east
Arjo Dedessa	14280	FS	Under study	
Humera	42965	FS	Under study	
Wabi-Shebelle basin irrigation dev.				
• Errer & Gololcha	11920	FS	Expecting financial and technical proposal from VVWDSE	
• Ilco-uen & Bulddoho	32000	FS	Under signing of the contract agreement with VVWDSE	
Lake Abay basin irrigation	21900	FS	under contract negotiation	(Gelana, Gidabo and Bilate)
Raya valley pressurized irrigation	18000	FSD	Expecting financial and technical proposal from VVWDSE Preparation of RFP has been finalized.	
Kobo-Girana pressurized irrigation	17000	FSD	Discussion with regional government has been started to decide upon the continuation of the project	
Ziway irrigation	15000	FSD	Expecting financial and technical proposal from VVWDSE	
<b>Total</b>	<b>510603</b>			

C= Construction; IS= Identification study; FS = Feasibility study; SC=Study and construction; FSD= Feasibility study and detail design

# **Recent Achievements and Priorities in Irrigation Water Management Research in Ethiopia with Particular Reference to Amhara Region**

**M. Zainul Abedin, Enyew Adgo, Melaku Tefera and Yacob Wondimkun**

SWHISA/CIDA Project, Bahir Dar

Amhara Regional Agricultural Research Institute (ARARI), Bahir Dar

mzabedin@rogers.com

## **Introduction**

Amhara National Regional State, with a population of more than 18 million faces both chronic and transitory food security due to a combination of factors. About 20% of the population, who are chronically food insecure women and female-headed households, suffer more from poverty than men and male-headed households. Agriculture is the mainstay of the economy of Amhara Region as the sector contributes about 62% to the Region's GDP. More than 90% of the labor force is engaged in Agriculture. Performance of agricultural sector basically dictates the growth rate of the economy. Despite relatively abundant surface and ground water resources and presence of the four major river basins of the country and Lake Tana, more than 95% of Amhara Region's agriculture, both crop and livestock sector is dependent on erratic and uncertain rainfall.

Poor performance of agricultural sector, mainly due to such erratic and uncertain rainfall, and drought erodes the capacity of rural households to withstand the declines in their income. Dependence on traditional production system, as well political and institutional neglect, has brought agriculture to a virtual stagnation. Even attempts during the recent past have not produced satisfactory results. Consequently, farmers are continuing to spiral down economically and their resilience to withstand the vagaries of nature is dwindling. Even the traditional livelihood coping strategies are continuing to dwindle. Continued poverty is leading to degradation of natural resources on which future of development depends.

Degradation of the natural resources is also a root cause of the low farm productivity, directly contributing to poverty and food insecurity. A vicious cycle has set in.

Continued poor performance of agriculture is also contributing to out-migration from rural areas to urban areas. More people are being attracted to live and work in the urban areas, thus a significant portion of the economically active population is being siphoned out of the rural areas. This has direct negative effect in the agriculture sector and create burden on the socio- economic development efforts of the urban centers where labor absorptive capacity is insignificant. There is an urgent need to improve the performance of the agriculture sector so that more and more jobs are created in the rural areas. However, these jobs should be economically attractive, which calls for making agriculture more profitable. There is a need to turn agriculture from subsistence to commercial agriculture. There is also need to emphasize on value addition to farm products to that poor farm families can generate additional income from agricultural products. These, however, will require creating environment so that producers have adequate access to both input and output markets.

Roads, easy access to market information, policy framework for market support, enabling private entrepreneurs to play fair roles, extension and development support to enable farmers to produce marketable surplus, organizing farmers to have control over output prices, etc. are very important in alleviating rural poverty and improving the livelihood of the farm families. Agro-based rural

industrialization should go hand in hand with agricultural development. The recently formulated Rural Development Policy is expected to assist the farmers to not only produce more but also gain economically.

Developing the irrigation potential is an essential requirement to overcome the problem of chronic food security and poverty. There is a need to improve the efficiency of the existing traditional and modern irrigation schemes. Though Amhara region is endowed with relatively higher amount of rainfall, there is a need to explore fully the ground water potential. However, much of the rain water flows across the borders. In addition, uneven spatial and temporal occurrence and distribution of rainfall compounds the problem farming under rainfed condition. With effective planning, policy and technologies, it should be able to deal with this uneven occurrence and distribution in space and time. Harvesting of rainwater, whether through household water harvesting structures, community based ponds, small-scale irrigation projects, improving performance of traditional irrigation schemes will greatly contribute to deal with these issues. Of equal importance is the developing and using the knowledge of how efficiently the use the water could be managed so that more people can benefit from water resources.

### **The water resources and irrigation potential in Amhara Region**

The region has four major river basins with small tributaries, which are part of Abay, Tekeze, and Awash River systems, Danakil depression with a total estimated annual renewable potential of 35Bm<sup>3</sup> fresh water (CoSAERAR, 2002); Lakes act also as sub-basins of these major river basins. The catchment area of the region that contributes for the renewable potential surface water is more than 134,056 Km<sup>2</sup> (MoWR, 2003).

An indicative point of the wealth of the region's undeveloped water resources are, first it is thought that most of the renewable water resources constitute surface water rather than groundwater, although the understanding and quantification of the latter is rather limited

(Table1). As stated in the MoWR 15 years water sector development program, availability of groundwater in Ethiopia in hard rock formations shows great variability from location to location, depending on recharge, degree of fracture, permeability, obstacles to water movement, concentration and nature of chemical in the water, depth of groundwater level; the case is true for the region as well (Muluken, 2005).

The recharge, in Abbay basin for example, expressed as an average continuous flow ranges between 250 and 300m<sup>3</sup>/s (BCEOM, 1999). However, the present boreholes are yielding an average of 5 litres/s, which indicates that there is a gap between the recharge and the estimation of the total abstraction through boreholes. On the other hand the Kobo-Girana valley feasibility study indicates that the estimated groundwater potential with in the valley is about 179 Mm<sup>3</sup>, in addition observations show that the presence of considerable potential of shallow groundwater in the region's alluvial deposits of flood plains; such as Fogera, Kobo-Girana, Borkena and Chefa plains, although no comprehensive survey of this resource has been undertaken.

Second, estimated potential land for large and medium scale irrigation of the region is about 650,000 - 700,000 ha and for small-scale irrigation is about 200,000 - 250,000 ha (of which less than 10% has been developed), indicates the magnitude of water resources available for development (BCEOM,1999).

The potential of water resource to be used for different purposes is available either in the form of surface or subsurface water. Even though the region's rainfall is known by its erratic nature, the average annual rainfall amount ranges from 600mm to 1600mm (MoWR, 1999).

This being changed into surface water and enriching the groundwater, depending on the nature of geological formation of the catchments, is assumed to supply water for domestic purpose, the indicated potential irrigable land and other economic needs by constructing diversions, dams, pumping the water after storage and/or boreholes (shallow or deep). The rainfall amount in most of the region



is changed into flood due to most of the catchments are almost bare; hence no drop of water get access to recharge the groundwater. However this is the case for the upland areas, some part of the flood at lowland is enriching the groundwater. Therefore, the groundwater in the alluvial deposits of flood plains should not be ignored especially for local and small-scale abstractions as well.

The hydropower potential of the region is quite large; estimated generating capacity is about 6000 MW. However, high dams and large reservoirs may require to produce sufficient firm power, because of three main reasons; no steep drops, the rivers flow is high for a short period, and variability over the years is very high. Many studies reveal that the country in general is known as it stands second next to Congo by the hydropower potential.

**Table1. The water resources of basins that the region has major shares (ESP, 2003)**

River basin	Catchment area (Km <sup>2</sup> )	Annual Runoff (Bm <sup>3</sup> )	Ground water (Bm <sup>3</sup> )
Abbay	199,812	52.6	1.23
Tekeze	89,000	7.63	0.18
Awash	112,700	4.6	0.13
Danakil	74,000	0.86	-
Total	475,512	65.69	1.54

In view of the water resources available, the estimated irrigation potential of the Region is about 900,000 ha. The estimated potential with large-scale irrigation schemes is about 650,000 – 700,000 ha and with small-scale irrigation schemes it is about 223,600 ha.

### Issues beyond irrigation

In developing the water resources, it is important to keep in mind that there is not only need for water for irrigation to support crop and livestock production, there is need for manage water resources in an integrated manner which will also support overall social and economic development in an environmentally sustainable manner. Improving access to safe drinking water for the rural people, use of water for generating power; to support industrial growth, mining and construction and harnessing the

potential for fisheries development are some of the important areas, which should be dealt with in an integrated way while developing and managing water resources. In other words, there is need for a comprehensive and integrated water resources management plan. Towards this goal, the Federal Government has recently formulated the Ethiopian Water Resources Management Policy.

Another important issue that is affecting both irrigated and rainfed agriculture in Amhara is widespread prevalence of HIV/AIDS. Though the relative prevalence is low in the rural areas as compared to the urban areas, this is posing a serious threat to sustainable development of agriculture as HIV affected families suffer from shortage of farm labor. In all development programs, there is need to integrate issues related to HIV/AIDS so that the issue can deal with it effectively.

Obviously, there is a need to generate technologies for irrigation water management, which will be appropriate to our predominantly small-scale and resource-poor farmers and which will help conserve our natural resources for our future generations. There is need to use appropriate approaches through which development and adoption of such technologies and knowledge at an accelerated speed is ensured. However, this cannot be done by an individual institution alone; it requires collaborative efforts of all stakeholders.

### Bringing stakeholders together

Sustainable Water Harvesting and Institutional Strengthening in Amhara Region (SWHISA) is a six-year project to be implemented by the Amhara National Regional State of Ethiopia with support from the Canadian International Development Agency (CIDA). SWHISA's purpose is to strengthen the capacity of institutions involved in water harvesting to work together effectively to strengthen farmers' associations, communities and families in planning, designing, implementing and managing sustainable water harvesting and use of water for irrigation. SWHISA will contribute to the ultimate goal of increasing food security of poor farmers through improved water

management. Strengthening research and extension capabilities of partner institutions to develop and transfer appropriate and sustainable irrigation water management technologies is an integral part of SWHISA. As the project has started to implement its work plan for the first year, it is necessary to document and synthesize the state-of-the-art knowledge of irrigation water management in Ethiopia, with particular reference to Amhara in order to avoid duplication, infuse synergy to ongoing initiatives and to build up on existing knowledge base. Under these circumstances, a workshop was organized on 5 -7 December 2005 at Alma Building in Bahir Dar to discuss the recent achievements with the following specific objectives:

- To document the recent achievements in research on irrigation water management with a view to identify technologies available for transfer and scaling up in Amhara region;
- To identify priorities for applied and adaptive research in irrigation for the Amhara region with particular reference to SWHISA and Amhara Regional Agricultural Research Institute (ARARI) objectives and activities;
- To discuss recent successes in transferring irrigation water management technologies in the Amhara Region and analyze innovative approaches used in successfully transferring such technologies; and
- To explore possibilities of establishing partnership with IARCs and universities to conduct applied and adaptive research on irrigation and water management in Amhara Region;

The workshop was jointly organized by ARARI and SWHISA in collaboration with of BoARD and BoWRD. The workshop was inaugurated by Dr. Tewodros Bekafa, Rural development Advisor to the President of Amhara Region. The inaugural ceremony was covered by electronic and print media, including Ethiopian TV.

### **The program, workshop format and participants**

A total of 24 papers were submitted covering research and development and 23 were presented. The workshop was organized into five technical sessions. On the first day, experiences from transferring irrigation water management technologies and on the second day, research achievements and research priorities for irrigation development were discussed. In the first session, 11 papers and in the second and third sessions, 12 papers were presented. Usually, each presentation was followed by an active discussion. Technical and policy issues were also raised and discussed in the general and summing up discussions after every session. Based on their experiences, knowledge and the papers presented, two multidisciplinary working groups were formed on the third day - one group for successful approaches and methodologies in generation and transfer of irrigation water management technologies and the second group for priority areas for applied and adaptive research on irrigation water management. In the afternoon, working groups presented their outputs and recommendations. The presentations and issues arising were discussed in details.

About 54 invited policy makers, senior managers, senior researchers and development officials from Ministry of Agriculture and Rural Development, Ministry of Water Resources Development, Ethiopian Agricultural Research Institute (EARI), International Water Management Institute (IWMI), Universities, USAID, Mekele Agricultural Research Center (Tigray), Private consultants, Worer, Debre Zeit and Melkassa Agricultural Research Centers of EARI, SARDP, BoARD, ARARI and its research centers, BoWRD, CARE, AMAREW project, ORDA and other NGOs and development projects had participated (Please see Appendix II for list of participants). The participants were drawn from various disciplines of research and development, which included irrigation agronomists, irrigation engineers, soil scientists, irrigation extension experts, economists, horticulturists, and social scientists. About 50% of the participants presented a paper. Unfortunately, there were no woman participants except the lone SWHISA

consultant. It was discussed and emphasized that in future such activities, the organizers should proactively ensure participation of women research and development workers.

**Issues and recommendations**

The following were the main issues raised and recommended during the technical and the final summing up sessions included the following:

**Recent research achievements and priority themes of research:**

- Recognizing that research experiences in Ethiopia in general are recent, and in Amhara Region in particular are in the nascent stage, there were five technologies (Table 1) identified as ready for validation, adaptation and/or demonstration in Amhara region, which include Irrigation scheduling for wheat, developed by Debre Birhan

agricultural research center., for transfer in similar agro-ecological conditions in Amhara

- Further analysis will be needed to decide whether the research results presented in several papers are ready for transfer or validation and to decide on their agro-ecological niche.

Additional information on possible technologies suitable for Amhara Region will be provided by EARI. Synthesis of this information may be done by SWHISA research group or a working group.

- The following priority thematic areas for research and extension on irrigation water management were identified:

**Table 2. List of technologies available for validation and/or demonstration in Amhara region**

Crop/area	Technology Practice	Brief description	Agro-ecological suitability	Potential benefit	Center
Wheat	Irrigation Schedule, Nutrient mgt	Apply water at Early tillering, booting and milk stages	Highland (Vertisols)	435 % MRR	DB
Various	Water abstraction	Rope and washer & other pumps	Current WHS Small streams	100 lit/min Less costs Uniform application	Sirinka And other centers
Horticultural & Oil seed crops	Alternative crops	Horticultural and Oil seed crops	Low lands Moisture stress		NRS
Alternative crops	improved varieties	Improved varieties of alternative crops	Low lands Moisture stress		NRS/ HLI
	Nutrient Mgt	Fertigation technologies			HLI/ NRS

DB = Debre Birhan agricultural research center

**- Irrigation water management:**

- Irrigation agronomy practice such as determination of crop water requirement, agronomic practices on irrigation, and water-yield production functions and decreasing post-harvest

- losses to increase yield as the most priority areas;
- Development and evaluation of design parameters;
- Irrigation method/system evaluation;

- iv. Monitoring and evaluation of water quality for agriculture water requirements and
- v. Documentation and understanding of indigenous successful practices, farmer innovations and successful adoption of modern technologies in both small-scale irrigation schemes and Household water harvesting schemes;

**-Water harvesting and efficient utilization:**

Include performance evaluation and design and development

**- Scaling-up of technologies**

**- Impact assessment**

**- Drainage and salt affected soils**

**- Integrated water resource management**

**- Integrated water resource development**

**- Small-scale and household level water harvesting technologies for supplemental irrigation:**

Include selection of water lifting and application technologies, optimal use of the stored water to supplement the terminal dry-spell in the rainy season and irrigation at sensitive stage of crop growth at full irrigation in the dry season.

Details of the researchable topics by crop type and agro-ecology be worked out by the working group.

**Priority Themes for Extension**

- Irrigation Water Management to include (i) development of appropriate extension approach; (ii) community participation; (iii) capacity building; (iii) improving the mechanisms of linkage with partners; (iii) emphasis on readily available technology package.
- Improve efficiency of Irrigation schemes through ensuring timely operation & maintenance; linking farmers to marketing outlets; selection of appropriate profitable crops; organizing farmers/beneficiaries in extension activities; considering land tenure as an important factor in adoption; community empowerment; improving partnerships among stakeholder; and ensuring timely availability of agricultural Inputs

**Research and Extension Approaches**

An analysis of the current stakeholders with respect to their objectives, organizational strengths and weaknesses were done. It was noted that the work on irrigation extension and development is fragmented and there are confusions with respect to roles and responsibilities of these organizations. It was also noted that the newly introduced Agriculture Extension Advisory Training Services might lack adequate emphasis on participation but it emphasizes on irrigation development. It was recommended that:

- Community participatory approach to agricultural research and extension be used with a holistic perspective.
- An integrated, scheme-based, holistic approach should be used for sustainable development and to improve the efficiency of the whole scheme and enhance productivity and income of the farmers. A scheme includes catchments area, headwork, the conveyance and distribution network, the command area, and the water users. It has also impact on the farmers and their use of water down stream. Level of adoption of improved water management technologies and improved farming systems is directly influenced by the level of access to input and output markets.
- Indigenous technical knowledge, traditional practices, and successes in irrigation water management and household water harvesting should be analytically documented so that research and development can build upon such knowledge and successes.
- Research and extension activities should contribute to improving market access for farm products as well as to inputs.
- Mainstreaming of gender and environmental issues, including involvement of female-headed household in irrigation research and development are very important for equitable distribution of benefits.

**Capacity development**

- There is a strong need for capacity building for research and extension, and improving the research facilities at the research centers. It was stressed that capacity building shall be in

line with the priority research themes. It was also felt that on-farm research and demonstration be undertaken in the six SWHISA project Woredas and in a few other non-project Woredas as well. The training needs and the requirements for facilities and equipments may be reviewed and improved by the group.

- Strengthen the capacity of farmers' organizations in using modern and improved technologies, irrigation and management practices for irrigation water management, including their capacity to resolve conflicts and to ensure efficient operation and maintenance of irrigation schemes.

### **Policy**

- Formulation of appropriate policies is needed for irrigation research and development. Constraints that need policy intervention include promoting community participation for scheme utilization (upstream and down stream users); payment for water used; Land tenure in reference to irrigation management and water equity; input and credit supply specific to irrigation; simplification of credit norms; improving access to credit and markets; redistribution of irrigated land to improve performance of irrigation schemes; size of irrigated land holding for cultivation; setting up of clear duties and responsibilities in technology development and dissemination process (BOWRD, BOARD, BOCP, ARARI).

### **Networking and partnership**

- Bureaus, public and private sector organizations, NGOs, universities, International Agricultural Research Centers, donor supported projects and entrepreneurs involved in irrigation development should work together as active partners. Such partnership should clearly delineate roles and responsibilities of each partner.
- A database for irrigation water management be created in the Region.
- The value of such workshop in establishing a network of professionals in irrigation water management was recognized and in future, such workshops be organized as and when

needed to facilitate working and learning together.

### **Conclusions**

The workshop brought together professionals from different parts of the country and from different institutions which helped identifying priority areas of research and development irrigation water management. This has definitely facilitated initiation of networking to learn from each other. It was recognized that well guided research and extension, with appropriate policy support, in irrigation water management for both small-scale irrigation schemes and household water harvesting schemes can contribute to:

- Reduction of expansion of agriculture to marginal areas;
- Generation of employment opportunities in the rural areas;
- Reduce migration or rural people to urban areas;
- Improving food security and reduce malnutrition; and
- Having positive impact on other sectors of the economy.

All these positive effects can eventually improve the rural livelihoods, and thereby, lead to equitable distribution of benefits of development. Institutionalization of networking process would be an important need.

The workshop also recognized that there is a need for the researchers and extension workers to change their attitudes towards their tasks, partnerships and towards the farmers. They need to expand the horizon of their thinking so that they see their individual roles and responsibilities and their organizations roles are integral parts of a larger socio-economic system that affects the livelihoods and economy. This would require that they think outside of their boxes.

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# Irrigation Practices, State Intervention and Farmer's Life-Worlds in Drought-Prone Tigray

**Woldeab Teshome**

Addis Ababa University  
woldeabt@yahoo.com

## **Abstract**

This study demonstrated that there is a need for irrigation systems on the part of the farmers, but the provision of irrigation and agricultural services don't dovetail effectively with the life-worlds of farmers. Since the mid-1980s, the Ethiopian government has responded to drought and famine through the construction of irrigation infrastructure aim at increasing agriculture production in drought-prone regions of Ethiopia. Planning of irrigation projects has been done at the center. However, not enough is known about farmers' reactions and responses to these government initiatives. This study started off by asking a central question: How do State irrigation interventions interface with irrigators' life-worlds in Tigray, a drought-prone region of northern Ethiopia? Two small-scale irrigation systems were examined through an ethnographic method. Interviews were carried out with various community members including women, priests, irrigators, Abo mais ('fathers of water'), engineers, and executive committee members of the water users association and government and NGO officials. This study documents the interfaces and social discontinuities between the live-worlds of irrigators and government bureaucrats embedded in irrigation management. Irrigation management sits uncomfortably between government bureaucracies and water users. In principle, water allocation is the responsibility of the 'water committee'. However, uncoordinated water allocation decisions on the part of local government bureaucracies have compounded water scarcity in the irrigation systems. Numerous socio-technical problems resulting from poor irrigation management frustrated irrigation interventions. These ranged from crop failure due to moisture stress, the lack of effective water harvesting strategies. Building irrigation infrastructure is less problematic than putting it to good productive use to service unmet demands. The water users themselves or an irrigation agency might better be able to appreciate the performances of an

irrigation system or deal with the issue of water equity. The local government bureaucracy, involved in numerous non-irrigation activities, finds it difficult to identify internal irrigation management problems encompassing water delivery schedules, and to make fair decisions in conflicts over water. On the other hand, the institutional viability of water user associations is questionable because of the absence of clear water rights which demotivates farmers from participating in irrigation management. Moreover the distancing by the bulk of farmers from irrigated agriculture through leasing out their plots to sharecroppers provides a good indication of the lack of enthusiasm amongst them to commit themselves to irrigated cultivation. No irrigator survives from rainfed and irrigated farming alone. All still need multiple livelihood strategies to survive.

## **1. The Problem**

In Ethiopia, government has been the main actor in initiating, planning and implementing development interventions since the mid 1950s. Modernization has been the driving ideology behind the various development plans that aimed at transforming the backward economy. Government is considered as 'the main provider of all benefits (Dessalegn, 1994) or as a Tigrian farmer conceived it 'Mengist Lehezbu Egziabher Lefteretu' meaning 'government is for its people, and God is for his creature'. The top-down nature of major development programs including the 1975 land reform, resettlement, villagisation, cooperativization and agricultural extension programs, indicate the history of forced change in the country. Local people were either forced or mobilized to 'participate' in the implementation of such projects, which were supposed to be 'beneficial' to local people.

Since the mid-1980s government has responded to drought and famine through the construction of irrigation infrastructure aim at increasing agriculture production in drought-prone regions of Ethiopia. Planning of irrigation projects has been done at the centre. However, not enough is known about farmers' reactions and responses to these government initiatives.

This study concerns state irrigation interventions in a drought-prone area designed to increase crop production to achieve food security at household level, and explores the planned interfaces with irrigators' life worlds in two small-scale irrigation systems located in Tigray region, northern Ethiopia.

## 2. Theoretical Approaches

### 2.1. An Actor orientation

The conceptual and theoretical framework of this study highlights the interfaces and social discontinuities between the life-worlds of irrigators and government bureaucrats embedded in irrigation management. An irrigation intervention constitutes an arena of struggle in which access to resources such as land and water provides the central point of dynamic interactions, encounters, confrontations and negotiations between different social actors. As Long and Ploeg (1989:226-227) explain, 'focusing upon intervention practices allows one to take into account the emergent forms of interaction, procedures, practical strategies, types of discourse, cultural categories and the particular 'stakeholders' (Palumbo 1987:32) present in specific contexts and to reformulate questions of state intervention and agrarian development from a more thoroughgoing actor perspective'.

In the livelihood domain, interlocking relationships among the different social actors including landlords (during the imperial regime), farmers, local government administrators, development agents, and Abo mai ('father of water') are central. The concept of 'domain' best expresses the nature of these interlocking relationships. As Long (2001: 241-242) notes:

*Domains represent the loci of rules, norms and values that become central to this process of social ordering and to the establishment of certain pragmatic rules of governance. The idea of domain is also important for understanding how social and symbolic boundaries are defined and upheld, though precisely which normative or strategic principles will prevail situationally or over the longer term remains an open question. Domains should not be conceptualised as 'cultural givens' but as being produced and transformed through actors' shared experience and struggles'.*

### 2.2 Irrigation system as a socio-technical system

In the present study, an irrigation system is considered as a 'sociotechnical system' (Mollinga, 1998; Vincent, 1997, 2001). Such an approach 'gives explicit attention to the multiple ways in which technology shapes social action, and is also shaped by it' (Vincent, 1997: 45). Mollinga (1998:14) outlines the social dimensions of an irrigation system in terms of three basic concepts: social construction, social requirements for use and social effects.

## 3. The Research Questions

Based on the above theoretical discussions, the following central research question has guided this study.

How do state irrigation interventions interface with irrigators' life-worlds in a drought-prone region of northern Ethiopia?

The sub-questions are:

1. What state interventions have taken place and how have they affected agrarian relations and irrigation technology choices in Ethiopia?
2. How is irrigated agriculture practiced, and what is the value of irrigated agriculture in the life-worlds of irrigators?
3. How do local government bureaucracies intervene in everyday irrigation



management and irrigated agriculture and what are the key interfaces and arenas shaping interactions and outcomes between agencies and farmers?

4. What are the coping strategies in respect to drought and famine employed by local people, and what other food provisioning/livelihood strategies exist apart from farming?

#### 4. Methodological Considerations

In the implementation of irrigation intervention interaction takes place between the intervening actors, the government and non-governmental agencies involved in the irrigation development on the one hand, and the farmers (often called 'beneficiaries') on the other. Of particular concern is the issue of the institutional control, at farm, tabia (sub-district), district and regional levels of state officers of government bureaucracies and NGOs. In view of this, I was interested to investigate how actors adopted, transformed or rejected the irrigation intervention by adopting 'pragmatic moves' (Schutz and Luckmann, 1974). Such an approach enabled me to take into account social actors' reasons and the social context of action.

A case study method was employed to conduct the research. One of the characteristics of qualitative research is the use of case studies (Stake, 1995; Neuman, 1997). Yen (1989:13) states that 'in general, case studies are a preferred strategy when "how" or "why" questions are being posed, when the investigator has little control over events, and when the focus is on contemporary phenomenon within some real-life context'. Thus, it was appropriate to undertake case studies that allowed me to investigate the life-worlds of farmers within the context of two irrigation systems. The approach taken was largely ethnographic, that is, it has been concerned with understanding social life and discovering how people construct meaning in natural settings. I wanted to learn what is meaningful or relevant to the people being studied, and how individuals experience daily life. The methodology was designed to employ a variety of methods to capture different aspects

of complex relationships. Thus, ethnographic interviewing, participant observation and a total of 60 household interviews were carried out in Gum Selassa and Hewane irrigation systems.

The fieldwork was carried out in two phases. The first phase was between January 2000 and September 2001. During this period visits were made to ten irrigation systems to gain first hand information about the implementation of irrigation development and management of the small-scale irrigation systems in Tigray. This was followed by the selection of two irrigation systems for further in-depth study. This second phase of the fieldwork was carried out between Augusts to October 2002.

#### 5. Irrigation Development in Tigray

Tigray region is situated in the northern tip of Ethiopia. The topography of the region is predominantly mountainous and the elevation ranges from 500 meters above sea level in the eastern part of the region (Erob) to 3900 meters in the southern zone near Kisad Kudo (Tassew, 2000). The climate includes all the three categories: kolla (lowlands), weyna dega (midlands) and Dega (highlands). The average minimum temperature is 5 °C and the maximum 40 °C.

The estimated population of Tigray is 3,494,000 of which 565,000 are urban and 2,929,000 are rural inhabitants. Over 90 percent of the population is follower of Orthodox Christian Church. The total area is about 80,000 square km of which the arable land is estimated to be 15,000 square km. The average holding is about one hectare. This varies from 0.5 hectare to 0.9 hectare in the densely populated highlands and nearly 2 hectares in the lowlands. (CSA, 1997).

The region is primarily agricultural and the majority of the population is employed in this sector. Agriculture is dependent on unreliable rainfall. For many years rainfall has been very low and erratic. As a result, repeated crop failure and scarcity of food have forced inhabitants to depend on famine relief in the form of food for work.

The Tigray farmers have a long history of practicing irrigation to supplement rainfed agriculture. Local people's initiative has been in practice using the available water supply for irrigation purpose. As Pankhurst (1986: 137) writes, quoting Plowden and Salt:

*Irrigation, though far from universal, was practiced, Plowden notes, "whenever necessary" – or possible, and in view of the "numerous rivulets" was "an easy task." Small channels, as Salt noted in Tigré, would be dug from the higher parts of a stream to conduct water across a nearby plain, which would be criss-crossed with small ditches to form "small compartments." Irrigation of this kind on ditches about two feet wide was also used in some areas for the cultivation of cotton.*

Surface irrigation including river diversion, spring development and pond systems, is widely used in the region to irrigate plots. In the highlands of Tigray, farmers construct dorra (ponds) for the storage of spring water to irrigate their farms (Mitiku, et al.2001). In Tigray 15,495 ha is irrigated using traditional methods and make up 5 percent of the estimated irrigable land of 324, 286 ha (ibid: 9). Diversions structures are made simply of stones and wood. They are frequently washed away by the floods. The canals are not lined and water loss through seepage is significant.

The current government believes irrigation intervention to be a drought-proofing strategy in Tigray. To this end, international organizations such as UNDP, UNECA and FAO have participated in designing of a project on 'Sustainable Agriculture and Environmental Rehabilitation in Tigray'. Nana-Sinkam (1995: 87) reports:

*With the framework of its 'Agenda on Emergency, Humanitarian, Rehabilitation and Reconstruction Affairs' and more specifically in consonance with 'its objective in Poverty Alleviation through Sustainable Development', UNECA, at the request of the Transitional*

*Government of Ethiopia (TOE), has launched a major undertaking called 'Sustainable Agriculture and Environmental Rehabilitation in Tigray (SAERT), which is only the first of 8 Program being elaborated in co-operation with UNDP and FAO within the framework of what is known as 'Sustainable Agriculture and Environmental Rehabilitation, Reconstruction and Development (SAERRD) for Ethiopia'.*

This program has been developed to address not only the issue of food security in Ethiopia but also the whole area of sustainable development in agriculture and natural resources. One of its objectives is 'to increase production as quickly as possible using extensive water harvesting systems for irrigation'. Furthermore, as Nana-Sinkam explains:

*The design process for the Tigray region anticipates the building of 500 irrigation schemes, principally using micro-dams within a period of ten years. This undertaking, ambitious as it may appear, has been carefully targeted taking into consideration the experiences of the region in irrigation as well as in participatory labor processes. The undertaking of the proposed schemes will involve extensive watershed management as well as adequate preparatory measures in organizing the agronomy components of irrigation schemes to an extent that the region can be self-sufficient in food resources and export to other Ethiopian regions and to other countries in the Horn of Africa (such as the neighboring Eritrea) within a matter of ten years (ibid.)*

Upon the recommendation of the above mentioned international organizations, the regional government established the Commission for Sustainable Agriculture and Environmental Rehabilitation of Tigray (Co-SAERT) making it responsible for the construction of micro-dams in the region.

In Tigray, the main institutional actors involved directly or indirectly in the irrigation intervention include the Commission for Sustainable Agriculture and Environmental Rehabilitation of Tigray, the Bureau of Natural Resources and Agriculture through the woreda department of agriculture, local government administrations, and non-governmental organizations such as the Relief Society of Tigray (REST) and the Dedebit Credit and Savings Institution (DECSI).

## 6 The Research Sites

### 6.1 Hewane Irrigation System

The Hewane irrigation system is situated in Hewane tabia, on the road connecting Addis Ababa with Mekelle some 55 km south of the regional capital of Tigray. The fields of the irrigation system encompass parts of the territory of four kushets (villages) called Ayboto, Korora, Maine and Hewane town<sup>1</sup>.

Hewane tabia is located at an altitude of 1800 – 2000 m.a.m.s.l. The total area of Hewane tabia is 4558 hectares<sup>2</sup>. The cultivable land is 2405 ha (53%). There is no rainfall gauge in the tabia so only the regional average is available (see chapter 2). The soil types are 20% tikur (black), 19% maekl (average), 40% huthu (sandy), 5% mkeyh (red), 16% tikur+maekl (black+average). The soil fertility is classified as 5% woferam (fertile), 65% mekakegna (average), 30% rekik (poor).

The Mikorer-Betmera and Adi-Mesano streams supply water to 36 ha plots in the Hewane irrigation system during bega (dry season). Historical evidence is lacking as to when irrigation started in this area. Local people said, 'our forefathers started irrigation long ago'. The Mikorer-Betmera stream passes along the eastern side of Hewane town, whereas, the Adi Mesano stream cuts across the farms located between Hewane town and Ayboto Kushet. The

two streams meet at a junction called Gudif where these rivers become the Hewane River. Apart from irrigation, the river water is used for various purposes including drinking, washing clothes, cooking and watering animals.

The Hewane irrigation system starts from south of Hewane, Menkuse village, and extends to Mai Neberi tabia, which is about 12 kms in length. The stream passes along the up-hill side of sloping to moderately flat agriculture lands. Gravity irrigation is carried out using earth canals bifurcating from the main stream.

Water availability in the Hewane River varies substantially from season to season, largely as a function of rainfall. This affects discharge from the spring, which is a source of its recharge. The keremt rainfall usually starts late June and peaks in August. After mid-September the rainfall stops. Farmers or the tabia agriculture office do not take water flow measurements in order to calculate the amount of discharge into the canals. Simple observation is employed to estimate the amount of water that could be obtained.

#### The water users

There are two types of irrigators based on the 'water allocation principle' adopted by the water committee. The principle is classifying plots into mesno and hayfo. The mesno (irrigation) plot holders receive river water from January onwards because they have been under the agricultural extension program 'Sasakawa Global 20003' since 1993. In this group, 220 farmers cultivate plots ranging from 0.015 ha to 0.125 ha including 'kitchen gardens'. This group is under an obligation to use chemical fertilizers and other modern inputs and follow agricultural extension advice. The hayfo plot holders mainly depend on rainfed agriculture. This group, however, gets water until the end of December depending on the availability of river water. The hayfo group will not obtain water after January because the river water is diverted

<sup>1</sup> According to the Central Statistics Authority, a settlement with two thousand persons or more is a town.

<sup>2</sup> The data were collected from the Hentalo Wajirat Woreda Agriculture Department.

3 Sasakawa Global 2000 project was initiated in 1993 by the Sasakawa Africa Association and the Global 2000 programme with the co-operation and support of the Ethiopian government.

to the mesno irrigators. About 210 hayfo farmers cultivate 20 –25 ha of land planting barley, lentils, vetch and chick-peas which require two or three times watering between September and December. Individual land holding ranges from 0.25 to 0.5 ha. In addition, both hayfo and mesno irrigators cultivate rainfed plots within Hewane tabia.

## 6.2 Gum Selassa Irrigation System

The Gum Selassa irrigation system encompasses parts of the territory of Adigudom and Arra Alemsegeda<sup>4</sup> tabias (sub-districts). It is located four kms east of Adigudom town. Adigudom is the main town of Hintalo Wajerat Woreda situated 39 km south of Mekelle. Gum Selassa irrigation system is at an altitude of 2061 m.a.m.s.l. The area is known for its flat agricultural land with no tree cover. Agricultural production is dependent on unreliable rainfall. During the last two decades, the agriculture of the woreda has suffered frequently from the scarcity and/or irregularity of rainfall.

The Gum Selassa micro dam was the first irrigation infrastructure constructed by the current government. There was no experience on the government's part on how to select water users and how much irrigable and rainfed land should be distributed to a farming household. Thus, the regional government set up a five-man committee to develop guidelines for land reallocation and the selection of irrigators in the Gum Selassa and Adha irrigation systems<sup>5</sup>.

The committee recommended that a minimum of 0.2 ha and a maximum of 0.25 ha of irrigable and 0.75 ha of rainfed plot should be allotted to farmer to achieve food security at household level (ibid: 6). The regional government approved 0.2 ha irrigable land and 0.75 ha rainfed to a household.

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<sup>4</sup> Arra and Arra Alemsegeda tabias were merged into the Arra Alemsegeda tabia

<sup>5</sup>The committee was composed of agricultural economists, a rural sociologist, an engineer and economist drawn from Mekelle University College, the Relief Society of Tigray, and the Bureau of Natural Resources and Co-SAE

The command area of the Gum Selassa irrigation system was taken as 120 ha. Based on the 0.2 ha allotment to an individual farmer, 600 farmers could get plots in the irrigation system. The committee suggested three different options of land allocation. One of the options was to allow '... only ... those farmers with land displaced and those farmers with land currently in the command area to be allocated irrigated land. This option was rejected as it would reduce the number of potential beneficiaries to be ensured an acceptable level of food security and thus affect the achievement of the principal objective of the project

Gum Selassa irrigation system was not the first irrigation infrastructure in Adigudom. Although they were short lived, the former government had constructed three small earth dams namely, Mai Genet, Mai Debleat Adi Ake and Hay Engula through food for work programs. Mai Genet earth dam was operational for one year and farmers planted tomato on one hectare. The other two dams have never been operational because of siltation and other technical problems.

The Gum Selassa irrigation system started operation in 1996. The construction took nearly two years, involving time 472, 000 man days. The total cost of the dam was US \$ 487 720. Local people participated in the Gum Selassa dam construction through a 'food for work program'. In addition, able-bodied people provided 20 days free labor in a year for the construction work.

The total storage volume of the Gum Selassa micro dam is 1,902,000 m<sup>3</sup> as. Co-SAERT engineers estimated 1,366,485 m<sup>3</sup> net storage for the irrigation of 120 hectare land considering evaporation loss, dead storage, conveyance water losses, extreme rainfall that could not be captured, human consumption and animal consumption (Yigzaw, 1994: 45).

The canal system is 'hierarchical' (Horst 1998), in which water is distributed from the two main canals to secondary, tertiary and field canals. The height of the concrete drop structures is about one meter. There are five division boxes along the primary canals. The longer primary canal is 3 kms while the shorter is 2.4 kms.

Excess water from the fields runs to the drain where seepage water flows. In 2000, a small part of the main canal (about 100 meters) was concrete-lined by Co-SAERT.

## 7. Key Findings

### 7.1. On the question of irrigation development

The current government has adopted an Agricultural-Development-Led Industrialization (ADLI) policy to promote rural development. The policy gives priority to the improvement of traditional agricultural practices to increase agricultural productivity. Irrigation development is one component of this policy. The government has issued a new irrigation policy whose main objective is to achieve food security at household level. Regional Commissions for Sustainable Agriculture and Environmental Rehabilitation have been established.

The Commission for Tigray (Co-SAERT), which was established in order to promote irrigation in the Tigray region, did not, however, achieve its 10-year target for micro dam construction. It constructed 44 dams, only a small proportion of the dams promised. These micro-dams had numerous technical and management problems. As a result Co-SAERT has now discontinued their construction.

### 7.2. On the question of the practice of irrigated agriculture and its value in the life worlds of the irrigators

The study shows that farmers in Hewane and Gum Selassa cultivate both rainfed and irrigated plots. While the Hewane system obtains water from a river, the Gum Selassa irrigation system abstracts water from a micro-dam constructed by the current government. Mixed farming is practiced in both irrigation systems.

Over a period of six years, the average yield of maize, onion and tomato has increased significantly in Gum Selassa and Hewane irrigation systems. For instance, the average yield went from 24 to 167.5 quintals of maize for Gum Selassa, and for Hewane, from around

16 to 83.5 quintals. Although the Agriculture Department advises farmers to observe its cropping pattern, farmers do not do so. They usually plant maize, onion, tomato and wheat. Maize is a crop preferred for household consumption, and onion because of the 'good income' earned from its sale. Furthermore, there was no effective advice given on irrigation scheduling or input supply. Water was sometimes applied in such a way that instead of irrigating crops, soils became flooded.

The study also finds that irrigated production interferes with rainfed agriculture and with off-farm activities. This is mainly because irrigated plots are harvested in May and June, which coincides with the need to plough both rainfed and irrigated plots that take advantage of the long rains.

The study indicates that no irrigator survives from rainfed and irrigated farming alone. All still need multiple livelihood strategies to survive. In addition, marketing is so insecure that farmers can lose the investments they make in agricultural inputs, which makes irrigated agricultural practices uncertain.

### Credit organization and debt trap

Although a credit service is available, the number of customers is limited. At Hintalo Wajirat Woreda level less than 50 percent took credit. Of those who did not take up credit, over 70 percent depended on local moneylenders. The leading credit institution DECSI in Tigray has high repayment rates and does not look out for the welfare of its customers, particularly with respect to the repayment schedule, whereby farmers had to deal with the negative impact of having to sell agricultural products during a low price period in order to pay back their loan. Furthermore, the study shows that the majority of DECSI borrowers settle their debts by either selling their property including their oxen and/or by borrowing cash from local moneylenders, paying 5 to 10 percent interest per month.

### The practice of Woferit (sharecropping)

The study documents that Woferit (sharecropping) is widely practiced in Gum Selassa and Hewane irrigation systems. In

2001, 41.5% of men and 83.2% of women in Gum Selassa, and 44% of men and 56% of women in Hewane leased out their plots. 'Uncertainty of access to irrigation water' ranked as the first reason for leasing out land. This was followed by 'not able to purchase fertiliser' and 'being a woman I cannot plough'. A large majority of the plot holders make agreements with the farmers leasing the land to collect one-third of their harvest.

The study concludes that the need to access irrigable land is the main reason for tenant farmers to lease in land. Land fragmentation and landlessness have become major problems in the region. As cultivable land is limited, further land redistribution has remained difficult on the part of the government. Thus, woforit (sharecropping) has been opted for as a major mode of accessing cultivable land in the two tabias.

### **7.3 On the question of intervention by local government in everyday irrigation management and irrigated agriculture, and on the key interfaces and arenas shaping the interactions and outcomes between agency staff and farmers**

In principle, water allocation is the responsibility of the 'water committee' (in Hewane) and 'irrigation committee' (in Gum Selassa). However, uncoordinated water allocation decisions on the part of local government bureaucracies have compounded water scarcity in the irrigation systems.

#### **Irrigation governance and water control**

The study shows that the pattern of irrigation management has remained largely the same since the imperial regime. In all three regimes, 'irrigation practices are inherently political practices' (Mollinga, 1998:30), since the local government bureaucracy has been embedded in their management. Earlier the landlords and local governors, and later the Agriculture Department and local government bureaucracies were involved in decisions of water allocation and conflict resolutions. Farmers had very weak negotiating power over their water rights.

In Tigray, there has never been an irrigation agency responsible for irrigation management. In the mid-90s, the government established Co-SAERT, responsible for construction of irrigation infrastructure in Tigray. Likewise, since Imperial times, there has never been either a government-initiated water users' association or indigenous irrigators' organizations responsible for water management in the Hewane irrigation system. Farmers have been requested by the local government to elect Aferchecka and later Abo mai who handle the tasks of water distribution and canal cleaning and maintenance. The link created through Abo mai between the local government bureaucracies and farmers has made irrigation management an appendage of the local government bureaucracy.

The study shows that, in the absence of a legal framework, the regional government attempted to establish a water users' association by simply handing over the micro-dam to water users. It was an imposition on the water users. Many farmers were not involved in its establishment nor did they participate in the water users' association. Representatives like the chairman were selected in their absence. As one informant noted, 'until recently it was the agriculture office that administered the irrigation system. But now we hear that farmers have taken over the dam'. The government did not discuss with farmers the conditions of its transfer, the power of the water users' association, nor the role of farmers or government support to sustain the irrigation system. As Vermillion (1995: 146) notes 'where farmer organizations lack full legal and political recognition to make all decisions necessary to manage the irrigation system they appear to have difficulty achieving cost efficiency, raising adequate revenue, applying sanctions and entering into contractual relationships with their parties'.

The claims of Co-SAERT that dams have been transferred to water users' associations are bogus. In terms of governance, the status of the irrigation systems is unclear. Co-SAERT's objective to bring about sustainable agriculture and environmental rehabilitation in Tigray is questionable. Interestingly, the Commission has recently transformed itself into the Bureau of

Water Resources Development by merging agencies involved in the water sector, while the management of the newly constructed irrigation systems is unknown.

### **Irrigation management tasks**

Every year the Woreda irrigation committee has to decide on the area to be irrigated based on Co-SAERT's measurement of the quantity of dam water. The study has shown, however, that the size of irrigated plots did not correspond to Co-SAERT's estimation between the 1998 and 2002 production years. The irrigation committee does not take account of the dam water measurement of Co-SAERT. The power to allocate water in the Gum Selassa irrigation system is mainly in the hands of the experts of the Woreda Agriculture Department. Guesswork has prevailed thus ignoring the professional support of Co-SAERT. The guesswork in the water allocation has tempted the Agriculture Department to reduce the size of irrigable plots to obviate shortages of water.

Until 2002, not all of the 110 ha of farmland of Gum Selassa were supplied with dam water. The highest share of irrigated land was 78.4 percent in 2002/03 while lowest was 7.5 percent in 1998/99. It was noted that 16.3 percent of the irrigated plots in 2002/03 were 'rainfed plots', which were not supposed to get dam water. In other words, among the 550 farmers who joined the irrigation system initially, between 119 and 470 of them received no water for six years

In Hewane, water allocation to users is based on the principle of classifying plots into hayfo and mesno (irrigation). The mesno plots have water priority over hayfo plots because they entail the use of improved agricultural inputs. But the switching of plots from hayfo to mesno or vice versa often takes place.

In both irrigation systems Abo mais are annually elected to carry out water distribution tasks. The source of water influences their number. 12 abo mais serve at 15 diversions in Hewane while only four are assigned to do so in Gum Selassa where only some of obtain water day and night. The availability of seepage water in Hewane means day and night distribution. While the water distribution system is an established and accepted practice, it is not always accepted by individuals. Irregularities in

water distribution occur that lead to petty feuds. Rotational scheduling of water regulates access to water and is based on the principle that he who sows first gets water first. Blocks get water by turn according to the requirement of each crop. While internally rotations are largely accepted, appropriateness to improve crop yields is still only poorly understood.

Irrigators are involved in canal cleaning every year, although their participation is not as expected. The most serious issue in system maintenance is the disiltation of dams which is no ones work in Tigray. Experts of Co-SAERT have clearly indicated that most of the micro dams will not serve the expected life span time due to siltation.

The study shows that conflict resolutions are carried out at three levels, at field level involving irrigators, elders, Abo mais and development agents, at Department of Agriculture and tabia administration level, and thirdly, depending on the seriousness of the conflict, at the Maheberawe firdebet (social court) which can impose fines. Farmers often appeal to the local administration or Agriculture Department when they cannot solve conflict over water at field level.

### **Imposition of fertilizer technology drives farmers away from irrigation**

Farmers in Hewane and Gum Selassa lease out plots to sharecroppers due to the inability and/or unwillingness to purchase chemical fertilizer. The study shows that in Hewane and Gum Selassa over two-thirds of the farmers purchased fertilizer through coercive persuasion, with the fear that they might be denied credit, food aid or employment opportunities in various construction works or with the threat of no access dam water. Local government bureaucracies did not pay any attention to farmers' unwillingness to purchase fertilizer. In contrast, since farmers were not coerced to purchase improved seed, the numbers buying it was very low.

Policies that encourage farmers to participate in the implementation of agricultural extension packages represent a significant shift from the top-down approach. In theory, government officials and rural development workers support

the idea of farmers' participation from technology identification to technology evaluation in the implementation of extension services. The former Minister of Agriculture is recorded as saying:

*'It is always important to keep in mind that it is the farmer who decides on how to manage the soil. Hence, his or her views and perceptions are central to achieving [sic] sustainable pattern of management. These views will strongly be enhanced by the prices he or she receives on marketing the products, accessibility to inputs, access to credit, training opportunities, and a reliable moisture regime. If farming is not profitable, farmers are reluctant to venture on something different' (SOS Sahel, et al 2001: 39).*

In Tigray, agricultural extension was based on the diffusionist model. Agricultural workers and local government officials were preoccupied with achieving the targets set for fertilizer sales to farmers and as a result, recommendations on fertilizer application to demonstration plots were 'a one-size fit-all' solution. As Chambers, et al (1989: 23) argue:

*it is not uncommon to find extension staff distributing undifferentiated blanket recommendations to farmers, making no concession to their varied economic capacities and widely different farming systems.*

Such blanket solutions cannot work for heterogeneous farming population who Long (2001: 181) points out use a variety of strategies for solving the production and other problems they face. The perceived benefits of using agricultural packages have a marked influence on farmers' receptiveness. For individual farmers yield increase per hectare does not correspond to their technical and social conditions since local soil conditions vary a good deal, not only from one tabia to another but also from one field to another. Oliver de Sardan (1988: 222) also notes that 'the minimization of risks and the search for security are the focus of many economic

strategies. Mistrust of high yield varieties (more risky if effective rainfall is below the average taken into account by agronomic researchers), reluctance to adopt new crops when marketing is hazardous'.

Commenting on participatory extension practice in the dry lands of southern Ethiopia, Dejene (2000: 6) maintains that 'the participatory approach is therefore considered as essential if extension is to be more client-oriented. However, our field observation shows that these principles are not followed in the current extension system. What is being practiced is top-down'. Thus the Ethiopian governments desire to help people overcome poverty has resulted in spearheading coercive strategies in the name of 'participation'.

#### **7.4 On the question of local coping strategies in respect to drought and famine, and other food provisioning /livelihood strategies apart from farming**

##### **Coping strategies with drought and famine**

Local people employed a combination of four categories of coping strategies with respect to the 1984/85 drought and famine. All employed one or more of the depleting, maintaining, reductive and/or regenerative strategies to cope with drought and famine. Food relief ranked first as a strategy for survival under severe drought and famine situation.

##### **Livelihood strategies**

The data presented earlier indicate that the Hintalo Wajerat Woreda (district) is still food insecure. Over 30 percent of the population receives food aid. Gum Selassa and Hewane tabias are located in the same agro-ecological zone. Farming has been and still remains the main source of livelihood there. Except for the irrigators in the two irrigation systems, farmers depend entirely on rainfed agriculture. The intended level of food security has not been achieved in Gum Selassa and Hewane tabias (since 66 percent of the households consumed what they produced within 6 to 9 months), and therefore many people have to combine farming and non-farming or trading activities. However this is not easy for people since in Hintalo



Wajerat Woreda there is a lack of jobs available in the area.

The government's decision to deploy local labor during slack period on the construction of Shelenat dams had the unintended negative effect of halting the soil and water conservation project. This work was halted for over five years, aggravating the gully erosion and slumping in the tabia. In Hewane this agro-ecological problem, mediated by political power, compelled farmers to find something else. Bee keeping thus became a livelihood strategy as their harvests from the shrinking farmland declined every year.

Traditional bee keeping is expanding in Hewane. Conversely, the rate of adoption of government promoted modern bee keeping practice has been low. The constraints quoted were the unaffordable price of frame hives and the lack of technical assistance from the Agriculture Department.

The study documents few formal and informal social organizations such as Mahber (religious associations) and equb (saving groups). These are weak social networks for developing survival strategies.

## 8. Implications of the study

I repeat here some of the implications of this study pertaining to the issue of livelihood practice, household food provisioning, irrigation access, water control, and irrigation management and governance.

First, irrigated agriculture is a complex livelihood activity and thus the analysis of existing livelihood practices is essential before embarking upon irrigation intervention. Interventions that do not consider local people's life-worlds are likely to pave the road to underdevelopment.

Second, the regional government assumed that irrigators cultivating their own plots could achieve household food security. However, the majority of plot holders, particularly women headed households, as I have shown, lease out their plots and collect one third of the yield.

This had serious implications on food provisioning at household level since the anticipated amount of grain is not available for household consumption. Another factor was that the credit service, although an important input to increase agricultural production, operated loan repayment schedules coincide with harvest time when prices were at their lowest. This reduced their purchasing capacity at a time when grain prices were higher. In both instances household food consumption is affected.

Third, numerous socio-technical problems resulting from poor irrigation management frustrate irrigation interventions. These range from crop failure due to moisture stress, the lack of effective water harvesting strategies. Building irrigation infrastructure is less problematic than putting it to good productive use to service unmet demands.

Fourth, the study shows that irrigation system management is embedded in local government bureaucracy and sits uncomfortably between government bureaucracies and water users. The water users themselves or an irrigation agency might better be able to appreciate the performances of an irrigation system or deal with the issue of water equity. The local government bureaucracy, involved in numerous non-irrigation activities, finds it difficult to identify internal irrigation management problems encompassing water delivery schedules, and to make fair decisions in conflicts over water. On the other hand, the institutional viability of water user associations is questionable because of the absence of clear water rights which demotivates farmers from participating in irrigation management.

Moreover the distancing by the bulk of farmers from irrigated agriculture through leasing out their plots to sharecroppers provides a good indication of the lack of enthusiasm amongst them to commit themselves to irrigated cultivation. Sharecroppers, on their part, cultivate the land for a limited period (one or two harvesting seasons). It appears that there is no appropriate incentive structure for sharecroppers to take over the irrigation infrastructure while they are cultivating on temporary basis. Under such cultivation

arrangements it is not surprising that water user associations under-perform.

Fifth, bureaucratic performance highlights a lack of expert knowledge and capacity in designing functional systems that provide what is needed in Gum Selassa. Furthermore, the absence of water management expertise has been noted in irrigation scheduling in both sites.

## 9. Looking to the Future

The need for irrigation systems on the part of farmers of Gum Selassa and Hewane is there, but the provision of irrigation and agricultural services does not dovetail effectively with the life-worlds of farmers. Although the provision of water, land and agricultural inputs to irrigators is a big stride towards mitigating drought-induced famine, other measures must be put in place to enable irrigators to provide their families with adequate food.

- Inappropriate irrigation technology contributes to social disruption and a waste of resources. Thus, technology choices should be commensurate with the capacity of the final users of irrigation infrastructure. The technology choice appears to be uncritically adopted. Faulty maintenance of the infrastructure, seepage, siltation and environmental deterioration are obvious problems, which are not dealt with adequately.
- Irrigation development should take into account not only the provision of water but also the agricultural production system.
- Intrusive practices, such as coercing farmers to adopt modern agricultural technologies like fertilizer packages, are inimical. Farmers are knowledgeable and struggle to reconstruct life cycles to bring about security and dignity for themselves. Acknowledging this and giving greater respect to their own potential and options can enhance development intervention. New reflections on how to maintain soil

fertility and yield acceptable to farmers should be sought.

- The need for more defined and coherent institutional arrangements in irrigation development is essential. There is a need to have a clear and well-defined policy on the handing over of micro dams to farmers, which should be specific as to the respective roles of farmers and government after hand over.
- An area of concern is the preoccupation of government and NGOs to simply construct irrigation infrastructure to solve production problems in drought prone areas. In years of recurrent drought, rivers and micro dams dry out and groundwater levels drop. Hence, under these circumstances irrigated agriculture is more vulnerable to drought than some less intensive forms of agriculture. As farmers have smaller and smaller plots, irrigation development in these areas may not be a fully effective means to mitigate recurrent drought and food insecurity.
- Differential access to water contributes to weak operation of the irrigation system. The provision for special water distribution arrangements at times of water scarcity can increase farmers' participation in irrigation management.
- Considering recurrent droughts in Tigray, food aid probably needs to continue. However, there is a need to work out how to link food-for-work to sound and wider investments.

## 10. On the Need for Further Research

This study has attempted to look into the social dimensions of irrigation with particular emphasis on state intervention and life-worlds of farmers. It is hoped that more research will be addressed to the question of farmers' knowledge, to options for irrigation that recognize the life-worlds and environment of farmers, and to the technical optimization of

irrigation without the preoccupation for bureaucracy.

In conclusion, as Chambers et al (1989) say, like all development activities, irrigation works when it contributes to the individual's need for 'subsistence, security and self-respect', and that the 'environment can be made valuable by first valuing the people who live in it'.

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# Keeping an Eye on Decentralization and Specification of a Resource Policy: an Overview of the Policy Study to the Promotion of RWH

**Moges Shiferaw**

NCCR North South

Mogeshiferaw2002@yahoo.com

## **Abstract**

Recently, in Ethiopia, RWH as an alternative water supply option has received a lot of attention as development actors and scholars, has increasingly recognized the importance to mitigate the problem of physical as well as economic water scarcity. This has resulted in widespread agreement to work towards the promotion of RWH technologies and efficient use of rainwater resources. However, the attraction of many actors, on the other hand, resulted in varied perceptions over the use, management and promotion of rainwater. This in turn has resulted in a heated debate about the solution to the crisis of rainwater management among stakeholders. The stakeholders' debates over the crisis of rainwater management have usually proceeded in terms of a divergence between appropriate rainwater policy and state political commitment to implement plans, in which stakeholders are largely, followed the treatment that it would be desirable to make low political commitment, not policy, liable for the crisis of rainwater management. The author of this paper argues that all stakeholders including government have debated over the different angles of the same problem; some with the structure of rainwater policy (decentralization of policy) and others with content (specification of rainwater policy). Basically, they are all debated over a single problem that is about policy. The author, rather, believe that all the debates are justifications on the need of rainwater specific and decentralized policy, even, the wider gap in perceptions itself is the result of lack of sound rainwater policy. It is the author's strong contention that in the absence of specified and decentralized resource policy, it is unnecessary, even undesirable, to debate over crisis of a resource management. What is important is to keep an eye on the content and structure of a rainwater policy; all

the other problems are the by-products of a policy defects.

## **The Policy Study**

ERHA held its 2<sup>nd</sup> general assembly; members, representatives of government, NGOs, donor agencies and SEARNET met in Addis to discuss the different concerns of rainwater use, management and development. A number of papers were presented on different concerns of RWH, which ranged from technical to social. Presenters forwarded quite a large number of important recommendations based on their experiences and professional background. Finally, some critical questions were raised from participants: who were responsible for the implementation of the recommendations? How ERHA and the people could monitor and supervise the implementation of the recommendations? How can we make government accountable to the implementation of the recommendations? The participants were realized that these questions could only be answered from water policy document. To this end, one proposal came out of the workshop: to conduct a policy gap analysis that would help to understand the different policy issues that hinder the use, management and promotion of rainwater.

With this intention, The Ethiopian Rainwater Harvesting Association (ERHA) in collaboration with Southern and Eastern Africa Rainwater Harvesting Network (SEARNET) commissioned a policy research mandated to conduct a policy research that can examine the policy gaps and their implications in terms of rainwater harvesting, which could be used as an

input for policy advocacy that geared towards addressing the problem of domestic water supply, sanitation and household food insecurity. This paper is an overview of the final policy research titled Policy Issues to the Promotions of Rainwater Harvesting: The Case of Ethiopia, which was produced by the same author in December 2005.

### **How Serious is Ethiopia's Water Crisis?**

Water supply in many parts of Ethiopia is entering an era of physical and economic scarcity. As a result, the country is one of the most food insecure countries on the globe due to scarcity of water resources combined with frequent occurrence of drought. Today, water scarcity problem is more and more severe in Ethiopia due to the increase in the: 1) supply side problems- such as the increase in population pressure, degradation of the natural environment, increase in livestock pressure, the increase in cost of supply and the increase in demand for other uses such as industries; 2) demand side problems such as the increase in demand for different services of water by different users and sectors; and 3) structural side problems such as lack of effective and efficient water institutions that ensure equitable allocation of the nominally accessible water among users and use systems. This is exacerbated by poor performance of the water sector due to lack of effective water institutions (water policy, laws and administration). Moreover, since most rivers of Ethiopia are crossing borders; implementation requires negotiation with downstream countries, which is politically challenging not to mention the manpower and political constraints. This scarcity has contributed a lot to the social, economic, environmental and political crisis in the country. In this regard, mention can be made of the presence of: water borne diseases which account for 70% of total diseases; the fact that 40/75% of the urban/rural population has no access to clean drinking water respectively, 95% of the population has no access to electricity, the country has lost 25% of livestock due to the recent drought; and on average 6 million people are exposed to

recurrent drought annually including the surplus producing areas.

Agriculture consumes 86% of total water withdrawal and it is one of the sectors that have been suffering from high degree of water scarcity. The study conducted by DPPC (2001) revealed that the frequency and severity of drought seems to have increased from time to time even in the surplus producing areas mainly due to the late onset or failure of both the main and short rainy seasons. For instance, on average more than 6.3 million people are exposed to hunger on yearly basis. This has resulted in malnutrition and low level of calorie intake. CSA (2000) reported the impact of food shortage (malnutrition) on children under age five as one of the highest in the world with the level of 47% underweight, 52% stunted and 11% wasted, respectively.

According to the author estimation, the net scarcity of irrigation water for cereal production is increasing at a rate of 6.6%, which is the difference between estimated irrigation water demand growth rate and estimated planned irrigation water supply growth rate for cereal production. In other words, if we assume that irrigation is the only means to fully escape from cereal deficit and diversion is the only means of accessing irrigation water, Ethiopia has to increase its irrigation water supply for cereal production by 7% annually or increasing the current plan of agricultural water supply by 6.55% annually. The estimations further reveals that given the current status and irrigation water supply plan, Ethiopia will require 77 years to fully escape from 2004 cereal deficit, which will require 4247 million m<sup>3</sup> of additional irrigation water. The current irrigation water supply plan for cereal production will only reduce 23% of the 2004 cereal deficit at the end of the planning period (2016). The estimation was done based on WHO standard of calorie requirement with certain assumptions like all water development plans will be realized and rainfall will be normally distributed (year 2001 production as base year). One can imagine how the late onset and uneven distribution of rainfall, and ill-performance of water development plans, which happens most often, can further aggravate the scarcity of water for agricultural production.

Next to agriculture, domestic water supply is the second high water consuming sector in the country. The domestic water coverage of the country is very low both in urban and rural areas. The national water coverage at the rate of 15 lpd for rural areas and 30 lpd for urban areas is estimated to be 15% and 65.5 % excluding Addis Ababa, respectively. About 40% of the existing rural water supply schemes are not functioning and people have to travel long distances to fetch unsafe water from rivers and other sources. Water is a health issues for about 75% of the population, who does not have clean potable water, and 92% of the population, who does not have access to adequate sanitation facilities. The coverage varied across regions. According to the author's estimates, assuming all the current plans are realized and if domestic water supply is to be continued in the same rate, Ethiopia will require additional 3 years and 11 years (after 2016) to achieve the MoWR recommendations (50lpc to urban areas and 25lpc per day to rural areas) of the 2004 and 2016 domestic water demand respectively. On the other hand, to achieve the 2004 UN recommendation (50lpc), Ethiopia will require additional 23 years from 2016. The most important domestic water supply in rural areas comes from groundwater sources even if the total available ground water potential of the country is not yet certainly known.

The above two sectoral scarcity analyses provide strong evidence that the current water scarcity gap is very high and it will continue even after 2016. These problems call for a new approach that enhances efficient management of the available water resources and identification of alternative freshwater augmentation technologies. To resolve the water scarcity problems, Ethiopia issued a water resource management policy in July 2000 with the overall goal of enhancing and promoting the national efforts towards the efficient, equitable and optimal utilization of the available water resources for the socioeconomic development of the country in a sustainable manner. Based on this policy, the country also developed Sectoral Water Development Strategies and 15 years (2002 to 2016) Water Development Programmes in 2001.

## **What Potential Roles Could RWH Play to Reduce the Water Crisis in Ethiopia?**

The research confirmed that rainwater has a potential role to contribute towards the multi-sectoral national development policies; and there is also a fertile ground (natural and utilization potential opportunities) for rainwater to play its vital role in all sectors of development. For instance, rainwater can help to achieve the national water management policy objectives through: i) improving the sustainability of water use as rainwater is a mother source of all water; ii) enhancing equity of water use across regions as the only viable water sources in moisture stress areas; iii) enhancing groundwater potential; iv) maintaining the hydrological balance (water cycle); v) mitigating over flooding due to excess rainwater; vi) improving efficiency of water uses and cost of water supply; vii) increasing the negotiation power of the country over the use of trans boundary rivers; viii) improving the success of watershed management and environmental protection interventions; and x) improving the different water services demand of users and sectors. Hence, rainwater management is the “ice-cream” of all other water resources management. It could be one of the key alternatives for the achievement of the national water management policy targets. It could also help to address both the cross cutting and sectoral objectives of the national water management policy.

Moreover, rainwater could also help to addresses the five strategies, Ministry of Agricultural and Rural Development strategies that have been designed to deal with food insecurity problems of moisture stress areas of the country. These are:

- i) Emergency assistance, which refers to provision of food and water without being displaced either through food for work for those able to work and free handout to those who are not capable of working;
- ii) Resettlement program – transferring a certain section of the drought affected people

to areas where there is enough water and fertile land;

iii) Natural resource development and development of animal resources, which is the strategy aiming at reducing the pressure on land by shifting the livelihood of people from cultivation to rearing of animals;

iv) Improving water resources utilization by promoting the utilization of ground and surface water so as to satisfy the different needs of the people; and

v) Soil conservation.

Thus, rainwater harvesting could be one of the most important options to address the policies and strategies of drought prone areas of the country including the settlement areas (since these are areas where there is no any form of water supply structure before). This is basically true for two reasons. First, the policy strategies create an enabling environment for the promotion of rainwater harvesting. For instance, the emergency assistance through food for work could be used as resources to finance natural resources development, soil and water conservation activities. On the other hand, conservation and efficient utilization of rainwater mean addressing food security through reducing soil erosion (increasing soil fertility), developing the environment (enhancing sustainability of resources use) and accessing the different services of water including source of water for livestock and pasture development. Besides, the major water consuming sectors, RWH can play a vital role in improving the water supply of livestock, wildlife, rangeland development and nursery site development. It can also help to mitigate emergencies created due to shortage of water (drought) and flooding.

Ethiopia has a fertile land, untapped rainwater potential and use opportunities, which could make rainwater utilization less costly as compared to other alternative sources. There are plenty of concrete evidences that support Ethiopia has untapped runoff potential due to the existence of conducive climate, soil type and land surface characteristics. For instance, in some parts of Ethiopia it is common to exercise

cultivation as steep as 30%. This has resulted in high yield of runoff associated with high level of erosion. Only 3% of the land is covered with forest. In most parts of Ethiopia, especially in the northeast, the vegetation cover including bush is becoming smaller and smaller for a number of reasons. This means that the country has high runoff yield as a result of low vegetation cover, among other reasons mentioned above. Most parts of Ethiopia are characterized by high amount of rainstorm amount, high yield of runoff. The rainstorm in the lowland area of Ethiopia is characterized by high intensity; meaning rainstorms intensity exceeds the rate of infiltration of the soil, resulting in high level of runoff. The distribution of rainfall is also one of the important factors that determine the yield of runoff, which is quite suitable in the case of Ethiopia.

Ethiopia is also rich in rainwater use opportunities (rainwater collection, storage and supply facilities). Since 560 BC, even before, Ethiopian people used different traditional rainwater collection facilities. For instance, roof harvesting of rain such as the use of church and school roof have long time experience in Ethiopia (Thomas et al, 2004). State promotion of rainwater-harvesting structures was started in 1970s to reduce soil erosion and as alternative intervention to address water scarcity. Other organizations like NGOs and bilateral agencies have been involved in soil and water conservation activities long time ago. Currently, a total of 450,000 modern rainwater-harvesting structures (RWH tanks/Cisterns, ponds and hand-dug wells) were constructed in four regions of the country in 2002/03 and 2003/04 (FAO, 2004). Existence of corrugated iron sheet roof, for instance, according to CSA estimate more than 50% of the population is living in houses made of corrugated iron sheet roof; the current rate of urbanization (9%) and high population growth (increasing number of houses); and the progress in the construction of social facilities such as roads, schools, health centers and other institutions will also show the availability of rainwater use opportunities.



## What RWH Actions are undertaken in Ethiopia?

Recently, rainwater harvesting as an alternative water supply has received the attention of the government, civic society institutions, NGOs and donor agencies. Accordingly, some efforts have been put in the last 3 years to the promotion of rainwater harvesting and some promising results are observed in terms of addressing the problem of domestic water supply, sanitation and household food insecurity. A number of RWH promotion activities have been undertaken in relation to food security both at national and regional levels. Introduction of new technologies from abroad; preparation of technology packages, piloting of technologies, preparation of training modules and conducting training are some of the promotional activities. For instance, achievement reports indicate that 38,338 shallow wells, 205,787 household and 49,311 community ponds, 5,632 cisterns and 32,727 springs have been constructed and developed so far. These structures are estimated to irrigate 93,326 hectares of land, which will benefit 732,336 households with an average family size of 5. RWH courses are given in 25 Agricultural TVET colleges for 37, 582 students (Lakew, 2004)

Rainwater harvesting for irrigation is promoted following two different approaches, individual and community based. Both of them are promoted by the Ministry of Agriculture and Rural Development and its respective regional bureaus. Sasakawa Global 2000 (SGS 2000) in collaboration with the Ministry of Agriculture and Rural Development has been promoting individual approach at pilot project level. The Ministry of Agriculture and Rural Development (MoARD) also gives more attention to individual approaches with the aim of achieving household level food security. In the individual approach, the water is fully managed by individual water owners and the owner is also expected to cover the lion's share of the cost of the infrastructure. In the case of communal rainwater harvesting, the system is fully managed by the user community and the community is responsible to contribute labor and local material.

## What is the Nature of Rainwater Management Crisis in Ethiopia?

Even though the multiples role of rainwater is widely recognized, it might be surprising that it is one of poorly managed sub-water sector in the country. The sub-sector is generally characterized by low economic, social, environmental, financial, technological and institutional performances. For the sake of simplicity, the author classified the overall crisis of rainwater use, management and development into four categories of performances namely, performances of introduced technologies, performances of technology promotions, performances of use efficiencies and performance of management.

**Performances of Technology Promotion:** - the performance of technology refers augmentation of RWH technologies, which can be measured from the deviation of the national RWH promotion plan. For instance, as compared to the 2004 national RWH promotion plan, the realized number of rainwater harvesting structures introduced during the physical year is by 50% less than the national target (MoARD, 2004) mainly because of inappropriate and unrealistic plans (quota system).

**Performances of Introduced Technologies:** - besides, the low limited number of introduced technologies (low promotion), the performances of the introduced technologies accomplishing far less than what had been expected, if not disappointing, in many areas of the country. Some evaluation reports indicate that most of the newly introduced RWH technologies had failed to achieve the physical targets in most regions of the country (in some regions up to 80%) due to low social, economic, ecological and institutional feasibility to the local context, in addition to technical problems.

**Performances of Use:** - the problem of RWH is not limited to the failure of introduced technologies in terms of achieving the physical targets, but also the use of feasible technologies and accessed rainwater resources. It is observed that poor operation and maintenances of feasible technologies, inefficient and

inequitable use of rainwater resources are also common in most regions of Ethiopia. This is mainly due to lack of policy instruments that provide incentive for collective action; investment for operation and maintenance; and efficient utilization of feasible technologies.

**Management Performances:** - lack of clear regulations on rainwater management has resulted in conflict among stakeholders on the use, management and promotion of RWH. Some of the reported problems include: lack of integration of uses; ignorance of environmental role of rainwater; lack of collaboration among actors; conflict of interest and approaches among implementers; conflict over the use and management of runoff; duplication of efforts and resources; lack of continuity of efforts; instability of implementation organs and confusion of roles, responsibilities and authority among actors; and poor maintenances and operation of communal RWH structures.

These performances problems have resulted in underutilization of the country's rainwater potentials and opportunities. This has made the contribution of rainwater to the national development plan insignificant as compared to the expected potential, but rather, under utilization of rainwater has resulted in loss of soil, ground water potential and hydrological balance of the country. This is because; unlike other resource potentials, runoff potential demands special attention for five reasons. First, it is harmful potential leading to soil erosion, if not utilized. Second, there is always a tradeoff between runoff potential and other resources potentials such as ground water. Third, the potential is created at the expense of other benefits such as soil erosion and deforestation. Fourth, it is a "perishable potential" unless we store. Fifth, under utilization has negative implication on the hydrological cycle of water and sustainability of water use. Thus, unless some actions are taken, underutilization of rainwater could affect the development of the country through reducing the potential of other economic resources such as land and other sources of water; and through increasing the economic and physical scarcity of the different services of water.

## **What are the Real Debates over the Management of Rainwater Crisis?**

RWH as an alternative water supply option has received a lot of attention as development actors and scholars, has increasingly recognized the importance to mitigate the problem of physical as well as economic water scarcity. This has resulted in widespread agreement to work towards the promotion of RWH technologies and efficient use of rainwater resources. However, the attraction of many actors, on the other hand, resulted in varied perceptions over the use, management and promotion of rainwater. This in turn has resulted in a heated debate about the solution to the crisis of rainwater management, use and development among stakeholders.

The author identified four lines of debates from the regional workshop. The debates were generally twofold: debates on core problems of rainwater use, management and promotion crisis; and debates on root causes of the problems. Accordingly, the two core problems of rainwater use, management and promotion crisis are the existence of inappropriate policy and poor implementation; and the two main root causes for the occurrence of the core problems are lack of capacity and political commitment. The first group (Group A) of stakeholders argues that the existing national water resources management policy and implementation capacity is sufficient enough to address all concerns of rainwater use, management and promotion. According to this group, what Ethiopia lacks is the political commitment of the government to put policies into practice.

Similar to the first group, the second group (Group B) also argues that the national water resources management policy and government political commitment is fair enough to manage rainwater resources, but government has limited capacity to put the policy into practices. Group B believes that enhancing the capacity and efficiency of government institutions is a solution to the current crisis.

Unlike the first and the second group, the third group (Group C) advocate on the need of

rainwater management policy. This group argues that the current national water resources management policy is not enough to address the different concerns of rainwater resources management. Group C argue that government knows the fact very well and has also the capacity, but what it lacks is the political commitment to develop a sound water policy for rainwater management.

The fourth group (Group D) on the other hand argues that even if government is politically committed and knows the problem very well, it has not the capacity to implement sound rainwater policy. Generally, group A and B argue that implementation is the main problem of RWH and the solution is also to enhance implementation. Group C and D on the other hand advocate for the importance of rainwater management policy. Besides, these four single solution groups; there are also groups who argue on combination of causes, cause sources and solutions. All argue that the solution is to resolve the root cause of the core problems. The solution quadrants of each group are summarized below.

Accordingly, for Group A /Group B, the solution is to enhance the political commitment/the capacity of the state to put the

**Table 1. Core problems and root causes of rainwater use and management as identified by regional workshop**

Core problems	Root Causes	
	Political commitment	Capacity
Policy	I	III
Implementation	II	IV

I-IV = Group ID during regional workshop

existing policy into practices. On the other hand, for Group C / Group D, the solution is to enhance the political commitment / the capacity of the government to develop sound rainwater policy.

However, these differences have resulted in rainwater harvesting technologies and institutions to be under pressure to change in

most regions of the country. Every where, there is a challenges for rainwater resources and technology management posed by efficiency, equitable and sustainability debates and a relentless reshaping of rainwater technologies and management institutions are going on both at national and regional levels. Moreover, the differences in perception among stakeholders have further aggravated the problem of RWH. This is because, the differences in perceptions has led to some confusion.

The confusion has created four unintended negative outcomes. First, it discouraged policy makers from taking an immediate corrective policy action since policy is politically sensitive that requires first to check the social acceptability of a policy action. Second, it has increased the complexity of policy advocacy for civic society institutions like ERHA, difficult to create a pressure group for effective policy advocacy. Third, it has increased the demand of robust analytical methodologies before any decision so as to ground recommendation discussions and to defend options against their recommendation, which could increase the cost of advocacy and policy recommendation. Fourth, it has hindered the collaboration of efforts and resources among actors, but rather, it has promoted implementation of uncoordinated and conflicting approaches of rainwater management. It is found that breaking the dilemma between alternative solution options among stakeholders is part of a solution to the current crisis of rainwater use, management and promotion. Then, the next question will be how can we break these dilemmas?

### Can Policy Break the Stakeholders Dilemma?

Despite the differences, all groups argue that the problems of RWH are related to either lack of government political commitment or capacity limitations or both. In other words, enhancing the political commitment to implement or develop a policy and improving the capacity limitations to implement or develop a policy are the solutions to current rainwater resources management crisis. The debates further confirmed that government is

both part of core problems and part of core solutions to rainwater resource management. Therefore, the question would be: how can we make government politically committed to implement and develop appropriate policies? How can we improve the policy formulation and implementation capacity of a government? The author argues below that it is only through policy that we can make government politically committed and get the capacity improved.

According to Len Abrams (2002) policy is defined as a set of decisions, made ultimately by the highest political level in a country after a process of dialogue and consultation, which determines what and how things will be done in any given sector. Policy in terms of resources management refers to the setout of a framework and guidelines as to how the resource in question is optimally utilized, managed, protected and conserved in a sustainable manner so as to enhance the overall economic development of the country. Thus, policy is the most important component of a water institution that influences the overall performance (economic, physical, financial and social performance) of a water sector directly and indirectly through determining the mandate of administration, the demand of capacity, legal implications and many other concerns of resource management.

A resource policy can play a multiple roles; it can serve as a framework for donors, civic society institutions, the people and government itself to examine performances of plans and political commitments. Generally, a resources policy can serve as framework: i) for donors, civic society institutions and the people to monitor and supervise the political commitment of a state towards a resource; ii) to setout the strategies and plan of a resources management, which later used as standard for the people and civic society institutions to evaluate planned achievements; iii) to make leaders accountable and transparent to their plan and political commitment; iv) to check the degree of people and other actors participation, which allow them aware of a resources development and management plans and strategies; v) to influence the inclusion of people interest and preferences in the resources management; vi)

for government to allocate resources and manpower in a sustainable manner; vii) for government to undertake follow up the progress and to identify gaps of implementation so as to take corrective actions; and viii) for government to set appropriate legislation, institution and resource administration set up. Hence, absence of a resource policy means that there is no way to make government accountable and transparent to its plan and political commitment; for civic society institutions, donors and the people to monitor and evaluate planned achievements; for government itself to check its performances and to take corrective actions; and to check continuity and coordination of efforts, and integration of uses etc.

The above conventional argument to the demand of policy clearly indicates that policy can make government accountable and politically committed to its policy, plan and strategy. A resources policy can also indicate the areas of capacity limitations that create an enabling environment for donors and other civic society institutions to provide appropriate supports. Governments had policies in the past and they will have in the future. However, these policies too often did not translate into actions. This is mainly because they lack transparency that both the people and civic society did not know about them so as to keep their eyes on implementation of those policies. Given this experience, breaking up the current debates with the conventional argument is unthinkable. Because, this experiences force us to answer question like: what makes then government accountable to policies? Here, we are not interested to debate why some governments are accountable to their policy and others not? Rather, we are interested to know what types of policy makes government accountable and transparent? This defiantly requires in-depth analysis of a policy in question. To do this, the author employed other description of a policy to further argue inline with the debates.

According to the author, a sound policy has to be evaluated from its content and structure. The content of a policy can be measured by the degree of policy specification. The degree of specification determines how the “rules of the game” that governs the relation, behavior and

action of all stakeholders in relation to a resource use, management and promotion or development are specified and qualified. In principle, the higher the degree of a resources policy specification, the better will be the use, management and development of a resource. This is because the higher specification of a resource means a more clarification on rights, obligations and conditions of use, development and management of a resource and a resource use infrastructure. The content of a policy has two dimensions: i) incentive dimension- that provides the incentive to invest on a resources, efficient use of a resources and coordination of efforts and resources towards the same goal; and ii) regulatory dimension, which provides the security to enjoy with the pre-defined rights. The regulatory dimension of a policy imposes regulation over externalities, which in turn avoids all sort of conflict between users, use types, regions, sectors and implementers. More specifically, the specification of a policy provides an enabling environment for all stakeholders:

- i) For end users - it provides the incentive and security to invest on RWH technologies and efficient use of rainwater resources and technologies in a sustainable and equitable manner;
- ii) For implementers- it provides the incentive for collaboration and integration of their efforts towards the same goal and vision;
- iii) For donors – it provides a clear framework to decide where and when to provide the right support and to monitor the achievements of their contribution;
- iv) For civic society institutions- it provides a clear framework to keep an eye on the implementation of policies and to identify gaps of implementation for policy advocacy; so as to make government accountable to the people and its plans;
- v) For the private sector- it provides the incentive to invest on alternative water saving RWH technologies for end users; and

vi) For government- it will be used as a guideline for strategy formulation, planning, resources allocation and monitoring and evaluation of resource sector performances. So sound policy determines the “rule of the game”, which governs the relation, behavior and action of all stakeholders in relation to a resource and a resources infrastructure.

The structural part of a policy, on the other hand, has to be measured the degree of decentralization of a policy. It is supposed to address the question, what type of policy structure provides incentive for efficient and effective implementation of a policy in question. Unlike the degree of policy specification (content of a policy), decentralization of a policy (a policy structure) determines the achievements of targeted development and RWH promotion plans and performances of introduced technologies. Thus, structure of a policy determines the efficiency and effectiveness of a policy; where as content of a policy influences the action and behavior of stakeholder over the use, management and development of rainwater either through providing incentive or imposing restrictions. In principle, the higher the degree of decentralization, the higher will be the efficiency and effectiveness of a policy implementation. This is because a decentralized policy provides quite a number of incentive structures to improve efficiency and effectiveness of policy implementation. Since rainwater is micro in nature, decentralized policy structure has a number of advantages over centralized policy structure.

Decentralized policy structure, among others: i) creates an enabling environment for the existence of good governances at local level, so that it forces local leader to be accountable and transparent to the people in terms of rainwater development plans and strategies; ii) creates the participation of people in the process of policy formulation, strategy design and planning, which will allow people to voice their interest, demands and preferences of rainwater use, management and development; and iii) provides incentive for people to participate and to committed themselves for the implementation of RWH policies. These and other advantages of decentralized policy structure improve the

social acceptability and feasibility of a rainwater policy. The social acceptability reduces the cost of policy implementation since the cost of compliances and policy enforcement will be minimal. Feasibility (economic, social, political and environmental) on the other hand has a direct implication on the achievements of planned targets (RWH promotions and development plans) and the performances (economic, social, financial, institutional and physical) of introduced RWH technologies. Therefore, decentralized policy structure is effective because it minimizes cost of policy implementation; and it is efficient because it allows achieving the targeted development plans and targeted technology performances.

Surprisingly, the above analysis justifies that all stakeholders including government are concerned with the different angles of the same problem. Some are concerns about the structure of policy and others are concerns about the content of a policy, but basically they are all debated over a single problem that is policy. The dual interpretation of this is that all the debates are a confirmation to the importance of policy, even, the wider gap in perceptions itself is the result of lack of specific and decentralized rainwater policy. Policy as we have seen it above is a central framework that shapes both the structure and the content of implementation and political commitment. Hence, in the absence of policy, it is unnecessary, even undesirable, to debate over crisis of a resources management. Thus, we can generalize that the root of a resource management crisis is lack of specified and decentralized structure policy; the other problems are the by-products of the process of policy formulation and implementation, which can be shaped and managed at any time in accordance with the policy framework.

Nevertheless, the optimal choice on the degree of specification and decentralization of a resources policy has to take into account both the gain and the cost of policy specification and decentralization. The gain can depend on the nature and the value of a resource to the national economy. One cannot expect the same degree of policy specification and decentralization for petroleum and water. For instance, for petroleum we might need high

degree of policy specification that clarify the rights and obligations of petroleum use and management, but it has to be supported by highly centralized policy structure. This is because; decentralization of petroleum (high value resource) management policy can create inequality between regions of a country unless it is managed by the central government. On the other hand, policy specification and decentralization brings quite a number of changes on utilization, management and development of a resource and also on institutions, legislations, technologies of use, budget allocation and so forth. These changes, on the other hand, can bring both unintended and intended social, economic, political and environmental implications over the use and management of a resource. Thus, before any resource policy recommendation, one has to critically examine the net gains from a resource policy. In the coming section, we try to examine the added value of rainwater policy specification and decentralization on the use, management and promotion of RWH technologies.

### **What Policy Gaps and Implications did the Policy Research find out?**

Generally, Ethiopia has different water related general and sectoral policies that are designed to address the sectoral demand of water through integrating the different sources with the intension that these policies can manage the different sources of water in a similar fashion. All the existing policies developed at federal level within the mandate of the respected federal Ministries. So far, there is no policy developed at regional level as far as water is concerned. Accordingly, the federal Ministries “in consultation with the respective regional bureaus” compile most water development strategies and plans. Thus, the regional states have to work within the framework of the federal policies, strategies and plans. These policies are, therefore, characterized by centralized structure and non-source specific in content; the policy gaps have to be examined accordingly. For instance, the only rainwater specific statement that one can find throughout the policy document is the general policy objective No.15, which states as:

Promote and enhance traditional and localized water harvesting techniques in view of the advantages provided by the schemes' dependence on local resources and indigenous resources.

And one statement in the document of implementation strategy

Emphasis will be given to water harvesting methods to enhance small scale irrigation development in areas where wet season runoff can be stored and used for food production through constructing dams based on seasonal runoff

Now, the question is: are these centralized structure and no-source specific water policies sufficient enough for RWH to play its vital roles and to manage rainwater resources and technology management crisis? In other words, does specification and decentralization of rainwater policy could lead to positive overall performance gain in RWH? Answering this question demands to understand the implications of policy gaps (lack of rainwater specific policies and decentralized policy structure) on the overall performance of rainwater resources and technology use, management and promotion. However, due to lack of empirical data on cost and benefits of rainwater policy, the analysis is limited to examine policy gaps and their implications, rather than calculating the net gain from policy. Moreover, lack of different policies structures in the country does not allow us to disentangle the gain from policy specification from policy decentralization. This has urged to use policy content as a framework of analysis and policy structure as a supporting case for explanation. But, any failure due to lack of incentive and regulation is accounted to policy specification problem, while any failure due to inappropriate plans, inappropriate strategies and infeasibility of RWH technologies to the local context is considered as structural problem of a policy. Below, six major policy components are identified to examine the detail of the policy gaps and their implications. These are: environmental, legislation, economic, technological, institutional and social component, which are discussed in a separate sub-section.

## **Environmental Component of a Rainwater Policy**

Environmental component of rainwater policy is supposed to addressing sustainable use of rainwater through influencing the water conservation, utilization, protection and development action and behavior of users towards the preset standard quality and quantity. In this regard, the soundness of a rainwater policy from its environmental aspect is identified to be measured by the existence of policies related to: i) abstraction control (limit of quantity of utilization); ii) water quality control (standard of qualities); and iii) pollution control. These restrictions are believed to influence the behavior and action of rainwater users and use systems, which could reduce over extraction or over use of rainwater; and improves the equity and sustainability of water use among users and systems. A water policy that misses one or more of these restrictions on the use of rainwater would lead to poor achievements of environmental conservation efforts, unsustainable use of water, and imposition of use externalities.

Poor achievements of environmental conservation efforts- there are a number of evidences that support soil erosion or land degradation in the high land parts of the country is the result of high concentration of rainfall, reaching annually up to 2200mm. To curb the problem of soil erosion, a lot of soil and water conservation program have been designed both by the government and NGOs; quite a lot of soil conservation techniques and methods have been introduced across the country; a number of soil and water conservation researches have been conducted, workshops were organized and recommendations forwarded at different levels. Despite all these efforts, the achievements are far less than what had been expected. Soil erosion and land degradation is still one of the critical problems, especially in the highland parts of the country. The country water policy stresses on the importance of basin watershed management approach. However, it is believed that micro level intervention is an appropriate strategy for RWH since it protects the land from degradation, the water from wastage. For this to happen, it entails the adoption of household-

level catchments approaches and micro catchments watershed administration, which is not the case.

**Unsustainable use of water resources:** - lack of rainwater specific policy that set out appropriate strategies and plans for unsustainable use of rainwater has reduced sustainability of water uses. In rainwater harvesting, the main interest is on the surface runoff which is the portion of rainfall that runs into rivers and finally into lakes and Oceans. The other part of rainfall is used for groundwater recharge, transpiration, and root zone of plants. Therefore, rainwater as a mother source is the base to maintain the hydrological cycle of water, sustainability of water use. For instance, the water and soil conservation strategies adopted so far are not user and rainwater centered, rather they are land centered. The approaches have been giving little attention, if any, to the opportunity benefit of rainwater. In those approaches rainwater is considered a threat (cause of soil erosion), which has discouraged conservation of water in different forms. Today, those areas have been suffering from physical scarcity of water due to lack of ground and surface water potentials.

**Encourage imposing environmental externalities:** – lack of limit on the abstraction of rainwater, which has resulted in lack of clear rights and obligations on run-off, has resulted in conflict over resource use that the upper catchments owner imposes externalities (over flooding or pollution or appropriation externalities) on down catchments user. For instance, provision externalities, upper users imposition of flood on down stream user, is common in Amhara regional state; and appropriation externalities, head users appropriation of more water against end users, is also a common problem in Tigray regional state.

In conclusion, RWH friendly environmental policy should: define the rainwater abstraction quantity and quality rights and obligations of users; define rules and regulation that governs the limit of abstraction in environmental friendly ways; clarify the implications of micro level watershed management administration; clarify the rights and obligations of user's

watershed management; and clarify catchments rights and put an obligation on the owner to bear the cost of damages created by inappropriate management of his catchments runoff. In other words, the environmental policy of rainwater harvesting should stress on the definition of rainfall catchments rights (abstraction and quality rights) and obligations (abstraction limits, pollution levels and quality standard) based on environmental friendly criteria.

### **Legislative Component of Rainwater Policy**

It is observed that rights over different attributes of rainwater and security of those rights have a significant influence to the management of rainwater resources and technologies. The two most important resource rights that hindered the management of rainwater resources and technologies are identified to be land and water rights. These rights hinder the performances of RWH through influencing the soil and water conservation behavior and action of resource users; the adoption of new technologies, techniques and practices of rainwater harvesting; and the incentive to invest on land and water resources.

### **Water rights Vs Rainwater Harvesting**

In Ethiopia water is the common property of all Ethiopians, and all citizens have the right to get access to water based on the rules and regulation of the government (MoWR, 2000). There are a lot of communally owned rainwater harvesting structures in the country, most of which are performing very poorly due to lack of timely maintenance and operation. Most scholars argue that the level of community participation determines the success of communal water conservation structure. In Ethiopia some actors including the government, participate and mobilize the community resources at all stages of the project so as to create a sense of ownership. Not only that they also hand over the final rainwater harvesting project formally to the community. With all these processes, the success is not attractive and researchers still recommend the continuous follow up of rainwater harvesting structures by



the responsible government organs. We argue here that it is not participation per se that determines the success of RWH, but rather, the involvement of end users at all stages of the projects. Community involvement, however, requires enabling policy environment that enhance collective action. Water tenure system is one of such policy instruments that enhance community involvement for collective action. Moreover, security of the water tenure system enhances the adoption of new rainwater harvesting technologies, methods and improved soil and water conservation practices and the willingness of resources users to invest in RWH, be it in the form of capital, labor or material.

Our field observation has also confirmed this fact. In Tigray, Amhara and Oromiya regions we have observed that clear definition of communal rights, individual rights with in the group and complete devolution of water management power to end users has improved performances of RWH technologies. It is observed that appropriate right should not be limited to water and the physical structures of the rainwater, but it has to also include the right of making decision at all stage of the project. The RWH rights have to be catchments right, i.e., right should be inclusive of land, water, vegetation, rights of the rainwater catchments in question. The other non- resources rights should also include the right to determine crop and method of cultivation; the right to determine the techniques, methods, technologies and practices of water harvesting; the right to protect the land against conversion to other uses, the right to determine the type of land use, method and practices of soil conservation activities, the right to determine the method and finance of rainwater harvesting structures, the right to determine the use of harvested rainwater and inter sectoral transfer.

It is also observed that the traditional communal schemes have shown better performance and sustainability of physical structures (operation and maintenance of scheme are done on time) as compared to government initiated projects. The discussion we had with the communities of communal RWH users revealed that the communities does not feel a sense of ownership at all. But, they had contributed resources and

labor because of government mobilization; they might call such contribution. In some areas like Fogerra district of the Amhara regional state, community members are not willing to use the structures. They rather feel that RWH structures are sources of health problem due to health officials' awareness raising. They even attached it to famine (bad luck to the future) since its promotion is attached to food security intervention with food security budget donated by aid agencies. As a result, the community felt that RWH structures are donors and/or state property and, therefore, they should be responsible for maintenance and operation. The community felt that they are only responsible to report the problems to owners (DAs or other government officials). In those areas, community awareness raising and water right clarification might be priority policy issues, before any project intervention. It is observed that the size and homogeneity of groups and capacity of leadership plays a significant role for the success of communally managed RWH structures. In the case of private RWH structures, however, land transferability right, price of water from other sources, expected benefits from rainwater and level of government intervention determine the willingness of individuals to invest for maintenance and operation of the rainwater harvesting structure.

### **Land rights Vs Rainwater Harvesting**

RWH not only requires transparent water right but also transparent individual and communal land tenure systems. Land tenure is a system of land ownership governed by the land law and land policies. In Ethiopia land belongs to the state and citizens. The user has the right to use the land for an indefinite time. Since rainwater harvesting involves long-term investment and the user requires a tenure system. For instance, rainwater-harvesting structures owned by private owners have shown better performance than the communal ones. This is because in the case of private RWH structures, the owners have the right to exclude outsiders and the ability to reap the benefit of labor and capital invested for rainwater collection either through sale or direct use. However, lack of transferability right of land in the form of mortgage, sell and collateral has affected the

adoption of rainwater technology in three ways. First, restriction on transferability of land in those forms (mortgage, sale and collateral) reduces the incentive of farms to adopt land-based water harvesting technologies. For example, farmers in Awe zone of Amhara region are not willing to have private rainwater harvesting structure in areas, which are far from their residence places. This is because; they feel that land nearer to the homestead is the most secured area that is not affected by future land reallocation. Second, restriction on market transferability of land reduces market exchange of land and also investment values on land including rainwater-harvesting technology since its transferability right is attached to land. Third, restriction on transferability of land reduces the possibility of using rainwater-harvesting structure as collateral to get access to capital. Rainwater harvesting structures can be used as important collateral assets. However, it has value to potential lenders only if the owner is able to transfer his right to the lender to the extent that it can be sold to third parties, in case of default. Thus, what is important is not the ownership of land per se, but rather it is the completeness (the existence of the three dimensions of land property rights) and quality (divisibility of rights) of land rights that determine the success of adopting rainwater technology, techniques and new water conservation practices.

Land right also affects the distribution of water. For instance, in Tigray region use of runoff from communal land exacerbates conflict, whereas in Amhara region, upper users' imposition of externalities (over flooding) on down stream catchment users is becoming the main sources of conflict. Both of them need to be tackled through incentive and/or deterrent policy measures. The problem with communal land right is very severe since users have no complete exclusion right leave alone the transferability and security right dimensions of a property right. This has reduced the incentive of individual user's collective action towards the development of rainwater structures. That is why in most of the cases the communal rainwater harvesting structures are initiated by external entities be it government or NGOs. This has resulted in low social, economic, physical and financial performances on

communally owned rainwater-harvesting structures. The external actors have also ignored the policy variables and they are focusing on technical feasibility of structures. However, field experiences tell us that how technology might be feasible and sound; enabling policy variables, which determine the nature and quality of water and land rights, influences the adoption. The above facts imply that RWH requires investment on land in the form of watershed management or soil and water conservation, which demands a clear land policy. Clear land policy is an important policy measure in the country for both optimal and sustainable use of the land and water resources.

To sum up, the above analysis provides strong evidence that unclear definitions and uncertainty in rainwater laws is a critical limiting factor to achieve a sustainable and efficient use of rainwater resources and technologies. Therefore, a sound rainwater policy is required to justify the need of legislation on water rights, distribution and utilization, and means of how to secure those rights. It should clarify: i) entitlement and responsibility of users; ii) the role of state and other stakeholders; iii) the process of water allocation within and between sectors and users; iv) the legal status of various rainwater user group; and v) sustainability of RWH use. It should further address questions like: i) who is bearing unwanted cost? ii) What is the prevailing institutional set up (or rights structure) that allows this situation to persist? iii) Who must bear the transaction costs necessary to resolve the situation? and iv) who gains and losses by this particular resolution of the problem? Legislative component of a water policy defines the legal environment (laws and regulations), which is required to regulate the water distribution among sectors and users at specific time, amount and space.

### **Economic Components of Rainwater Policy**

It is recognized that rainwater has a paramount potential to reduce the current level of water scarcity. However, it might be surprising that rainwater and rainwater technologies are the most poorly managed resources in the country

mainly due to the provision of inappropriate subsidy both to rainwater and other water supply sub sectors.

### **Inappropriate Subsidy to Promote RWH**

Ethiopia has been giving support (subsidy) to promote both the communal and private RWH for the last three years. The support includes free provision of plastic sheets and other related materials. This free provision of supports or subsidies has created a number of social, environmental and economic problems. These include: increase users' dependency on public or state resources, lack of sense of ownership for the property, inefficient use of RWH facilities and irrational use of public budget. These results are the outcomes of lack of appropriate RWH promotion policy and strategy that governs the provision, monitoring and evaluation of supports. Such kind of capacity building efforts (subsidies) does not improve the efficiency and effectiveness of rainwater resources management. This is because the subsidy efforts do not take into account the capacity that the local people already have. This is called "blanket" subsidy approach, meaning the same type and level of subsidy is given for all communities regardless of their initial potentials (skill, resources, services, experience, and technology) accumulated throughout their life. A subsidy system that takes into account the existing local potentials is called "thresholds subsidy". The central approach of this subsidy is to fill the resources, technology, skill and experiences gaps that allow users to sustain the provision of water services. Hence, the amount of RWH subsidy shall be determined based on three key factors: i) the level of capacity already available with in the community or resources user; ii) the amount of water required to get access to the different services of water based on some standard criteria; and iii) the type of technology chosen for RWH. This definitely requires estimating the standard water demand of water user; and assessing the capacity and the willingness of the user to get access to the different services of water. Once we know the water demand and capacity of the user, the next step is to search for appropriate RWH technologies that satisfy the water demand of an individual water user or a group.

### **Inappropriate Subsidy to Other Water Supply Sectors**

Even though, the national water policy encourages efficient utilization of water for higher economic and social values, but most components of the water sector are still operated with subsidy for social reasons. All domestic urban (except Mekele town) and rural water supplies are still operating with government subsidies. Similarly, except in few areas of the Amhara regional state, irrigation water is supplied free of charges. The current high government subsidies both for irrigation and domestic supply reduce the value of water. Given the low preference to rainwater, subsidies and free supply of water from other sources, has further reduced the demand of rainwater, which in turn reduces the demand of RWH technologies and efficient use of rainwater resources and structures.

The water sector subsidy has five implications on the economic use and management of rainwater resources and technologies. First, the current low water price for domestic supply both in urban and rural areas, and zero price for irrigation water discourage users to invest in rainwater harvesting structures even under the condition where there is no alternative water sources and the cost of rainwater supply is cheaper than other sources. Second, the low price of water supply has created a negative attitude towards the value of rainwater so that users have no interest to use the already accessed rainwater leave alone saving and conserving it. The evidence from most urban areas of Ethiopia (even water scarce areas like Harer) shows us that rainwater is not considered as a water sources at all.

Third, low water price discourages efficient utilization of water (opportunity cost of water). For instance, water utilization efficiency of users in Fogerra district of the Amhara regional state is different from source to source. Efficiency is very high in the case of pump water users since access to water through pump is costly both in terms of fuel, maintenances, and operation as compared to other water sources. As a result, motor users are the ones who tried to adopt different soil moisture conservation practices and techniques to increase the per unit productivity of land and to

minimize their cost of production so as to compete in the product market. Surprisingly, due to high cost of water supply, motor users in Fogerra are forced to shift their cropping pattern from high market value crops to crops that are not grown up by government subsidized irrigations scheme users. Thus, the government subsidy of irrigation scheme (low price of irrigation water supply) reduces the market competition of farmers who invest money and labor on water including rainwater harvesting.

Fourth, low price of water discourages the adoption of new rainwater harvesting techniques, methods and practices. In most area of the country, users are reluctant to adopt new water conservation and rainwater harvesting structures due to the fact that government supply of water is by far cheaper than accessing water through the adoption of new technologies and method of water conservation. As a result, the most critical source of conflict in Amhara region as far as rainwater is concerned is the upper users' imposition of flood on down stream users. This is because users have no interest to invest money, time and labor in harvesting rainwater even if there is high scarcity of water. Since government supplies water in nearby areas with zero or very low price, they prefer to have the same support rather than finding their own means like rainwater harvesting.

Fifth, the low price of water reduces the incentive of private sector to involve in the supply of the different services of water for users including rainwater harvesting. From this, one can safely conclude that high government subsidy of the water sector reduces the value of rainwater, the adoption of new technology, incentive for investment and efficient utilization of rainwater.

The above facts indicate that how RWH is uniquely affected by water economic policy and how it is sensitive to allocation of other water sources. This is because decision on rainwater use requires taking into account other several economic variables. Generally, it is observed that other sectors water subsidy is a cause for rainwater water use inefficiency. Thus, improving efficiency of rainwater use urges to

introduce appropriate water price to other water supply sectors.

### **Institutional Component of Rainwater Policy**

Institutions involved in the rainwater sub sector and the framework of rules within which they operate are so critical to the achievement of RWH vision, plans and targets. In this regard, institutional aspect of rainwater policy has provided a framework and context for private, public, NGOs, community and individual users' role in the conservation, management, development, protection, and utilization of RWH. It has also reflected the capacity implications of the policy at different levels in terms of manpower, research and information so as to implement the intended policy targets.

Ethiopia is very much known in institutional revolution. In the history of Ethiopia, intuitional reform is always associated with the emergence of a new state administration. Water institutions are not free from such type of new state oriented reform. "Water Resources Department under the Ministry of public works" was the first water institution established in 1956. The current government also undertook water sector reform to fit into the national free- market economic policy and political system of decentralization. Accordingly, proclamation No.197/2000 grants power to the "Ministry of Water Resources" to allocate and appropriate water to all regions regardless of the origin and location of sources. It is a regulatory organ responsible for the regulation of water resources of the country. According to the MoWR (2002), Environmental Protection Authority (EPA), Ethiopian Electric Power Corporation (EEPCo), Ethiopian Electric Power Authority (EEPA), Ministry of Works and Urban Development (MWUD), Ministry of Health, the Water Supply and Sewerage Authority of Addis Ababa; and the Addis Ababa Municipality are directly or indirectly involved in the management of water resources at federal level. Recently, the Ministry of Agriculture and Rural Development took the responsibility to supervise small-scale irrigation and rainwater harvesting.

Proclamation No.41/1993 also vested power to regional states that include small-scale hydropower. They are responsible to: i) supervise the implementation of water quality standards for different services; ii) supervise the balanced distribution and utilization of region's water resources; iii) ensure the implementation of laws, regulations and directives issued in relation to the protection and utilization of water in the region. Accordingly, most regional governments have established water resources development bureaus. Some regions like Amhara, Tigray, SNNP and Oromiya have established specialized institutions such as water work construction enterprises, commission for sustainable agriculture and environmental rehabilitation like SNNP, Amhara and Tigray; and/or irrigation authorities like Oromiya.

With regards to rainwater, initially it was not as such recognized as water source at federal level. It was treated under soil and water conservation packages through the Ministry of Agriculture (food for work programmes for instance) and its respective regional agricultural bureaus until today; and natural resources development bureaus in 1989. The revision of the country's food security strategy (the inclusion of rainwater harvesting) was a breakthrough event for the taking up of rainwater issues into the agenda of policy makers. From this time onwards, the agenda of water harvesting has been raised in the name of food security for the last three years both at regional and federal levels. Recently, the Ministry of Agriculture and Rural Development established a separate department responsible for rainwater harvesting. Similarly, regional states have been using different organizational structure to promote RWH and they have undergone a number of institutional reforms. The reform is still going on in most regional states. For instance, in Amhara regional state, rainwater has been constantly handled by the Bureau of Agriculture and Rural Development. While in Oromiya it was managed by Irrigation Development Authority in the past, but recently it has been under the Bureau of Agriculture and Rural Development. The case of SNNP is similar to Oromiya. In Tigray the Bureau of Water Resources has implemented it. Institutional environment, users' management

and institutional capacity building are identified as the three major institutional policy constraints to the promotion of RWH.

Institutional environment- defines mandate of actors, which clarify the roles, responsibilities, and authority of actors. Specially, in the regional states there are so many actors including NGOs, environmental protection bureaus, water bureaus, rural development and agricultural bureaus, health bureaus, land authority and others, which have different concerns (even some times opposite concern) in the management of rainwater. However, all this actors lack clearly defined roles, responsibilities and authorities. It means there are no clearly defined framework, rules and regulations that govern the interaction, communication, planning and coordination of implementations. According to regional bureau officers, lack of this clarity hinders the promotion of RWH by: i) reducing the incentive for coordination of efforts and resources; ii) increasing conflict over roles due to confusion of roles and responsibilities; iii) hindering experience sharing on best practices; iv) reducing the level of community participation, and ignoring indigenous water management institutions and local experiences; v) reducing the sustainability of efforts, continuity of activities and efficiency of implementation; vi) reducing accountability and transparency of end users; and vii) increasing roles promoting contradictory approaches; viii) increasing institutional instability, which has created job insecurity; and x) reducing clarity between the roles and responsibilities of federal bureau and regional states.

**Users' management:** – in the national water management policy stresses decentralization as devolution of resource management power to regional states. But, rainwater requires absolute decentralization up to end users since most of the policy concerns of RWH are micro by their nature than as stated in the national policy. Decentralization of rainwater management, therefore, requires complete devolution of rainwater catchments to end users including catchments user right, exclusion right, management right, resources mobilization right, right of selecting services and service providers and right of institutional self determination.

Moreover, the management rights has to be as comprehensive as possible, it include rights over other resources of the catchments such as land, forest and wildlife of the catchments. Lack of rainwater friendly complete and comprehensive decentralization has resulted in lack of incentive for collective management, investment and sense of responsibility, which in turn resulted in poor maintenance and operation of communal rainwater structures and conflict over the use of rainwater and RWH structures. The current population centered local government administrations further hinders the promotion of communal RWH. This is due to the fact that RWH demands to have rainwater centered (micro level watershed) administration rather than structures like “kebele”, “gott” and “cell” (in the case of Amhara region for example).

**Capacity building:** - The national management policy also stresses on the need for enhancing the capacity of regional states. Unlike other sub sectors of water, RWH as new area of intervention might require special attention in improving the capacity of stakeholders at different levels beginning from public awareness raising. Lack of rainwater specific policy in this regard made RWH deserves little attention in all aspects of capacity building (research, information and human development) as compared to other water sources like rivers, groundwater and lakes for three reasons. Even the accomplished ones are either inappropriate or unsustainable for three reasons. First, its role was recognized very recently in the name of food security and hence its role is limited to drought mitigation. Second, instability of implementing organs, especially at regional levels has increased due to reshuffling and staffs turnover. Third, lack of awareness on the value of rainwater at all levels discourages many people from working on RWH. That is why the failure of most RWH structures is associated with technical problems due to lack of skill in installation, design and site selection at all levels.

Therefore, clarification on institutional issues believed to enhance the participation of all stakeholders; avoid confusion of roles and responsibilities to reduce duplication of efforts; enhance coordination of efforts and resources;

improve capacity and effectiveness of services provision; and clarify the rights and obligations of users in the resources management.

### **Technological Component of Rainwater Policy**

Technology, here, refers to rainwater storage technologies in situations where water is needed to be stored for different purposes like for flood control, domestic supply, irrigation, etc. The choice of a storage systems is determined by a number of local conditions such as amount of water storage required; type and size of catchments; rainfall amount and distribution, soil type and permeability; availability and cost of construction materials; affordability; local skills and experiences and availability of other water sources. The three important technological policy constraints of RWH are: financing technology, managing technological externalities and technology quality control. A policy addressing these concerns means: reducing externalities associated with RWH technologies such as health hazards and water losses; improving quality of technologies in term of social, economic and environmental acceptability; and enhancing financial sustainability of technologies.

### **Technology failure due to technical problems**

Recently, Ethiopia has introduced a number of rainwater harvesting technologies from different corners of the world and there is no empirical evidence that clearly indicates one type of technology is better than the other. Even the type of technologies already introduced in the country is not certainly known. However, some preliminary studies indicate that the performance of most of the adopted rainwater harvesting structures area not achieving their intended objectives due to technical, environmental and hydrological reasons. As most engineers argue it is true that the choice of the technologies is site specific because its success is determined by a number of area specific variables like soil type, land characteristics, rainfall availability and variability and other area specific variables. On the other hand, rainwater-harvesting

technologies introduced from countries of more or less similar environmental and economic conditions are not successful as intended to be. Moreover, we have observed successes and failures of the same technologies introduced under similar ecological, technical and hydrological conditions due to the difference in the socio-economic characteristics of the user, especially in the case of privately owned structures.

The dual interpretation of this is that the choice of a technology is also influenced by the ability to afford and the willingness of the decision maker to buy the technology or to invest for operation and maintenances. This could also be influenced by policy incentives. Thus, we argue that the choice of the technology is not only determined by technical, social, economical and topographical factors but also by policy variables, which are mostly ignored by researchers. These include incentive policies such as different forms of subsidies, which encourage users to invest in and adopt new RWH technologies, and techniques. On the other hand, deterrent policies such as taxation would discourage users from misusing RWH structures and impose technology externalities. Generally, technology policies that enhance user's investment on RWH technologies, reduce problems related with rainwater storage facilities such as cost, siltation, evaporation, seepages and health hazards; protect the technology from external damage; protect users' right to determine the choice of technologies; and encourage the use of other storage facilities constructed for different purposes such as road, water channel, railway, etc are areas of RWH policy interventions that demand the attentions of policy markers.

There are some policies in this regard, but they give more weigh to the adoption of new, labor intensive and indigenous technologies as stated in the rural development and agriculture policy. These policies are not sufficient to successfully promote RWH. It requires additional policy intervention or clarification in the area of technology externalities, technology financing conditions and quality control of technologies. This will minimize the social cost of RWH technology adoption. Therefore, RWH related technological policies shall be policies that

provide incentive both to end users and other actors to invest on economically sound, socially acceptable and environmentally friendly RWH technologies. Since all technologies are not appropriate for all users at all times and places (one shoes can not fit all), a RWH policy shall answer the question as to when and where RWH technology will be appropriate.

### **Equity /Social Component of a Rainwater Policy**

Equity in water allocation refers to fairness with respect to distribution of costs and benefits of a resource among individual or group users, systems and regions. Inequitable allocation of water could be natural (due to uneven distribution of resources) and /or project oriented like the introduction of RWH technologies. The most important inequity of RWH projects can be manifested in 5 ways. These are: i) income inequality- income disparity created due to the project; ii) gender inequality- unequal treatment of the voice and the choice of men and women in the project designing, implementation; and distribution of the cost and the benefits of the project; iii) inequality of upper and downstream users – resulting from externalities of the project (when the upper stream project user imposes externality on downstream user); iv) cattle raiser and farmer inequality – when cattle damage the RWH structure of the farmer or the health hazard of cattle affects the RWH farmer; and v) generation inequity- resulting in over abstraction of rainwater without taking into account the hydrological cycle of water and ground water discharge role.

The national water management policy addresses some key issues of water appropriation. The addressed policy issues are more focusing on improving the initial water inequalities created due to uneven distribution of the natural water sources, mainly to improve the inequity of water allocation among regional states. However, implementation of water projects by itself can also create inequalities; inequalities result from unequal distribution of costs and benefits of a project between poor and rich, current and future generation, pastoralists and agriculturalists, upper stream users and

downstream users, men and women. This would create income disparity, externality, conflict and degradation of the water resources. Thus, policy should also highlight a framework that will urge a project planner to take in to account all those concerns. The following examples can help to examine the important of rainwater specific policies to minimize inequalities.

### **Regional Water Supply Inequality**

Lack of region rainwater specific might be one of the causes for the aggravation of regional water allocation inequities. As it is known, the national water potential is distributed unevenly and mismatch with the settlement of the population. It is estimated that only 30% to 40% of the population is settled in area where 80% to 90% of the water sources are found. On the other hand, more than 60% of the population is settled in areas where only 10% to 20% of the water sources are found (MoWR, 2000). This definitely requires either to transport water from water surplus regions to water deficit regions and/ or looking for other supply options like rainwater harvesting to provide the different service of water a least at basic survivable level leave alone equity. However, with the current national capacity and uneven distribution of the water resources, addressing the issues of equity using the current approach of focusing on ground water is unthinkable, especially in those areas where population is highly dispersed and has limited access to other alternative water sources. In this situation, RWH technology has paramount role to address regional water distribution inequalities. However, due to lack of rainwater specific policy that provides appropriate region specific incentives and strategies hinder the promotion of RWH technologies in moisture stress area. Contrary to the actual fact, better RWH promotion efforts have been put in those areas where there is alternative source of water. But, the availability of alternative options and low price of water supply from other sources reduces the acceptance of RWH technologies in those areas, but rather, it increases the degree of water allocation inequalities between regions. Take for example, the price of water per truckload, which ranges from Birr 500 to 800 in Afar region, and people who are not able to afford this price that is used to travel 15 to 20

km to fetch water for domestic consumption (MoWR, 2002). Surprisingly, the efforts to promote RWH are very minimal in those areas, even; attempts are unsuccessful, due to lack of appropriate policy incentives to individuals and groups to invest on RWH technologies.

### **Income Inequality between Users**

Government has been promoting private RWH technologies more than communal for reasons of divisibility and addressing household level food security. The high cost of rainwater structures, however, increases the disparity of water allocation between the poor and the rich people. In most of the cases, the rich, the one who able to afford the privately owned rainwater harvesting structure, while the poor are forced to buy water at relatively high price. This is mainly due to lack of appropriate RWH micro financing policy that addresses the interest of the poor. Existing micro financing institutions are becoming profit oriented and demand group guarantee, which excludes the poor and marginalized group since group members are not willing to take responsibility for the poor. This further exacerbates the income gap between the poor and rich due to the fact that the poor have been denied access to water for production.

### **Sectoral Water Supply Inequality**

Lack of sectoral rainwater use policy and strategy also increases the inequality of rainwater allocation among sectors. Rainwater has significant contribution in all water demanding sectors. However, except the agricultural sector (food security), the other sectors give very little attention, if any, to RWH. Others consider it as a threat to their sectoral development like health and environment. This undermines the potential roles that rainwater can play and reduces the true economic value (opportunity cost) of rainwater. Thus, maximization of rainwater opportunities entails the creation of enabling policy environments that enhance the maximization of rainwater opportunities to the sector in question.



## Other Inequalities

The other misleading concept in the policy document is the issues of gender. Gender does not refer to only women. By definition it refers to the qualitative and independent character of women and men's position in the society. Therefore, equal attention need to be give for both sexes in terms of incorporating their voices and choices in all stages of the project. The other policy element, which is ignored by the national water resources management policy, is management of externalities created due to the use or over use of water resources. Moreover, given water is a scarce resource, equity of RWH benefits should take in to account efficiency of rainwater uses (economic aspect). This means a rainwater policy should also keep the balance between efficiency and equity of rainwater use. This is especially important for rainwater resources management, which exhibits tradeoffs between efficiency and equity.

## Summary

Generally, centralized and non-source specific policies do not fit to manage all water sources in a similar fashion due to the difference in the nature of sources, which determine the technical, environmental, social, economic and political feasibilities of a water source in question. This means that different water sources require different policies due to the need to use different strategies, technologies, institutions, legislations, and environmental regulations. The difference in implications requires to recommend new approaches to administration, new roles for government officials, recognition of multiple stakeholders, new roles for civil society institutions and NGOs, administrative coordination, information sharing and communication, a legal framework, research, capacity building and strong local institutions, so and so forth. Thus, there is strong evidence on the need of rainwater specific and decentralized policy that could address environmental, institutional, technological, legal, social and economic concerns of rainwater resources and technologies; so as resolve the current rainwater resources and technology management crisis and gear rainwater utilization towards the

national overall socioeconomic development. Unless some actions are taken, it is very difficult, if not unthinkable, to promote RWH technologies, to smoothly handle the current rainwater resources and technology management crisis, to fully manage externalities of unused potentials, and to fully use the potentials and use opportunities of rainwater for the development of the national economy as it has been expected, using the current general water policy. Thus, this section clearly answer the question of what type of rainwater policy do we need. Now the follow up question would be: To what extent should it be specified and decentralized? We will discuss it in the coming section,.

What Alternative Policy Options Did the Research Propose? Given all the discussion in the above sections the author argues that two levels rainwater specific policy is an ideal policy in the context of Ethiopia (see the detail of the argument from below).

The current integrated sector-based water policy is an overarching framework that was developed based on national demand and supply concept of sectoral uses such as irrigation, hydroelectric power, industry and domestic consumption. This has ignored regional differences in water demand coverage, availability of water sources; development targets and approaches. Similar to the national water policy goal, regions have different development approaches based on their conditions. For instance, different regions have different soil and water conservation, food security, and agricultural production strategies. That means, the water resources management has to be in line with the regions' general development strategies and water demand of different sectors. Moreover, different regions have different water potential with different levels of water constraints. They have also different sources of water, which are more or less sound under different contexts and settings. For instance, rainwater harvesting supply options may be viable for moisture stress areas where there is limited permanent water sources or if supply measures are costly.

On top of that the potentials and constraints of RWH are too area-specific (land, soil, climate

and topography specific) and user specific (livelihood style, economic capacity to afford the technology and culture of user), which necessitates micro-level area, and users centered intervention. The constraint of promoting RWH in one region is not necessarily the same as in other region and this is true of the solution too. Thus, all issues are difficult to be managed by uniform national water management policy.

For this reason, national water policy needs to be supported by region specific water policy so as to address region specific constraints under the framework of the national rainwater policy. In this regard, the two levels RWH specific policy, national RWH specific policy coupled with region specific RWH policies, satisfies both conditions of a quality resource policy (better degree of decentralization and resource specification). The national RWH specific policy could help the country to carefully examine the different roles of RWH in satisfying the different services of water to the national economy, its linkage with other water sources and regional water use implications (hydro politics implications). Region specific rainwater policy is also important to give more attention to the specific requirements of regions, and mitigate area and user specific constraints of RWH promotion.

Unlike other options, two levels rainwater specific water policy is quite important to mitigate the current problems since rainwater specific policy will: i) develop basic rainwater specific utilization, development control and conservation principles at national and regional levels; ii) develop rainwater friendly legislative and institutional reforms, and land policy that fits RWH; iii) clarify the role, responsibility and authority of actors in the promotion of RWH, and right of users in the management, development and utilization of rainwater; iv) give value for the potential role of rainwater to sustain other water sources (linkage with other sources); v) optimally allocate rainwater among users and use systems; vi) improve efficiency and equity of rainwater utilization among users and use systems; and vii) effectively implement RWH specific projects and allow continuity, and coordination of efforts; and viii) identify

RWH specific capacities required at different levels such as research, human capital and information.

This will allow rainwater institutions to play their vital role of improving the technical, social, economic, financial and environmental feasibility, and sustainability of rainwater harvesting efforts. It will also enhance the commitment of political leaders and other actors to allocate resources for promoting rainwater harvesting in a sustainable way. Currently, rainwater harvesting is strongly attached with food security policy, which is mostly promoted by donors and external resources like EU, IFAD. Implementation is also quota centered rather than demand driven in most regions of the country. Moreover, policy urges the development of strategic planning for rainwater resource development, protection and utilization, which makes implementation effective, efficient and sustainable. It also encourages water users to conserve rainwater and invest on alternative rainwater harvesting technologies. Generally, two levels RWH specific policy will help us maximize all the opportunities of RWH and fully tackle the aforementioned environmental, economic, social, institutional, legislative and technological constraints of RWH promotion. However, its implementation is so costly since implementation of the policy requires having separate institutional, administration and legislative support both at national and regional levels. In this regard, South Africa is the only country with rainwater specific national water policy in Africa

# Poverty Reduction through Irrigation and Smallholder Markets (PRISM)

**Kebede Ayele and Shibru Tedla**

IDE/ESAT

kbdayele@yahoo.com

## 1. Introduction

Today, more than 1.2 billion people live in “extreme consumption poverty”<sup>1</sup>, which the international community defines as the equivalent of living on less than one dollar a day. Seventy-five percent of these people live in rural areas, have very small plots of land and depend on agriculture for their livelihood<sup>2</sup>. Solutions to rural poverty must focus on these rural poor farmers. These farmers must grow high-value crops on their small parcels of land, in order to materially enhance their wellbeing and incomes. But to do this, it usually requires irrigation.

Traditional surface irrigation practices have in the past been suitable for smallholders who are fortunate enough to have abundant low-cost supplies of water. However, the traditional practices smallholders use do not utilize water very efficiently in terms of crop yield per unit of the water applied. Furthermore, the income disparity between the millions of smallholders and the rest of society is widening while simultaneously there is growing competition for the world’s finite freshwater resources. Therefore, since water is usually the most critical factor that directly affects the intrinsic production capacity of their land, it is critical that smallholders begin using more efficient water supply and irrigation technologies.

Unfortunately, the available configurations of the modern and efficient water supply strategies and irrigation technologies, which were

typically designed for relatively well financed larger farms, are not well suited for the needs of smallholders. It does not work to simply downsize a sophisticated water management technology to fit a small plot. Polak, et al. (1997) recognized that it is not sufficient to merely scale-down “state of the art” irrigation technologies that are appropriate for larger commercial farms. Systems must be re-engineered to match smallholders’ unique characteristics (e.g., small landholdings, low capital availability, low risk tolerance, and relatively low opportunity cost of family labor). Features that are important to smallholders include: 1) low investment cost; 2) suitable for various plot/field sizes at about the same cost per unit of area served; 3) rapid return on investment; 4) simple affordable maintenance; and 5) operating at very low pressure heads.

Thus, greater attention must be given to developing and disseminating appropriate water technologies that will enable smallholders to have access to and better control over water for crop production. Providing appropriate and efficient irrigation technologies requires the development of new low-cost products specifically designed for smallholders. Then manufacturing them as locally and inexpensively as possible and marketing them to the smallholders.

The following definition (which is from an engineering perspective) of a technology that would be appropriate for smallholders was presented by Amadei (2004): “An appropriate technology is usually characterized as small scale, energy efficient, environmentally sound, labor-intensive, and controlled by the local community. It must be simple enough to be maintained by the people who use it. In short, it must match the user and the need in complexity

<sup>1</sup> Rural Poverty Report 2001, International Fund for Agricultural Development, Oxford University Press Inc., New York, NY, 2001.

<sup>2</sup> Reaching the Rural Poor: A Strategy for Rural Development, World Bank 2001.

and scale and must be designed to foster self-reliance, cooperation, and responsibility.”

The availability of affordable small-scale irrigation technologies (ASITs) unlocks the potential benefits of modern pressurized irrigation systems for literally millions of resource-poor farmers (even where water supplies were considered insufficient or too costly to acquire for traditional irrigation methods). With this belief, the International Development Enterprises (IDE), a non-profit organization, has taken up the challenge of developing and intensifying the use of ASITs in developing countries through a methodology it calls PRISM (Poverty Reduction through Irrigation and Smallholder Markets). PRISM envisions the smallholder as a micro-entrepreneur who transforms natural resources (land and water), human resources (labor and know-how), and purchased inputs, such as ASITs, into high value agricultural products that can be marketed at economically rewarding prices. IDE uses the PRISM methodology to assist in the creation of pro-poor rural market systems based on: a) exploring and identifying market opportunities, and b) good water control. Since water is an essential input in all agriculture production systems, ASITs play an important role in integrating smallholders into the market system and improving their livelihoods (Heierli, 2000; Postel, et al. 2001).

PRISM was developed by the International Development Enterprises (IDE). IDE is a non-profit organization that employs market principles to strike at the roots of rural in the world's least developed countries. Since 1981, IDE has worked to reduce poverty in Asia and Africa by helping the rural poor increase their agricultural productivity and income. Using relatively few resources, IDE has helped empower some two million small-farm families to progress from subsistence agriculture to small-scale commercial farming and begin an upward spiral out of poverty.

IDE is working in Asia (India, Bangladesh, Cambodia, Nepal, China, Vietnam, Myanmar, Pakistan) and Africa (Zambia, Zimbabwe, Malawi, Niger). Currently, the Ethiopian Society for Appropriate Technology (ESAT) is

collaborating with IDE to introduce the PRISM approach to Ethiopia.

## 2. Conceptual Foundations of PRISM

PRISM is founded on the following key concepts and principles:

- **Focus on the smallholder.** Effective solutions to poverty must deal with smallholders for the simple reason that they constitute the majority of the world's poor. We define smallholders as farmers cultivating between 20 square meters and two hectares of land. The term “smallholder” denotes a rural household operating in the context of at least under-developed market systems, with highly restricted access to land, water and capital.
- **Smallholders' comparative advantage in high value crops.** Smallholders have an important advantage over larger farmers in that their family labor can be applied to their small holdings with little or no cost of supervision. The smallholder can capitalize on this characteristic to develop a comparative advantage on labor-intensive farming systems where the factors of production must be closely managed. Comparative advantage is most readily developed in the production of certain high value crops, such as fruits, vegetables, flowers, etc. With concentrated, labor-intensive production systems, it is possible for smallholders to achieve higher yields per unit area and better quality produce than farmers that cultivate larger areas with capital-intensive farming systems. Larger farms, on the other hand, are usually better suited to the production of staple crops, which require less intensive management and are more adaptable to mechanization than most high value crops.

This comparative advantage of smallholders can be further enhanced through the provision of products and services that are suited to their unique characteristics and that will enhance their ability to grow and sell crops efficiently.

- **Designing solutions from a smallholder perspective.** Production technologies, both hardware and resource management practices, must be designed to suit the characteristics and resource availability of smallholders (Figure 1).

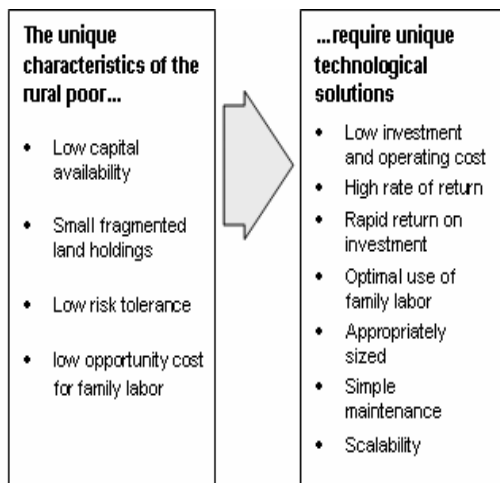


Figure 1. Pro-Poor Technology Development

- **The smallholder’s place in the value chain.** Smallholders are micro-entrepreneurs and they are served by other micro and small enterprises’ (MSEs) in input and output markets (see Figure 2). Smallholders’ profitability depends on the degree to which they are integrated with these market systems, both as purchasers of agricultural inputs and producers of saleable crops.
- **Market demand is the driving force.** Demand for agricultural commodities provides the “pulling force” that drives the value chains in which smallholders participate.
- **Constraints to effective smallholder market participation.** Smallholders, and the MSEs that serve them, face a range of constraints at the farm level and in the input and output markets. The lack of water access and control is usually a key constraint. Other constraints may relate to technology, market information, access to credit, technical knowledge, and socially prescribed gender/socio-cultural roles.

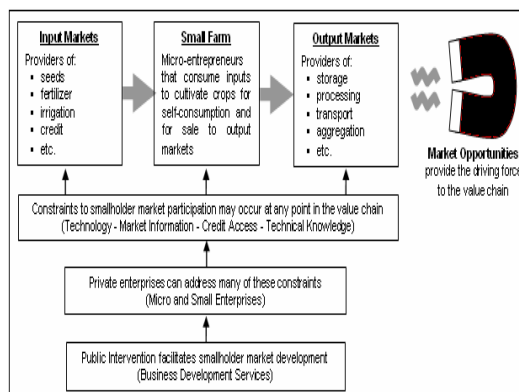


Figure 2. Effective Interventions for Smallholder Market Development

- **The role of public investment.** Public intervention in market facilitation is required to create market environments in which smallholders can participate effectively. Public intervention may take the form of Business Development Services (BDS) such as research and development, creating market linkages, awareness raising and demand creation, infrastructure development, and policy support.

### 3. The Three Pillars of PRISM

The PRISM approach is based on three pillars: water control, supply chains and market access

- i) **Water control:** Water is often a key constraint to smallholder productivity. The livelihoods of the large majority of small-scale farm families are dependent on rainfed-agriculture. Their options to diversify into irrigated-agriculture are constrained by lack of appropriate and affordable water control technologies. In the PRISM approach, smallholder farmers are supported to get access to water lifting, water-storage and water-distribution technologies that are low-cost, simple and adaptable (these technologies will be discussed later in great detail).
- ii) **Private supply chains for delivery of inputs and outputs:** Experience shows that smallholder farmers must have regular access to a series of inputs and services, such as seeds, fertilizers, agro-chemicals, low cost irrigation

technologies, credit, transport, etc. These inputs and services are better delivered by the private sector. The private sector comprises exporters, importers, distributors, local manufacturers, whole sellers, retailers, installers and advisors. Usually, in remote areas with predominantly poor farmers, this private sector is missing or underdeveloped. This bottleneck can be overcome through supply chain development interventions.

iii) **Market access:** A primary cause of the persistent poverty faced by the rural poor is that they have limited interaction with markets. With less than one dollar per person per day, they cannot afford to purchase agricultural inputs or invest in production technologies, resulting in low land and labor productivity that does not raise much above subsistence levels. Consequently, they have little or no surplus production to sell to the market. The poor farmers' access to market is also constrained by many other factors, such as lack of market information on product demand and price, inadequate or no entrepreneurial skills, poor road network and transport services. Often, small farmers get low price for their produce due to low product quality, their weak bargaining power and market glut at harvest time due to excess supply. PRISM views smallholders as entrepreneurs and enhances supports them to actively participate in markets by helping them produce marketable high value crops, access timely market and through market development interventions.

For the interest of this symposium, our presentation will concentrate on PRISM's pro-poor water control (micro-irrigation) technologies that have been developed and promoted by IDE in Asia and Africa (Zambia and Zimbabwe).

#### 4. Micro-Irrigation Technologies

The water technologies that are described below include the following: treadle pumps and storage tanks to supply water for crop irrigation; and low-cost drip irrigation systems to apply water to high value crops. The development of these efficient and affordable water technologies provides smallholders with

an essential tool for intensifying their farming practices. This allows them to grow high value crops and significantly boost their farming income.

#### The Treadle Pump

The treadle pump is a true and mature appropriate water technology designed, manufactured and marketed with smallholders in mind. It is a simple low-cost manual (foot-operated) pump that can lift water from shallow groundwater sources or surface water bodies. The typical pump consists of two vertical cylinders fitted with pistons that are interconnected using a pulley (or lever) system so when using a stepping motion, as one treadle is pushed down the other treadle is moved up. Basic treadle pumps can lift water from depths of up to seven meters with a flow rate ranging from about 30 to 80 liters per minute (lpm) depending on the rigor of the operator, water depth, and cylinder diameter. Pressure treadle pumps can not only lift water, but also provide pressure heads of up to 20 m at the pump outlet.

Treadle pumps are beautifully suitable for agricultural use by smallholders because:

- They are inexpensive, for example, in Southeast Asia, the retail cost of a basic pump ranges from US \$12 to \$15 including the wood or bamboo treadles and support structure (see Figure 1). However, in Africa the typical cost ranges from \$55 to \$95 because pressure pumps are usually required and they generally have steel treadles and supports so they are compact and portable to facilitate moving to a secure location when not in use. The cost of a shallow borehole well (when necessary) varies according to local geological conditions, but typically ranges from \$20 to \$80 in alluvial soils.
- The design and construction of the pumps is simple, so local craftsmen can manufacture them using readily available tools and materials; and they can be maintained and repaired easily by the users. Parts requiring periodic replacement such as plastic piston seals, which are common to many popular hand pumps, are usually available in

local markets. The foot valve at the bottom of each cylinder is made from rubber that can be replaced using a discarded bicycle tire inner tube.

- Because they have two pistons, water is kept in motion during the up- and down-strokes resulting in a continuous flow and efficient use of manual energy.
- Leg muscles are used in a natural walking motion making it possible for an operator to pump for several hours per day delivering enough water to drip irrigate roughly 2,000 m<sup>2</sup> of vegetable cropped area.

Keller and Roberts (2003) presented the following brief history of treadle pumps:

“The treadle pump was developed in Bangladesh by an (NGO), Rangpur-Dinajpur Rural Services (RDRS), and popularized by another NGO, International Development Enterprises (IDE). Beginning in 1986, IDE-Bangladesh facilitated a market network of approximately 65 manufacturers, 700 dealers, and 5000 installers and stimulated demand for the pumps through mass media campaigns in rural areas (Hiereli 2000). To date, approximately 1.5 million treadle pumps have been distributed through market channels in Bangladesh and another half million have been distributed through similar programs in other Asian countries.”

Shah et al (2000) studied the socioeconomic impact of the treadle pump in eastern India, Nepal, and Bangladesh. The research indicated that treadle pumps enabled smallholders to intensively manage water and other inputs on “priority plots” within their land holdings, which significantly increased their agricultural production and income. The average additional net income to land and labor was found to be more than \$100 per year per smallholder, and a significant percentage of them were making an extra \$500 or more per year. The extra income enabled some treadle pump owners to graduate to a higher level of mechanization by purchasing engine driven pumps for irrigation.

Shah also pointed out that with treadle pumps, the cost of new irrigation development in these areas is only \$100 to \$120 per hectare, with the

poorest farmers being the beneficiaries. In view of this success several NGOs are actively involved in the promotion of treadle pumps throughout Asia (including China) and Sub-Saharan Africa using the market creation approach to development.

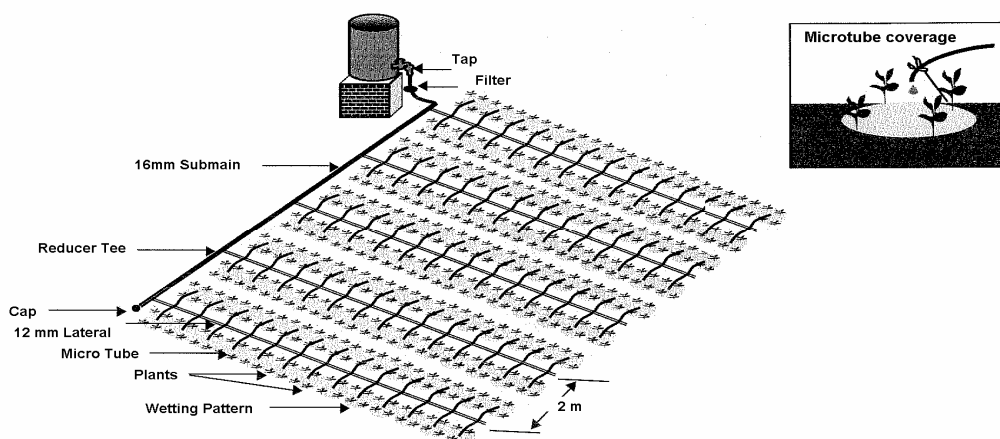
### Low-Cost Drip Irrigation

Drip irrigation has the potential to be the most efficient irrigation technology when evaluated in terms of crop production per unit of water applied. This is because the water can be uniformly delivered to each plant through a closed pipe system. Thus converting from traditional surface irrigation to drip irrigation can significantly increase the area of land that can be fully irrigated with a given volume of water.

Figure 4 shows a schematic of an IDE low-cost micro-tube drip irrigation system. These drip systems are low-cost, require a minimum of filtration, are available in small packages, operate at low inlet pressure, and are easy to understand and maintain by smallholders. These low-cost drip systems are available with sizes ranging from 20m<sup>2</sup> to 2 hectares (ha). They are very affordable, with an installed cost in India of between \$0.03 and \$0.05/m<sup>2</sup> (\$300 to \$500/ha) for the laterals with drippers plus the sub-main, depending on field size, lateral spacing and layout. Where as the standard commercial drip systems cost from \$0.15 to \$0.25/m<sup>2</sup> (\$1,500 to \$2,500 per ha).

The affordable design of the low cost IDE system is made possible because:

- The systems operate at inlet pressure heads of from 1 to 3 m, so lightweight tubing and inexpensive fittings can be used and leaks are easily repaired.
- The major system components are plain tubing and simple fittings and the microtube drippers and fittings are installed in the field.
- The plain tubing and simple fittings can be manufactured by utilizing inexpensive manually controlled extruders and simple molds; therefore,



**Figure 4. Schematic an IDE low-cost micro-tube drip irrigation system.**

- the entry cost for manufactures is very low, which assures a competitive marketing environment.
- The systems are lightweight and the lateral and sub-main tubing is packaged in tight rolls; therefore, transportation and handling costs are low.
- The system components are simple and easy to assemble without sophisticated tools; therefore, farmers can install their own systems.

Besides being affordable the IDEal drip systems have the following other attributes that are important to smallholders: 1) under low operating pressure heads (1.0 to 2.0 m) the discharge rate from the micro tube drippers is about ideal for individual vegetable plants such as tomatoes; 2) dripper clogging is minimal even with little or no filtration when using water from dug wells; and 3) on relatively level small fields the application uniformity is comparable to that achieved by conventional drip systems used in developed countries (Keller and Keller 2003).

These low-cost drip systems only cost about fifth of standard commercial drip systems. The availability of these low-cost drip irrigation systems in small affordable packages unlocks their potential benefits for literally millions of

resource-poor farmers. In addition, it opens the potential benefits of irrigation even where water supplies were considered insufficient or too costly to acquire for traditional irrigation methods to be practical. To date, more than 200,000 low-cost drip irrigation systems have been distributed through market channels in India, Nepal and other areas in Asia.

### **Bagging Water for Irrigation**

Cost effective storage of the runoff water from small catchments or water from perennial wells or streams to use for irrigation during the dry season has been a major challenge. A recent innovation developed by IDE that looks promising is to store water in low-cost plastic lined tanks. The first level of experimentation has already been completed and the tanks are now being tested in a pilot study in India. Each tank stores 10 cubic meters of water that is completely enclosed to eliminate evaporation losses. The installed cost is roughly \$40 to \$50 and the life expectancy is 5 years.

## **5. Conclusion**

Ending poverty requires nothing less than four simultaneous revolutions in water, agriculture, markets and design; each centered on small farms and dollar-a-day farm families (Polak 2005).



- A revolution in water is needed to open access for the rural poor to income generating, affordable, small plot irrigation and domestic water supplies.
- A revolution in agriculture is needed to open opportunities for small farm enterprises to develop new varieties of fruits, vegetables, herbs and other labor intensive, high value crops optimized for small farms and the smallholder based agricultural practices required to produce them.
- A revolution in design is needed, based on the ruthless pursuit of affordability, to develop a whole new generation of income generating technologies and strategies that serve the rural poor.
- A revolution in markets is needed to create new markets that open smallholder access to affordable small plot irrigation and inputs, and to new markets for the high value crops they produce.

The PRISM approach is conceived, developed and promoted on the basis of these underlying revolutionary ideals. In collaboration with IDE, the Ethiopian Society for Appropriate Technology (ESAT) is introducing PRISM to Ethiopia. Introduction of the methodology and implementation of the low-cost, appropriate irrigation technologies are being done in partnership with donors, NGOs and the private sector. Achievements made in less than one year are very encouraging and indicated to us that the technologies are very appropriate to the Ethiopian smallholders farming systems and, thus, are well demanded.

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## Group discussions and findings

One of the most important aspects of the symposium is the group discussion, its plenary presentations and discussions. The group discussions and presentations focused on three major topics, with the following title and key questions:

### **Group 1: Current Practice of SSI, MI & RWH Technology in Ethiopia**

- Identify and list out the type of technologies and best bet technologies under use
- Whether the technologies are already introduced in Ethiopia?
- What are the climatic, water and agronomic factors needing such technologies?
- Adoption by farmers and how far?
- What are the constraints for scaling up?
- What are the enabling environments for scaling up?
- Recommendations for future and way forward

### **Group 2: The Private Sector for Irrigation and Agricultural Water Management**

- What are the roles of the private sector?
- What are the opportunities for the private sector?
- How far does the private sector involved in SSI, MI and RWH?
- What are the constraints for the private sectors active engagements?
- What are the major problems for the private sectors active engagement in the sub-sector?
- What are the enabling environments needed for private sector?
- Recommendations for future and way forward

### **Group 3: Policies and Institutions for Agricultural Water Management, Irrigation and Technology**

- What are the land and water related factors in terms of technology adoption and empowerment?
- What are the opportunities?
- What are the constraints and problems?
- What need to be done in terms of issues related to policy, institutions, input supply, technology adoption, capacity and awareness?
- Recommendation for future and way forward

Based on the above basic discussion points, the groups made extensive discussions and have come up with discussion results and list of recommendations and options for the way forward. The plenary concluded the following as major highlights of the group discussions:

### **Group 1: Current practice of SSI, MI and RWH**

- Range of AWM technologies, adoption and effectiveness are not clear. Therefore inventory, selection and adoption of appropriate technologies are highly important
- Demand-driven development and promotion of technologies based on evaluations
- Need for capacity building in various levels in small scale irrigation involving private sector. Particularly, extension should also have the right training for irrigation and AWM
- Improve irrigation extension system
- Subsidies at community level and full cost recovery of irrigation development is difficult and unjustified
- Need for network to disseminate appropriate technology
- Community based watershed management
- Water Users Association (WUA) which is composed of water users beyond the boundary of community should be enhanced.

- Redistribution of land-might bring more problem- rather land consolidation might be productive. However, it demands diversification/ to provide alternative means of the livelihoods for those who have to leave the land, part of the essence of rural entrepreneurship.
- Technical and economic analysis of small scale irrigation should be carried out
- Proper post-harvest technology is vital for perishable products obtained from irrigation. Market linkage must be established.
- Technology development and adoption system should be created.

### **Group 2: Private sector involvement**

- Roles of Private sector have been identified through the group discussion
- Private sector is the investors in the forms of capital and knowledge for the farmers in small scale irrigation schemes.
- The private sector has not been taken seriously, partnership is difficult because there is no role definition in sales, trade, input supply and output marketing
- Private sector involvement has been limited so far yet very much needed to promote irrigation in Ethiopia.
- Market creation awareness for the best tested technologies for farmer's selection and adoption. There are no established market chains: flow of information, lack of continuity and uniformity
- Enabling environment for the private sector involvement. Formalizing business: bureaucratic chains has to be reduced
- Farmers should be given opportunities whether to adopt the best tested technologies
- Applied Research: can also play important roles: locating and important roles, royalties for innovations and patent rights are important
- Lack of improved varieties, insufficient quantity, absence of seed certification, timeliness for private sector to participate in seed multiplication and distribution
- Organize farmers themselves to engage in seed multiplication (in remote areas). Give incentives
- Government should outsource many issues to private sector

### **Group 3: Policy and Institution**

- Land distribution-land consolidation, refer above
- Know-how development at all levels- policies exists but the question is whether they are implemented at the grassroots level.
- Coherent policy –from federal – regional-defined roles and responsibilities are important
- Institutional instabilities are highly detrimental for sustainable development, and they are particular the cause for eroding capacities for irrigation in the regions. Hence, stable structure and accountability are needed
- Coordination of the efforts (public, private, donors, financial, technical etc) financial, technical should be enhanced.

### **Main conclusions and way forward**

The following points are put forward as main highlights of the workshop:

1. Ethiopia has not yet utilized its natural resources appropriately for comprehensive agricultural development. It has been heavily reliant on rain fed agricultural production which is heavily influenced by shocks of dry spells and droughts. Ethiopian GDP is heavily reliant on rainfall variability. The country has to optimize the rain fed system and benefit out of irrigated agriculture.
2. Technology adoption, replication and out scaling in irrigation and agricultural water management are limited. The causes are limited capacity and know how, lack of the right

- extension, lack of network, limited market access and economic analysis and inadequate involvement of private sector
3. There have to be a frame work of thinking for sustained development of the agricultural water management and irrigation sector. It should have a comprehensive and easy to understand frame work. Comprehensive-integrated agriculture entrepreneurship development in the small scale irrigation schemes should be promoted. Commercialized agriculture, processing, manufacturing, trade create opportunities for all the actors in small scale irrigators. This strategy also allows us to take advantage of the unused resources/ investments. We have clearly understood the importance of irrigation in its forward and backward linkage, employment opportunities, implications to the GDP and the overall economic growth.
  4. Irrigation should be taken as a key sector at the government, private sector, donors and financial institutions within the framework of integrated water resource management.
    - Need for irrigation focused institution- including in the regions
    - Some water Management-small scale irrigation schemes are not functioning as expected. Need to understand why and put forward recommendation for rehabilitation.
    - Strategy needs to be developed by the public sector
    - Allocation of adequate budget to the irrigation and agricultural water management is important. The sub-sector is significantly under funded.
    - Incentives- Tax holidays are important undertakings that need to be provided due attention for significant private sector participation
    - Irrigation need to be developed within the framework of implementing integrated water resource management
  5. Need to build capacity to learn from experiences and acquire expertise in irrigation.
  6. Rural entrepreneurship should come as the first priority.
  7. Coordination of efforts is needed.
  8. Public sector must create the technologies for the private sector to scale-up.
  9. What are the public investment plans especially on irrigation? There are a lot of donors who are ready to fund irrigation projects.
  10. How large – scale interventions/ systems incorporate small scale schemes?
  11. In irrigation development, public sector should not do all the work. But there should be involvement of other sectors.
  12. Large scale irrigation interventions could be an alternative to resettlement of people to virgin and environmentally sensitive areas. What are the lessons from other countries? Research Institutions could provide ample opportunities on providing lessons learnt on linkage of resettlement and irrigation

### **Way Forward**

1. Synthesized recommendation and policy briefs can be submitted to the donors and policy makers.
2. Enhance the established steering committee among USAID, MoARD, MoWR and IWMI with involvement of private sector and other pertinent institutions and organizations

### **Tasks**

- Guide the study, compilation and information system on best practices of SSI, WH etc in Ethiopia (i.e. inventory, cost benefit analysis/ increased land and water productivity/ low cost technologies)
- Steering committee will select and disseminate the best practices through regular workshops and study tours (annually or biannually).

- Needs for further analysis and collection of information: Donors who have funded irrigation projects/ universities/international institutions/ NGOs would have carried out evaluations. But such information has not been collected systematically and still scattered.
- Continue dialogue with public and private sectors based on the outputs of this symposium.
- Follow up on the symposium recommendations.

### **Comments/ suggestions**

- Create a network to materialize the efforts of the participants and organizers.
- Engage the private sector more seriously. Next symposium could be partly funded by the private sector.
- It is Important to focus on holistic AWM, micro irrigation, small scale irrigation, linkage of large scale to small holders, etc

## **Exhibition content**

The exhibition part of the event involved display of posters, photographs, equipment, products and demonstration of operation of water and irrigation technologies. A total of 8 posters, 2 sets of photographic exhibition and over 10 different equipment that are used for water lifting and field application have been exhibited and demonstrated by institutions, organizations and companies from Ethiopia, Kenya, Egypt and Israel.

The participants were;

1. Agritech Systems PLC
2. Approtech/Kenya
3. Brruh Tesfa PLC
4. Kombolcha Agricultural Research Center
5. Center for International Development Cooperation of Israel's Ministry of Foreign Affairs (MASHAV)
6. Organization for Relief and Development in Amhara
7. Oromiya Agricultural Research Institute
8. Pump Manufacturers/Egypt
9. Relief Society of Tigray
10. Teppo Agricultural and Trade PLC
11. United States Agency for International Development/ Amarew project

# Closing address

## **H.E. Mr Adugna Jebessa**

Minister for Ministry of Water Resources

Dear participants of the symposium;

It is my great pleasure to be with you at this very special moment of concluding the three days special event under the theme of “Best practices and technologies for Agricultural Water Management in Ethiopia”.

As you are all aware of, our country Ethiopia, is suffering from recurring drought due to erratic rainfall occurrence both in amount and distribution and high environmental degradation. As a result, the people loose their means of livelihood and remain in the trap of poverty, the country remain food in-secure and make it relief dependent.

On the other hand, Ethiopia is bestowed with enormous water and land resource potential that can be tapped in the effort to attain food security. It is therefore, an alternative with out a choice to detach the agricultural sector from its dependency on the erratic rainfall through utilizing the resource endowments wisely and efficiently.

So far, only less than 5 % has been developed from the overall potential area of 3.7 Million hectares of irrigable land. This indicates that a great deal of work is expected from all actors and professionals engaging in the water sector development works. A great deal of work is also needed to rehabilitate the degraded land and water resources for sustainable development of the water and land resources themselves. That is why all of you are gathered here together to share your collective and individual experiences and lessons that will help the development of the agricultural water management and irrigation sector.

The government of Ethiopia is creating a conducive environment to foster the water sector development through setting proper policies, strategies and sector programs besides its existing efforts of expanding irrigation infrastructures.

As part of this effort, the Government has planned to develop more than 400, 000 Ha of land with in the coming five years under its poverty alleviation and sustainable development program.

In these respect wider range of alternative technologies and practices are required to properly develop and manage this development plan. It is my belief that efficient and sustainable development of irrigation, inter-alia, requires an integrated approach with other social, economic and environmental aspects.

Therefore, this symposium made a thorough discussion on:

- Current practices of SSI, MI and Rain Water Harvesting Technologies in Ethiopia
- Reviewed private sector participation for irrigation and Agricultural Water Management
- Reviewed policies and institutions for technology selection

I have been impressed by looking at the topics that have been discussed, the number of posters and exhibition material presented during the last two days. It has been very important knowledge and experience sharing.

I therefore, have a strong believe that the participants of this symposium and Exhibition have come up with very useful and practical recommendations in fostering sustainable agriculture and the expansion of irrigated agriculture in Ethiopia.

Finally, I would like thank the organizing committees who have prepared this very practical and learning symposium. I also would like to thank all the participants of this Symposium for their dedication of their valuable time and shared experiences and best lessons with respect to the irrigation sub-sector.

I would like to thank USAID for providing the necessary financial and technical support and IWMI for leading the organization of the symposium and exhibition. Thanks also to the Ministry of Agriculture and Rural Development to co- organize the event.

Thank you



# Symposium and Exhibition program

## Symposium and Exhibition on Best Practices and Technologies for Small Scale Agricultural Water Management in Ethiopia, 7-9 March 2006

<i>Time</i>	<i>Subject</i>	<i>Presenter</i>
<b>Day1: 7th March 2006</b>		
08:30 – 9:00	Registration	
9:00-9:10	Welcome and Introduction of the Program	Dr. Seleshi Bekele, IWMI
9:10-9:30	Opening Addresses	1. USAID Country Director H.E. Mr. William Hammink 2. State Minister for Ministry of Agriculture and Rural Development: H.E. Ato Yacob Yala
<b>Theme 1: Assessment of Current Practices of Small Scale –Agricultural Water Management and -Irrigation Development in Ethiopia</b>		
Chair Person: Ato Dejene Abesha		
Rapporteur: Ato Yacob Wondimku and Ato Solomon Cherre		
9:30-10:00	Current Experience on Existing Small Scale Irrigation	Ato Yalew Belete (MoARD)
10:00-10:30	Coffee Break	Organizers
10:30-10:50	Amhara Water Resources Inventory	Ato Melkau Teffera & Ato Yacob Wondimkun (SWHISA)
10:50-11:10	Small Holder Farmers Experience on Pressurized Irrigation Systems in Kobo Valley	Ato Adinew Abate
11:10-11:30	Improved Agricultural Water Management: Assessment of Constraints and Opportunities for Agricultural Development in Ethiopia	Dr. Seleshi Bekele
11:30-12:30	Discussion	
12:30-14:00	Lunch	Organizers
14:00	Opening of Exhibition	Ato Adugna Jebessa: State Minister for Ministry of Water Resources
14:00-15:30	Visit of Exhibition	Organizers
15:30-16:00	Coffee Break	Organizers
16:00-17:00	Visit of Exhibition	Organizers
18:00-19:00	Reception	Organizers

### Day 2: 8<sup>th</sup> March 2006

#### Theme 2: State of the Art and Best Technologies Review in RWH, SSI and MI

Chair Person: Dr. Tilahun Amade

Rapporteur: Ato Lakew Desta and Ato Tesfaye Tadesse

8:30-9:00	Review of Agricultural Water Management Technologies	Dr. Regassa Namara & Dr. Seleshi Bekele (IWMI)
9:00-9:20	Best Practice and Technologies for Agricultural Water Management	Dr. S. S. Magar
9:20-9:40	From Soil & Water Conservation to Small-Scale Irrigation	Mr. Chris T. Annen (GTZ)
9:40-10:00	Simple and Low-cost Drip Irrigation System: An alternative approach to raise household farm productivity	Dr. Mekonnen Ayana (AMU)
10:00-10:40	Discussion	
10:40-11:00	Coffee Break	Organizers

**Theme 3: Accessibility and Private Sector Participation in Irrigation Development, Technologies and Equipment**

Chair Person: Ato Teshome Atnafe

Rapporteur: Dr. Mathew McCarthney & Ato Teshome Lemma

11:00-11:30	Private-public Partnership and Technological Imperatives for Irrigation Development	Ato Alemayehu Mengiste (Agritech)
11:30-11:50	The Adoption of Micro Irrigation Technologies (Private Sector Participation in Irrigation Development)-KickStart Experience	Mr. John Kinaga (Kickstart)
11:50-12:10	The Green Water Paradigm: Optimizing Agricultural Productivity in Eastern & Southern Africa	Prof. Bancy Mati (ASARECA SWMNet)
12:10-12:30	Farmers oral presentation	Ato Nega Kebede and Adino Molla
12:30-12:50	Integrating Agro Enterprise Approach and Small Scale Irrigation: Experiences of Catholic Relief Services (CRS/Ethiopia) in Water Development and Management	Dr Legesse Dadi (CRS)
12:50-14:00	Lunch	Organizers
14:00-14:30	Discussion	

**Theme 4: Policies and Institutional Support Conditions for Small Scale Irrigation in Ethiopia**

Chair Person: Dr. Belay Demessie

Rapporteur: Ato Eteffa Emanna and Dr. Mathew McCarthney

14:30-15:00	Irrigation Policies, Strategies and Institutional Support Conditions in Ethiopia	Ato Solomon Cherre (MoWR)
15:00-15:20	Recent Achievements and Priorities in Irrigation Water Management Research in Ethiopia with Particular Reference to Amhara Region	Dr. Mohammed Zainul Abedin & Dr. Enyew Adgo (ARARI and SWHISA)
15:20-15:40	Coffee Break	
15:40-16:00	Irrigation Practices, State Intervention and Farmer's Life-Worlds in Drought-Prone Tigray, Ethiopia	Dr. Woldeab Teshome (AAU)
16:00-16:20	Keeping an Eye on Decentralization and Specification of a Resource Policy: An Overview of the Policy Study to the Promotion of RWH	Dr. Moges Shiferaw (Private)
16:20-16:40	Poverty Reduction Through Irrigation and Small Holder Market	Ato Kebede Ayele & Prof. Shibru Tedla (IDE)
16:40-17:00	Discussion	Participants
17:00-17:30	Group formation	

**Day 3: 9<sup>th</sup> March 2006**

Group 1: Current Practice of SSI, MI & RWH  
Technology in Ethiopia Group

Chair Person: Dr. S.S. Magar/ Dr. tilahun Hordoffa  
Rapporteur: Dr. Mekonnen Ayana

Group 2: The Private Sector for Irrigation & Ag.  
Water Management Group

Chair Person: Prof. Bancy Mati  
Rapporteur: Dr. Regassa E. Namara

Group 3: Policies and Institutions for Technology  
Group

Chair Person: Dr. Zainul Abedin  
Rapporteur: Dr. Godswill Makombe/Dr. Michiko E.

8:30-10:30	Group Discussion	
10:30-11:00	Coffee Break	Organizers
11:00-12:30	Group Discussion continues	
12:30-14:00	Lunch	
	Chair Person: Ato Alemayehu Mengiste	
	Rapporteur : Ato Hune Nega	
14:00-15:00	Plenary: Presentations of Groups 1 to 4	Rapporteurs
15:00-15:30	Plenary Discussion	Participants
15:30-16:00	Coffee Break	Organizers
16:00-16:30	Way Forward	Symposium Participants
16:30-17:00	Closing	H.E. Ato Adugna Jebessa, State Minister of Ministry of Water Resources

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## List of participants

### **AAU**

#### **Woldeab Teshome**

P.O.Box 150197  
Addis Ababa, Ethiopia  
Tel: 251-911673413  
Fax: 251-9239732  
E-mail: woldeabt@yahoo.com

### **A Glimmer of Hope**

#### **Asfaw Afera**

P.O.Box 13196  
Addis Ababa, Ethiopia  
Tel: 251-11524550  
Fax: 251-11525668  
E-mail: asfaw@aglimmer of hope.org

### **ADB**

#### **H/mariam H/meskel**

P.O.Box 25543 code 1000  
Addis Ababa, Ethiopia  
Tel: 251-116627726  
Fax: 251-116627742  
E-mail: h.hailemskel@afdb.org

### **Agritech Systems P.L.C**

#### **Alemayehu Mengiste**

P.O.Box 6064  
Addis Ababa, Ethiopia  
Tel: 251-116639240  
Fax: 251-116639245  
E-mail: agrsys@ethionet.et

### **Agri-Service Ethiopia**

#### **Tewodros Tekleab**

P.O.Box 6460  
Amaro Kelle, Ethiopia  
Tel: 251-114651212  
Fax: 251-114654088  
E-mail: ase@telcomnet.et

### **Aiada Hic**

#### **Ahmed Mohammed**

Addis Ababa, Ethiopia  
Tel: 251-9111814041  
E-mail: ahmedmbj2006@yahoo.com

### **Ambo College of Jimma University**

#### **Hussein Mohammed**

P.O.Box 44  
Ambo, Ethiopia  
Tel: 251-911450141  
Fax: 251-112362237  
E-mail: hihussien@yahoo.com

### **Habtamu Ashagre**

P.O.Box 19  
Ambo, Ethiopia  
Tel: 251-112362434

### **ARARI**

#### **Enyew Adgo**

P.O.Box 527  
Bahir Dar, Ethiopia  
Tel: 251-582205173  
Fax: 251-582205174  
E-mail: enywodgo@yahoo.com

### **Amio Engineering PLC**

#### **Ibrahim Yassin**

P.O.Box 25946  
Addis Ababa, Ethiopia  
Tel: 251-911222641/251-114169150  
Fax: 251-114-663265  
E-mail: amioeng@ethionet.et

### **Muzemil Mohammed**

P.O.Box 25946  
Addis Ababa, Ethiopia  
Tel: 251-911228093  
Fax: 251-114663234  
E-mail: amioeng@ethionet.et

### **Arbaminch University**

#### **Mekonnen Ayana**

P.O.Box 21  
Arbaminch, Ethiopia  
Tel: 251-468810453  
Fax: 251-468810279  
Mekoamu@yahoo.com

**P.N.Darde**  
P.O.Box 21  
Arbaminch, Ethiopia  
Tel: 251-916831213  
E-mail: pndarde@rediftmail.com

**Shipra Sarkar**  
P.O.Box 21  
Arbaminch, Ethiopia  
  
Tel: 251-916831213  
E-mail: drdarde@rediffhail.com

**Bank of Abyssinia**  
**Berhanu Hailu**  
P.O.Box 18915  
Addis Ababa, Ethiopia  
Tel: 251-15514130  
E-mail: berhanugen@yahoo.com

**Bruh Tesfa Plastic P.L.C**  
**Jemal Shehahmed**  
Mekelle, Ethiopia  
Tel: 251-400472  
E-mail: bruh-tesf@ethionet.et

**Mulu Aynalem**  
P.O.Box 1581  
Mekelle, Ethiopia  
Tel: 251-400453  
Fax: 251-400467

**Bruh Tesfa Drip Irrigation**  
**Aklilu Yemesgen**  
P.O.Box 1581  
Mekelle, Ethiopia  
Tel: 251-344410891  
Fax: 251-3444400476  
E-mail: bruhtesfa@ethionet.et

**BoARD**  
**Tadesse Amsalu**  
P.O.Box 437  
Bahir Dar, Ethiopia  
Tel: 251-582202790  
E-mail: tadess-2@yahoo.co.uk

**Care Ethiopia**  
**Teshome Lemma**  
P.O.Box 4710

Addis Ababa, Ethiopia  
Tel: 251-911419364  
E-mail: tlyami@yahoo.com

**CHF-Partners in Rural Development.**  
**Leslie Gardiner**  
P.O.Box 1551, code1250  
Addis Ababa, Ethiopia  
Tel: 251-113728655/911252751  
igardiner@chf-ppartners.ca

**CRS/Ethiopia**  
**Bekele Abaire**  
P.O.Box 6592  
Addis Ababa, Ethiopia  
Tel: 251-911420375/46553590/93  
Fax: 251-114654450  
E-mail: bekeleab@crsethiopia.org.et

**Legesse Dadi**  
Addis Ababa, Ethiopia  
Tel: 251-114670297  
Fax: 251-114654450  
E-mail: legsseda@crsethiopia.org.et

**DBS RRV, Dapol**  
**S.S. Magar**  
Dapolo.Dist Ratragiri, India  
Tel: 251-912358282064  
Fax: 251-912358282074  
E-mail: ssmagar1942@yahoo.co.in

**Degnna**  
**Asfaw T/mariam**  
P.O.Box 20  
Mekelle, Ethiopia  
Tel: 251-344403927

**EDRI/IFPRI**  
**Gezahegn Ayale**  
P.O.Box 2479  
Addis Ababa, Ethiopia  
Tel: 251-5506066  
Fax: 251-5505588  
E-mail: ayeleg2002@yahoo.com

**EIAR**  
**Fentaw Abegaz**

P.O.Box 2003  
Melka Werer, Ethiopia  
Tel: 251-9111886405  
Fax: 251-116461251  
E-mail: fentaw@rediffmail.com

**Embassy of Finland**  
**Antti Rautavaara**  
E-mail: Antti.rautavaara@formin.fi

**Embassy of Israel**  
**Tsedele Lemma**  
P.O.Box 1266  
Addis Ababa, Ethiopia  
Tel: 251-116460999  
Fax: 251-116461961  
E-mail:  
embassy@addisababa.mfa.gov.cl

**ERHA**  
**Ephraim Alamerew**  
P.O.Box 2767/1000  
Addis Ababa, Ethiopia  
Tel: 251-116638513  
Fax: 251-116638514  
E-mail: erha@ethionet.et

**Gebeyehu Uka**  
Addis Ababa, Ethiopia  
Tel: 251-918763062  
Fax: 251-116638514

**Mahlet Mebrate**  
P.O.Box 27671/1000  
Addis Ababa, Ethiopia  
Tel: 251-6638514/13  
Fax: 251-116638514  
E-mail: erha@ethionet.et

**ESAT-IDE**  
**Berhanu Assfa**  
P.O.Box 5998  
Addis Ababa, Ethiopia  
Tel: 251-115519606  
E-mail: berassefa@yahoo.com

**ESSS**  
**Taye Bekele**  
P.O.Box 147  
Addis Ababa, Ethiopia

Tel: 251-111505596  
Fax: 251-515288  
E-mail: nsl@ethionet.et

**Ethio Agri CEFT**  
**Ayalew Nigussie**  
P.O.Box 1006  
Addis Ababa, Ethiopia  
Tel: 251-116621029  
E-mail: ayalewnigussie@yahoo.com

**ESAT**  
**Shibru Tedla**  
P.O.Box 5998  
Addis Ababa, Ethiopia  
Tel: 251-115519606  
E-mail: shibru@ossrea.net

**ESTA**  
**Abebe Mekuriaw**  
P.O.Box 2490  
Addis Ababa, Ethiopia  
Tel: 251-911500814  
E-mail: abebe\_mekuriaw@yahoo.com

**Ethiopian Sugar Industry Support Center**  
**Girma Teferi**  
P.O.Box 15  
Wonji, Ethiopia  
Tel: 251-222200187  
E-mail: girmateferi@ethonet.et

**FAO**  
**Yibeltal Tiruneh**  
P.O.Box 5536  
Addis Ababa, Ethiopia  
Tel: 251-115517233  
Fax: 251-115515266  
E-mail: yibeltal.tiruneh@fao.org

**FHI**  
**Getahun Shibeshi**  
P.O.Box 4181  
Addis Ababa, Ethiopia  
Tel: 251-116621977  
E-mail: gshibeshi@fhi.net

**GCT****Ayele Shifraw**

Addis Ababa, Ethiopia  
Tel: 251-115522784/911759780  
Fax: 251-115514979  
E-mail: Gck@ethionet.et

**Gitz SUN Tigray****Chris Annen**

P.O.Box 931  
Mekelle, Ethiopia  
Tel: 251-344404940  
Fax: 251-344404941  
E-mail: gtasuutg@ethionet.et

**IDE/ESAT****Kebede Ayele**

P.O.Box 19480  
Addis Ababa, Ethiopia  
Tel: 251-911401623/115517217  
E-mail: kbdayeale@yahoo.com

**IFAD****Abebe Zerihun**

P.O.Box 28059 code 1000  
Addis Ababa, Ethiopia  
Tel: 251-911619112  
E-mail: abebe.zerihun@undp.org

**IFPRI****Kassu Wamisho**

Addis Ababa, Ethiopia  
E-mail: k.wamisho@cgiar.org

**ILRI****Girma Tadesse**

P.O.Box 5689  
Addis Ababa, Ethiopia  
Tel: 251-911406188/116463215  
E-mail: g.tadesse@cgiar.org

**International Centre for Tropical  
Agriculture****Tilahun Amede**

P.O.Box 1412 code 1110  
Addis Ababa, Ethiopia  
Tel: 251-116463215  
E-mail: T.Amede@cgiar.org

**IWMI****Dominik Ruffeis**

P.O.Box 5689  
Addis Ababa, Ethiopia  
Tel: 251-911739881  
Fax: 251-116461252  
E-mail: druffeis@cgiar.org

**Godswill Makombe**

P.O.Box 5689  
Addis Ababa, Ethiopia  
Tel: 251-116463215  
Fax: 251-116461252  
E-mail: g.mahomb@cgiar.org

**Matthew McCARTNEY**

P.O.Box 5689  
Addis Ababa, Ethiopia  
Tel: 251-116463215  
Fax: 251-116461252  
E-mail: m.mccartney@cgiar.org

**Michiko Ebato**

P.O.Box 5689  
Addis Ababa, Ethiopia  
Tel: 251-116463215  
Fax: 251-116461252  
E-mail: m.ebato@cgiar.org

**Regessa Ensermu Namara**

Ghana  
E-mail: r.namara@cgiar.org

**Seleshi Bekele**

P.O.Box 5689  
Addis Ababa, Ethiopia  
Tel: 251-116463215  
Fax: 251-116461252  
E-mail: s.bekele@cgiar.org

**Yasir A. Mohamed**

Addis Ababa, Ethiopia  
Tel: 251-116463215  
Fax: 251-116461252  
E-mail: y.mohamed@vcgiar.org

**Japan Embassy****Fitsum Kalayu**

P.O.Box 5650  
Addis Ababa, Ethiopia

Tel:251-115511088  
Fax: 215-115511350

**JICA**

**Kozo Inada**  
P.O.Box 5382  
Addis Ababa, Ethiopia

**Masahiro Yagi**

Addis Ababa, Ethiopia  
Tel: 251-115531223  
E-mail: tokeyagi@yahoo.co.jp

**Kickstart International**

**John Kinaga**  
P.O.Box 64147  
Nairobi, Kenya  
Tel: 254-020-78738011  
Fax: 254-020-7838011/703046  
E-mail: john.kiuaga@kickstart.org

**KGVDP**

**Adinew Abate Retta.**  
P.O.Box 182,Kobo  
Ethiopia  
Tel: 251-918340172/333340089  
Fax: 251-333340474  
E-mail: kagvdp@ethionet.et

**Adino Molla Shumye**

Kobo, Ethiopia  
Tel: 251-333340089

**Nega Kebede Amene**

Kobo, Ethiopia  
Tel: 251-333340089

**Kombolecha Agricultural  
Mechanization and Poultry Center**

**Nuru Mohammed**  
P.O.Box 72  
South Wollo, Ethiopia  
Tel: 251-335510345

**Komobolcha Agricultural  
Research Center**

**Geta Kidan Mariam**  
P.O.Box 72  
Kombolicha, Ethiopia  
Tel: 251-335510345

Fax: 251-335512140  
E-mail: getajuddab@yahoo.com

**MIT-Brhue Tesfa  
Alemayehu Ambaye**

Mekelle, Ethiopia  
Tel: 251-706037

**MoARD**

**Amare Worku**  
Addis Ababa, Ethiopia  
Tel: 251-115151426  
E-mail: amarewa@yahoo.com

**Ayalew Abate**

P.O.Box 5673  
Addis Ababa, Ethiopia  
Tel:251-911465480  
Fax: 251-116610710  
E-mail: ayalewa@gmail.com

**Dejene Abesha**

Addis Ababa, Ethiopia  
Tel: 251-115156804

**Hune Nega**

P.O.Box 20766  
Addis Ababa, Ethiopia  
Tel: 251-911637518  
E-mail: hunenega@yahoo.co.uk

**Jemal Kedir**

P.O.Box 32876  
Addis Ababa, Ethiopia  
Tel: 251-5512734

**Lakew Desta**

P.O.Box 30259  
Addis Ababa, Ethiopia  
Tel: 251-911401459  
E-mail: Lakewdes@yahoo.com

**Tadesse Bekele**

P.O.Box 62347  
Addis Ababa, Ethiopia  
Tel: 251-116460119  
Fax: 251-116460183  
E-mail: moa.crop@telecom.net.et



**Temesgen Mamo**

Addis Ababa, Ethiopia  
Tel: 251-115156804

**Yacob Yala**

Addis Ababa, Ethiopia

**Yalew Belete**

Addis Ababa, Ethiopia  
Tel: 251-5156804/5150716

**MoWR****Getaneh Assfa**

P.O.Box 41189  
Addis Ababa, Ethiopia  
Tel: 251-911401175

**Gezahegn Alemu**

P.O.Box 5744  
Addis Ababa, Ethiopia  
Tel: 251-116-611111  
E-mail: gezahegn-almu@yahoo.com

**Leulesegd Tadsse**

P.O.Box 5673  
Addis Ababa, Ethiopia  
Tel: 251-6625515  
Fax: 251-6630459  
E-mail: leul-tad@yahoo.com

**Solomon Cherie**

P.O.Box 5673  
Addis Ababa, Ethiopia  
Tel: 251-911887678  
E-mail: solomoncherie@yahoo.com

**Tesfaie Tadesse**

P.O.Box 2306 code 1110  
Addis Ababa, Ethiopia  
Tel: 251-911688696  
E-mail: testadabdi2003@yahoo

**Teshome Atnafie**

P.O.Box 100894  
Addis Ababa, Ethiopia  
Tel: 251-911611238  
Fax: 251-116637048  
E-mail: teshome987@yahoo.com

**Ms. Consultancy****Hirut Ayele**

P.O.Box 30504  
Addis Ababa, Ethiopia  
Tel: 251-6517869

**National Meteorological Agency****Almaz Demessie**

P.O.Box 1090  
Addis Ababa, Ethiopia  
Tel: 251-911197120  
E-mail: ssimretds@yahoo.com

**NCCR North-South****Moges Shiferaw**

Addis Ababa, Ethiopia  
Tel: 251-911242588  
E-mail: Mogeshiferaw2002@yahoo.com

**NETAFIM****Wondwosson G/Marim**

P.O.Box 21799 Code1000  
Addis Ababa, Ethiopia  
Tel: 251-116185713  
E-mail: retafimeth@ethionet.et.

**Nil Basin Initiative/Env.Project****Yesuf Abdella**

P.O.Box 12760  
Addis Ababa, Ethiopia  
Tel: 251-911682235  
Fax: 251-116464876  
E-mail: ymohammed@nilebsin.org

**ORDA****Asrat Melaku**

P.O.Box 132  
Bahir Dar, Ethiopia  
Tel: 251-582204703

**Million Alemayehu**

P.O.Box 8122  
Addis Ababa, Ethiopia  
Tel: 251-115504455/54  
Fax: 251-115517244  
E-mail: orda.liaison@ethionet.et

**Wubshet Atnafu****Jemal Yasin Mohammed**

P.O.Box 97

Kombolcha, Ethiopia  
Tel: 251-335530467/5530922

**Abdu Husein Garfu**  
P.O.Box 97  
Kombolcha, Ethiopia  
Tel: 251-335530467

**Mohammed Ahmed**  
P.O.Box 97  
Kombolcha, Ethiopia  
Tel: 251-335530467

**Oromiya ARDB**  
**Bezuayehu Tefera**  
P.O.Box 21118 code 1000  
Addis Ababa, Ethiopia  
Tel: 251-911606845  
E-mail: bezuayehte@yahoo.com

**OSHO,GAA, Zway dugda Project**  
**Dedefo Tenesho**  
P.O.Box 1214  
Osolcho, Ethiopia  
Tel: 251-916821173  
Fax: 251-15536967  
E-mail: osho@ethionet.et

**OXFAM GB**  
**Mulu Tesfaye**  
P.O.Box 2333  
Addis Ababa, Ethiopia  
Tel: 251-911341643  
E-mail: mtesfaye@oxfam.org.uk

**REST**  
**Ermias Hagos Girmay**  
P.O.Box 20  
Mekelle, Ethiopia  
Tel: 251-344406642  
E-mail: ermiash2000@yahoo.com

**G/Tsadeki K/mariam**  
P.O.Box 20  
Mekelle, Ethiopia  
Tel: 251-410149  
Fax: 251-406714  
E-mail: gtsadikk@yahoo.com

**Kahsay Girmay**  
P.O.Box 20  
Mekelle, Ethiopia  
Tel: 251-3444406300  
Fax: 251-344406714  
E-mail: kahsay-girma@yahoo.com

**Maria Strintzos**  
P.O.Box 8078  
Addis Ababa, Ethiopia  
Tel: 251-115514378  
Fax: 251-115512694  
E-mail: restpr@ethionet.et

**Teklewoini Assefa**  
P.O.Box 8078  
Addis Ababa, Ethiopia  
Tel: 251-15514378  
E-mail: rest@telecom.net.et

**SDVC (Sustainable Development through Value Creation)**  
**Yonas Habtemariam**  
P.O.Box 1000496  
Addis Ababa, Ethiopia  
Tel: 251-911206522  
E-mail: yonasmariam@yahoo.com

**Selam Technical & Vocational center**  
**Mesfin G/Medhin**  
P.O.Box 8075  
Addis Ababa, Ethiopia  
Tel: 251-116462942/0911414948

**Tamiru Mamo**  
P.O.Box 8075  
Addis Ababa, Ethiopia  
P.O.Box 116462942

**EWTEC/JICA**  
**Yuji Maruo**  
E-mail: yumaruo@ethionet.et

**SWMnet**  
**Bancy M.Mati**  
39063-00623  
Nairobi, Kenya  
Tel: 254-722-638872

Fax: 254-2-0-7224001  
E-mail: b.mati@cgral.org

### **SWHISA**

**Mohammed Zainul Abedin**  
P.O.Box 325  
Bahir Dar, Ethiopia  
Tel: 251-582207201/2222011  
Fax: 251-582222012  
E-mail: mzabedin@rogers.com

### **Melaku Tefera**

P.O.Box 441  
Bahir Dar, Ethiopia  
Tel: 251-918761399  
Fax: 251-582222012  
E-mail: melakutef@yahoo.com

### **Yacob Wondimkun**

Bahir Dar, Ethiopia  
Tel: 251-582222011/918764215  
Fax: 251-582222012  
E-mail: wyacob@yahoo.com

### **Swiss Federal Institute of Technology**

**Samuel Luzi**  
Zurich, Switzerland  
Tel: 251-911462043/0041446320790  
E-mail: luzi@sipo.geess.ldhz.ch

### **Tappo Agriculture**

**Kebreab Abebe**  
P.O.Box 885  
Addis Ababa, Ethiopia  
Tel: 251-15515179  
Fax: 251-5515145  
E-mail: teppo@ethionet.et

### **Tigray BoARD**

**Mezgebe Tsegaye**  
P.O.Box 10  
Mekelle, Ethiopia  
Tel: 251-914709609  
Fax: 251-344403710  
E-mail: mezgebetsegay@yahoo.com

### **TWRMB**

**Tesfa-aelm Gebreegziabher Ebare**  
P.O.Box 520

Mekelle, Ethiopia  
Tel: 251-3444406930/6677  
Fax: 251-344441064  
E-mail: tesfa-almge@yahoo.com  
/zhope2005@yahoo.com

### **University at Bern**

**Evelyne Tauchnitz**  
Berne, Switzerland  
E-mail: e.tauchintz@gmt.ch

### **Franziska Sigrist**

Berne, Switzerland  
Tel: 251-911462043  
E-mail: franziska.sigrist@gmx.ch

### **Unzphos Agro Znd.LTD.**

**Tushar Trivedi**  
Mumbaz, Fndza  
Tel: 251-911610695  
Fax: 251-912256606689  
E-mail: triveditj@uniphos.com  
/tusharcht@yahoo.com

### **USAID**

**Bill Hammiuk**  
Addis Ababa, Ethiopia  
Tel: 251-113510851

### **John McMahon**

P.O.Box 1014  
Addis Ababa, Ethiopia  
Tel: 251-115510713  
Fax: 251-115510043  
E-mail: Jmcmahon@usaid.gov

### **Belay Demessie**

P.O.Box 1014  
Addis Ababa, Ethiopia  
Tel: 251-5510088  
Fax: 251-5510043  
E-mail: bdemissie@usaid.gov.

### **Metselal Abraha**

P.O.Box 1014  
Addis Ababa, Ethiopia  
Tel: 251-5510088  
E-mail: mabreha@usaid.gov

**Fekadu Yohannes**

P.O.Box 61  
Bahir Dar, Ethiopia  
Tel: 251-918768272  
Fax: 251-582202555  
E-mail: fekaduyoh@yahoo.com

**Water Aid/ECWP**

**Kidanemariam Jembere**

P.O.Box 4812  
Addis Ababa, Ethiopia  
Tel: 251-114661684  
Fax: 251-114661679  
E-mail: k\_jembere@yahoo.com

**Water Harvesting & Small Scale  
Irrigation & RIOP Department**

**Abera Legesse**

P.O.Box 62347  
Addis Ababa, Ethiopia  
Tel: 251- 5156804

**World Vision Ethiopia**

**Zerihun Beyene**

P.O.Box 3330  
Addis Ababa, Ethiopia  
Tel: 251-116293034  
Fax: 251-116293346  
E-mail: zerihun-beyene@wvi.org

**Yerer Eng. Plc.**

**Habtamu Beza**

Addis Ababa, Ethiopia  
Tel: 251-115518036  
Fax: 251-115536970  
E-mail: yerer@ethionet.et



### Postal Address

P.O.Box 2075  
Colombo  
Sri Lanka

### Location

127. Sunil Mawatha  
Pelawatta  
Battaramulla  
Sri Lanka

### Telephone

94-11 2787404, 2784080

### Fax

94-112786854

### E-mail

[iwmi@cgiar.org](mailto:iwmi@cgiar.org)

### Website

[www.iwmi.org](http://www.iwmi.org)



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