2nd Forum on Irrigation & Water for Sustainable Development

15 –16 December, 2008 Ghion Hotel, Addis Ababa, Ethiopia
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Organized by:
Ethiopia National Irrigation Steering Committee

Sponsored by:
International Water Management Institute (IWMI)

Ministry of Agriculture and Rural Development (MoARD)

Ministry of Water Resources (MoWR)

United States Aid and International Development (USAID)

Japan International Cooperation Agency (JICA)

IWMI International Water Management Institute   MoARD   MoWR   USAID FROM THE AMERICAN PEOPLE   JICA

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Acronyms and Abbreviations

AEZs	Agro ecological Zones
AWM	Agricultural water management
ASAL	Arid and semi arid lands
BoARD	Bureau of Agriculture and Rural Development
BoWRD	Bureau of Water Resources Development
BBF	Broad Based Furrow
CSA	Central Statistics Authority
EPLAWA	Environmental Protection and Land Administration Use Agency
ERWHA	Ethiopian Rain Water Harvesting Association
FAO	Food and Agriculture Organization
FDK	Family drip kit
FTC	Farmers Training Center
GDP	Gross Domestic Product
GOs	Government Organizations
ICARDA	International Center for Agricultural Research in the Dry Areas
IWMI	International Water Management Institute
NGOs	Non Governmental Organization
OoA	Office of Agriculture
Pd	Person-days
RWHT	Rain Water Harvesting Technologies
SNNPR	Southern Nations and Nationalities Peoples Region
SWC	Soil and Water Conservation
USAID	United States Agency for International Development
WH	Water Harvesting
WSDP	Water Sector Development Program

Acknowledgements

This booklet is the result of a two-day forum and exhibition organized by the Ethiopian National Irrigation Steering Committee in collaboration with the Ethiopian Ministry of Agriculture and Rural Development (MoARD), Ethiopian Ministry of Water Resources (MoWR), United States Agency for International Development (USAID) and the International Water Management Institute (IWMI). The main objective of the forum was to bring together and share experiences among government institutions (policymakers, technical experts and academicians), nongovernmental organizations (NGOs), the private sector (smallholder farmers, commercial farmers, producers and distributors of irrigation equipment), international donors, financial institutions and related stakeholders who are working in irrigation, water, natural resources management, investment and other socioeconomic sectors. Over 150 participants from 50 institutions participated in the forum. A total of 25 papers from the ministries of Agriculture, Water, and Finance and Economic Development; regional states of Amhara, Tigray, Oromia and Southern Nations, Nationalities, and People's Region (SNNPR); the Water Resources Think Tank Group; researchers from IWMI; and the private sector have been presented during the forum. In addition, an exhibition was held comprising of irrigation equipment, posters and products from over 10 organizations. In-depth discussions were held during parallel and plenary sessions, which resulted in key recommendations being put forward. The organizing committee is very grateful to all those who have provided a high level of recognition, those who provided financial support, individuals and institutions that participated, those who presented the papers and those who contributed to the exhibition as well as those who helped in the logistical arrangements to make the event a success.

Project
The reports and papers included in this booklet and on the CD are part of the projects related to the Agricultural Water Management Technologies Inventory, Characterization and Suitability Assessment.

Collaborators
The forum and exhibition was organized by the Ethiopian National Irrigation Steering Committee in collaboration with the following organizations:

IWMI International Water Management Institute

International Water Management Institute (IWMI)

MoARD

Ministry of Agriculture and Rural Development (MoARD), Ethiopia

MoWR

Ministry of Water Resources (MoWR), Ethiopia

United States Agency for International Development (USAID)

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International Water Management Institute (IWMI)

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Welcoming address

1.1 Dr. Seleshi Bekele Awulachew

Senior Researcher and Head, East Africa and Nile Basin Office
International Water Management Institute (IWMI), Addis Ababa, Ethiopia

Your Excellency, Ato Teffera Deribew, Minister of Agriculture and Rural Development, dear Participants of the symposium and ladies and gentlemen…

On behalf of the technical program committee and on behalf of the International Water Management Institute, which is one of the co-organizing institutes, I would like to welcome you to the Second Forum on Irrigation and Water for Sustainable Development to be held today and tomorrow here at Ghion Hotel.

Excellencies, allow me also to introduce the program of the Forum. This Forum is organized by Ethiopian National Irrigation Steering Committee and is designed to provide presentation of papers, exhibitions, discussions, debates and put forward recommendations on irrigation and broader water management for agriculture and other sectors.

The forum is addressing key questions such as:

- What are the current policies, strategies, implementations, and impact of irrigation developments including constraints?
- What are new innovations, thoughts and directions that speedup agriculture development, accelerate growth, taking natural resources endowment of Ethiopia, particularly water and land and in line with PASDEP and targets of the Millennium Development Goals (MDGs)?
- What are the various water management technologies tested, which ones are making significant impact, and what are typical impacts of past investments, and how do these investments be sustainable and out-scaled?

Based on these questions, the main objective of this Forum is to bring together and share experiences among government institutions (policymakers, technical experts and academicians), NGOs, the private sector (smallholder farmers, commercial farmers, and producers and distributors of irrigation equipment), international donors, financial institutions and related stakeholders who are working in irrigation, water, natural resources management, investment and other socioeconomic sectors.

Accordingly, the Forum themes are subdivided into three categories:

1. Recent development of irrigation subsector policy and strategies
2. Water-centered growth corridor - concepts and innovations
3. Experience and impact of irrigation development in Ethiopia

During the Forum, 25 papers from the ministries of Agriculture and Rural Development, Water Resources, and Finance and Economic Development; regions of Amhara, Tigray, Oromia and SNNPR; the Water Resources Think Tank Group; researchers from IWMI; the private sector; and donors are scheduled to be presented. In addition, an exhibition of irrigation equipment, posters and products from over 10 organizations are on display. Over 150 people from over 50 institutions are participating in this event.

Accordingly, the two-day program includes the following (as you may also see it on your program sheet):

- Opening remark by the Chair of the Steering Committee
- Opening of the Forum by guest of honors
- After the opening we will have a group photograph
- After the photograph we will have the opening of the exhibition and a coffee break
- The rest of the program is as shown in the program sheet

Thank you very much.

According to our program, I now call on Ato Sileshi Getahun, the Director of Natural Resources of Ministry of Agriculture and Rural Development (MoARD) and Chair of the National Irrigation Steering Committee, to provide us with an opening remark on behalf of the Steering Committee and invite the guest of honor to open the Forum.

Dr. Seleshi Bekele Awulachew, welcome speech and opening address.

Photo credit: Apollo Habtamu

About the Symposium and Exhibition

Seleshi B. Awulachew
Head for East Africa and Nile Basin,
International Water Management Institute (IWMI)

1.1. Background

The main development objective of the Ethiopian Government and its partners is poverty eradication. Hence, the country's development policies and strategies are geared towards this end. In line with this, bilateral and multi-lateral donors, NGOs and various institutions share the concepts and priorities identified in the "Plan for Accelerated and Sustained Development to End Poverty" (PASDEP, MOFED 2006).

Although Ethiopia's economy and majority of people's livelihood is dependent on agriculture; there are key challenges that need to be addressed on transforming agriculture by overcoming multitude of problems including biophysical and water management issues to help attainment of PASDEP and sustainable socio-economic growth of the country. The dominant agricultural system in Ethiopia is small-holder mixed production of cereals and livestock under rain-fed conditions, leaving the system, population and economy extremely vulnerable to effects of metrological and hydrological variability which manifest itself as prolonged dry spells and drought. There is also 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 these areas. This dominant small holder agriculture system of Ethiopia is not benefiting much 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 targeting the poor but also with strong linkage to private sector and markets with the necessary institutional support services could provide ample opportunities in terms of coping strategy against climatic externalities, 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 easily disseminated, adapted and replicated to enable usage of appropriate technologies to overcome the stated challenges protect the livelihoods and bring about the desired growth and wealth creation. It is critical time in Ethiopia to bring together all stake holders who are involved in policy and decision making, technology and knowledge generation, knowledge brokering, manufacturing, trading, users to discuss, exchange knowledge and seek mechanisms through which the technologies could be accessed and the uptakes could be enhanced.

Cognizant of the above, a national Steering Committee was established in the past few years involving many actors such as government: MoARD, MoWR; bilateral and multilateral donors: USAID, JICA, AfDB, IFAD, GTZ, FAO, World Bank; private sector representative; NGOs and International Research Institution (IWMI) and have been engaged in promoting sustainable agricultural water management practices in Ethiopia. One of the functions of the Steering Committee being to organize a biannual forum focusing to facilitate experience sharing among different stakeholders a national Irrigation and Water Forum is organized during December 15-16, 2008 in Addis Ababa, Ethiopia.

1.2. Objectives of the forum

The objective of the forum is to 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 stakeholders that are working in irrigation, water, natural resources management, investment and other socio-economic sectors.

Specifically, the forum is designed to:

1. Enable participants to exchange information, knowledge and reflect on issues related to water, irrigation and agricultural policies, strategies and developments
2. Present key challenges of irrigation and agriculture existing, new, innovative and indigenous knowledge and ideas related to Ethiopia's growth opportunities and enrich such thinking through discussions

Create a platform for exchange of experience on recent interventions in irrigation and agricultural water management sectors. Particularly, share existing knowledge; 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

Opening address

1.2 HE Ato Teffera Deribew

Minister, Ministry of Agriculture and Rural Development (MoARD)
Addis Ababa, Ethiopia

Honorable ministers,
Distinguished guests,
Ladies and gentlemen,

On behalf of the Ministry of Agriculture and Rural Development and myself, it gives me great pleasure and an honor to welcome you all to this important Forum on Irrigation and Water for Sustainable Development Program.

Ethiopia has large water reserves that could be used for a wide range of irrigation development programs. It has 12 river basins with an annual water runoff volume of 122 billion cubic meters. In addition, the groundwater potential is estimated to be 2.6 billion cubic meters.

At present, only about 3 to 5% of the irrigable land is under irrigation while the irrigation potential has been estimated to be about 4.25 million hectares of arable land. This depicts the fact that if we maximize our efforts to utilize the untapped water resources for irrigation development, we will be able to overcome the challenges of food insecurity within the shortest time possible.

Generally, Ethiopia's water resources have not been adequately utilized to contribute to the economic and social goals of the country.

Cognizant of this, the National Water Sector Policy has been developed. This policy has the overall goal of enhancing and promoting the national efforts towards efficient, equitable and optimal utilization of the available water resources for the socioeconomic development of the country in a sustainable manner.

In this regard, the government has committed itself to take commendable intervention measures to translate policy into action.

Excellencies,
Honorable delegates,
Ladies and gentlemen,

Water is the first fundamental resource for survival and it is a key component for socioeconomic development activities including agriculture, power, transportation, fishing, wildlife conservation, health and industry.

Sustainable use of water is important for our planet and is also fundamental for both food production and well-functioning ecosystems. However, unsustainable water use is very common, especially in Ethiopia. Inefficient water use, fluctuation in water availability, increasing scarcity and declining water quality are the major challenges facing the water sector of our country.

Water and Land are the major assets for majority of the rural poor people in Ethiopia who depend on agriculture for their livelihoods. Water resources are considerable and if managed more effectively, they could make a substantial contribution to rural poverty reduction. Major opportunities to increase food security and household incomes are being missed because of inadequate investment in water for agriculture especially for smallholder land users.
One opportunity lies on utilizing past experiences and knowledge, gathered through many years of project implementation, into innovative policies, strategies and actions aimed at the sustainable use of the full potential of water for agriculture in Ethiopia.

Excellencies,
Honorable delegates,
Ladies and gentlemen,

The countries of the United Nations have committed themselves to achieving the Millennium Development Goals (MDGs). One of these goals includes the target to halve the proportion of the world's people who suffer from poverty and hunger and to ensure that current trends in the loss of natural resources are effectively reversed at both global and national levels by 2015. Another Millennium Development Goal targets to have the people who have no access to safe and reliable drinking water.

Changes are needed in the use of water in the agricultural sector. More effective and efficient use of water, more diversification of crops and better environmental adaptation are some of the possible options.

Farmers have an obligation to manage the water they need as carefully as possible. Local communities have to be in charge of development. They possess the know-how for action that truly leads to implementation, moreover, the efforts to eradicate poverty.

Let us not forget that agriculture in Ethiopia is the cornerstone for economic and social development and, therefore, in poverty alleviation.

Excellencies,
Honorable delegates,
Ladies and gentlemen,

The adoption of sustainable water management and irrigation development targeting the poor but also with strong linkages to the private sector and markets together with the necessary institutions and other support conditions could provide ample opportunities in terms of a coping strategy against climatic externalities, 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 easily adapted and replicable to enable usage of appropriate technologies to overcome irrigation and water associated challenges, protect the livelihoods and bring about the desired growth.

It is, therefore, high time in Ethiopia to bring together all stakeholders who are involved in policy and decision making, technology and knowledge generation, manufacturing, trading and use of technologies to discuss, exchange knowledge and seek mechanisms through which the technologies could be accessed and the uptake could be enhanced.

It is my belief that this Forum is exemplary in terms of creating synergy and collaboration amongst different sectors including sister ministries, donors, private sectors, international institutions, NGOs and other stakeholders. With our joint effort we will be able to bring about desirable changes in agricultural water management for the attainment of food security objectives and poverty reduction.

Please allow me to take this opportunity to thank the steering committee members of Agricultural Water Management for organizing this forum and taking the initiative to bring all stakeholders together to discuss our common agenda of water and irrigation.

I would also like to extend my appreciation to IWMI, USAID, JICA, AfDB, GIZ, World Bank, FAO and others for their technical and financial support rendered for the realization of this Forum.

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

I thank you all!!!

Ato Teffera Deribew, welcome speech and opening address.
Photo credit: Apollo Habtamu

1.3 HE Ato Shiferaw Jarso

Basin Affairs Advisor Minister to the Prime Minister

Dear Participants

Ethiopia is a country suffering from repeated drought and poverty. Many reasons can be sighted for this. But misuse/underutilization/mismanagement of the natural resources is the main reason. The lowland parts of Ethiopia (which are hit by recurrent drought), and marginalized and unaddressed areas of the country, can have good development potential if solutions to some very limiting factors are solved. Food-insecure areas can be changed to food-surplus areas and even to development centers that relieve the pressure on the dwindling resources of the Highlands. Apart from the life-saving intervention, there is also an equity issue and balanced development to be addressed in the Ethiopian Lowlands. Major problems in the Highlands of Ethiopia, which is linked with population pressure on limited resources, improper utilization, and management of the natural resources and lack of good governance, can be taken as main areas of focus.

In a country like Ethiopia, where the use of water for development is minimal, water is definitely an entry point for development. But lack of an integrated land use plan and area-based development plan derived from the land use plan are also key limiting factors for economic development next to water.

These two are pillars of the growth corridor development approach and are inseparable. The major reasons to go for land use planning are to identify the best beneficial use of land. In doing so, potential growth corridors, growth poles and growth centers will be identified. Without this, it will be difficult to create a large-scale countrywide movement and bring the required fast economic development for the following main reasons:

- The enormity of the socioeconomic problem facing the region’s demand and a huge mass movement to face it.
- The natural resource base is not well-known, mismanaged or underutilized.
- Existing land use plans are at reconnaissance levels; studies at detailed scales cover only a few pocket areas.
- Basin master plan studies need further detailed studies to be implemented.
- Development activities in newly developing areas, which were not covered even by previous regional-scale studies, shall follow the land use plan based on systematic studies.
- There is no spatial development plan to establish a strong rural-urban link and ensure sustainable urban development.
- To setup an area-based development plan, spatial development and natural resources development plan there must be a workable land use plan.
- Considering a few pocket fast-growing areas as corridors and focusing on them doesn't bring the required fast overall socioeconomic transformation throughout the country, and the conventional way followed to develop them doesn’t bring huge mass mobilization.
- Addressing equity and life-saving issues of the marginalized areas is equally important when working on high potential areas.
- There are areas with high potential for development but there is no detailed plan to pick them as the development corridor right away.
- Every piece of land has its own potential but some potential areas are not easily identified; they need a more detailed study.

- Starting with, and focusing only on, a few high-potential areas may not help us to meet set development targets such as the MDGs and reaching the middle-income level by 2020.

Therefore, assessment of the potential of available resources and designing its best utilization through land use planning and implementation of an area-based development plan on a watershed level is a prerequisite to ensure sustainable development. Joining this with the immense human resources will undoubtedly lead us to the aspired development stage.

Thank you.

Policy, Strategies and Investments

TAKING FORWARD THE GROWTH AGENDA OF THE PASDEP: FROM CONCEPT TO ACTION

Markos Feleke

Ministry of Finance and Economic Development (MoFED), Addis Ababa, Ethiopia

Abstract

The current five-year development strategy of the government, a "Plan for Accelerated and Sustained Development to End Poverty (PASDEP)", has an objective to lay out the directions for accelerated, sustained and people-centered economic development as well as paving the groundwork for the attainment of the MDGs. To achieve this, from the pillar strategies adopted in the document, a massive push to accelerate growth is one of the objectives and the development of economic growth corridors are its subcomponent. Given the vast arable land, labor and water resources of the country, agriculture and water resources are natural entry points for the growth corridor approach in the country. It is well-recognized that Ethiopia is well-endowed with a diverse potential of natural and labor resources within its various regions, which will provide the basis for multi-faceted economic development and growth. However, these potential resources have to be developed with basic economic principles of efficiency and rational utilization, in order to make the best use of these resources for the country's sustained growth and poverty alleviation. This underscores the need to employ a spatial development approach with broader geographical significance based on the respective identified potential of areas to effectively utilize the optimal benefit out of the resources, in a manner that interconnect different economic activities within the regions irrespective of geographical boundaries, and will ultimately accelerate overall national growth and poverty reduction. To facilitate this, the government is currently giving emphasis to lay out and promote spatial economic growth corridor development strategies within the framework of the national overarching strategy of Agricultural Development Led Industrialization (ADLI), which can harness the parallel and diversified resource endowments of the country and enhance the country's growth pace further.

THE ROLE OF THE ETHIOPIAN STRATEGIC INVESTMENT FRAMEWORK FOR SUSTAINABLE LAND MANAGEMENT (ESIF-SLM) IN IRRIGATION DEVELOPMENT

Sileshi Getahun
Director, Natural Resources Management Directorate, Ministry of Agriculture and Rural Development (MoARD), Addis Ababa, Ethiopia

Abstrct

In Ethiopia, agriculture is the dominant economic source. Food insecurity has long been with the country and averting this perpetuating problem has become the major concern of the country's government in recent years. A complex combination of factors leads to food insecurity, including changes in climate, widespread land degradation, limited alternative livelihood opportunities, increased population pressure, poor market integration, limited access to basic services, inputs, credit and information, technological factors, and national policies and implementation constraints. Even during the normal harvest, on average, there are some 5 million chronically food insecure people in Ethiopia. This chronic situation is frequently aggravated by unexpected shocks such as drought. With about 45% of the population affected during drought years, the extent of food insecurity has become alarming. The government has developed a strategic plan of poverty reduction, a "Plan for Accelerated and Sustained Development to End Poverty (PASDEP)," to address this problem. The struggle to secure food in the country requires an increase in agricultural productivity from rain-fed agriculture and increasing production using irrigation water from the small-scale irrigation schemes. However, due to lack of water storage and large spatial and temporal variations in rainfall, shortage of water constrains production of more than one crop per year. Hence, there seem to be frequent crop failures owing to dry spells and droughts. The country has put policy directions and strategies for ensuring sustainable agricultural production to avert problems arising from moisture deficiencies. Focus has been given to promote and strengthen small-scale irrigation and water harvesting schemes. Since the mid-1980s, the Ethiopian Government has responded to drought and famine through promotion and construction of irrigation infrastructures aimed at increasing agricultural production. These are traditional, small-, medium- and large-scale irrigation schemes performing at different levels. Formally accounted overall irrigation development is estimated at some 5–6% of the potential of 3.7 million hectares. The Ministry of Water Resources estimates that, to meet Ethiopia's cereal requirements by 2015 it would require cultivation of 1.2 million hectares of newly irrigated land. The high cost-high risk combination offered by this type of potentially very profitable investment has so far resulted in underutilization of this important resource. A number of interventions are currently under consideration or have already been launched. These include: the construction of several multipurpose dams for irrigation and hydropower, a new program in the Awash and Nile basins to develop more than 100,000 hectares of land, small-scale irrigation schemes in the Highlands, and the Nile Basin Initiative (NBI). The latter is a regional initiative by the Ministry of Water Resources in 1999 including the basin countries (Egypt, Ethiopia and Sudan) to achieve sustainable socioeconomic development through equitable and efficient use of their shared water resources. In addition to these schemes, efforts are underway to promote

in situ and ex-situ water harvesting interventions as a means of coping with the shortage of water for agricultural production. In the past few years alone, about 61,810 hectares of land have been developed by water harvesting schemes in different parts of the country.

In the country, water development for agriculture is a priority, but poorly designed and unplanned irrigation undermines efforts to improve livelihoods and exposes people and the environment to risks. From the viewpoint of the physical performance of schemes, irrigation schemes are constrained by sedimentation of structures due to erosion from unprotected watersheds; flooding of the schemes including their command areas; and shortage of water during peak periods of demand for water, which is attributable to increased dry spells. These are some of the problems faced by many irrigation schemes in Ethiopia. Integration of watershed management with the development of irrigation schemes is becoming compulsory to ensure the reliability of available water, and to maintain and increase operational efficiencies of the schemes. The importance of watershed management and a watershed approach strategy while developing irrigation will be discussed in the presentation. Within irrigated agricultural settings, water management is one part of farm management. Improvements in farm water management must be viewed in the context of overall farm management. In irrigation management, the performance of the technical aspects of farm irrigation systems alone may not bring adequate results of the schemes, and identify the range of constraints that hinder farm water management and efficiencies. An interdisciplinary approach and integration of farming practices are an effective way to sustain and ensure effectiveness of the operations of irrigated agriculture and, where necessary, identify both the strengths and weaknesses in irrigation systems and their operation. More importantly, the country has recently developed a program and framework, namely Ethiopian Strategic Investment Framework for Sustainable Land Management (ESIF-SLM) involving all the partners and stakeholders under the leadership of the government. The framework is aimed at harmonization and alignment of the ongoing and future efforts in Sustainable Land Management investments. The role of this framework and its linkages to irrigation development is another point of discussion.

SMALL-SCALE IRRIGATION DEVELOPMENT INTERVENTIONS UNDER IFAD-SUPPORTED PROJECTS

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Abstract

Irrigated agriculture is becoming increasingly important in meeting the demands of food security, employment and poverty reduction. Small-scale irrigation, as commonly defined, comprises an irrigable land area of less than 200 hectares of modern/communal schemes, which, in most cases, is developed and managed by the user groups themselves, who are predominantly smallholders. An exception to this is the spate irrigation, which exceeds the above set limits as being practiced in most regions of Ethiopia.

The International Fund for Agricultural Development (IFAD) has been supporting the construction of many small-scale irrigation schemes under the Special Country Programs, SCP-I and SCP-II, and most of these schemes are currently in operation. However, some of these schemes are not operating with full capacity due to various reasons. Such reasons, among others, include frequent reorganization and rapid staff turnover, limited staff capacity and technical know-how, problems associated with the legal empowerment of water users associations (WUAs) and the lack of community participation in the development process. The key lessons learned from these programs include:

First, SSI development should be underpinned by improved catchment area planning.

Second, acknowledging indigenous knowledge in the development of traditional irrigation structures and organization.

Third, the development of irrigated agriculture should be carried out in conjunction with rehabilitation of degraded lands.

Fourth, there is a need to strengthen linkages between WUAs, rural financial institutions, output markets, and agricultural research and extension services.

Finally, create a conducive environment for knowledge sharing.

In conclusion, Ethiopia has several years' experience with traditional irrigation schemes that have been developed and operated for centuries without any support or interference from outsiders. These traditional schemes have a highly effective organizational structure and the entire community participates in their operation and maintenance. It is important to build on this traditional wisdom in establishing the organizational structure for the irrigation schemes that will be developed in the future. WUAs should take charge of the development process in the same way it has been doing in traditional schemes.

1. Introduction

Irrigated agriculture is becoming increasingly important towards meeting the demands of food security, employment and poverty reduction. Small scale irrigation, as commonly defined, comprises an irrigable land of less than 200ha of modern/ communal schemes, which in most cases is developed and managed by the user groups themselves, who are predominantly smallholders. An exception to this is the spate irrigation which exceeds the above set limits as being practiced in most regions of Ethiopia.

In this regard, IFAD has been an important supporter of small-scale irrigation in Ethiopia over a number of years and the most recent one is the Participatory Small - scale irrigation programme (PASIDP).

2. SSI schemes Implementation under IFAD supported projects

IFAD has been supporting the construction of many small-scale irrigation schemes under the special country programmes one and two (SCP I & II) and most of them are currently in operation. However, some of these schemes are not operating with full capacity due to various reasons.

3. Problems encountered in the implementation of previous SCP I & II SSI Schemes

Frequent re-organization of Departments and Agencies coupled with rapid turnover of staff, has caused considerable delays in programme implementation. Limited staff capacity and technical know-how also hindered support for farmers. In addition, lack of training for farmers and WUAs has contributed to poor O&M of completed schemes.

Experience in SCP II has shown that the use of WUCs as field level farmers organizational units, to manage and maintain irrigation facilities has not been a success. As membership of water users cooperatives have been organized on voluntary basis, most participants opted to withdraw from membership of the WUCs without meeting their obligation. This undermines the role of all the other members and the result is that no maintenance has been carried out and hence the schemes have rapidly deteriorated.

Although these programmes did make good physical progress in developing small-scale irrigation infrastructure, the impact of the programme has been somewhat less than was expected because the communities were not sufficiently involved in the development process and lacked ownership of the schemes on their completion. This has led to poor maintenance of the facilities and inefficient use of the water resources available.

4. Lesson Learnt from Previous SCP I & II

The key lessons include the following.

First, such development should be underpinned by improved catchments area planning based on a rigorous analysis of water quality, availability and extraction rates while taking into account the needs of all users across the river basin. This will be critical in minimizing conflicts among diverse water users.

Second, there is a wealth of indigenous knowledge in the development of traditional irrigation structures and organizations, which should be internalized in the development of future small-scale irrigation schemes.

Third, while rural communities have largely been responsible for selecting beneficiaries of irrigation schemes, experience suggests that there is a need for introducing communally accepted criteria to ensure that more vulnerable groups are not excluded from the decision making processes and programme benefits.

Fourth, the development of irrigated agriculture should be carried out concomitant with rehabilitation of degraded lands and protection of the environment at least within vicinity of the watershed and catchments areas,

Fifth, in order to secure the long-term profitability of small-scale irrigation schemes, there is a need to develop linkages between water users' associations and rural financial institutions, output markets, and agricultural research and extension.

Lastly, the lack of institutional capacity at woreda and local levels strongly suggests that programme design must be sufficiently flexible to allow for knowledge sharing and learning by doing, including community sensitization and training, staff orientation workshops, local, regional and overseas study tours, and regular staff training to cope with staff turnover.

5. Rationale for the New IFAD'S Financed Development Project (PASIDP)

According to PASDEP, the Ethiopia economy must grow by at least 6 to 7% per year in order to achieve Millennium Development Goal of halving poverty by 2015. A sustained increase in agricultural growth would, therefore, be necessary in order to contribute to the desired economic growth with equity. However, that increase cannot be sustained under the dominant rain fed agricultural production system characterized by wide fluctuations in output due to varied rainfall patterns and drought. The government estimates that in order to close evident food security gaps in the face of a rapidly growing population, and simultaneously secure the desired growth rate in agricultural production, about 1.2 million ha must be brought under irrigation by 2015.

Over the past ten years, IFAD has spearheaded the development of small-scale irrigation schemes in Ethiopia and the new irrigation development support has become realized since 10 March 2008. PASIDP is national in scope with special emphasis on drought prone, food secure and high density areas of Tigray, Amhara, Oromia and SNNPR states. It will expand outreach by consolidating development potential in these regions.

6. Approach to PASIDP

The new PASSIDP would (i) innovatively build on indigenous knowledge; (ii) promote beneficiary participation in the selection, construction, operation, maintenance and management of irrigation schemes; (iii) secure communal ownership through establishment of grassroots organizations such as water users' associations; (iv)ensure flexibility in programme implementation; (v) promote capacity building of community based organizations and strengthen institutional capacity at kebelle, woreda and regional levels; and (vi) ensure gender mainstreaming in small-scale irrigation development.

It is generally believed that any approach to small-scale irrigation development has to give due attention to sustainable natural resource use and management, including water resources. Towards this objective, the programme would test-check the capacity of the water users in cost-sharing the investments for the scheme development and also to follow on operations and maintenance. This is very basic for the sustainability of the schemes that is being developed under the programme. Similarly PASIDP attempts at ensuring that at least 25% of the beneficiaries are female-headed households, youth and the landless.

PASSIDP would pay special attention to gender mainstreaming, inter-alias, through proactive measures to: (i) increase women's access to irrigated land; (ii) increase access to technical training; and (iii) improve women's participation in decision-making at all levels.

7. Summary & Conclusion

There is long year experience in Ethiopia with traditional irrigation schemes that have been developed and operated for centuries without any support or interference from outsiders. These traditional schemes have a highly effective organizational structure and the entire community participates in their operation and maintenance. It is important to build on this traditional wisdom in establishing the organizational structure for the irrigation schemes that will be developed. WUAs should take charge of the development process in the same way it has been done in traditional schemes.

EXPERIENCE FROM AGRICULTURE SECTOR SUPPORT PROJECT (ASSP)

Tessema Legebo[1], Jan Twarowski[2] and Hailemichael Taye[3]

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Abstract

In countries like Ethiopia, where multitudes of its population live in rural areas, agricultural development plays a central role not only in changing rural livelihoods but also in the nation's economic development. However, it is hardly possible for agriculture, which merely depends on rain-fed sustainable agriculture, to play a leading role in achieving this. In addition, smallholders dependent on rain-fed agriculture are vulnerable to food insecurity and poverty, especially in this time of erratic climate change. Hence, it is very important to invest in irrigation development so that the higher productivity irrigated agriculture becomes the main source of agricultural production. Out of a total irrigable potential of about 4,256,457 hectares, only a total of 247,470 hectares have been developed so far under traditional and modern small-, medium- and large-scale irrigation systems. This means that only 5.8% of the existing irrigation potential has been developed at present. In China, it is reported that the 45% of cultivable land that is irrigated, produced 75% of the nation's food in 2002. In the world, even if the irrigated area only accounts for 20% of the arable land, it comprises 40% of all crops produced. Developing irrigation infrastructure is not an end in itself. It requires integration of various supporting activities from planning and execution of the physical scheme to water management, crop production and marketing, in order to realize the potential of the investment.

This paper presents the experiences of the Agriculture Sector Support Project (ASSP) of the Ministry of Agriculture and Rural Development, funded by the African Development Bank (AfDB) and the Government of Ethiopia. The paper discusses integrated approaches used by the project to alleviate poverty and bring sustainable development through integrated irrigation development. After presenting the approaches being implemented by the project, the sustainable development framework to be applied to evaluate the project activities are explained. Finally, selected conclusions and lessons learned in the project implementation process are summarized. In general, besides the physical infrastructure, sustainable irrigation development processes have to incorporate social consensus, planning and implementing the schemes, institutional and physical mechanisms for water management, operation and maintenance cost recovery, technologies for crop development, linking production with markets and introducing post-harvesting technologies. In the entire process, it is important to see whether each activity is socially acceptable, financially viable, economically reasonable, environmentally friendly and equitable.

Introduction and Background

Ethiopia is an agrarian society, rated as one of the poorest countries in the world (ranked 172nd out of 174 countries in the UNDP index), with a per capita income of USD 110. The incidence of poverty is higher in rural (47%) than urban (33%) areas with rural households suffering from not only poor agricultural technology but also highly vulnerable to external shocks such as drought, famine and increased environmental degradation. Ethiopia's food security strategy targets the chronically food insecure, moisture deficit and the pastoral areas. It also focuses on environmental rehabilitation as a measure to reverse the level of degradation and also as a source of income generation for food insecure households. Water harvesting and the introduction of high value crops under small-scale irrigation, livestock and agro-forestry development provides the thrust of the food strategy of the country.

An Agriculture Sector Review undertaken by the Bank Group in March 2002 identified the need for a sector wide integrated project necessary to tackle the problems of food security and rural livelihoods. It particularly recommended investments in small-scale irrigation and water harvesting, agricultural marketing and natural resources conservation. Government thereafter sent a formal request to the Bank for financing the identified project after which the Bank undertook the appraisal in September 2003 and project operations began in mid-2005.

The project is being co-financed by the African Development Bank Group (ADF loan and ADF grant amounting to UA 21.24 million and UA 17.76 million, respectively), Government of Ethiopia (UA 6.11 million or 11% of total costs), Regional States (UA 6.10 million or 11% of total costs), beneficiary communities (UA 4.26 million or 7.7% of total costs).

The project is being implemented by the Government of Ethiopia (GOE) and more specifically by the nine Regions of the country (Amhara, Oromiya, SNNP, Tigray, Afar, Benishangul-Gumuz, Gambella, Harari and Somali) plus Dire Dawa Administrative Council. Due to the reorganization of the Ministry of Agriculture and the expansion of its mandate, the implementing agency changed from the Ministry of Finance (at appraisal) to the Ministry of Agriculture and Rural Development (MoARD); working through the Regional Bureaus of Agriculture and Rural Development, Bureau of Water, Mines and Energy, and participating Woredas and Kebelles.

The project objective is to improve the rural livelihoods and food security among the drought-prone and vulnerable food insecure population through promotion of small-scale irrigation (SSI), Rain Water Harvesting (RWH), sustainable environmental conservation and capacity development for all stakeholders.

2. Project Description

2.1 Small-Scale Irrigation (SSI)

Strategically, the project focuses on four major regions (Oromiya, SNNP, Amhara, and Tigray) where undeveloped potentials were in excess of 1,000 ha and where there were on-going practices to quickly expand the area under irrigated agriculture. Furthermore, the project supports studies and pilot small-scale irrigation development in the remaining emerging regions, with a view to going into full development in the future. The Project supports SSI development in 71 schemes covering an area of about 7,740 ha directly benefiting 29,020 house holds. The project is to finance the improvement of 472 km of access routes from the SSI sites to the main feeder roads, to facilitate marketing of farm produce. This is being undertaken as a package lumped in with the SSI civil works construction. The Project assists communities desiring irrigated agriculture to form their own WUAs and trains them to undertake tasks associated with the irrigation development.

2.2 Rain Water Harvesting (RWH)

Micro catchments are treated from the upper watersheds through to homesteads by combining conventional soil and water conservation techniques to reduce soil erosion with the construction of storage structures to meet different community water demands (i.e. drinking for human and livestock including backyard irrigation). The primary focus of this component is on the development and delivery of infrastructure and services but with emphasis on maintenance and sustainability. The beneficiaries contribute 20% of cost of civil works construction in the form of labor. Over the

5-year project period, 238 Woreda offices and 474 Kebelles in 8 Regions are to be supported. Within each Woreda up to 6 micro watersheds in two Kebelles are to be treated giving a total of 590 micro watersheds.

2.3 Crop Development and Marketing (CDM)

Improvement of farmer management skills, marketing support and soil conservation for enhancing crop productivity; MoARD is to implement these activities, through the Regional Bureaus of Agriculture and Cooperative Promotion Offices at the Woreda and Kebelle levels. It seeks to train 30,000 farmers on irrigation techniques; 80 entrepreneurs and 1,200 farmers on crop marketing; and increased crop production.

2.4 Integrated Watershed Management (IWM)

This component comprises two sub-components: (i) highland watershed mgt; and (ii) Lowland watershed management that covers two separate but interdependent ecosystems, namely fragile mountain areas and lowland forest and agricultural ecosystem respectively. In addition to the environmental benefit of the plantations, fuel wood output is estimated at 500,000 m^3 with an estimated value of about ETB 5 million by PY12.

2.5 Training and Capacity Building (TCB*)*

The project is expect to train 27,900 farmers and 27,785 staff in Small Scale Irrigation techniques; 1,645 Development Agents (DAs) & key farmers, 2,390 staff, 96 inter-farm visits in rain water harvesting including 3 National and 20 regional Workshops; 1,000 farmers and 118 Staff in watershed management; the idea behind TCB is to also enable staff to successfully undertake activities planned under future irrigation development investment.

3. Financial Arrangements

The Bank Group and the Federal Government of Ethiopia (GoE), including contributions from the Regional States and Communities, will finance the Project. ADF loans amounting to UA 21.24 million or 38.3% of total costs are to be utilized to finance 68% of small scale irrigation, crop development and marketing, and project coordination, excluding salaries and allowances, while Grant resources of UA 17.76 million or 32% of total costs are to finance 73% of rain water harvesting techniques, all capacity building and watershed management.

GoE's contribution amounting to UA 6.11 million or 11% of total costs will finance all local staff salaries and allowances. Regional States (Oromiya, Amhara, Tigray and SNNPR) contribute UA 6.10 million (11% of total costs) to finance 22.7% of SSI (or 25% of SSI civil works). This is in the form of equipment and expertise used for civil works construction under force account. Beneficiary Communities contribute UA 4.26 million (7.7% of total costs) representing 20% of civil works costs of water harvesting schemes and 10% of civil works costs of SSI in the form of labor.

4. Expected Financial Benefits

Experience from the IFAD-assisted project has shown that it is possible to calculate financial returns to households involved in both rainwater harvesting and small-scale irrigation. It was assumed that under the rainwater harvesting, representative farmers would be growing high value crops on 0.1 ha. Average farm returns at 100% cropping intensity are estimated at ETB 3,683 (or US$ 425) per household backyard water harvesting structure, with a total of 2,950 households benefiting directly at full development.

For SSI, a total of 7,509 ha were put into production by PY5 and by this time, it was estimated that a total of 28,389 households would benefit (20,252 HH at low altitude; 8,137

HH at mid altitude) two representative farm models are assumed: 0.25 ha per plot for mid altitude and 0.27 ha per plot for low altitude. Annual incremental income at full development was estimated at ETB 4,630 (or US$ 535) per household. These will be compared very favorable with a per capita income of US$110 for Ethiopia.

5. Institutional Arrangements

The executing agency is the MoARD which provides technical coordination, supervision and support for SSI, IWM and WH through the Natural Resources Development Sector, for Crop Development through the Agricultural Development Sector and Marketing and inputs through the Marketing Sector. The PCU was established under the MoARD to provide coordination support. A National Project Steering Committee (PSC) has been constituted as per appraisal and is fully functional. The National PSC meets once or twice a year when important issues arise and for the review of project progress. Each region has a Regional PSC, which is chaired by the Bureau Head of BoARD and whose members include BoWR, Environment and Land Administration, Cooperative Promotion and the Food Security Coordinating Unit.

The regional project coordinators are responsible for day-to-day implementation of the project activities, through their Regional offices (BoARD for CDM, WH and Watershed Management and BoWR for SSI). They are supported by Woreda/Kebelle staffs who are working closely with communities for direct project implementation.

6. Implementation to Date

6.1 Small Scale Irrigation Development (SSI)

Currently 24 out of 48 schemes (50% of current target) are already complete with a further 17 schemes still under construction. Construction has not caught up with the plan because the relatively quicker Force Account works have already been taken up, leaving the longer process of contracting out the works (and sometimes even the design) for the upcoming SSI sites. Schemes are lagging by about 12 months due to: slow start in some regions; lack of funds as replenishment was delayed due to slow settlement by regions; greater use of National Competitive Bidding for construction and use of consultants in some cases for design, which requires a lengthy process of procurement; lack of capacity in the emerging regions. However in terms of hectares, about 76% of the planned hectares are under construction (or completed) as of 30th June 2008 (5,897 ha out of 7,740 ha).

The number of households in command areas under construction is an important indicator of progress as it tracks the farmers who will potentially benefit from the Project. To date 66% of the households targeted at appraisal (19,302 of 29,020 households) to receive access to SSI schemes are already being assisted in that their schemes are either under construction or completed. The number of household that have completed schemes and will begin or continue benefits are 7,207.

6.2 Crop Development and Marketing

From the 24 completed Small Scale Irrigation 3,114 ha are or have been under production to date serving 8,772 households. The efforts so far made in improving the farm management skills under irrigation focused on introduction of technical messages and practices such as double cropping of vegetable and other crops. This was achieved through the establishment of eleven horticultural nursery and demonstration sites. Apart from the activities on fruit nursery and demonstration sties, selected contact farmers 5,616 have been provided with skills training and attended experience exchange visits and supplied the necessary inputs. As a result, there has been a trend to gradually shift the cropping pattern from grains and staples (teff, maize, sorghum, etc.) to high-value crops such as fruits and vegetables (onions, potatoes, tomato, pepper, lentils, spices, etc). The construction of basic storage facilities has been expanded to complement the high-value crop production.

The income per hectare per season was derived after cropping patterns and crop budgets were obtained at several SSI schemes in Tigray and Amhara, which are the only two regions where production was underway in mid-2008. The assumptions and calculation show that the overall average regional incremental income per hectare is ETB 22,728. This compares to ETB 21,856 per hectare, at appraisal. However, the amount is likely to be conservative especially as farmers gain experience with production and marketing annually. A more detailed model will be developed as part of the upcoming cost-recovery study in 2009.

6.3 Water Harvesting

About 159 micro-watershed sites completed compared to 170 planned (92%) in the project to date. Some performance improvement has been noted, particularly for backyard irrigation and community livestock ponds. Construction of water harvesting ponds for household irrigation is also improving. The project envisions 5 pilot ponds to be introduced in each of 590 communities throughout the 10 regions, for a total of 2,950 ponds. To date, only 187 of these ponds have been or are being established. This is against a cumulative target as of 731 (26%).

6.4 Watershed Management

Progress in the watershed management (WSM) component is very good and some regions (Amhara, SNNPR and Oromiya) are achieving and even exceeding their targets. In the cases where targets have been exceeded, the region has benefited from lower unit costs for the activity than was originally anticipated. Therefore, based on the regional performance revision of targets have been made in the Mid Term Review (MTR). Some like Amhara and SNNPR are still doing well even after revised targets especially in some activities. The revised plan for terracing was 4,352 km (25% achieved) and seedling distribution 27.2 million (43%), nurseries 61 (77%), forest road rehabilitation 300 ha (24%) and sustainable land husbandry 4615 ha (18%), plantation 4313 ha (44%).

The performance of this component is expected to continue on a positive track. The actual accomplishments on the ground go beyond nursery establishment, seedling production and plantation. The quality of the maintenance of plantations is crucial as is the promotion of income generating activities among participants however it is important to note that benefits will flow from these conservation activities only after several years.

6.5 Training and Capacity Building

The life of project plan is to train 40,000 farmers (14% achievements), 3,892 development agents (45%), 1,915 woreda experts (40%), 847 regional (53%) and 407 federal experts (35). Overall training (farmers and staff) achievement is 19%. Progress in training is lagging compared to appraisal a Training Needs Assessment (TNA) has been done with the assistance of a local consultant to ascertain the true level of need and the key constraints to implementation of training. Its findings showed that training targets were too ambitious, that there was limited capacity of project implementers to organize and deliver training, the inadequate familiarity with the project and an overly heavy emphasis on SSI at the expense of other components.

The TNA also identified that Farmers' Training Centers (FTCs), which are newly established in most Kebelles and responsible for farmer training, could be better utilized by the project. Currently the majority of FTCs are not equipped even with simple essentials like chairs and desks and supplies like chalk and demonstration equipment. The TNA report also indicated that inadequate flow of financial resources constrained the implementation of the training activities at Woreda level. Hence, the system for the release of training funds needs to be streamlined to enable Woredas to schedule and run their training programs more regularly.

In terms of other project interventions, the capacity of the PCU, Regional Coordination Units (RCUs) and other units at federal and regional levels has been enhanced through provision of office and field equipment and the provision of 300 motorcycles (compared to 185 motorcycles envisaged at appraisal). But lack of project vehicles has continued to hinder mobility of federal and regional staff to undertake periodic supervision and provide technical support at Woreda level. Initially, government resisted the purchase of vehicles (as per the appraisal) but very recently, the issue was resolved after the PCU was allowed to purchase 17 new 4-WD vehicles. The purchase of these vehicles is in process.

7. Implementation Review

Despite the problems faced by the project during takeoff it is now on course to achieve its objectives. The overall progress in the small scale irrigation scheme construction and watershed management components has been good to date. However, more intensive work is required to accelerate the water harvesting and crop development & marketing and training components. A key demand has been the need to improve farmer extension services, provision of inputs, creation of marketing linkages and training in higher value crop irrigation and land use. An extensive effort has to be exerted to enhance the extension services in Small Scale Irrigation sites, to accelerate adoption of improved technologies suited to irrigated systems, to strengthen Water Users Associations and marketing coops, to facilitate access to modern inputs and financial credit and to create market linkages.

7.1 Small Scale Irrigation

The total number of SSI schemes, including additional ones, is now expected to be 83 and the Project is projecting an expansion of the SSI component to cover 10,030 ha (an additional 2,290 ha from the appraisal target). Savings in unit per hectare costs mean that this increased area may be developed under the Project using existing resources. Getting these additional hectares into the construction phase, however, will take time given the fact that future sites are going to be mostly undertaken by contractors which requires a longer procurement process compared to force account. This is one of the reasons for why an extension in project deadline is likely to be required.

Other issues that will require consideration as the project moves forward is the transition of WUAs into WUCs that can obtain legal standing so that communities avoid conflicts and manage a common shared resource – water. Also important will be to ensure beneficiaries are able to undertake effective and timely operation and maintenance (O&M) of their schemes and are assisted by the relevant regional authorities to address unanticipated design defects that could limit the operation of their schemes especially where contractors have formally handed over the schemes and are no longer liable. The project must exert more efforts to ensure that dependency tendencies are avoided after SSI schemes are handed over. Timely transfer of schemes to communities and clear ownership guidelines are critical aspects to this effort.

7.2 Crop Development and Marketing

The key issues under the CDM component include the need for more efforts to intensify extension services in SSI sites. This requires a big shift from a ‘business as usual’ approach to one focusing on improved irrigation agronomy, water management, promoting high value crops, community organization and linkages with Micro Finance Institutions and market networks. Inadequate or a complete absence of transport facilities for DAs and Supervisors needs to be addressed as more SSI schemes come under production.

To date assessments have revealed that there has not been much change in the techniques of crop production and farming practices in the regions. Too much emphasis has been given to civil works and there has even been a tendency to consider scheme construction as an end in itself with little attention given to institutional, social and economic aspects of the irrigation system as a whole. In this regard, the project will be training DAs and lead farmers, located within participating Woredas, and so that more updated skills are disseminated amongst the beneficiary communities. This training will be done in Farmers Training Centres, close to each community.

7.3 Water Harvesting

The analysis indicates that this component is behind in relation to set targets. The low performance of this component is attributed to: (i) inadequate vehicles for monitoring and supervision which is a critical constraint given the scattered sites; (ii) disincentives for field work by Project and GoE staff as per diem levels have sometimes been below cost; and (iii) regular staff not having their performance evaluation include performance on Project activities. These problems have been resolved to a certain extent by the procurement of 300 motorcycles, the improvement in per diem rates and the increased focus given by the regional steering committees.

Other concerns include the need to protect water storage ponds from direct intrusion by the surrounding communities and livestock as many of these ponds are used for multiple purposes due to a lack of alternative water supplies. Communities have to be sensitized on the need to construct an effective surrounding pond fencing (for safety, environmental and sanitation reasons) and be provided with treadle pumps to deliver water to points outside the fencing to structures such as livestock troughs, washing basins, potable water storage, etc. The communities need to also be assisted to form viable management institutions to enforce safe and effective use and maintenance of the WH ponds.

7.4 Watershed Management

The overall high level of achievement in this component is due to a demonstrated demand and appreciation by beneficiaries for improving watershed areas and the payment of wages for the physical work, which benefits local residents including farmers, the landless, rural unemployed and youth of both genders.

The sustainability of watershed activities requires a longer period to assess overall and it needs careful community mobilization and sensitization to nurture the seedlings at newly planted areas, to maintain physical works and to shift to a ‘cut and carry’ system for fodder. Additional emphasis is being placed on apiculture and other income-generating activities. In addition, the community should sufficiently aware in terms of ownership to sustain the interventions.

7.5 Training and Capacity Building

Although the training and capacity building interventions are lagging behind this component is arguably the most important strategic intervention to manage the SSI schemes. The project needs to work more proactively with the regions in adopting a more innovative training strategy that would include adoption of better training approaches, developing training modules and training materials, outsourcing part of the TOT training programs and organizing experience exchange visits. The project will place an emphasis on farmer training so that the shift to irrigated crop production and marketing is properly accomplished. The lack of responsible staff to handle and effectively coordinate training activities at all levels has shown the critical need to recruit Training and Community Development Officer.

7.6 Cross Cutting (Environment, Gender and Others)

In terms of environmental measures the integration of the watershed management and small scale irrigation components, to address the problem of siltation within new schemes, has been embraced. In addition the project is promoting the idea of schemes having O&M budgets, based on practical plans that the communities will finance. The issue of cost recovery requires further analysis and a study in this regard is to be undertaken. The Study's outcomes will be key drivers in promoting scheme sustainability for communities. For the Water Harvesting ponds although there is no noticeable negative impact associated with them, high pressure on water use from both livestock and communities for multipurpose use, in the absence of adequate pond protection measures, is causing adverse environmental safety and sanitation concerns. Hence the urgent need to install protection measures and extractive pumps are being proposed.

Greater attention must be given to the implementation of mitigation measures outlined in the Environmental & Social Management Plan. Guidelines have been developed which incorporate the ESMP of the Appraisal Report and the project is in the process of improving its monitoring and reporting of environmental aspects of the Project. Awareness of HIV/AIDS and malaria/waterborne diseases is integrated into the project design and regions have been implementing these activities in general, though it has been patchy to date and needs to be up-scaled.

Communities are routinely consulted during the planning of project activities and their views are considered in the design of SSI schemes in particular. The WUAs and WUCs generally are functioning, though clearly they require strengthening and support of the project. The project is committed to gender mainstreaming and is taking adequate steps to meet this requirement. For example the recruitment of an M&E expert for each main region would ensure more effective gender mainstreaming. ASSP is also making the regions accountable for their gender targets through their respective bureaus

8. CONCLUSION AND RECOMMENDATIONS

The project should treat the Watershed mgt component as a holistic package undertaken with the sites that will benefit from CDM and WH. This is dependant on the strong collaboration between the Bureau of Water Resources and Bureau of Agriculture and rural development across all Regions. For the TCB component, the Project should focus its attention on providing extension services and training farmers, community leaders and women groups active in irrigation and crop management. This should be in conjunction with building capacity for the FTCs.

Poor market infrastructure is one of the major constraints that have hampered efforts to accelerate irrigated agriculture in Ethiopia. The road connectivity from the SSI command areas to the main road and the nearest towns is the major market constraint and a major potential disincentive to farmers who would like to shift to high value crops. The access roads constructed by scheme construction crews are not all-weather and do not provide durable service to access markets for produce. It has been assessed the possibility of upgrading the access roads to all-weather ones but with the current level of highly escalated road construction costs, opening up of SSI sites by improving the road access, although highly commendable, is beyond the scope or funding of the project.

The major constraints under the CDM component include the need for more efforts to intensify extension services in SSI sites geared towards irrigated agriculture. This requires a big shift towards focusing on improved irrigation agronomy, water management, promoting high value crops, community organization and linkages with MFIs and market networks. DAs in each Kebelle, with the help of the local FTC, are critical in this effort but more extension effort is required to mobilize the DAs and capacitate the FTCs.

WUAs/WUCs are usually organized towards the end of SSI scheme construction. This would undermine active participation and ownership by scheme beneficiaries. It is recommended that such associations be organized right from the early stage of planning and their active participation is ensured throughout the construction and development phase. The project also needs to exert more efforts towards making CDM activities more gender responsive including a fair representation of both genders in the leadership of the associations.

The TCB component is considered an important strategic intervention to effectively manage the SSI schemes and allow the beneficiaries to take full ownership of them. In order for the project to work more proactively with the regions in adopting a more innovative training strategy it is recommended that a 'Training and Community Development Officer' be recruited for each of the four main regions.

Based on the TNA, a more realistic training plan has been prepared and includes the training of increased numbers of government staff at MSc level in local Universities. The major reduction in the training plan is made under staffs training where the main emphasis will be given to DAs and Woreda experts who are mostly dealing with provision of technical support to the participating communities. The TNA also includes enhancing the capacity of FTCs in the various Kebelles and the recruitment of Regional Training and Community Development Officers for the four main regions.

At appraisal, upper catchments treatment was not adequately integrated with the SSI component and resources were not adequately earmarked. In the course of implementation, this element was found very essential to minimize siltation, sedimentation and ensure sustainability of the irrigation system.

Modernizing irrigation under age old rain-fed and backward farming practices is a very challenging task, requiring very intensive extension work. The extension services need a strategic shift to make them more relevant to modern irrigated agricultural practices.

Efforts in irrigation can only be effective and lead to sustainable benefits if they are linked to market access. The experience from other SSI projects indicates that comprehensive efforts are needed in creating and facilitating market opportunities including a level playing field for encouraging the private sector to participate as well as establishing good roads access and agro-processing facilities in rural towns for the purposes of increasing value addition.

Community participation from the onset of the project is instrumental to ensure a sense of ownership among beneficiaries and for them to operate and manage the SSI and WH sites in a sustainable manner. This requires strong institutions (WUAS/WUCs) that are well empowered to set their own tariffs and work in a legally safe environment.

Water Centered Growth Corridor

WATER-CENTERED GROWTH CHALLENGES, INNOVATIONS AND INTERVENTIONS IN ETHIOPIA

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Abstract

Ethiopia's economy and majority of the people's livelihoods are dependent on agriculture. To develop the socio-economy of Ethiopia and eradicate poverty, the policy and interventions should focus on agriculture as an entry point. In line with this, the government, bilateral and multilateral donors, NGOs and various institutions share the concepts and priorities identified in the "Plan for Accelerated and Sustained Development to End Poverty (PASDEP)." There are key challenges that need to be strongly addressed on transforming agriculture by overcoming a multitude of problems including biophysical and water management issues to help achieve the targets of PASDEP and sustainable socioeconomic growth in Ethiopia. This particular paper aimed at addressing the water management challenges that Ethiopia has faced in the past and is facing today, and to stimulate ideas on how to manage water resources to meet the growing needs for agricultural products, to help reduce poverty and food insecurity, and to show how water can be used as an important entry point to transform its socio-economy and contribute to sustainable development and the environment. The issues discussed will focus on innovations, policies and technologies that enable better investment and management decisions in water use, particularly focusing on agriculture and irrigation but also briefly looking into other water-related subsectors such as hydropower, water supply, watershed, drought and flood management as well as other biophysical aspects. It has also been attempted to make the paper suitable for decision-makers rather than scientists, in order to raise useful ideas for dialogue and further discussions, studies and researches. The paper, therefore, does not claim exhaustiveness. The target audiences of this paper are the people who make the investment and management decisions in water and water management for agriculture, and other subsectors - agricultural producers, water managers, investors, policymakers and civil society. The paper has benefited from the review of key policy and strategy documents of Ethiopia, outputs of various outcomes of research, civil society meetings and workshops, data and information available in government institutions, and global knowledge. The key major issues that are discussed in the paper include the following:

- Socioeconomic development challenges of Ethiopia, viewed from a water resources perspective.
- The water resources endowment, development extent, potentials and economic/socioeconomic development linkages
- Water-related innovations and agriculture
- Water-related interventions in various agro-ecologies
- Policy and strategy actions needed

This paper should also be viewed with other components such as river basin growth pole/corridor concept,

institutional reform and research capacity building. It focuses on analyzing key problems and associated interventions, and can be applicable in the contexts of the current situation and the future possible reform under growth zones that can be taken as plausible pathways for development.

1. Introduction

Civilization of human being and socio-economic development are strongly associated with the capacity to manage and utilize water for beneficial purposes such as agriculture, power production, clean water supply, etc and cope with the negative externalities of impact of water such as flood, drought, contaminations, etc. Water is closely linked with hunger, poverty and health.

Some seventy percent of the 600 million “$-poor” and the 200 million malnourished people in Africa live in rural areas, with agriculture as their sole or primary source of food and income. Agriculture is their only way out of poverty. Soil nutrient loss and lack of access to safe and reliable water are the chief biophysical factors limiting small farm production and therefore critical to any poverty reduction strategy for the rural poor. Ethiopia is strongly challenged with water management, and unable to enhance the positive role of water and mitigate the negative externalities, and as such no time in its history able to manage water fully and effectively to accelerate its development. The current situation is encouraging and excellent start particularly since 2003.

The key and major issues that are discussed in the paper include:

- The key socio-economic development challenge of Ethiopia, viewing from water angle
- The water resources endowment, development extent, potentials and economic/socio-economic development linkage
- Water related innovations and agriculture

This particular paper aimed at the water management challenges that Ethiopia has faced in the past and today, stimulate ideas on how to manage water resources to meet the growing needs for agricultural products, to help reduce poverty and food insecurity, and to show how water can be used as important entry point to transform its socio-economy and contribute to sustainable development and environment.

The issues discussed will focus on innovations, policies and technologies that enable better investment and management decisions in water particularly focusing on agriculture and irrigation but also briefly looks in to other water related sub-sectors such as hydropower, water supply, watershed, drought and flood management as well as other biophysical aspects.

It is also tried to make the paper suitable to decision makers rather than scientists, to raise useful ideas for dialogue and further discussions, studies and researches. The paper therefore does not claim exhaustiveness. The target audiences of this are the people who make the investment and management decisions in water and water management for agriculture and other sub sectors—agricultural producers, water managers, investors, policymakers, and civil society. The paper has benefited from the review of key policy and strategy documents of Ethiopia, outputs of various outcomes of civil society meetings and workshop, data and information available in government institutions and global knowledge.

- Water related interventions in various agro-ecologies
- Policy actions needed

This paper should also be viewed with other components such as river basin growth pole/corridor concept, institutional reform and research capacity building. It focuses on analyzing key problems and associated interventions, and can be applicable in the contexts of the current situation and the future possible reform under growth zones that can be taken as plausible pathways for development.

2. Water and development challenge of Ethiopia

The main development objective of the Ethiopian Government is poverty eradication. Hence, the country's development policies and strategies are geared towards this end (MOFED: PASDEP 2006).

Ethiopia's economy and majority of people's livelihood is dependent on Agriculture. To develop the socio-economy of Ethiopia and eradicate poverty the policy and interventions should focus on Agriculture as entry point. This is a correct, clear and precise direction that the current government has put forward. There are key challenges that need to be strongly addressed on transforming agriculture by overcoming multitude of problems including biophysical and water management issues to help attainment of PASDEP and sustainable socio-economic growth of Ethiopia.

It is essential to think differently about water in order to achieve a multiple goal. This will have profound effect towards sustainable development through mitigation of rainfall variability, ensuring productivity and production growth, food security, eradication of poverty, sustaining development, reversing degradation and acceleration of growth. The contexts of these challenges are briefly discussed in the following paragraphs with the intention of recapping their importance.

2.1 Poverty is a Vicious Cycle in Ethiopia

The poverty situation in Ethiopia is in a vicious cycle, and requires key entry points for intervention. The following flow of recurrences reflects how poverty is linked to and aggravated by various factors.

Population growth (leads to aggravate) ➔ agriculture and livestock into marginal land and deforestation ➔ land & water degradation ➔ poor productivity, food insecurity ➔ deepening poverty ➔ poor health, malnutrition ➔ inability to invest in maintaining or improving land productivity ➔ further degradation and population growth, etc, and these are further aggravated by shocks of climate variability, conflict/war, etc. How to transform this "vicious cycle" in to a "virtuous cycle" is the key question that needs to be addressed.

2.2 Unmitigated rainfall and hydrological variability

Unmitigated hydro-meteorological variability currently costs the economy over one-third of its growth potential, see for example Figure 1. PASDEP's analysis also shows for example, the 2002/2003 drought has cost Ethiopia with negative 3.3% real GDP growth, while the following years were positive 11.9% and 10.6%, which slowed down the growth averaged over the three years at 6.4% only. The structure of the Ethiopian agricultural economy, and hence the overall socio-economic development is heavily reliant on rain fed subsistence agriculture, which makes it particularly vulnerable to this variability. Unmitigated variability is reflected not only in terms of drought and its consequences, but also in terms of prolonged dry spells, seasonality and floods. Ethiopia's extremely low levels of hydraulic infrastructure and limited water resources management capacity undermine attempts to manage variability. It is not an overstatement to mention that Ethiopia's economic performance virtually hostage to its hydrology and the cause for deepening poverty.

In order to transform agriculture as a basis for industry and eradication of poverty and wealth creation, it is important to understand the critical issues that can facilitate the process and identify hindering factors to mitigate the effects. Agriculture should grow both in productivity (kg of yield per hectare of land, water or any other Input) and production (volume of total produce). A number of factors are affecting these. The key variables for these are seed varieties, soil fertility and agricultural water management (AWM). Additionally, other factors such as market, infrastructure, institutions, etc also come to in the equations.

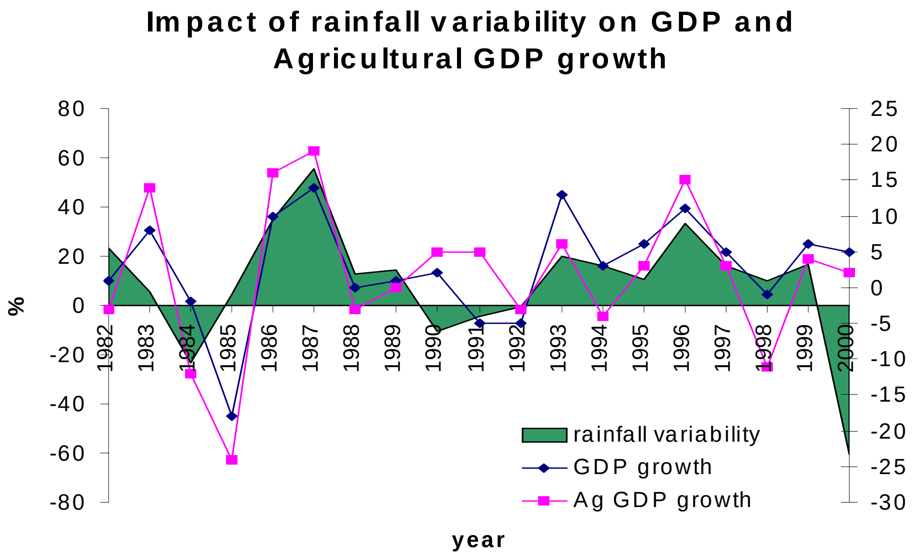


Figure 1: Impact of Rainfall variability on GDP and AG GDP

While past efforts (prior to the 2002/3 drought) mainly focusing on the first two key variables and AWM was given low priority. The low priority context of the past is evidenced by low investment in irrigation including related sectors such as water supply, hydropower, etc. However, in the recent past few years, the trend has completely changed and water has been recognized as a key factor in Ethiopian agriculture and socio-

Economic development and actions are clearly visible beyond the words.

2.3 Low Productivity of Agriculture

Agricultural productivity is low and stagnant in the whole of Sub-Saharan Africa, and it is not particularly peculiar to Ethiopia. Figures 2 (World Bank, 2003) and Figure 3 (Molden 2007) show this evidence. Sub-Saharan Africa never benefited from the Green Revolution of the 1960s and 1970s with high-yielding crop varieties, irrigation, fertilizers, and pest management. The result is extremely low cereal yields (oscillating ≈_1 ton/hectare) and merely 5% of agricultural land under irrigation. South and Southeast Asia, on the contrary, were at the heart of the Green Revolution, with higher yields (at least twice as high as in sub-Saharan Africa; and large irrigation withdrawals amounting to 60% of agricultural water use Rockstroem et al (2007).

SSA has yet to close the agricultural product gap as the Asia and Latin America have done through the green revolution, so does need Ethiopia, may be at a better speed. Ethiopia needs a higher poverty escaping velocity because of its rapidly growing population, and the opportunity of the focus for development that exist today. Therefore, there are tremendous opportunities to improve productivity of agriculture.

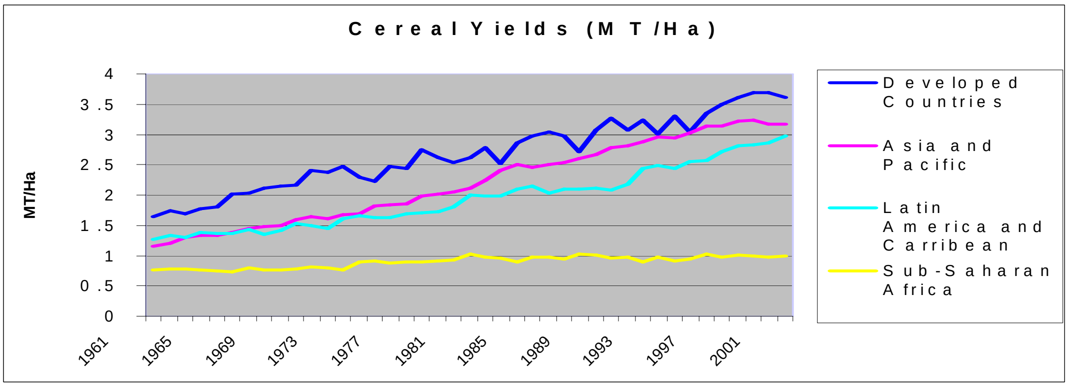


Figure 2: Comparative cereal yield of SSA

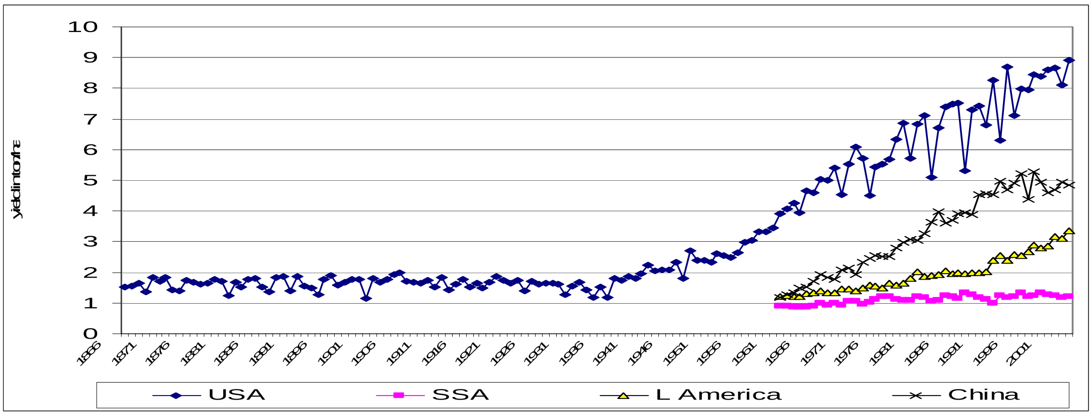
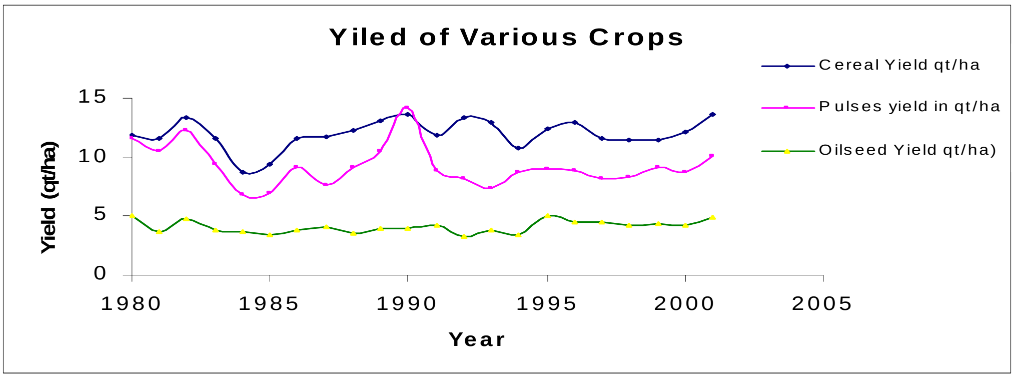


Figure 3: Comparative maize yield

It is also important to look in to productivity of agriculture in Ethiopia separately. The data until, 2001 for cereal yield in Ethiopia, does not show any difference with the SSA, and it was low and stagnant, see Figure 4. Leaving the 2002/2003 production that was hit by drought, Ethiopia is improving productivity and production since 2004. Based on PASDEP data Figure 5 shows this evidence. The figure also shows the determined plan to improve productivity, which enables to reach the current level of Latin America. Based on these evidences, it is further possible to increase production and productivity, but one has to be seriously careful how to overcome the 2002/3 type problem and the use and management of rainfall and water.



a) Low productivity of agriculture

Growth Attributes (up to 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

b) Productivity growths for various crops and growth attributes

Figure 4 a) and b) Productivity of agriculture

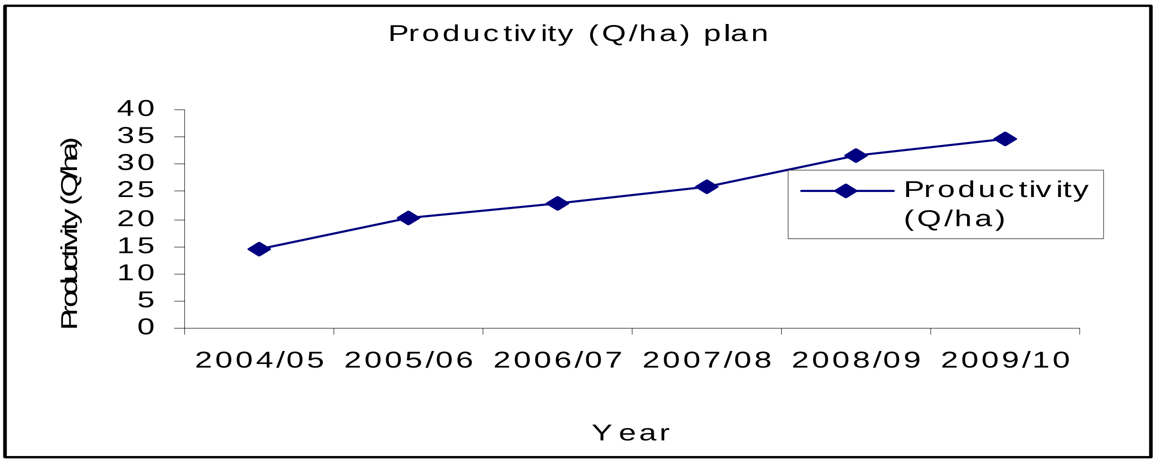


Figure 5: Estimated productivity during PASDEP period

2.4 Food Insecurity

Food deficiency and famine occurrences in the country are 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). The tragedies of the earlier two have claimed thousands of lives (See figure 6 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 6 and 7 show the drought and disaster affected population, proportion and the amount of imported food aid.

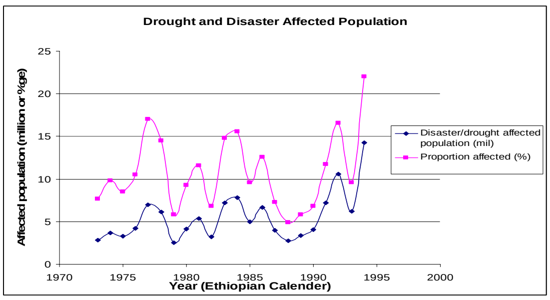


Figure 6: Drought and Disaster Affected Populations during the last decade

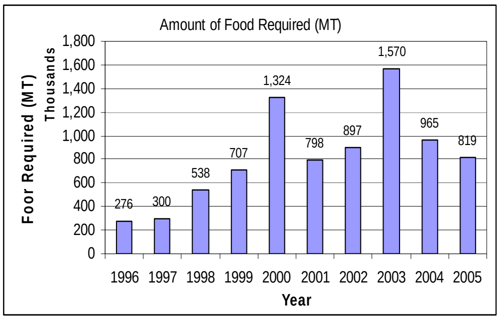


Figure 7: Amount of food aid imported (Data Source: DPPC)

2.5 Eradication of Poverty, Enhancing and Sustaining Development

Eradication of poverty on sustainable basis is not simple. In today's competitive world it requires significant investment in various sectors. The Millennium Development Goals (MDGs) pledge, among others, to reduce the number of chronically hungry people by half by 2015. Ethiopia has also put forward a target of reaching middle income countries in 20 years. Achieving these goals is major challenge and requires substantial investment in the smallholder agricultural sector, which is the key occupation for the majority of the poor.

Even for investments 'only' in 'water', we must recognize that to make effective decisions on investments in agriculture, increase of five different types of 'capital' must be considered: natural capital, social capital, human capital, financial capital, and physical capital. For successful and sustainable agriculture, access to all five capitals is needed in reasonable amounts. However, some of these capitals may already be available while one or two others are in short supply. Opportunities for successful investments can be created by increasing the one or two essential capitals that are most lacking. Direct and indirect investments can increase the capitals that are in short supply. Since augmenting 'natural capital' requires quite different actions from augmenting 'human capital', and the same for the other capitals, one needs to distinguish the decisions that need to be taken to increase those capitals that are most needed.

When all capitals are reasonably available, production processes are more efficient and hence yield a higher return on investments than when one or more capitals are lacking. This is an important consideration for investment decisions, and as a policy feed back to Ethiopian policy.

Rural development policy and strategy recognizes the abundance and availability of *human capital* in the form of labor and *natural capital* particularly land and to some extent water. We have to clearly reflect that Ethiopia is doing very well in increasing the human capital, evidenced by expansion of education at all levels, that can also support the mass of the less skilled agricultural labor in the rural areas. No other recent evidences in SSA that matches Ethiopia's expansion of higher education. Despite over all low budget, Ethiopia is allocating significant share of its budget to agriculture and water development (still more can be done), hence improving its financial capital flowing to the sector. It has to continue investing in the two sectors.

Although there are strategies and encouraging results achieved in recent years, the *physical capital* and infrastructure of Ethiopia are far from adequate. Similarly, the *social capital* needs transformation. Ethiopian people, particularly, in the highly vulnerable areas have developed dependency syndrome on external/foreign aid. Philosophically, dependence on aid, and not having once own reliable solution, are one of the causes for remaining in poverty for long and the cause to retarding escaping velocity out of poverty. The culture, religion, population dynamics, settlement character, etc should be transformed to assist development not hinder development and continue to be obstacle of progress.

Critical factors therefore are lack of physical capital, financial capital and natural capital (problem of matching the existing natural capital with the population settlement, as most people live in degraded areas while natural capital endowments such as fertile land and water are placed at far places from settlement). The other's such as social and human capitals development should continue and can reach reasonable stage in near future.

2.6 Challenges of Resources Degradation and Sustainability

Various studies such as (Hurni, 1993) and other land use and degradation papers show that soil losses in cultivated land caused by water, through sheet and rill erosion, reach alarming levels of up to 100–200 Mt ha/yr, affecting 50 per cent of the agricultural areas. Population densities and herd sizes are the highest in Africa, and continue to grow rapidly putting a severe pressure on the land. Currently, crop yields and livestock production are among the lowest levels in Africa, leaving over 40% of Ethiopian's poor. Hence, the urgent necessity to reverse this trend and assess the impact of water erosion hazard in Ethiopia at a national scale, the level at which most policy decisions take place that affect the land husbandry and where environmental action plans are coordinated.

Degradation of land and water resources in Ethiopia has been accelerated due to a number of factors. It is crucial to address the problem and the pertinent technical and political solutions should be sought. Three examples how politics is related to degradation in the past:

– One of the root causes of Ethiopia's poverty and deepening degradation is associated to the Derg regime and associated land and land tenure policy. The resilience and capacity of rural Ethiopia to cope with climate variability impact has been eroded immediately after nationalization of land. Rural Ethiopia used to have a buffer of grain accumulation on the hands of land lords and well to do farmers in traditional silos and storage mechanisms, prior to the Derg regime. Small impact of climate variability used to be contained by using such reserves without external aid, until it came to the out proportioned disasters that have occurred in 1974 in Northern Ethiopia. Unsecured partitioning of land in to small parcels not only created degradation but also abolished the social buffer coping strategy
– Nationalization of land and redistribution to the poor farmers was correct and just solution. However, ownership and use right of the land were not secured and in many parts of Ethiopia and use rights used to change hands in short period of time. This is one of the major responsible factors to cause mining of natural resources such as forest and lack of protection of soil. Farmers, once allocated land (temporarily), they take out all the possible resources from the land and never interested to invest on foresting, soil protection, etc except when forced by mass movement, which did not work
– Recently, important decisions have been made in relation to the issue of land use

right and certification, which potentially reverse the ill factors of the above. These should however be accompanied by land use policy and strategy that can help reversing degradation and enable regeneration of highly degraded environment.

A very fundamental and important issue is therefore to strengthen the use right and belongingness of farmers to their land and land resources so that they can invest on measures that help reversing degradation.

2.7 Lack of Finance and Capacity for Investment in Irrigation and Globalization

No doubt that, irrigation and investment in water infrastructure has transformed the socio-economy of many countries through increasing productivity, mechanization and modernization of agriculture, enhancing agro industries, enabling green revolution, etc. The investment in 1970's was also dictated by high food price. Figure 8, obtained from Comprehensive Assessment (Molden, 2007), show such relationship of investment and food price.

Africa, has missed the past opportunity, due to low level of investment during the 1970's and investment was curtailed by making various reasons including low food price as pre text, and many pessimist argue it is not possible to repeat green revolution in Africa.

For low food price and competitiveness of poor countries and their farmers, there is no level playing field. OECD countries are giving their farmers some US$380 BN annually – that is probably higher than the sum of the annual budget of SSA? The average EU farmer receives 35% of his/her income from government subsidies; a Swiss farmer gets 69%! Rijsberman, F (2006). Still under these conditions, Brazilian farmers or farmers from merging economies are succeeding, and why not countries like Ethiopia.

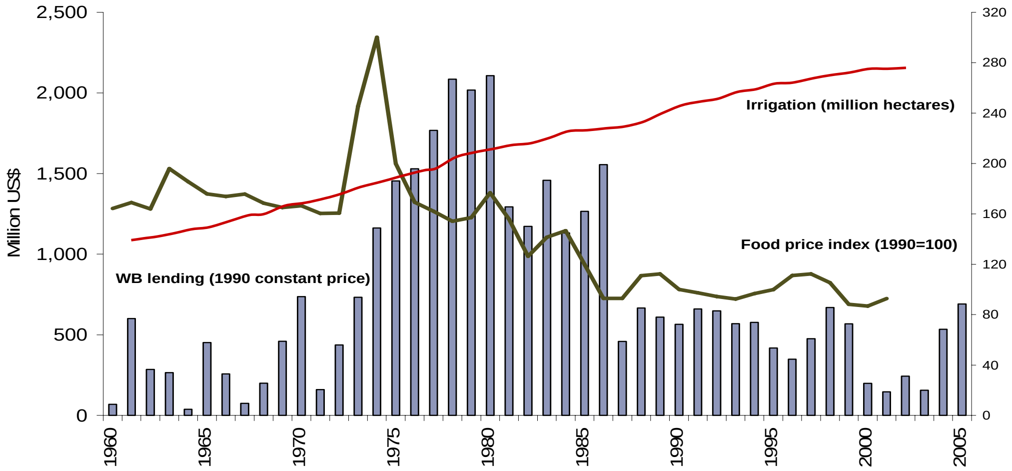


Figure 8: Food price and irrigation investment

Globalization continues over the long run, providing new opportunities for commercial and high-value agriculture but presenting new challenges for rural development. Unless we act now, tomorrow is too late

Ethiopia indeed had problems of financing even if it has chosen to invest in water, particularly irrigation. However, it is highly paramount to give this sector a priority, as started in the recent years. It is possible to lower investment cost by developing strategy for investment, such as focusing on multi purpose systems, target irrigation investment to high value crops, ascertain involvement of entrepreneurs in forward and back ward linkage, involve also foreign investors, etc

Ethiopia is essentially in a difficult position due to its Trans boundary nature of water resources. While working to enhance cooperation, bilateral relation and unilateral measures, we have to invest on tributary, non-trans boundary Rivers and less problematic rivers and at the same time seek long term and permanent solution to the trans boundary problems. The past has shown that Ethiopia was not helped earnestly to develop its share of resources, and often bilateral supports fade away as dictated by the political interest in the Middle East.

3. Water Resources and Economic Linkage

Ethiopia has 12 river basins from which 8 are basins with significant quantities of flow. One of the basins is a Lake Basin having numerous lakes fed by a number of rivers and streams. The remaining 3 are dry basins receiving deficit rainfall that can not produce river and significant runoff overcoming evaporation. The basin map is shown on Figure 9

Figure 9: Map showing the 11 basins of Ethiopian rivers

3.1 Water Resource Endowment: Is Ethiopia Really a Water Endowed Country?

Considering the above, Ethiopia is considered as the water tower of Eastern Africa. This is factually true when considering half of the country, particularly the western and South Western part of the country. The endowment can be used for productive purpose that can transform the countries socio-economy. However, as long as this resource is not available for productive and economic purpose, physical availability during particular seasons of the year does not show economic availability and the country is considered as economically water scarce. The Eastern and North Eastern part of the country is having a double challenge of having both physical and economic scarcity. Figure 10 showing the rainfall distribution which reflects the water scarcity and endowment in the various parts of the country.

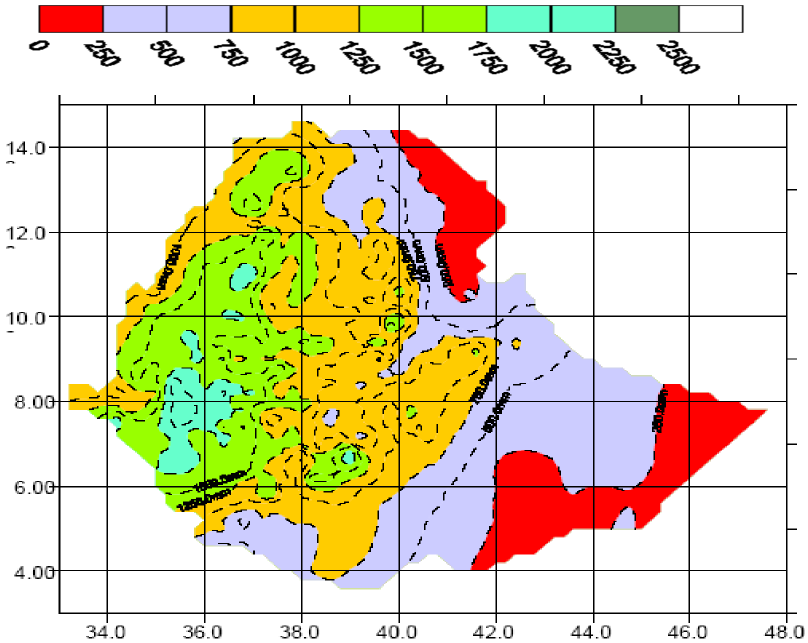


Figure 10: rainfall distribution in various parts of Ethiopia

Even the physical water availability is dwindling due to rapidly growing population. Figure 11 shows the per capita averaged past and future physical water availability in Ethiopia.

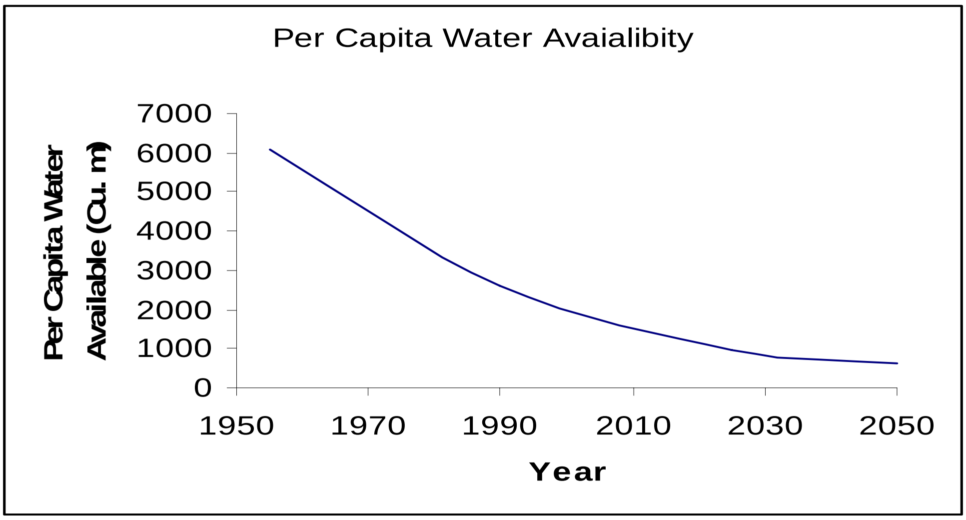


Figure 11**: Per capita physical (not economical) water availability of Ethiopia**

'Water Poverty Index, attempts to reflect the physical availability of water (the degree to which humans are served by that water) and the maintenance of ecological integrity. The index clusters components in five dimensions: access to water; water quantity, quality and variability; water uses for domestic, food and productive purposes; capacity for water management; and environmental aspects. By these measures, Ethiopia is water poor and heavily constrained by economic water scarcity

3.2 The Water Resources Infrastructure Need

This water resource from the excess runoff basins could, in principle, provide supplementary irrigation to overcome the effects of rainfall variability and overcome drought during the major and secondary rain seasons, as well as full irrigation during the dry season to intensify production and maximize the return on available land and water resources.

There are many challenges that must be confronted before water resources can be better utilized and productivity in agriculture is enhanced. Some of the most relevant ones with respect to agricultural water and availability of water are to overcome rainfall variability, dry spells and drought; increase availability of per capita storage for productive and consumptive purposes and even out the availability of water in space and time; overcome soil degradation and overcome water holding capacity and productivity problems.

Figure 12 (Awulachew, 2001) shows the phenomenon of temporal water resources distribution of major rivers in Ethiopia. The figure particularly shows that the scope of Ethiopian water resources to bring meaningful development without reliable water control infrastructure is minimal. The hydrograph distribution of all rivers show that there is considerable variation of runoff in a year, and considerable flow occurs in the period of Mid June to Mid October, where in most case no irrigation is needed except in erratic rainfall areas in the form of supplemental irrigation. Hence, we have to be convinced without confusion that, Ethiopia needs significant water storage to make leap frog in development. This issue becomes clear if one compares the per capita storage availability in developed, middle income and poor countries. The precipitate water storage in m^3 in North America is over 6,000 , about 3,200 in Brazil, 1,300 in Thailand and 43 in Ethiopia (without considering the ones under current construction)

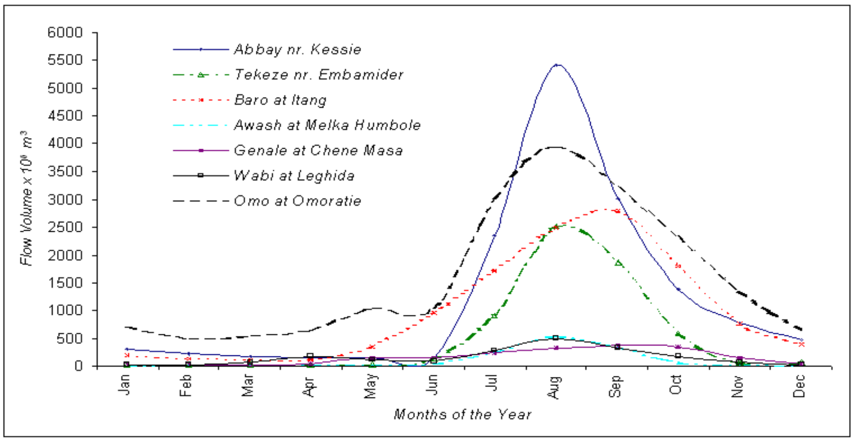


Figure 12: Temporal Water Distribution of Ethiopia

What should be new now is that the emphasis on 'investments in water.' Although it will become clear quickly that there is no such thing as investing in 'water only', articulating it this way does help to focus upon the issue. Physical and economic scarcity of water is very common, and growing, problem in Ethiopia. Although it is not a magical single-factor solution, investments in water combined with complementary policies (for example, to encourage private enterprise) and infrastructure (for example, roads and communications) can bring the rural and prie-urban poor a significant improvement in household food security, poverty relief and economic growth. The impact of investments in water will also be far greater, if accompanied by investments in other sectors, (such as roads, communications and health and by appropriate policies effectively implemented) and vice versa.

The bottom line, as shown in the following Figure obtained from the World Bank, the rate of return of investment on infrastructure is very high for countries in Type 1 level of development, which is reflecting the actual current situation of Ethiopia. As also discussed in the WB CWRAS for Ethiopia, the hydraulic infrastructure investment should be a priority. Added to that Ethiopia's peculiar advantage of integrating various developments that combines consumptive (irrigation, domestic, industrial, urban water supply) and non consumptive (hydropower, flood protection, environmental services) water resources developments makes the rate of return very high.

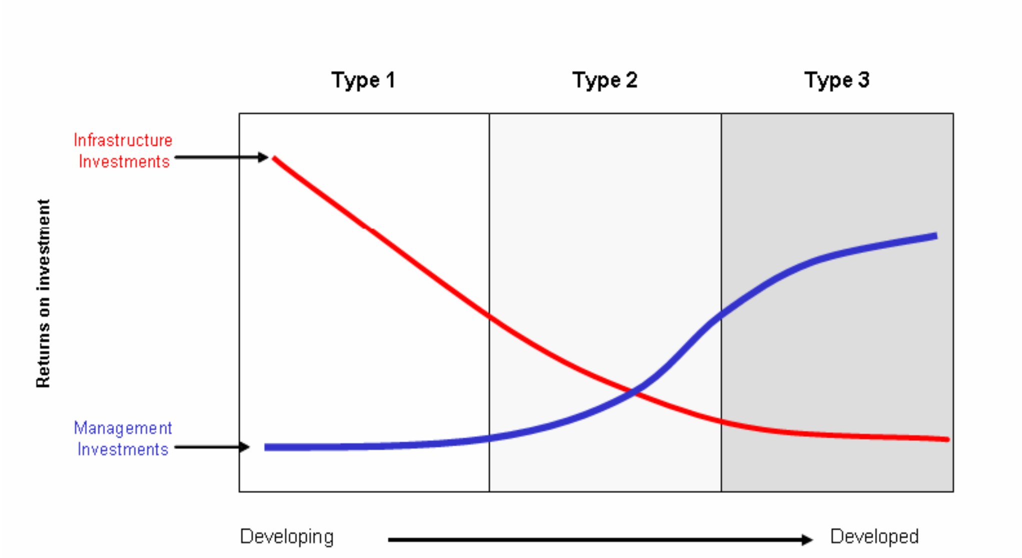


Figure 13: Schematic representation of rate of return of investments vs stage of development of water infrastructure (Sited in WB 2006)

Often, discussion of hydraulic infrastructures for water control and management confused with building dam only. The infrastructure or measures for agricultural water management for example can include dams, diversions, pumping stations, ground water wells, conveyance systems such as canals and pipes, shallow well development, flood harvesting, rain water harvesting, in situ moisture maximization, appropriate field water application, etc. The choice depends on the type of water resources available, the size and extent of development anticipated and the available human, technological and financial capacities. Important is to have open attitude and approach towards all and possible combination combined with innovations.

In conclusion, Ethiopia's challenges are overwhelming and require innovations and key interventions to bring sustainable socio-economic development. Due to neglect in the past and lack of sufficient investment and resources development, the inhabitants of country is subjected to deep poverty, is in state of low resilience and coping strategies and having vulnerable economy. It is important to think differently how to manage its resources effectively to overcome these situations. In the recent past the country has enjoyed growth. This must be made sustainable through key and strategic investment, among which water is an important entry point.

4. Water-related innovations for agriculture

4.1 Lessons Learnt

Despite, great emerging pace and encouraging development now, Ethiopia has not utilized its water resources effectively to transform agriculture and was subjected to all the calamities and key challenges by effects of rainfall and climate, as discussed earlier.

If water plays such a key role in Ethiopia's challenges, then why has it not been addressed already? Key issue is investment. Some people argue on this and generally on water resources development projects in Africa, particularly irrigation projects, have a reputation for being several times more expensive than Asian projects and for not delivering results. Books can be written on this to explain what went well, what went wrong and how could it be made working. Have we learned from the past and do we know where to invest in the future in Ethiopia? Can we put in place innovative policies and strategies? Is there a task for research, for science and technology, to develop such solutions?

Rijesberman, F (2006) discusses similar questions on SSA. For answering such challenges, Jeffrey Sachs's proposal is clear: we have the answers and the key is increased investments. Others, such as Lomborg, question whether there are good investment opportunities where the benefits to society clearly outweigh the investment costs.

For water, however, both camps came to the same conclusion: (1) for water supply and sanitation we have excellent investment opportunities; and (2) for increasing water productivity in agriculture, developing innovative solutions including using research is a good investment opportunity.

This has been also an emerging clarity from many people and decision makers in Ethiopia. World Bank responds that water resources development and management is a core issue for Ethiopia's development.

Therefore, can water play a key role in Ethiopia's transformation? Certainly, yes! It has been instrumental in Asia. Water use for human purposes, primarily for irrigated agriculture, increased six-fold in the 20th century. This has transformed agriculture, particularly in Asia and enabled miraculous economic growth, in the form of green revolution for example. The most important water-related innovations associated with this transformation in the 20th century were (Rijesberman, F 2006):

1. Large to very large dams, of which there are now over 45000 in the world, the majority constructed between 1960 and 1990 particularly in the US, Australia, China and India.
2. Small, cheap diesel and electric pumps which revolutionized irrigated agriculture in Asia, particularly in India and China, where over half of all irrigation is now from groundwater through an estimated 20 million pumps in India alone.
3. Pressure irrigation, i.e. forms of sprinkler and more recently drip irrigation, that have transformed irrigation in Israel, North Africa, Europe, and the Americas.

Innovations that have been much talked about, but that have had much less impact are the most heavily promoted institutional and policy innovations, i.e. irrigation management transfer or participatory irrigation management and water pricing. Off course, they have to be put in place with correct institutional arrangements, with necessary effectiveness and needed efficiency. We are addressing these issues separately, and their importance should not mask the priority areas need, investment in the above 3.

A comprehensive recent study by International Water Management Institute, World Bank, African Development Bank, FAO and IFAD shows that, surprisingly, irrigation projects in Africa are not very much more expensive than in Asia. Small projects are more expensive than large projects, however, and there have been many more small projects in Africa than in Asia. Based on similar other studies key conclusions are:

- Farmers ***are*** the private sector.
- Large has a place: Large dams ***can*** be good and small dams ***can*** be bad.
- ***Farmer participation*** in irrigation O&M makes for better projects.
- Success is influenced by ***other sectors***: fertilizer, roads, markets, output prices.
- ***High-value crops*** (vegetables, primarily) outperform staple foods by a considerable factor.
- Have ***multiple-use*** projects: domestic ***and*** productive use (crops, fish, livestock, trees and environmental services)

4.2 Suggestions for Ethiopia Situation

Understanding the above, the current conditions and past experience in Ethiopia, we propose the following are the most important innovations and approaches towards improving water management for agriculture that could lead to transformation of Ethiopian agricultural centered socio-economy growth:

1. Growth pole/center concept could be applied as a major socio-economic growth approach in selected areas of the country with precisely defined objective and as a National (Federal) undertaking. This yields various benefits among which resettlement and irrigation are prominent ones. It is absolutely essential to resettle people from heavily populated, extremely degraded high land to fertile areas. This, unlike in the past should be fully combined with irrigation and agro industrial development in major river valleys of Ethiopia. Consider educated, multi-disciplinary and organized farmers. Look in to primary outward markets, and how the sparsely populated, fertile, water reach boarder areas of Ethiopia, can be tapped in to nucleuses(growth poles/centers) of socio-economic development and export opportunities;

2. Improve water control, use and management: This could be from small dams up to large dams that could be used for single to multi purpose development. Investment becomes attractive and rate of return becomes high if we invest on multi purpose systems. Large scale irrigation can be combined with large scale hydropower and flood protection. This is proven, we do not need outside evidence for this and the small Koka and Fincha reservoirs are adequate examples. Opponents of such ideas may argue that large scale systems and dams are detrimental to environment, not sustainable, not pro poor, etc. Such group of people may bring out evidences of

some failed schemes. On the other hand, Ethiopia has proven record that such systems are working efficiently, are beneficial to the poor, beneficial to the environment and beneficial to the income of the state[1]. In fact, obsession and waste of time by such kind of discussions painfully delay accelerated growth. Up scaling this kind of systems, needs new way of thinking and innovation. The key to this is taking river corridors as entry point for new settlement strategy and growth pole, which is discussed separately;

3. The choices and types of interventions that need to be made in various zones could be variable. PASDEP identified water based agro-ecologies (adequate rainfall, moisture stress, pastoralist areas). As a case in point among these three systems, in addition to the discussion made in PASDEP document, in pastoralist areas livestock are mostly the sole livelihood options. Livestock require a great deal of water. The quantity needed for drinking is not significant; however, if it is not available in reasonable distance and spatial distribution in these areas it can reduce the productivity of livestock quite substantially. The water required for feed production is quite significantly higher than the water for drinking.
   - Make water availability and access at key spatial points
   - Develop forage and animal feed resources using improved fodder technologies and irrigation
   - Improve livestock productivity and livestock water productivity
   - Ascertain that livestock are means of poverty alleviation and poverty creation, and not simply means of security, social status, etc,

   Appropriate interventions based on these agro-ecologies and production systems can be identified depending on natural, technical, social, financial capacities supported by relevant research, study and intervention strategies. These require appropriate institutional and human resources capacity development;

4. There is strong rational to develop irrigation sector in Ethiopia and multiply the current effort. The reasons are:
   – Irrigation can increase productivity of land and labor, at least doubles
   – Without intensification of agriculture the country faces huge challenges to cope with population growth

[1] The example of Koka dam and reservoir can illustrate this. The koka dam, built in 1950s, enabled generation of hydropower at the reservoir, enabled improved management of flood downstream (although not fully), helped to augment the low flow of upper and middle Awash, hence over 20,000ha of irrigation development, enabled green valley corridor, etc. If we just take the Wonji irrigation scheme, it is having about 6000ha state owned and about 1,500ha out growers (the latter, supplying about 25% cane requirement of the factory). This system and the integrated sugar industry employ about 5,000 permanent and over 7,000 casual workers plus over 1,200 out growers. If, however, the 6,000ha land is distributed to the same labor force as traditional subsistence farmers, it is highly possible that all would have lived under poverty. This system enabled a considerable benefit not only to have reliable income to the employees and the out growers but also to their dependents, when summed up together could be estimated to be over 40,000. The house holds under these systems, besides having good income that can not be obtained had it been under traditional farming, get better social facilities such as school, health service, electricity, water supply, etc. The system, since it is profitable, is also offering significant benefit to the economy of the nation

- Irrigation reduces reliance on rainfall and mitigates the consequences of its variability
- Irrigation can help mitigate agricultural expansion to marginal land and reduce degradation of natural resources
- Ethiopia has significant untapped potential
- Irrigated agriculture can contribute to the export market
- Irrigation can create more job opportunities and foster dynamic economy and rural entrepreneurship through forward and backward linkages, etc

5. Invest also on large scale rainwater harvesting and associated technologies such as low-cost pressure irrigation, treadle pumps, etc. that will help improve water productivity of rain fed agriculture through better water management (and supplemental irrigation). Key to this is doing not make this a blanket recommendation. Identify areas where this makes meaning and return, such as low rainfall, moisture deficit and drought prone areas – and there maybe something to learn here from the Brazilian experience (e.g. re-introduction of the African grasses that have been developed into very successful fodder crops for the Brazilian cerrados);

6. Large water infrastructure projects are capital intensive with long gestation periods. Based on experiences else where in the world (Egypt, Brazil, India, etc.,) these interventions are affected by government initiative and investment in some cases using PPP. Large scale regulation and control of water is made by public investment, deliberately, and can be made accessible to large scale investors or small holder irrigation sector entrepreneurs. Private sectors invited to utilize the water resources at secondary, or tertiary canal levels or on developed ground water wells, where by they are mainly expected to cover the O&M or in some case the water fee. For Ethiopia, it makes sense very much to follow such approach. The recently started Koga irrigation is a case in point. Many others should follow, with clear and conscious solution towards "cost recovery" issue when dealing with multilateral agencies.

7. Enhance use of ground water combined with ground water recharge and watershed rehabilitation. Pumping of shallow and deep ground water in valley bottoms, and ground water potential areas can be an important entry point that needs to be given attention. Small diesel pumps for shallow wells at household or community based as well as deep tube wells can be used depending on the ground water resources availability and reliance. Means of water application could be drip, sprinkler or other forms of irrigation;

8. Reform of public water management; even if water management is devolved to the lowest appropriate level, there remains a crucial role for government, particularly as basins close and water use needs to be (re-)allocated to higher value use(r)s at basin scale, but also to set water prices (or other incentives for wise use) and quality standards. There are issues to be resolved in upstream downstream interactions, inter-regional water allocation, etc.

9. Enhance water resources management capacity and

institutions. Given Ethiopia's challenge on hydrology, low infrastructure, lack of dependable institutions, the need for such capacity is high. The capacity in the country is low and existing capacities are not also well utilized. Equally important is measures on how to reverse the brain drain. Existing capacity development efforts should continue. Investment in education in particular will be crucial to develop the capacity needed to plan, design and implement effective and appropriate water resource development and management interventions

10. Focused research in water is missing. Despite, attempts to come up with research priorities, justification of the needs, etc, research in the water sector is not established. Universities try to undertake ad-hoc research, which are not sufficient. MoWR established a research department, which has no developed capacity to undertake research or sponsor research. EIAR focuses on agriculture research that does not include water, and will not also in a position to address such issues in foreseeable future. It is timely and highly important to develop the water research system in Ethiopia, by having an independent institution which can also takes in to account and integrate the efforts of various universities and presence of global institution such as IWMI, which has wide experience in developing countries. Just two examples: Crop water requirement in various agro ecologies and for various crops is not known. Research can help to establish this which can help irrigation extensions to communicate to farm how much water and when to apply to crop fields. Another example, Remote sensing, Geographic Information System (GIS) and hydrologic modeling research in Ethiopia can lead to seasonal drought forecasting, appropriate cultivation of crops as drought tolerant or high yielding, practical drought mitigation strategies and insurance and improved performance of reservoirs and irrigation systems. Marvelous results on water management and agricultural productivities in Egypt, Israel, Brazil, etc are dependent on adoptive and applied research pertinent to their own situation. Prosperity and breakthroughs for development of rich nations of the world is obtained through research. Ethiopia needs applied research which can put knowledge in to use through adoptions and adaptation

11. Multiple use systems that produce high water productivity by integration of domestic use with productive use for crops, livestock, fisheries, forestry and ecosystem services (as also mentioned under 1);

12. Public-private partnerships with government providing a favorable policy environment and access to markets, and the private sector providing the investments (as in Brazil, or Kenya). Parallel to discussion under point 4, above, there areas where the private sector can be attracted to invest. Ethiopia is now providing this opportunity, yet at smaller scale for example in flower industry. This favorable policies can extending to horticulture, and other agricultural product;

13. Clean water supply to rural and urban area is a key to productivity: Most of the diseases in Ethiopia is occurring as a result of water borne diseases, and in majority of child and infant mortality is associated due to lack of clean water supply and sanitation. Implementing the existing policy that makes water supply a priority should be effected. The progress in this highly encouraging. However, O&M issues are crucial, while investing in new systems. The target set in the PASDEP to bring down the malfunctioning system to 10% by 2010, from the current 30% is useful measure. However, it requires significant actions in terms of capacity, facilities and institutional investment;

14. Hydropower is the white gold of Ethiopia that should be realized. Ethiopia's over 30,000MW potential of economically feasible renewable hydropower energy is an asset that needs to be exploited. No time in Ethiopia's history that this resource is under development than today. The target set to have 2,800MW generation by 2010 from current 791 MW is well underway. This should be further up scaled and continue with confidence for a number of reasons. If current growth continues for few years to come, Ethiopia's future energy consumption itself becomes very high. The benefit of water can feed one another where by the power generated at head dam can be used for pumping of water downstream or from deep wells to irrigate, to be utilized for power supply in manufacturing, agro industry, agro processing, etc. As discussed earlier, hydropower system combined with other consumptive sector development helps lowering investment cost. Parallel to this cascading systems are also effective way of harnessing this potential and lowering the investment cost (examples of Gilgel Ghibe, Mosel valley in Europe can be adopted wherever possible). Ethiopia can export this energy say to Sudan, Kenya, Djibouti and even North Africa and Europe to generate revenue, which can even outweigh the cost of fuel oil need. Hydropower is the one of the cleanest form of energy and can not be contested for environmental impact, except for the opinions of anti-dams. The water productivity of hydropower for energy is much higher than that of bio-fuels;

15. Improve energy access: Rural Ethiopia is currently under energy crises situation. The need for fire wood combined with expansion of agricultural land due to population growth, uncontrolled usage of tree for construction, uncontrolled grazing are key elements for degradations. Limited and costly power supplies force reliance on biomass. Even urban poor do not use electricity for cooking, due to cost or lack of appropriate utensils. Ethiopia's current energy balance relies heavily on the use of fuel wood, crop residues, and dung. At the same time, removing these organic materials from the soil contributes significantly to land degradation and reduction of soil fertility. While accessing modern energy supply is a key issue, and the current plan of connecting 6000 villages with electricity, innovations are also needed how Ethiopia's rural system access appropriate household facility and reasonable cost of electricity that secures the benefit to the poor leading to

higher than using traditional energy;

16. Reverse degradation of Ethiopia: management of our watersheds is crucial for water resources, livelihoods, and the environment. However, we should not expect miracles from just watershed managements without entering in to the phase of investment which enables control, use and management of water that combines soil, forest and other natural resources. Improvements in watershed management, land use planning, and forest management will be crucial in managing water resources and river ecosystems more broadly. Improved watershed management can slow watershed erosion, moderate the hydrological cycle, regulate runoff and groundwater, improve infiltration, water retention and base flows, and reduce potential flood damage. An important lesson from experience in Ethiopia is the need to effectively include stakeholders in the planning, design, and management of watershed interventions. In addition to the above, a new innovation for Ethiopia's natural resources renewal and reversal of degradation are: resettlement combined with irrigation as discussed in the river corridor based growth pole, creating enclosures of highly degraded areas, provision of clearly defined land use plan (example stop cultivating crop say above 30% slope but use such landscape for high value tree crops, fodder production, agro forestry and indigenous trees), invest on interventions that can reverse degradation;

17. Incorporating the needs of livestock in to water planning and management could bring big benefits. Such integration, particularly in the pastoralist and poor livestock keepers help to get more from their animals, while using less water and more accessible to improve livestock productivity, reduce degradation of land and water resources

18. Ethiopia should look in to synergizing investments of various sectors such as roads, market linkage, and industry and water infrastructure. Investment in new valleys for example should be accompanied with this kind of synergies and look outward markets and development of necessary infrastructure towards such goals;

19. While undertaking necessary interventions in the highly vulnerable areas, Ethiopia should rethink on its focus. The past billions of dollars investment to enable survival of the worst affected areas due to climate variability have not transformed Ethiopia. The country should be able to identify growth pole zones such as river corridors and valleys to relocate its people, investment and focus.

5. Policy Actions Needed

Despite remarkable efforts, record growth in the last few years, Ethiopia's agricultural system is not yet significantly benefiting from the technologies and innovations of water management and irrigation that could improve productivity and significantly reduce the vulnerability of the agricultural system to climatic variability. The majority of the poorest are rural dwellers who have limited access to agricultural technology, limited possibility to diversify agricultural production, and cope with underdeveloped rural infrastructure, and weak access (sometimes lack of access) to agricultural markets. 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. Improved water management for agricultural could help not only coping with variability and reduce vulnerability but also, it is an important entry point to break the vicious cycle of poverty by improving productivity. Despite significant efforts of government and other stakeholders to improve agricultural water management and enhance irrigation a number of constraints related to policy, institutions, strategy, technology, capacity, infrastructure and market exist. Addressing these constraints is vital to achieve sustainable growth and accelerated development of the sector in Ethiopia. We have put the following necessary measures in relation to policy that can contribute to the accelerated socio-economic growth and in line with mainly taking water as entry point. These measures however need further enrichment through study, research and dialogue

Policy action 1: Add dynamism, synergies and completeness to the exiting policies, strategies and sector development plans

Having the existing water policy is good, and was expected for many years in the past. However, it should be very well communicated to the society. It should have adequate implementing capacities and implementation strategy, with well defined measures in terms of human resources, institutions, etc. It should be dynamic enough to include versatile overall theories one such proposed approach being Growth pole/corridor, which should have water as one of its solid pillars or input. Water should be seen in this context as an economic propelling factor that has the capacity to create linkages between primarily agricultural producing systems that would give rise to non agricultural production.. The policy should have adequate M&E in place. Irrigation sector strategy and sector development plan for example need to be revised based on new information and economic development, the main agenda being installing the efficient and effective PPP. The small scale irrigation sector strategy should be clearly put in place. What can be done at federal, regional, river basin, watershed, and household levels should be clearly defined. Mandate and responsibilities should be complementary and synergetic not competing. Government's decisive role as a catalyst for wealth creation, in the irrigation sector, has to be enhanced through PPP.

Policy action 2: Change the way we think about water and agriculture.

Thinking differently about water is essential for achieving our multiple goals of ensuring food security, reducing poverty, transforming socio-economy of Ethiopia rapidly, and benefiting the environment. Instead of reliance on rainfall only, think of rainfall is the source of water that should be captured at all phases for beneficial purposes. View rain as the ultimate source of water that can be managed. Invest on water control infrastructure. Unless we invest in these systems in Ethiopia, growth of agriculture and socio-economy remains marginal. Focus on rain, rivers and groundwater. Instead of blueprint designs, craft institutions while recognizing the politically contentious nature of the reform process. And instead of isolating agriculture including irrigation as a production system, view it as an integrated multiple-use system.

Policy action 3: Fight poverty by improving access to agricultural water and its use: Develop water sector entrepreneurship.

Target livelihood gains of stake holding farmers (irrigation entrepreneurs) by securing water access through water rights and investments in water storage and delivery infrastructure where needed, improving value obtained by water use through improved and affordable technologies, and investing in infrastructures such as roads and markets. Multiple-use systems—operated for domestic use, crop production, aquaculture, agro-forestry, forestry and livestock—can improve water productivity and reduce poverty. Empowering entrepreneurs to use water better, and targeting the right groups by ensuring the right to secure access, improving governance of water resources, supporting the diversification of livelihoods, targeting industrious entrepreneurs—in irrigated areas—offers the best chance for reducing poverty quickly. This should also open space new thinking for entrepreneurship development, investment, etc

Policy action 4: Manage agriculture to enhance environment and ecosystem services.

Good agricultural practice can enhance other environmental ecosystem services. In agro ecosystems there is scope to promote services beyond the production of food, fiber, and animal protein. Agricultural production does not have to be at the expense of other services that water provides in rivers and wetlands. But because of increased water and land use, and intensification, some ecosystem change is unavoidable, and some times difficult choices are necessary. The issues in Ethiopia are that our environment and ecosystem are devastated due to poor agricultural practices that have never addressed the water issues seriously and appropriately. Absence of proper water management and lack of productivity are responsible to have almost no conservation area and degradation in most part of the country

Policy action 5: Increase the productivity of water

Learning from past experience and experience of other countries, we should also focus on getting more yield and value from less water. Such approaches have the benefit of meeting reduction of future demand for water, limiting environmental degradation and easing competition for water. Similar to multiple use system, multi purpose development provide such opportunity. Improving efficiency and performance of existing schemes, including understanding the cause and revitalizing the failed systems will help improving the productivity

Policy action 6: Upgrade rain fed systems

Rain fed agriculture is upgraded by improving soil moisture conservation (note the importance in crop fields) and, where feasible, providing supplemental irrigation. Unlike in the past of focusing on just seed and fertilizer, water management in the rain fed system should be given adequate attention. This should not also be confused with full irrigation systems. These techniques hold underexploited potential for quickly lifting the greatest number of people out of poverty and for increasing water productivity. Investment only in one, namely water or soil fertility (fertilizer) or seed may only increase productivity by 50% percent. If the three are combined together productivity can increase to 300%. Mixed crop and livestock systems hold good potential, with the increased demand for livestock products and the scope for improving the productivity of these systems.

Policy action 7: Reform the reform process—targeting state institutions.

Following a realistic process to suit local needs, a major policy shift is required for water management investments important to irrigated, rain fed agriculture and water management. A wider policy and investment arena needs to be opened by breaking down the divides between rain fed and irrigated agriculture, small and large, federal and regional. It is important to link sub-sectoral investments to synergize by talking and planning together. Reform cannot follow a blueprint. It takes time. It requires discussion, negotiation and coalition building. Civil society and the private sector are important actors. But the state is often the critical driver, though state water institutions are often the most in need of reform. Establish the Ethiopian Water Council/commission under the Ministry of Water Resources that would

- consist of Government, Line Ministries, NGO, Civil Society, Regional States, etc
- forges water as central element in the evolvement of the Growth pole and other growth interventions
- Asserts that all water related projects/programmes/interventions are stream lined synergized and integrated within river basin planning frame work.
- Advises the government on trans-regional and trans-boundary river systems utilization, management, etc.

Policy action 8: Deal with tradeoffs and make difficult choices.

Because people do not adapt quickly to changing environments, bold steps are needed to engage with stakeholders. Informed multi stakeholder awareness creation, discussions, negotiations are essential to make decisions about the development, use and allocation of water. Reconciling competing demands on water requires transparent sharing of information and choosing optimum strategy that would ultimately benefit all.

Policy action 9: Define growth corridors

It is possible to define growth corridors, taking river valleys, which can adequately feed Ethiopia and enhance national income. Urgent definition of these corridors is essential

Policy action 10: Resettle people from degraded area to high potential areas with irrigation potential

Many countries in the world can be sited as example. Reduce resettlement from degraded areas to virgin area with out irrigation is inferior compared to resettlement to irrigation potential areas. The environmental degradation implication is also quite significant and at times can be disastrous. It is better to make such resettlement with well designed strategy that includes irrigation and agro industrial development

Policy action 11: Settle groups of educated farmers

New development areas and corridors should be inhibited by combination of educated farmers of skill mixes, with adequate financial loans, access to land, infrastructure, facility, linkage to investors, etc.

Policy action 12: Develop research and capacity building of water in Ethiopia

No one in Ethiopia current claims in undertaking coherent and effective water and agricultural water management research, and there is huge gap in terms of undertaking, focus, capacity, ownership and institutionalization. There is strong usefulness of research to enhance development. The country needs water research pertinent to policy, institutions, technologies, agricultural and water productivity, Tran's boundary, climate variability, etc issues. The current efforts are not supported with the necessary instruments such as budget, facility and manpower

Policy Action 13: Livestock and pastoralist

Policies leading to strategic sourcing of animal feeds, strategic provision of drinking water, enhancing animal productivity and reducing herd sizes are important interventions needed. It is important to manage livestock in a way that it can provide more benefit, reduce land, water and ecosystem degradation.

Policy Action 14: Manage human resource and capacity

Some of key public institutions are suffering due to not only brain drain but also internal migration. It is important to ascertain that public institutions do not loose capacity, drained during reform processes. Ethiopian water expertise in Diaspora community is probably higher than what exists in Ethiopia. Policy and strategy to harness this capacity should be seen as part and parcel of managing the internal capacity.

Policy Action 15: Commit and raise necessary financial resources

It is important to allocate sufficient public funding, clearly and deliberately earmarked for these key interventions. It is important to establish and develop the water resources fund, considering the entire citizen at home and abroad.

Policy Action 16: Enhance and encourage key institutions and CSO

Integrate water in agricultural research by building relevant capacity. Developing an independent water research institute is long overdue, and such institute is strategic for Ethiopia. Accepting water advisory council at various levels is one means of tapping in to the potential of the HR capacity of the country. Establishing/strengthening Ethiopian Water Resources and related associations can contribute to the development and enhance the engagement, thinking and involvement of professionals.

In conclusion, the above key lessons and policy interventions and actions are proposed based on the prevailing situation, key problems and challenges identified in the context of previous sections. These are suggestion that require further discussions, enrichment, actions and not blue prints. They can serve as important discussion and way forward issues that can involve key professionals, policy makers, and citizens of Ethiopia. We encourage that these be brought to the wider frame work of the think thank group.

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CONTEXT REVIEW AND SYNTHESIS OF WATER AS A MAJOR ENTRY POINT FOR AGRICULTURE AND ECONOMIC GROWTH

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Abstract

This paper provides a brief account of the socioeconomic context focusing on the macroeconomic aspects in relation to the water sector. An argument is created by raising the following questions regarding the place and role of water resources for the national economic development in Ethiopia.

Do the Ethiopian development policies and strategies give equal place for water as much as they do for land and labor as primary resources?

How can one bring the third pillar - water (between land and labor) - as a key resource into focus for national economic development?

The underdevelopment of Ethiopia's vast amount of water resources is one of the underlying factors of the socioeconomic challenges that the country faces.

"The challenges facing Ethiopia are daunting: the dynamics of population growth, very low productivity, structural bottlenecks, dependence on unreliable rainfall and being landlocked, combine to pose challenges almost unequalled anywhere in the world. Government efforts to accelerate progress as rapidly as possible, including a big push on education, expanding infrastructure, opening the economy, building institutions and devolving administration, are like those of an athlete running uphill - extra efforts are

required just to keep the pace" (PASDEP).

devolving administration– are like those of an athlete running uphill:

1. Introduction

1.1 The Role of Water Sector

This paper provides a brief account of the socio-economic context focusing on the macro-economic aspects in relation to the water sector. It argues by raising the following questions regarding the place and role of water resources for the national economic development in Ethiopia.

Do the Ethiopian development policies and strategies give equal place for water as much as they do for land and labor as primary resources?

How can one bring the third pillar (water) (among land and labour) as a key resource into focus for national economic development?

The underdevelopment of Ethiopia's vast water resources is one of the underlying factors of the socio-economic challenges the country faces.

"The challenges facing Ethiopia are daunting: the dynamics of population growth, very low productivity, structural bottlenecks, dependence on unreliable rainfall, and being land-locked combine to pose challenges almost unequalled anywhere in the world. Government efforts to accelerate progress as rapidly as possible – including a big push on education, expanding infrastructure, opening the economy, building institutions, and

extra-efforts are required just to keep the pace"(PASDEP).

Due to lack of resources and consistent attention to develop the water resources, the contribution of water to the national economy has been very low, even compared to the other sectors. According to the Ministry of Finance and Economic Development (MoFED) data, over the period 1960/61 to 1990/91 the value added of "electricity and water sector" grew only from 21 million birr to 180 million birr. The same database2 shows that the GDP from this sector reached around 370 million birr. This value added refers to collection, purification, and distribution of water for household, industrial consumption. It does not account for water used in creating agricultural value production, which could also be difficult methodologically.

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[2] The old data series of National Account provided by MOFED.

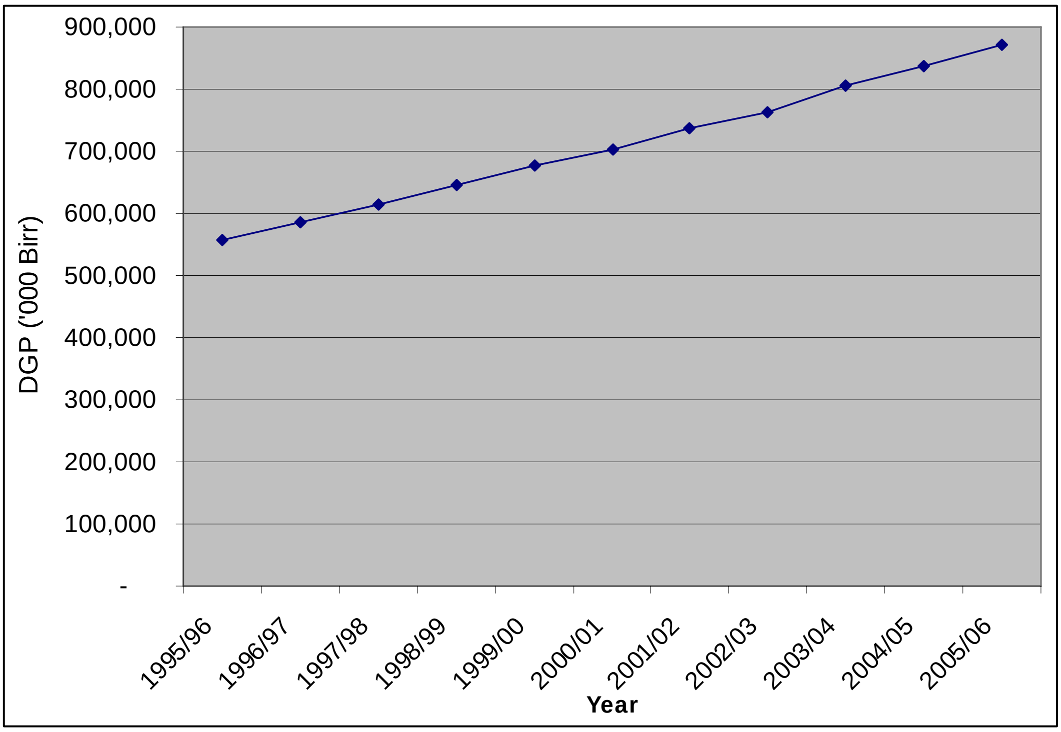

Figure 1: Gross Domestic Product of Water Sector in Ethiopia at Constant Market Price ('000 Birr)

Source: Computed based on the data of the Ministry of Finance and Economic Development (MoFED)

The new data series of the National Account treats the value-added from water separately from electricity and gives much higher figures (see figure 1). As shown in the figure, GDP of the Water sector in Ethiopia (at constant market price) has been growing steadily from 556 million birr in 1995/96 to 870 million birr in 2005/06. Looking at a time series data over decades, the percentage share of value-added of electricity and water sector in the real GDP was lower than 2.5 percent during the last 5 decades showing that water recourse development in the country has been minimal even compared to other sectors. Average share during the period was only 1.4%, only slightly rising from 0.7% in the 1960s to 1.6% in 1990s and 2.1% in the years after 2000.

The burden of raising resources for water development has been a major challenge for the country. The finance for the water sector comes mainly from the national budget as government Contribution. There are external source in the form of grant and loan channeled through the Government. For the water sector development plan period 1992-1998, out of a total of close to 3 billion birr allocated for the sector 73% was from the government while the reaming 17% and 14% were from grant and loan, respectively (see Table 1) . While 80% of the government resource was used up, only less than 50% of both grant and loan was used may be showing the difficulty of meeting the commitments from the donors and lenders and capacity to mobilize and utilize on the part of the sector. During the period 1999-2002, the contribution of the government to the water sector budget rather drastically dropped to 17% while the total budget was also dropped to only one-third of the pervious period (1992-1998). The share of grant and loan rose to 35% and 48%, respectively. Similarly, utilization of the government budget was also much lower during this period (see Table 2).

Table 1: Budget Allocation and utilization by source of finance 1992-1998 (inclusive)
'000 Birr

Budget Activities	Budget Allocated				Budget Utilized			
	Gov't	Grant	Loan	Total	Gov't	Grant	Loan	Total
Water supply	1251349	434571	348083	2034003	1062032	92401	152558	1306991
Urban	1251349	131993	348083	173425	926353	63887	152558	942799
Rural	…	302577	0	302577	335679	28514	0	364193
Irrigation	548434	18623	77734	644791	344805	9083	34591	388497
Medium and large	207077	18623	77734	303435	165250	9083	34591	208924
Small scale	341356	0	0	341356	179554	0	0	179554
Basin Development	122515	34000	0	156515	110929	34000	0	144929
Hydropower	72703	5705	0	78408	62626	3395	0	66021
Meteorology	160026	3575	0	19601	12581	0	0	12581
Hydrology	9780	4928	0	14708	5372	31642	0	37014
GRAND TOTAL	2164807	501402	425817	2948026	1598345	170521	187149	1956033
Source	73%	17%	14%	100				
Rate of Utilization					79%	34%	44%	66%

Source: UNESCO (2004).

Table 2: Budget Allocation and utilization by source of finance 1999-2002 (inclusive)
'000 Birr

Budget Activities	Budget Allocated				Budget Utilized			
	Gov't	Grant	Loan	Total	Gov't	Grant	Loan	Total
Water supply	15241	0	197145	212386	16145	0	90607	106752
Urban	15241	0	197145	212386	16145	0	90607	106752
Rural	0	0	0	0	0	0	0	0
Irrigation	17560	111460	196456	325476	23068	423	36366	59857
Medium and large	4618	0	3243	7861	3686	0	0	3686
Small scale	12941	111460	193213	317614	19382	423	36366	56171
Basin Development	9482	0	0	9482	7917	0	0	7917
Hydropower	17164	14955	0	32119	3857	8885	0	12742
water resources	14210	0	0	14210	3881	0	0	3881
Meteorology	38475	24229	0	62704	42633	2919.65	0	45552.65
Hydrology	2720	9055	0	11775	1379	2159.9	0	3538.9
capacity building	23128	123695	0	146823	14730	81320	0	96050
GRAND TOTAL	137983	283396	393601	814980	113613	95707.55	126973	336293.6
Source	17%	35%	48%	100				
Rate of Utilization					34%	28%	38%	100%

Source: UNESCO (2004).

Table 3: Water sector program cost and financing (Million Birr)

Program/activity	2002/03	2003/04	2004/05	Total
Water supply and sanitation	910.9	1237.2	1414.6	3562.7
Irrigation and drainage	486.9	756.1	760.9	2003.9
Hydro power study and design	9.4	39.2	61.8	110.4
Basin development studies	35.9	42.9	50.8	129.6
Water resources database /assessment	33.5	31.5	32.7	97.7
Water resources management	87.3	103.6	197.3	388.2
Capacity building and general service	46.6	179.2	214.6	440.4
Meteorology	23	32.6	41.6	97.2
Transbaoundary waters	0.7	0.9	1.1	2.7
Total	1634.2	2423.2	2775.4	6832.8
GDP	16,941.5	18900.9	20131.8	
Total water as % of GDP	10%	13%	14%	29

Source: United Nations Educational, Scientific, and Cultural Organization. (2004).

In recent years, 2002/03 to 2004/05, budget allocated fro the water sector significantly increased reaching a total of 6.8. Billion birr for the three years all together (Table 3). In terms of development programs within the sector, water supply and sanitation took the biggest share during 1992-1998 and 2002/3 to 2004/05 followed by irrigation development. During the period 1999 -2002, however, bigger emphasis was given to irrigation development, particularly the small-scale irrigation. Unfortunately, the attention given to basin development was very minimal in all times.

While water sector development is regarded as a major sector with potential to bring about poverty reduction and sustainable development for the country, the percentage contribution of the Government as budget from the GDP is smaller. For the years 2002/03 to 2004/05, the share of resources allocated for water sector ranged only from 10% to 14% of the GDP.

For the PASDEP plan periods that range from 2005/06 to 2009/10, indicative program cost for the poverty- oriented sectors shows a plan to allocate 22.9 billion birr in the first plan year and reach 44.3 billion in the fifth year (MOFED, 2006). In this plan the resources are separately indicated for irrigation development and clean water and sanitation separately. During the plan the resource for irrigation is expected to be 9% (in 2005/06) and reach 13% in 2009/10, while for clean water and sanitation will be 12% (in 2005/06) and reduce to 4% of the total for poverty-oriented sectors in 2009/10.

2. Water Resources and Development Polices and Strategies

Rural policies and strategies very well recognize the importance of land and labor as the two most important pillars for development. One may ask the implications of not mentioning water as one of the potentially abundant resources to be exploited for the national economic development. In this respect, how to bring the third pillar (water) to the attention and focus in critical policy making and strategy design is an issue. Success towards improving agricultural productivity rests on integrating labor, land, water and technology as well as the functionality of forward and backward linkages among economic sectors.

Table 4: Highlights of Donor Assistance Strategy, 1980–2001

Period	Policy, capacity development	Adjustment and growth	Physical infrastructure	Poverty and human services	Agric. & environment
1980-91	Technical assistance planning agency CEM	Coffee processing IMF standby (1981–82)	Energy Transport / telecom, Towns	Education V–VII Family health	Irrigation, PADEP
1992-94	CG1–2 (1992, 1994) SPA, PFP1 -PFP3	Economic recovery and reconstruction program, SAC I and SAF sector dev't	Road rehabilitation, Calub Gas , Gilgel Gibe hydro	Food security	Improved seeds, Fertilizer
1995-2001	CG3–4 (1996, 1998), PFP4 - PFP5, SIP (or SDP), MTEF/PIP, PER2–PER6	ESAF (1996–99), Export promotion, SME development, Rail rehabilitation	Power distribution, Water supply, Road SIP, Energy	Family planning, Social rehabilitation, SIP (Education Health), Conservation	Sale of state retail, Support services, Research and training, Food security

Source: Berhanu Abagaz (1999). (Source: World Bank 1992, 1995, 1997a; USAID 1999; Maxwell 1998; IMF 1999b; Ethiopia 1998a.

CEM=Country economic memorandum
CG = Consultative Group (multidonor conferences)
ESAF =Extended Structural Adjustment Facility
MTEF = Medium-term Economic Framework
PER = Public expenditure review
PFP = Policy Framework Paper
PIP = Public investment plan
SAC = Structural Adjustment Credit
SIP = Sector investment program
SME = Small and medium enterprises

Over the last 2 decades development programs and projects in Ethiopia did not give adequate attention to water resources development (see the Table 4). It is more so in the donors assistance programs leaving the government attention and resources for the sector to be minimal. Over the period of two decades major focus of donors' assistance framework was on other sectors and programs. There are some for water development in irrigation, water supply and Gilgel Gibe Hydro Electric Power Project. No assistance was there to have significant changes in the water sector according this summary of projects/programs provided above.

Better than any other time, PASDEP has given attention to the water sector development issues. The document highlights that: i) Ethiopia possesses substantial untapped water resources that could play significant role in reducing poverty and accelerating growth; ii) Various efforts have been made to develop this resource to increase its contribution to the national economy; iii) However, mainly due to the uneven distribution of the resources and limitations of financial and technical inputs, only limited progress has been made so far.

In PASDEP, a plan for Water Management and Irrigation Development is indicated focusing on the following areas:

Major effort will be made to promote and strengthen small-scale irrigation schemes (river diversion, micro-dam construction, ground water abstraction, etc.) for supplementary and double cropping;
The program will also include strengthening water harvesting and utilization practices through provision of appropriate technologies;
The extension and training programs for farmers' to use water resources efficiently;
Helping build the community-level institutional structures necessary for effective irrigation management;
In addition, where there is a comparative advantage, the government will promote and strengthen medium- and large-scale irrigation.

However, not only such big promises to focus on water resources, it also needs a shift in attitude and thinking about the notions and assessments of the resource base of the country. When one reads a statement below, one still feels a bias towards land and labor:

"Ethiopia's Rapid and Sustainable Growth strategy has to be based on taking advantage of its most abundant resource: labor, (due to the opportunities of low wage rates)" (PASDEP).

While the need for strategic efforts to raise domestic resources for water development is crucial including encouraging participation of the private sector, the following notion (mentioned in program document) should be revisited towards a paradigm shift in some self-reliance and initiating development resources mobilization. When do we start also generating own resources??

"At $100 per capita there is little domestic surplus to be accumulated, so the strategy to moving forward has to involve a significant injection of external capital, either in foreign direct investment, or of donor financing for infrastructure investments"(PASDEP).

There are encouraging signs to promote water resources development for contribution to poverty reduction and sustainable development of the country. There have been achievements during the PRSP implementation periods. More is also planned during implementation of the PASDEP. As reports show, outcomes by the end of SDPRP 2004/05 in improving access to water were encouraging where the coverage of rural access to water within distance of 1.5 km reached 35% and urban access within distance of 0.5 km is 80%. Similarly, cumulative farm land developed with irrigation during the plan period was 62,057 hectare. Targets set for PASDEP period 2005/06 to 2009/10 shows that the area developed under medium and large scale irrigation is to reach 322680 ha and supply of clean water (% of population) will reach 84.5%.
There is more to be done to mainstream water resources development as a center of a sustainable socio-economic development of this country taking the growth pole concept as one possible direction.

3. The concept of Economic Growth and Development

3.1. Defining Economic Growth and Development

A comprehensive discussion and comparative analysis of various theories of economic development was given by the ECONOMIC DEVELOPMENT ADMINISTRATION: U.S. Department of Commerce3. The following discussion is based on the summary provided in that review document. Comparative analysis of the different theories, their assumptions, circumstances for their application and views held about their successes and failures are vital in order to be able to identify a suitable strategy to lead economic growth and development.

According to leading economists development is a qualitative change, which entails changes in the structure of the economy, including innovations in institutions, behavior, and technology while growth is a quantitative change in the scale of the economy - in terms of investment, output, consumption, and income.

According to this view, economic development and economic growth is not necessarily the same thing. Because it is thought that development is both a prerequisite to and a result of growth. Moreover development comes prior to growth in the sense that growth cannot be sustainable without the innovations and structural changes in an economic system. On the other hand, growth, in turn, will also cause/lead to new changes in the economy, enabling new products and firms to be created as well as numerous small innovations. Together, these advances bring increased productivity to an economy, thereby enabling production increased efficiency. Environmental critics and sustainable development advocates, furthermore, often point out that development does not have to imply some types of growth. An economy, for instance, can be developing, but not growing by certain indicators. The argument is that the measure of productivity should not be solely monetary; it should also represent and shed light on how effectively scarce natural resources are being used and how well pollution is being reduced or prevented.

Economic development is fundamentally about enhancing the factors of productive capacity - land, labor, capital, and technology - of a national, state or local economy. By using its resources and powers to reduce the risks and costs which could prohibit investment, the public sector often has been responsible for setting the stage for employment-generating investment by the private sector.

There is an argument that there can be trade-offs between economic development's goals of job creation and wealth generation. Increasing productivity, for instance, may eliminate some types of jobs in the short-run. There is lively debate within the field about the differing goals for place-based development strategies and also about whether place-based or people-based is best.

3.2. Economic Development Theories

Economic development encompasses a wide range of concerns. To most economists, economic development is an issue of more economic growth. To many business leaders, economic development simply involves the wise application of public policy that will increase competitiveness.

To those who think that government should more actively direct the economy, economic development is a code phrase for industrial policy. To environmentalists, economic development should be sustainable development that harmonizes natural and social systems. To labor leaders, it is a vehicle for increasing wages, benefits, basic education, and worker training. To community-based leaders and professionals, economic development is a way to strengthen inner city and rural economies in order to reduce poverty and inequality. To public officials at state and local levels, economic development embodies the range of job creation programs.

[3] http://www.eda.gov/Research/EcoDev.xml.

Theories of economic development abound. Varying in basic, fundamental ways, they make different behavioral assumptions, use different concepts and categories, explain the development process differently, and suggest different policies. The theories used by economic developers determine, either explicitly or implicitly, how these developers understand economic development, the questions they ask about the process, the information they collect to analyze development, and the development strategies they pursue. Ultimately, theoretical insights influence how successful economic developers are in promoting local competitiveness. Value differences, contending ideological positions and varied theories of how economic development occurs and how it should be practiced are presented in the economic development theories (a detail summary is provided in Table 5).

Table 5: Summary of Economic Development Theories

Theory	Basic Categories	Definition of Development	Essential Dynamic	Strengths & Weaknesses	Application
Economic Base	Export or basic and non-basic, local or residentiary sectors	Increasing rate of growth in output, income or employment	Response to external changes in demand; economic base multiplier effects	Most popular understanding of economic development in the United States and a simple tool for short-term prediction. Inadequate theory for understanding long-term development	Industrial recruitment and promotion for export expansion and diversification, expansion of existing basic industries, import substitution by strengthening connections between basic and non-basic industries, and infrastructure development for export expansion
Staple	Exporting industries	Export-led economic growth	Successful production and marketing of the export staple in world markets. Externa l investment in and the demand for the export staple	Historical perspective on economic development. Descrip tive theory difficult to apply	Build on export specialization. State does everything possible to increase competitive advantage. Characte r of economic base shapes political and cultural superstructure
Sector	Primary, secondary, and tertiary sectors	Greater sectoral diversity and higher productivity per worker	Income elasticity of demand and labor productivity in primary and secondary sectors	Empirical analysis possible. Categories are too general	Promote sectoral shifts. Attract and retain producers of income elastic products
Growth Pole	Industries	Propulsive industry growth leads to structural change	Propulsive industries are the poles of growth	General theory of initiation and diffusion of development based on the domination effect	Growth center strategies
Regional Concentra tion and	Commodities and factors (Myrdal) or	Higher income per capita	Spread and backwash effects (Myrdal) or	Address the dynamics of development	Active government to mitigate backwash effects and reduce

Theory	Basic Categories	Definition of Development	Essential Dynamic	Strengths & Weaknesses	Application
Diffusion	industries (Hirschman)		trickle-down and polarization effects (Hirschman)		inequalities (Myrdal). Location of public investments spurs development (Hirschman)
Neoclassical Growth	Aggregate (macro) or two-sector regional economy	Increasing rate of economic growth per capita	Rate of saving that supports investment and capital formation	Supply-side model	Government should promote free trade and economic integration and tolerate social inequality and spatial dualism
Interregional Trade	Prices and quantities of commodities and factors	Economic growth that leads to greater consumer welfare	Price adjustments that result in equilibrium terms of trade; price-quantity-effects	Unique emphasis on consumer welfare and price effects. Ignores the dynamics of development	Government intervention should promote free trade. Infrastructure development, efficient local government
Product Cycle	Products: new, maturing, or standardized	Continual creation and diffusion of new products	New product development; innovation	Popular basis for understanding development among researchers	Development strategies promote product innovation and subsequent diffusion
Entrepreneurship	Entrepreneurs or the entrepreneurial function	Resilience and diversity	Innovation process; new combinations	Mediated theory	Support industrial milieu or ecology for development
Flexible Specialization	Production regimes, industrial organization	Sustained growth through agile production, innovation and specialization	Changes in demand requiring flexibility among producers	Detailed analysis of firm/industrorganization; aggregate outcomes and relationships seldom specified	Encourage flexibility through adoption of advanced technologies, networks among small firms, and industry cluster strategies

Source: http://www.eda.gov/Research/EcoDev.xml.

The economic theories present various orientations including focus on the export sector or primary or tertiary sectors, commodities or factors, etc. They also define conditions or factors that constitute dynamisms in the development. One of the existing theories of economic development is the growth pole theory. Growth pole theory treats industries as the basic unit of analysis, one that exists in an abstract economic space. This theory states that economic development is the structural change caused by the growth of new propulsive industries. Propulsive industries are the poles of growth, which represent the essential dynamic of the theory. Growth poles first initiate and then diffuse development. Growth pole theory attempts to be a general theory of the initiation and diffusion of development based on François Perroux's domination effect. Growth center strategies are based on this theory.

The other papers will more elaborate the concept of growth pole in relation to its application/use for Ethiopia’s water centered national socio-economic development.

Issues for discussion: policy implications.

Water resource as a center for promoting growth corridor and basin development needs a serious and consistent attention. In fact among the challenges for Ethiopia's agricultural lead economic growth is the lack/inability to ensure the following basic conditions.

The country does not have an effective land use plan and related law that would have enforced proper and sustainable utilization of land and natural resources. Proper and integrated land use system saves the environment as a basic source of water for development. Lack of such policy and law means the settlements, cultivations, urbanization, deforestation and water pollutions will continue uncontrolled. The disturbance of the natural eco-system leads to gradual deterioration of the water system/ hydrology.

Valuation and costing of water resources for agricultural and industrial use: this does not seem to be thought of yet. In fact, lack of water valuation and costing system not only lead to misuse of the meager resource, but has hindered water development, as there is no incentive to invest in water resources development and its efficient utilization. If one vales water, then he will be accountable to properly and efficiently utilizes the scarce resource. On the other hand, valuing water will promote investment and employment in water sector development. There are many examples of empirical works on how to value water for agricultural uses.

Health of water: in Ethiopia in many settlements, particularly in urban areas, the water bodies – rivers, springs, wetlands, etc. are badly polluted and threatened. This is largely attributed to lack of urban environmental and sanitary policies, regulations of settlement, infrastructure like sewerage system and waste disposal mechanisms. For instance, the many rivers that flow from the watersheds of Addis Ababa (also other towns), which are part of the Awash rivers basin are heavily polluted as houses are constructed in the river banks, factories are constructed along the river banks, water ways are disrupted, wastes are discharged to rivers, etc. There is a significant level of worry about contamination of the ground water. Environmental health and protection of water bodies from pollution need to be an integral part of water resources development.

Inputs for water development: there widely known and distributed inputs for agricultural development like fertilizer, improved seed, agronomic practices, etc for land productivity. In the same way there are skill trainings and labor saving technology to improve labor productivity. It is also important to support similar input systems to promote water use and productivity.

Sustainable water resources development also needs enhanced watershed protection. One of the interventions required is to change the settlement pattern in the country where sloppy lands are settled leading to deforestation and disruption of the natural water cycle.

The science and technology policy of the country is less water centered. I.e. research works less oriented towards innovations and technologies that raise water productivity, water use efficiency and management. It needs reorienting the research strategies and support/ incentive mechanisms.

The need for a framework for private sector investment in water development, distribution and marketing. It could be due to lack of adequate information of how to do it, its economic feasibility, lack of regulatory system to support such development.

The energy policy: the country's energy policy should be a comprehensive one that takes into account factors that affect the hydrologic system of the country. As the electricity tariff is expensive for ordinary citizen, the dominant source of household energy even in urban areas is biomass (fuel wood and charcoal) leading to an incentive to deforest land for fuel wood and charcoal production, and using crop residue. These have direct and indirect consequences for environment and water resources. Attention should be given to a public policy that considers the trade- offs between high electricity price for home consumption and disasters on the environment from deforestation and long term effects like desertification.

It needs a serious and well-thought national policy and strategy towards mobilizing resource for water development. Why not a 1 birr tax on every transaction of goods and services consumed by citizens, economic agencies and institutions? This will raise millions of birr for water for the new Ethiopian millennium and through that saving life and ensuring better future for the coming generation. It is also a way of making better aware of the crucial role of water in nature and human civilization.

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ECONOMIC DEVELOPMENT: IMPERATIVES AND REQUIREMENTS

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Absract

Majority of the Ethiopian population, constituting about 85% of the total population and 90% of the poor, live in the rural setting; where agriculture is the dominant way of life. Out of this population, a significant number of people (85%) are settled in the Highlands of Ethiopia, which is made up of 35% of the total landmass areas, which are mostly humid and wet, and are involved in cultivating crops and rearing livestock in a mixed farming system. The remaining population (15%) is pastoral and cattle herding community that has remained in the Lowlands of the country, which, in most cases, is hot and dry. Here, rearing herds of livestock and moving constantly in search of feed and water for cattle makes it a way of earning a living.

The rural setting, which is responsible for agricultural production (60% of the country's gross domestic product (GDP), is characterized by frequent drought, less productivity, unbalanced and minimal growth, food insecurity, and multifaceted vicious production and social crises due to poverty. Apparently, agricultural production is highly constrained by the absence of moisture/water, implying that there is a clear economic role for water in any meaningful development.

Due to the backward production system, population pressure, poor infrastructure development, etc., the agriculture sector is yet unable to lay the basis for industrialization, despite the fact that the government has an agricultural development-led industrialization policy. Thus, the forward linkage to industrialization appears to demand a well-thought-out development theory and framework that will link the rural setting of agriculture with the urban setting (industrial, service, trade, etc.) for sustainable and assured socioeconomic development.

Here the challenge is to ascertain the usefulness of the growth corridor as the most viable theory of growth that would bring, among other things, the forward and backward linkages and to articulate the following:

a) Its inputs/pillars, e.g., natural resource base such as water, minerals, etc.
b) Process (interventions that make use of resources), irrigation development, urban development, social and economic infrastructure development (health, education, water supply, etc.).
c) Output/objective, e.g., social and economic development, etc.

Working in the water and irrigation sector for the last 24 years, it has been possible to closely observe that there is a need to contribute to a sound and scientific approach to solve the problems at hand and, therefore, to reorient the development process on a right track to reach at a holistic development rather than the prevailing piecemeal approach of independent, discredited interventions/projects of various magnitudes.

1. Socio Economic Development:

Imperatives and Requirements

1.1 Poverty eradication

The poverty situation in Ethiopia is a phenomenon that needs full apprehension and appropriate policy to deal with until it is done-eradicated completely. The challenges facing Ethiopia in this respect are enormous: the major ones being; population growth, very low productivity, over dependence of the agricultural system on unreliable resource base (rainfall) and limited infrastructure development.

The different mechanisms hindering Ethiopia's progress are not independent, but rather interact with each other and constitute what can be seen as "poverty traps" self-reinforcing mechanisms that prevent the country from breaking out from a combination of low-income levels and low productivity growth.[FDRE, MoPED-2006]

The Ethiopian Government endeavour to enhance growth and to exit from the lingering cycle of crisis are manifested through its prominent efforts on education, infrastructure development (road, telecom, hydro-power), opening the economy (although at slow pace) and changing its role of direct wealth creation to wealth regulation by privatizing state owned business, installing effective decentralized local administrations and its commitment to building capacity of public institutions. However, there still remains so much to be accomplished so as to be done with poverty once and for all.

1.2 Sustainable economic growth

All conventional growth theories including the Growth pole, aim to build sustainability in economic growth and achieve significant GDP growth. The creation of a conducive environment for private public partnership and private investment should also be among the main objectives of growth theories that would ensure sustainable economic growth.

Sustainable economic growth requires the prevalence of a strong financial sector, well-developed human resources and institutional arrangement. Not only is this, but sufficient which has market & conservation based origination. These in turn have to be linked to urban/township development so as to achieve a higher GDP growth from the synergy of urban–rural linkage towards increased economic activities in trade, service and manufacturing industries.

Sustainable economic growth demands maintaining macroeconomic stability, monetary expansion consistent with targets of controlled inflation, as well as a stable exchange rate and sustainable export sector development.

2. Basic Concept and Its Variations

2.1 Note on this paper

This paper deals with the strategic operational planning of growth pole/center and has the objective ascertaining it's use as a major direction and analyzing the applicability of this approach based on lessons learnt from international and to the extent possible on domestic experiences.

The analysis includes the possible aspects of improving the growth pole strategy and articulating key areas of precaution as applied to Ethiopian context, considering peculiarities and socio-economic dimensions.

This paper has extensively and generously used and consulted an important research work of Takahiro Miyoshi (1997), a dissertation entitled" Successes and Failures Associated With the Growth Pole Strategies" submitted to the University of Manchester for the degree of MA (Econ). In addition to this; domestic experience and working papers of Concert Engineering as related to relevant regional planning exercises have been referred. The valuable experiences thus consulted would have contributed to what ever worth this paper is. If there are any critics it will only be on the authors behalf.

2.2 Genesis of growth pole/center: concepts and its imperative for implementation

2.2.1 Genesis

The concept of growth poles (in some literatures sited as growth center) has been developed by Francois Perroux (1955). Even though a lot of studies about growth pole strategies began their analysis from Perroux's work on growth poles, few actually attempted to fully understand this theory, since "the theory was too complex, to abstract, and too non operational"[Takahiro Miyoshi (1997)].

a) Growth pole as net work of polarization

The operational aspect of growth pole renders itself the need for the creation of a network of poles that would create a corridor of growth. The growth pole is a set that has the capacity to induce the growth of another set ("growth" being defined as a lasting increase in the dimensional indicator); the pole of development is a set that has the capacity to engender a dialectic of economic and social structures whose effect is to increase the complexity of the whole and to expand its multidimensional return [Perroux, 1988, p49].

Although, Perroux indicated that development has to be brought about by a certain concentration (agglomeration) of economic activities in an abstract space, according to him "growth does not appear everywhere at the same time; it manifests itself in points or 'poles' of growth, with variable intensities; it spreads by different channels with variable terminal effects for the economy as a whole." From this it follows that growth pole is selective and does segregation in spatial context.

b) Growth pole to consist of propulsive unit

In operational terms, regional socio-economic development has to posses propulsive /driving elements which are essentially the basis of the growth.
However, as previously discussed, the growth poles are not individual phenomenon, rather they consist of net work or 'relationship' of propulsive units, and therefore it can be stated that the growth pole is "a propulsive unit coupled with the surrounding environment" ,which could be explained in systems approach to comprise of input, process and out put (refer to figure1) .
Considering a growth pole that has the objective of rural socio –economic development[CECEandTRG, BoFED-2007],
a) Inputs (pillars), could be water resources, urban development and private public partnership, while

b) process(objective interventions) that will utilize the inputs could be irrigation development, livestock development, social and economic infrastructures such as water supply, electricity, road telecommunication, market, schools health facilities, trade service, manufacturing etc.,

c) Out put (objective) is essentially socio economic growth**.**

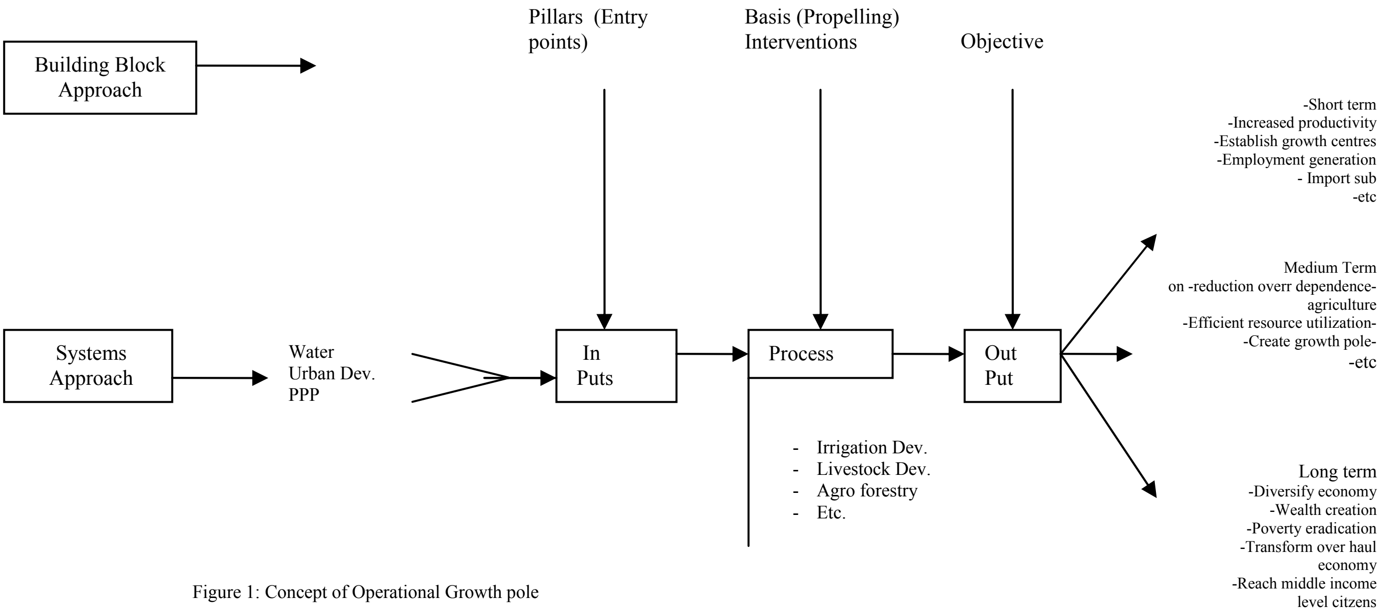

Figure 1: Concept of Operational Growth pole

3. Empirical Evidences: Growth Pole beyond Theory

3.1 Developed Countries

United States of America

In 1965, two important Acts were passed in the USA: the Appalachian Regional Development Act and the Public Works and Economic Development Act, and obviously "their outlines have utilized the growth centre concept in their operation" [Hansen, 1972b, p266]. The Appalachian Region extends from north-eastern Mississippi to southern New York. The growth pole intervention was very successful in creating job opportunities, reducing migration and rising income levels.

France

France had implemented growth pole strategies intensely in the 1960s and 1970s. In 1960, The Fourth Plan had been activated which selected "development areas" in order to bring about industrial development in backward regions (the West, South-West, parts of the North and Centre of France), which were seriously behind Paris. The result is not straight forward and it was both success and no result, but this seems to be attributed to "the nature of regional policy", which was uniformly applied.

Italy

Italy has been facing a problem of serious regional disparity. Southern regions have been lagging and underdeveloped. In 1957, the Italian authorities considered a growth centre was needed to stimulate the Southern economy and to reduce the disparity by a development policy named 'Law 634' [Allen and McLennan, 1970, p67]. There were two types of growth centers considered in this scheme: "The Areas of Industrial Development" (Aree di Sviluppo Industriale), which must have a population of at least 200,000 and must contain a rapidly developing industry with basic infrastructure; the other is "The Nuclei of Industrialization" (Nuclei di Industrialization), whose industries must be relatively small and of mainly labor intensive technology.

Spain

The first attempt of a growth pole strategy in Spain was expressed in the development policy in 1964 [Richardson, 1975]. In that plan, two out of seven of the development poles, were designated as industrial promotion to boost the regional development while the reminder were industrial development poles to spread the effects of growth of the industrial promotion poles. In his view, the Spanish growth pole strategy was fairly successful in terms of inter-regional equality with the payment of causing intra-regional and urban-rural disparity.

United Kingdom

The UK had also attempted to pursue the growth pole policy. In 1945, the Distribution of Industry Act set 'Development Areas' which had relatively high unemployment rates. Thus, the primary objective of the Act was to provide job opportunities through the internal distribution of industries. In 1960, the Local Employment Act replaced 'Development Areas' with smaller 'Development Districts' and it made clear the concern about unemployment problems. The policy has resulted in favorable chain effects in the employment generation and economic growth.

Ireland

In the 1950s, while Ireland's economy was experiencing a recovery from the last world war, "the western half of the country, characterized by a profusion of small farms, an inhospitable environment, and heavy out-migration, was scheduled as a block of 'Underdeveloped' Areas. In the late 1950s, industrial grants were introduced to encourage industrialization in the Western region, and the growth pole concept emerged. This policy was also supported by investment from overseas and it worked well to boost the economic growth of the Western region.

Japan

Mizushima, an integral part of Kurashiki City in Okayama Prefecture, in Japan used to be an underdeveloped area before the Korean War, but the Korean War in the 1950s accelerated its industrialization [Lo, 1978]. Mizushima had been considered as an industrial centre since the first attempt made by "the Mizushima Coastal Industrial District Development Programme" (1952). The Law for the Promotion of New Industrial City Construction in 1962 intensively promoted a growth pole approach to the development of the Kurashiki.
The development of Mizushima was a typical case, in that private manufacturing investment followed the public infrastructure investment and it brought about increasing job opportunities. The result was quite successful during the 1960s.

3.2 Developing countries

Korea

The rapid economic growth of post-war Korea has left a problem of heightened interregional inequalities. 25% and 9% of gross output was concentrated in Seoul and the Busan area respectively. The value added disparity was widened by 9.5 times at the mean deviation during the period 1962-1972. In this context, the Korean government introduced a new development plan in 1972, in which the industrialization was to continue but accompanied with rural development and comprehensive land development.

Industrial complex cities in the southern coastal area did not establish expected linkages with rural hinterlands, so there was little spread (diffusion) effects of growth. Secondly, the urbanization of Seoul did not appear to be halted, and an imbalance has still remained. Thirdly, industrialization has reduced agricultural and fishery production in the southern coastal area and environmental disruption has begun. Finally, the economic growth of the local economy has not brought about increased fiscal benefits to the local governments.

Chile

In the late 1960s, Chile implemented the first comprehensive national plan for regional development based on the growth pole concept in Latin America [Richardson and Richardson, 1975]. In the strategy, three levels of growth poles were created: (1) a national pole centered around Santiago, (2) three multi-regional poles centered on Antofagasta, Valparaiso, and Concepcion, and (3) a series of regional growth poles corresponding to the twelve regions. The actual locations were chosen on the basis of the greatest development potential. Thus, some poles were functional poles, for example Arica for automobiles and electronics, Santiago for electronics, Conceptions for steel and petrochemicals and Punta Arena for petrochemicals. However, they were implemented too passively and abandoned later on due to a change in government policy.

China

Before 1949, industries in China were concentrated in the coastal areas of Manchuria. Most of the factories, motive power used and the manpower employed were concerned within the mechanized manufacturing operations. While those coastal areas enjoyed high industrialization and rapid growth, interior cities outside of these growth areas were left backward, poor, highly dependent on primitive agriculture and with fragmented economies. In order to solve these problems, the First Five-Year Plan proposed 472 out of a total of 694 industrial projects to be placed in the backward interior provinces, but it did not succeed since, physically, China is too large to expect some linkage effects through the limited number of rural industrialization projects. Thus, a form of the growth poles concept was introduced in order to achieve "a proper balance between intra-regional self-sufficiency and interregional specialization and exchange" [Johnson, 1970, p328]. If the objective was to encourage urbanization, that policy was successful, but since the objectives were decentralization, this medium size policy resulted in adverse effects.

India

In India, the economy was highly concentrated in a few urbanized cities. According to Johnson [1970], the planners' first policy was to "cluster industrial estates on the outskirts of large cities, thereby unwittingly aggravating an already excessive urban polarization and exacerbating acute problems of housing and sanitation". This centralization left rural villages underdeveloped and poor, thus, the Indian Fourth Plan (1969 -74) implemented an egalitarian policy targeting a balanced regional development. The main scheme was investment subsidies (15%) to backward areas with less than 2,500 persons and attempted to establish a village centered industry.

However, the result was a scandalously wasteful underutilization of factory space, for the reason that a small center with less than 2,500 people simply could not supply the versatile manpower needed for a range of industrial enterprises and was utterly incapable of providing the requisite marketing, transport, repair, and credit facilities which a group of small shops would require"

Algeria

In 1965-71, Algeria promoted a highly concentrated industrialization growth policy based on the export of oil. Indeed, about 90% of total exports were dependent on oil during this period. With an abundant trade surplus from the oil exports, Algeria concentrated its public investment around the capital city to establish an industrial complex which consisted mainly of hydrocarbon industries and steel-manufacturing industries. However, as Sutton [1975] pointed out, this highly capital intensive industrialization policy, which was relying on natural resources, brought about little effect on employment.

Indeed, during this period, while Algeria had enjoyed high national economic growth, its regional imbalance was worsened and food shortages prevailed in the country because of a neglect of a proper agricultural policy. It is difficult to judge whether Algeria had a certain conception about regional policy during this period since "national rather than regional policy dominated into the 1970s". This is an example in which case a growth pole was utilized purely as a national development objective, and it worsened the regional development in terms of balanced growth.

Kenya

Kenya has experienced a high concentration of population and economic activities in Nairobi and Mombassa, so that it has resulted in high migration and unemployment rates. Thus, Kenyan regional policies have always been aimed at the redistribution of economic activities and urban population. The Second Development Plan (1970-1974) clearly expressed that it has been following the line of a growth pole strategy. It identified seven growth centers (Nakuru, Kisumu, Thika, Eldoret, Kakamega, Nyeri and Embu), which were selected in terms of an expected potential of growth and they were given a high priority in public works.

However, it does not seem that these policies were effective in reducing the prevailing urban growth. The growth center policies adopted in Kenya during the 1970s hardly merit the name since the designations were insufficiently selective, the centers were not integrated into an overall strategy for the country as a whole, and implementation was ineffective. He pointed out that one of the reasons of the failure is that the distribution of investment was too fair because it was distributed purely depending on the proportion of the population. This example shows that the growth pole strategy requires a careful consideration of the economic system rather than just focus on location issues (equity).

Ethiopia

Ethiopia had various versions of the growth pole application the pioneering and most notable effort being the plan drawn during the third development plan(1971-1976) of the Imperial regime .This program envisaged the selection of growth centers focusing mainly on the rural setup that were supposed to have natural endowment. The growth centers included Wolaita (WADU), Arssi (ARDU), Tahtay adiabo (TAHADU) [IEG-1968].

The most recent efforts of some kind of growth pole creation efforts could be attributed to the Kobo –Girana valley development project[FDRE,ANRS CECE and COSAERAR-1999] and the Raya valley Integrated development project [FDRE,TNRS CECE and REST-1999] sanctioned by the Amhara and Tigray regional governments respectively. These programmes are based on the natural resources of vast valley lands aiming at rural development.

The performance and results of the above sited endeavors are not formally analyzed and as such it is not possible to ascertain their outcome. However, there are some indications on the ground that these areas are having better agricultural yield levels in quantity and quality as well as specialized agricultural products.

4. Core Idea and Variations: Growth Pole Corridor under Ethiopian Context

4.1 Lessons to be learnt from growth pole experiences

In the 1960s, the trend of development economics had a general characteristic. This was well represented by Rostow's stages of development. In his influential thesis "The Stages of Economic Growth: A non-communist manifesto" in 1960, Rostow argued that all countries could be located in one of a hierarchy of development stages, such as the traditional society, the transitional stage, the take off, the drive to maturity, and the stage of high mass consumption. In this hierarchy, developing countries are in the traditional or the transitional stage. For such underdeveloped countries, it is necessary to accelerate economic growth to shift to the take off by "a leading sector". This notion of a leading sector has a similarity to Perroux's "propulsive units"

Williamson [1965] has investigated the history of some developed country's economies and concluded that income disparities among regions are rising at the early stage of national economic growth, and then the regional dualism or divergence disappears at the mature stage. However, maintaining sustained balance is a decisive task, which is usually handled by conscious state intervention.

Despite the fact that the application of growth pole theory in the past since the sixties has proven to be effective and useful, it also had setbacks that have to be well recognized. The major omission so to say of the classical growth pole concept is that:

1) It lacks clarity in properly articulating the pillars or entry points of a given area as this is variable depending on location, natural endowment, socio-economic conditions etc.,

2) It does not properly and adequately define the "propelling interventions "as this is also inherently linked to the pillars or entry points.

3) Lacks the means to involve important and decisive inputs such as policy, legislative, institutional and political will of governments.

4) It was urban centers biased

5) Conclusions regarding regional growth disparity were drawn at a very early stage of the growth pole implementation

6) In rendering spatial context to growth pole theory, planners forget the inherent forward and backward linkages to be developed within and beyond the specific area of a given regional planning.

According to the official Ethiopian government five years development plan,[FDRE, MoPED-2006] there is a direction to pursue on the growth pole approach," Ethiopia consists of at least three very different sorts of economic and agro-climatic zones: the traditionally settled semi-arid highlands, potentially productive semi-tropical valley areas, and the hot semi-arid lowlands, each of which require different responses to maximize their potential. The PASDEP will distinguish between them, particularly in agriculture, but also in the private sector development agenda. There will be a particular focus on rural growth poles, and tapping areas of high potential – such as productive river valleys, areas with potential for multi-cropping, and for integration into markets", states the official Ethiopian government five years development programme .[FDRE, MoPED-2006]

Apparently the plan presents the approach but it should have also elaborated the context and building blocks. This paper focuses, among other things on this issue and it is discussed below:
The growth pole strategy can never be generalized as a set of programmes. The confusing nature of this strategy, in terms of the various objectives and programmes, has caused a misunderstanding and misuse in its application. Therefore a very clear understanding of the application and its implications both good and bad has to be made in order to take all the necessary measures towards a comprehensive development of the country. Indeed, it is not possible to generalize various growth pole strategies as a fixed set of programmes.

The growth pole strategy should be used based on its imperatives particularly in Ethiopian context as related to a)it's polarization and corrective measures thereto b) Domestic market and export sector (including, commodity, labor know-how, etc.) as a key for it's development c) it's linkage to urban sector d) it's role as national endeavor (see chapter 5 of this report)

The concept of Growth pole as has been explained earlier maintains that it has purpose; it is selective and needs to be synergetic in forming physical and conceptual network of growth poles. For ease of understanding, it can be explained using either the "building blocks" or "systems" approach, that can complementarily elaborate the concept (see figure 1). The major building blocks are; pillars (entry points), basis (propelling interventions) and objectives. These are fundamental for any viable growth pole/corridor implementation. The systems approach presents elements under these building blocks, which could vary based on the specific and peculiarities (natural resource base, social, technical, financial, etc) of a given growth center/pole. The Tigray region western zone development strategic plan (DSP)[CECE andTNRS,BoFED,2007] for instance has identified(figure 2) three input (pillars)(water, urban, private-public partnership development),while the process(propelling interventions) are irrigation development, agro forestry, livestock development, trade, service agricultural processing, etc., The purpose being: to reduce economic dependence on rain fed agriculture and to boost diversified agricultural production, to diversify the economy, to enhance the creation of wealth in the rural community towards a stable economic growth.

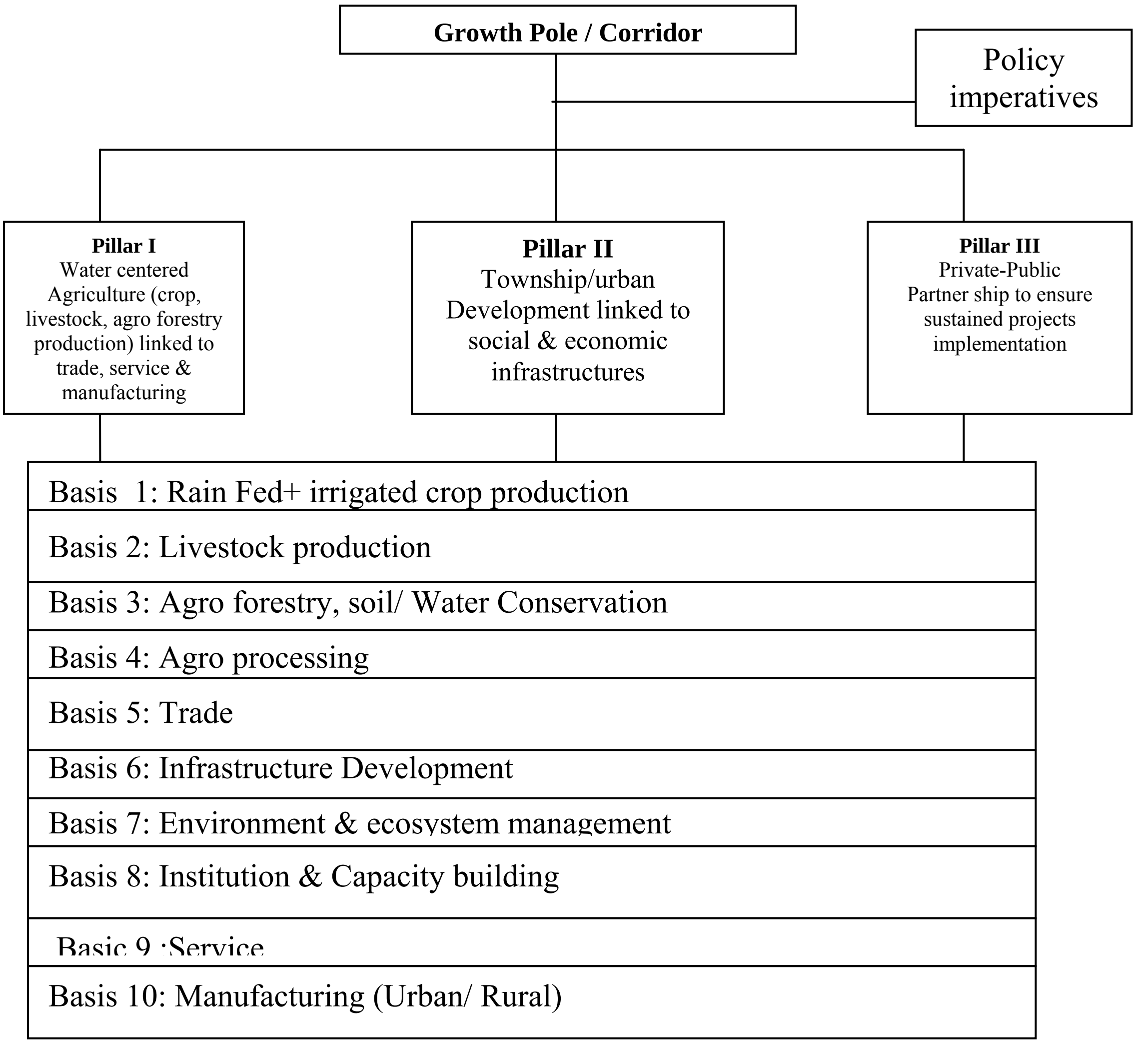

Figure 2: Western Zone Growth Pole Frame Work

4.2 Growth Pole and Water Resources Development

Water resources development has increasingly become the most critical element in the socio economic growth of Ethiopia. In fact according to the World Bank's recent report, Ethiopia's growth will be undermined until it attains water security. Un mitigated hydrological variability increases poverty rates by 25 percent and costs the Ethiopian economy about 40 percent of its growth potential[WB-2006].

Although Ethiopia's water resource is characterized by its extreme seasonal variations (hydrological variability) which imply the need for storage, it has an abundant nature (more than 125 billion cubic meters of surface and ground water each year) that could fulfill its growth needs. Thus one of the best ways of addressing growth issues within Ethiopian context is to realize the linkage between growth and water resources development.

The growth pole being probably one of the best growth theories that can be applied to Ethiopian conditions, it needs the fusion of this theory with the most prevalent and useful resource, the water resource.

4.3 Growth pole through river basin development?

Recognizing the dominant nature of water resources on the growth of Ethiopia entails what strategies, methods and techniques to apply in order to link the growth pole concept with water resources development.

The river basin provides the natural geographic and drainage boundaries within which all natural resources and mainly the water resources exploitation and management can be systematically planned and implemented [A. Mengiste, 1999].

From this it logically follows that if water resources are taken as one of the pillars of any given growth pole development in Ethiopia, then the best methodology of planning and implementing the water resources development is through the river basin approach.

This approach will also yield the opportunity to analyze the natural relationship between all the resource (agricultural, social, environmental, etc,) in a basin and it will yield the most durable and synergetic development interventions[EEA-2005].

5. Why Growth Pole? It's Imperative

A) Polarization and corrective measures

Development is a lengthy process during which interaction of not only between two industries, but up and down and across the whole of an economy's input-output matrix takes place [Hirschman, 1958 p66]. In practice, Hirschman argued that the key problem for Least Developing Countries economies was a series of "interlocking vicious circles" where the factors of production and abilities were "hidden, scattered and badly utilized" [Hirschman, 1958, p5], thus they need "pressures" or "tensions" to mobilize the largest amount of resources. Therefore, a certain level of polarization will be expected to stimulate the development at the depressed area. "Economic progress does not appear everywhere at the same time" and " that once it has appeared powerful forces make for the spatial concentration of economic growth around the initial starting-point" but it should be attached with a supplement policy such as building residential satellite cities around the growth pole, investments in service infrastructure in rural areas, establishment of appropriate transport system in a whole country, etc., thus reducing the tensions or pressures for polarization. Although there are negative aspects of polarization, it seems that the growth pole strategy could be still the best strategy with some corrective and supplementary state intervention to ensure equity and balanced growth.

B) Export sector as a key for development

North [1955] studied the history of economic growth of North America and pointed out that "the success of the export-base has been the determining factor in the rate of growth of regions. The importance of the export base is a result of its primary role in determining the level of absolute and per capita income in a region, and therefore in determining the amount of residentiary, secondary and tertiary activity that will develop" [North, 1955, p346], the expansion of the export sector is the key for mass development. Perloff [1960] also thought that manufacturing industry was identified as a key factor for regional economic growth, and businessmen decided the location of economic activities by the regional advantages of the most needed natural resources.

C) Linkage to urban sector

Lewis [1954] and other "dualists" saw that development had to be brought about by the expansion of the urban-industrial sector, which produces more efficiently and more economically with the higher technologies compared to the rural-agricultural sector. For example, in his famous article "Economic development with unlimited supplies of labor", Lewis [1954] assumed there to be two contrasting sectors; one is a traditional, overpopulated rural subsistence sector whose labor productivity is very low or near zero and where there is abundant surplus labor, another is a high-productivity modern urban industrial capitalist sector which has enjoyed higher income and technology and where profits are saved and reinvested.

Since the traditional sector is overpopulated and is characterized by low productivity, the modern sector has ensured a higher wage, then surplus labor in the traditional sector will shift to the modern sector where high productivity and more employment is enjoyed. This growth of the modern sector does not stop here, because there will be a reinvestment from profits, which enables this sector to receive more labor from the traditional sector.

d) Growth pole to be seen as national endeavor

Governments have tended to misunderstand a growth pole strategy to be just investment in a limited area, however, in order to boost the agglomeration economies, other conditions, such as a good infrastructural support, transport system, skilled labor, encouraging entrepreneur's environment, etc., are necessary.

Empirical evidence has shown that the effects of regional policies are related to the condition of the national economy. Even if the government has the best regional policy, it will end up as a failure if it is without the backup of growth of the national economy. Growth pole planning which has been made with such careful analysis and supported by sufficient investment may be a success, otherwise, it doesn't bring about any effects, or sometimes it causes negative effects, and is therefore a failure.

6. Purposes of Growth Pole

Various growth pole strategies can be considered in practice depending on their objectives such as national growth, regional growth, regional equality, rural development, and so on. The methodological fallacy at times is that the growth pole strategy is considered as a generalized strategy (blanket recommendation), which is practically impossible and non responsive to local and peculiar growth demands of different areas. As a result it is criticized in terms of a particular objective, which the strategy could not target.

Growth pole strategy manifests itself in one or all of the following[Takahiro Miyoshi-1997]:

"It involves encouraging the growth of employment and population within a region at particular locations or planned poles over some specified period."

"Requires a limitation on the number of locations or centers which are designated as planned poles"

"Necessarily requires spatial discrimination or selectivity among locations"

"Inevitably involves a modification of the spatial structure of employment and population within a region."

While the general characteristics of growth pole strategies in practice can be stated as above, they will have various interventions in the implementation process. Sometimes, the growth pole strategies for different objectives appear to be contradictory to each other. The following sections will discuss objectives of growth pole strategies for a) rural development and urban system (migration and settlement) as an application.

6.1 Rural Development

Rural areas have tended to be forgotten in development strategies in the past; however the current situation is that they have now become a main objective. Stohr and Taylor [1981] discussed the different types of development strategies, and they grouped them into the "from above" type and the "from below" type: the "from above" is top-down, centre-outward development; the "from below" is bottom-up, periphery-inward development. They concluded that "from below" was especially appropriate for Least Developing Countries, where most of the poorer population lived in the periphery areas and migrated to the urban areas, but were still in poverty. In this context, there has been an argument about the 'agro-politan' development in the rural areas. Friedman and Douglas [1978] studied the development processes of Asian countries and argued that the traditional top-down policy based on the industrialization paradigm was "inoperative as a guide line to the future" [Friedman and Douglas, 1978, p181] Because of the situation which the Least Developing Countries have been facing, such as rising import prices, declining export markets, and deterioration in the terms of trade, the following concluding remarks were made to put in place appropriate development strategy [Friedman and Douglas, 1978, p181-182] :

"Limited and specific human needs should replace unlimited generalized wants as the fundamental criterion of successful national development..."

"Agriculture should be regarded as a leading or 'propulsive' sector of the economy."

"Attaining self-sufficiency in domestic food production should be regarded as a high priority objective."

"Existing inequalities in income and living conditions between urban and rural classes should be reduced."

"Facilitative measures to increase production of wage goods for domestic consumption should be given high priority."

"A policy of planned industrial dualism should be adopted whereby small-scale production for the domestic market is protected against competition form large-scale capital-intensive enterprise."

Besides the agro-politan development, it is possible to establish small market towns in rural areas, as Johnson [1970] advocated. Johnson argued that "the countryside is inadequately provided with accessible market centers" [Johnson, 1970, p171], and argued for the establishment of more small-scale industries and less concentrated urban strategies. Although he was against the urban-biased growth pole strategies based on the development of large industrial complexes, he still followed the growth pole concepts, since he wrote "a well-dispersed network of promising 'growth points' should be selected in different regions of a country" to establish "agro-urban community" [Johnson, 1970, p219]. Moreover, Johnson acknowledged the value of industrial growth poles in a limited sense, in that they should have some positive linkages with small towns and rural growth centers.

6.2 Urban system: Migration Control and settlement (Sedenterization)

According to Townroe [1979], Least Developing Countries have been "suffering from a condition of 'primacy' in their urban hierarchy: the largest city in the country is considerably larger than any other city and is growing as fast as or faster than other cities" [Townroe, 1979, p93]. Moreover, most of these developing countries have been experiencing a rapid increase of national population. These high growth rates of population are reducing the agricultural land area available per capita in many countries, thereby maintaining or increasing rural-urban migration flows to cities which are themselves experiencing large rates of natural increase [Townroe, 1979, p93]. Therefore, it is necessary to consider a proper urban system that can reduce such migratory pressures on the limited number of urban areas. The growth pole strategies have been considered explicitly and implicitly as regional planning tools to control the migration. In Ethiopian context, urban development at less populated areas such as fertile river valleys within the frame of Growth pole development is very instrumental to take-off the population load from the rural highlands which no more have the carrying capacities.

Even in developed countries, the urban system is important since there has been the assumption that the "long-run performance of the national economy is strongly influenced by the nature and form of the urban system" [Parr, 1996, p16].

In the case of settlement (sedenterization), the issue is that of changing the livelihood of the pastoral and agro-pastoral communities of Ethiopia. This community consists of quite a significant portion of the population (8%) [IFPRI, 2006]. In this case, the strategy must consider urbanization a long-term goal to be achieved through process of pastorallism-to sedenterized way of life-to-townships – through-to urbanization with the influence of the existing near by urban cities.

In this case planned growth poles need to be located with in the rural areas with the purpose of creating intermediate urban centers as they can be 'magnets' to pastoralists in the short term and they will be 'counter magnets' against larger urban cities in the long term. The problem is how to choose the location of such influential intermediate urban towns. In theory, these are the towns which have more backward and forward linkages and have more potential to provide market for the agricultural production while in turn they are also the sources for the house hold goods and industrial products demand of the rural population.

7. Way Forward

7.1 Growth pole strategic planning framework

The growth poles linked to river basin planning will prove to be the most viable socio economic transformation mechanisms of Ethiopia. Therefore the application may consider the following, by making use of a detailed Logical Frame Work Analysis (LFA):

A) Objectives/targets

The objectives of growth pole strategies are more often confused as universal; however, it could vary based on the prevailing objective reality (chapter 6). Thus the benchmark for success evaluation should be based on the objective. It is mandatory to establish defined growth poles/centers objectives and targets. Objectives and targets such as those articulated in PASDEP including Universal Access Plan and Millennium Development Goals could serve as the basis.

Due to the nature of growth poles, regional disparities are expected to emerge that will wither away in the course of economic growth (but with effective and conscious balancing efforts of state). Furthermore growth pole development programmes/projects are to be evolved using the joint Regional and Federal arrangement due to the multi sectoral and Trans-regional economic and resource utilization aspect.

b) Pillars/inputs

Sufficient study and analysis (such as identification and reconnaissance survey) has to be carried out on socio economic development opportunities, potentials and constraints so as to define pillars. The pillars need to ensure spatial and temporal context with proper linkage to propelling interventions.

C) Process/propelling interventions

Articulation of interventions (which are basis of the strategy) in a synergetic and integrated manner to establish set of development programmes. All interventions need to have forward and backward linkages within urban –rural setting. The aspects of spatial and temporal dimensions need prominent significance and practical application.

7.2 Institutional arrangements

One of the key issues for successful growth pole implementation, is that the existence and full operational capacity of organizations, policy instruments and committed political will of government. The growth pole/center or corridor development entails the planning and implementation of multitude of projects and programmes that range from simple livelihood improvement interventions such as schools and clinics to complex engineering outfits.

Due to the fact that Growth pole development would have some kind of institution (structure, linkage and mandate has to be decided; possible option could be the water resources council commission and river basin organizations) at Federal level in addition to the regional executive organ, the requisite organizational (human resource) capacity at the federal and development corridor level itself has to be competent. This capacity will evolve with time provided there is sufficient nucleus to start with. However, the necessary pre-development and on going capacity building aspects have to be well thought out.

Policy instruments can revive or wither out all kinds of development efforts. Thus, as growth pole development in its holistic nature is rather new practice to Ethiopian conditions; supportive policy measures have to be routinely improved considering peculiarities of growth pole developments. Some of the important aspects are: land allocation and administration, private public partnership for the many interventions, water infrastructure development and cost recovery, equity of investment and wealth distribution, etc.

The aspiration and divine goal of the government in terms of the growth of the country is expected to be that of accelerated and tangible socio-economic transformation that ensures stable and modest income level to all citizens. To this effect planes are drawn and programmes/projects are being implemented. However, this effort has to systematically continue with commitment and un reserved passion to realize the fruits of growth pole development, which has to be coupled and integrated with the ongoing development activities in the sectors of agriculture, infrastructural development, health, education, etc., as well as private sector development to yield measurable results.

Sample Logical Framework (Source; DSP – TNRS, BoFED, 2007)

	Narrative Summary	OVI (Objective verifiable indicators)	MOV (Means of verification)	Assumptions
Over All Objectives	Creation of growth corridor using the pillars of water, etc.	- House Hold income improvement - Absolute poverty reduction - Exit from heavy dependence on agriculture - Stable economy	- House hold economy survey -Impact assessment survey - Nutrition surveillance - Gross Regional Product - Macro economic parameters - Total Capital outlay of the private/public sector	- Sufficient political will & governance (wealth creation & distribution) - Project implementation commences soon (resource mobilization) - Competent capacity at all levels
Immediate Objective	- To induce water centered/based development program to bring about changes in agricultural production, linked to manufacturing, trade and service - To establish township / urban development linked to social and economic infrastructure development - To create Private public partnership to ensure contribution towards Overhauling of the economy	- Expansion of irrigable land & yield increment by quantity quality & variety - Growth of livestock related products - Growth of habitable urban nodes - Creation & growth of manufacture, trade & service facilities	- Hectarage of irrigated land - Crop & livestock related yields per hectare - Number of urban nodes with the requisite infrastructure & service, economic & social centers - Gross regional product	- Sufficient political will & governance (wealth creation & distribution) - Immediate project implementation commencement (resource mobilization) - Competent capacity at all levels
Out puts	- Agriculture - Industry, Trade, service - Economic and social infrastructures - Off farm employment generation schemes, and private sector development - Support services such as land tenure, private public partnership, agricultural extension, credit and marketing, capacity building	- House hold income improvement - Absolute poverty reduction - Expansion of irrigable area & growth of livestock & livestock related products - Sufficient level of public service delivery & growth of production, social & service centers	- Hectarage of irrigated land - Crop, livestock related products value - Number of urban nodes with the requisite infrastructure, production service, economic & social centers - Gross regional product - Employment rate	- Balanced attention is given to all components. (Agriculture development, township development, private public partnership) - Competent capacity at all levels.

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CREATING EXTENSION SERVICE DELIVERY THROUGH PUBLIC-PRIVATE PARTNERSHIPS

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Agricultural extension services have been used and practiced a long time ago in different countries of the world, having different objectives, definition and changing approaches. Initially, it was linked with expanding the research work of the universities beyond the campus. There were more than ten definitions given for extension during the last 50 years. In 2004, it was defined as: Extension is a series of embedded communicative interventions that are meant, among others, to develop and/or induce innovations which supposedly help to resolve (usually multi-actor) problematic issues. Scholars are still giving their working definition for 'extension' based on their local specific knowledge and conditions. According to the World Bank, extension is defined as a "process that helps farmers become aware of improved technologies and adopt them in order to improve their efficiency, income and welfare." The effectiveness of agricultural services depends on a number of factors that include the relationship between extension service activities and changes in the attitude of farmers, the skills to use technologies and improved practices, farmers' access to information and availability of technology, input supply, and other support mechanisms.

Globally, the agricultural extension service delivery has not been free from problems. The major challenges are: problem of coverage, lack of appropriate and relevant technologies, poor policy environment for agriculture and rural development, weak institutional arrangements, inefficient institutional support services such as supply of inputs, credit and agricultural markets, lack of political support and commitment, shortage of funds, etc.

In order to solve the problems, different researchers and experts have worked a lot to bring about applicable and sustainable solutions. In this regard, there are emerging views on extension services that includes no longer a unified service and top-down approach; it is a network of knowledge and information support for the rural population; extension needs to be viewed within a wider rural development agenda (since market, social and environmental production systems need a differentiated set of services); stage of extension's transformation - from innovation to execution; and providing a menu of options for innovation, information and investment. As a result of these views and consensus reached, there are expected policy changes that governments should take under their specific conditions. Governments need to act in defining and implementing a coherent extension policy for the pluralistic system (a change in role) – pluralistic extension system that includes growth of multiple service providers, reduced public sector responsibilities, requires change in nature of agriculture research and structure of the agricultural sector. The actors involved in establishing a creative partnership in providing the extension services include the government, private sector, civil society, NGOs, etc. In general, the creation of public-private partnerships (PPPs) is the key under any extension policy reform process. The goals of the extension system should encompass transferring knowledge from researchers to farmers; educating and advising farmers on their decision making; enabling farmers to clarify their own goals and possibilities; and stimulating desirable agricultural development.

1. Introduction

1.1 History of extension Service

Agricultural extension service has been used and practiced long time ago in different countries of the world having different objectives, definition and changing approaches. Initially it was linked with expanding the research works of the universities beyond the campus. But as time goes the objective of extension. There were more than ten definitions given for extension for the last 50 years (1949 to 2004). In 2004 it was defined as: Extension {is} a series of embedded communicative interventions that are meant, among others, to develop and /or induce innovations which supposedly help to resolve (usually multi actor) problematic issues. Scholars are still giving their working definition for extension based on their local specific knowledge and conditions. According to the World Bank extension is defined as a "process that helps farmers become aware of improved technologies and adopt them in order to improve their efficiency, income and welfare" (Purcell and Anderson 1997, 55). Berhanu also give a broader definition to extension service under Ethiopian context as "a service of information, knowledge and skill development to enhance adoption of improved agricultural technologies and facilitation of linkages with other institutional support services (input supply, out put marketing and credit) (Berhanu et al, 2006, 3). The effectiveness of agricultural services depends on a number of factors that includes the relation ship between extension service activities and change in attitude of farmers and skill to use technologies and improved practices, farmers' access to information and availability of technology input supply and other support mechanisms.

The agricultural extension service delivery globally has not been free from problems. The major challenges are: problem of coverage, lack of appropriate and relevant technologies, poor policy environment for agriculture and rural development, weak institutional arrangements, inefficient institutional support services such us inputs supply, credit and agricultural market, lack of political support and commitment, shortage of funds etc.

In order to solve the problems different researchers and experts have worked a lot to bring about applicable and sustainable solutions. In this regard there are emerging views on extension services that includes no longer a unified service and top-down; it is a network of knowledge and information support for rural population; extension needs to be viewed within a wider rural development agenda (since market, social , environmental, production systems- needs differentiated set of services); stage of extension's transformation- from innovation to execution; and providing a menu of options for innovation, information and investment, As a result of this views and consensus reached there are expected policy changes that governments should take under their specific conditions. Governments need to act in defining and implementing a coherent extension policy for the pluralistic system (a change in role) –Pluralistic extension system that includes growth of multiple service providers, reduced public sector responsibilities, requires change in nature of agriculture research, and structure of the agricultural sector. The actors involved in establishing a creative partnership in providing the extension services include government, private sector, civil society, NGOs etc. In general the creation of the Public- private partnership (PPP) is the key under any extension policy reform process. The goals of extension system should encompass transferring knowledge from researchers to farmers; educating and advising farmers in their decision making; enabling farmers to clarify their own goals and possibilities; and stimulating desirable agricultural development.

1.2 History of Agricultural Extension Service in Ethiopia

Agricultural extension service in Ethiopia has followed the same world trend in establishment and development. The start years goes back to the 1953 with the establishment of the then Imperial Ethiopian College of Agriculture and Mechanical Arts. At the later dates the mandates of agriculture extension service giving undergone restructuring and shifted to the Ministry of Agriculture. During all this fifty years time different extension systems has been introduced and practiced in different parts of the country that includes the land grant model, filed service, the comprehensive package, Minimum package I & II, Training & Visit (T&V) system, Participatory Demonstration and Training Extension System (PADETS), and training and advisory services. The common features of all the extension models are focusing on transfer of technology that was generated from the research systems, top-down, state managed, based on donor funding, address the rain fed agricultural production system. Irrigation extension has been non existent. The extension programs were not based on a long term strategic vision of the extension service that encourage varies partners and agencies within the agricultural extension system to provide efficient and effective services that complement and reinforce each other.

2. Challenges of the Extension Service

In general the following are the major constraints of the past and current agricultural extension service delivery:

- Absence of the national framework of agricultural extension policy that has been developed in a participatory manner-top down
- Un clear extension approach
- Lick of suitable adaptation of technology packages to local conditions
- Frequent restructuring of the extension institutions
- High turn over of staff
- Limitation in the quality of field and technical staff
- Inadequate budget for the implementation of the extension system
- Limited private sector involvement in service delivery
- Administrators unnecessary interferences on technical matters
- Lack of monitoring and evaluation of the extension system
- Weak system of agricultural inputs supply and distribution (seeds, fertilized, credit, subsidies etc) systems
- Involvement of experts on duties other than extension responsibility
- Weak market linkage and information system
- Weak linkage of research-extension-farmer
- Absence of public private partnership in extension service delivery
- Not enough attention given to indigenous knowledge of local people
- Absence of irrigated agriculture focused extension and research systems

3. Future Direction/ the Way Forward

The agricultural extension service delivery has faced with many problems that need immediate attention by the policy makers. Consultation made with the ministry (MOARD) officials and experts reviled that there is a dire need to revisit the current extension practices and systems and work out a new extension policy framework and systems. Irrigation extension is not totally focused and institutionalized within the existing different public institution's organo-gram. The current extension service delivery system needs to be studied in a participatory way to formulate the national agricultural extension policy framework. The following strategic actions are worth mentioning at this stage in time:

- Study the effectiveness of the current extension systems implemented through out the country and formulates a pluralistic national extension system policy frame work.
- Make sure the newly formulated extension system address effectively both the rain-fed and irrigated agricultural production systems under the growth pole concept.
- Define the role of the different stakeholders in delivering the services-public, private, civil societies, NGOs etc
- Promote the PPP in delivering extension service for the irrigated agriculture under the suggested growth pole concept
- Establish one national agency/body that is responsible for organization and support/facilitation of the Ethiopian professional entrepreneurs (out side ad inside) and partners to establish commercial irrigated farms. The facilitation works include access to credit finance with project collateral, access to land, tax holidays etc.
- Look the appropriate institutional arrangements for delivering the extension services that avoids duplication of efforts. The basin based development institutions, the current bureau of agriculture and rural development, bureau of water resources, irrigation development authority etc need to be studied in order to have the appropriate organizational arrangements and staffing to deliver the irrigation extension system for farmers.
- Establish a merged agricultural research and extension institution-less than one umbrella organization. The attempts made to establish a research extension farmer liaison committee/council at national and regional levels have not been functional and effective in rendering the required coordinated services.
- Strengthen the agricultural training institutions that produce trained skilled manpower in the areas of agricultural extension. Revisit the current curriculum of the ATEVET colleges and maintain the quality of education. Acquiring practical skills are very vital in terms of transferring knowledge and skills to the farmers.

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Current Growth Corridor Case Study Examples

THE TANA BELES GROWTH CORRIDOR: OPPORTUNITIES AND CHALLENGES

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Abstract

The Government of Ethiopia's "Plan for Accelerated and Sustained Development to End Poverty (PASDEP)" seeks to build on, and broaden, the previous development strategy, which had focused on expanding support to smallholder agriculture, basic education, access to water and sanitation, primary health services, access to roads and electricity and safety nets for the poorest in all parts of the country. PASDEP complements this equity-oriented thrust by focusing public investment and policies to exploit comparative economic growth advantages located in different agro-ecological zones. PASDEP identifies the Tana and Beles zones as the first of five proposed growth zones in the country, and envisions complementary investments in infrastructure, appropriate levels of basic inputs and agricultural technology to increase productivity and facilitate market systems, particularly for high-value crops targeted at local and foreign markets. PASDEP lays a multi-sector, integrated vision as a conceptual foundation for this Plan, leading to the formation of growth zones to accelerate growth.

Introduction

The Government of Ethiopia (GoE)'s Plan for Accelerated and Sustained Development to End Poverty (PASDEP) seeks to build on and broaden the previous development strategy, which had focused on expanding support to smallholder agriculture, basic education, access to water and sanitation, primary health services, access to roads and electricity and safety nets for the poorest in all parts of the country. PASDEP complements this equity-oriented thrust by focusing public investment and policies to exploit comparative economic growth advantages located in different agro-ecological zones. PASDEP identifies the Tana and Beles zone as the first of five proposed growth zones in the country and envisions complementary investments in infrastructure, and appropriate levels of basic inputs and agricultural technology to increase productivity and facilitate market systems, particularly for high-value crops destined to local and foreign markets. PASDEP lays a multi-sector, integrated vision as a conceptual foundation for this plan, leading to the formation of growth zones to accelerate growth.

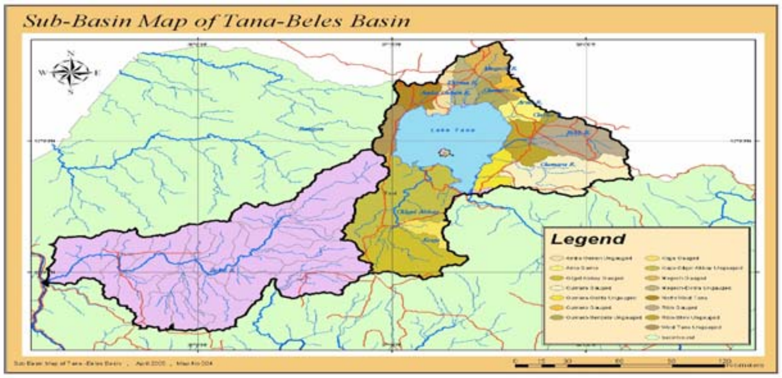
Water Management on River Basin Framework

The growth zones are expected to be fueled by investments in the substantial land and water resources of the region. The Water Resources Strategy of

Ethiopia (2006) also clearly demonstrates the need for investments in multipurpose water infrastructure in combination with the market infrastructure investments needed to fully leverage their growth potential. The GoE has also promulgated a progressive proclamation (proclamation no. 534/2007) to set up basin management organizations to improve holistic water resources planning and management. The proclamation derives substantially from the Ethiopia Water Resources Management Policy (1999) and serves as a legal basis for creation of individual or combined river basin organizations (RBOs) for all the river basins of Ethiopia - including High Basin Councils as decision making bodies with River Basin Authorities as their technical arm. A key task of the RBOs will be to formulate and monitor implementation of sub-basin plans for integrated water resources management.

The Tana & Beles Sub-basins

Although Ethiopia has substantial water resources, these have neither been developed nor managed well, leaving populations vulnerable to the destructive impacts of water and climate variability, while not providing benefits from effectively harnessing the water and land resources. There are 12 basins in Ethiopia with Abbay (Blue Nile basin) being the largest with a basin area of about 200,000 sq km. Tana (catchment area 15,054 sq km) and Beles (14,200 sq km) form important sub-basins of Abbay basin.



The Tana and Beles sub-basins of the Blue Nile, located in the Amhara and Benishangul regions, are the nucleus of a growth zone with ample potential in Ethiopia.[4] The zone covers; centers of production in these sub-basins (mostly agricultural and agro-industrial), with domestic markets in neighboring locations and in Addis Ababa, and with export markets through Djibouti, in the East, and the Sudan, in the West. The Lake Tana and Beles sub-basins have extensive endowments and potential to strengthen economic growth and long-term development throughout the growth zone.

Cooperation on the Nile

The vision of the Tana sub-basin as a growth zone based on the development of water resources from the Blue Nile is sustained on the achievements in recent years under the Nile Basin Initiative (NBI), actively supported by the Bank though its facilitation role as well as through the administration of the Nile Basin Trust Fund. The NBI was formally launched in February, 1999 by the Council of Ministers of Water Affairs of the Nile Basin States. The initiative includes all Nile countries and provides an agreed basin wide framework to fight poverty and promote socio-economic development in the region. The initiative is guided by a shared vision of achieving "sustainable socio-economic development through equitable utilization of and benefit from the common Nile Basin water resources". The Nile countries seek to realize this shared vision inter-alia through a Subsidiary Action Program comprising sub basin projects. The Eastern Nile Subsidiary Action Program (ENSAP), which includes the countries of Egypt, Sudan, and Ethiopia, seeks to initiate a regional, integrated, multi-purpose program through a first set of investments. Harnessing the growth potential the Tana and Beles area underpinned with water resources development and management would also serve as a pilot for the proposed regional joint multi-purpose developments proposed under ENSAP, while deriving maximum benefits through greater synergy among investments. Already a number of projects on irrigation, flood management, watershed development, etc. are at different stages of implementation/preparation through ENSAP.

The Tana and Beles Zone Characteristics

Lake Tana, the source of the Blue Nile, is a very valuable water resource, but is also ecologically fragile. Lake Tana is showing growing signs of stress resulting from several social, environmental, economic, and institutional factors that need to be addressed to ensure sustainable development of its sub-basin in a manner that optimizes its socio-economic benefits while protecting its valuable environmental and cultural resource base.

[4] A growth zone refers to a geographical region, such as a sub-basin rather than a single rural or urban centre, which generates economic activities well beyond its (or theirs) regional administrative boundaries.

Social[5]**:** There is widespread poverty in the Tana and Beles sub-basins. The annual per-capita incomes are extremely low in both the Tana (~$125 with 43% of the 3m population in absolute poverty) and Beles (~$100 with 54% of the much smaller 0.05m population in absolute poverty) sub-basins, and indicate both the significant development needs as well as the lack of adequate institutional capacity in the sub-basins. Rural populations live very difficult lives with poor access to even basic services (water supply, sanitation, transport, electricity). There are significant concerns of providing for growing populations, migration and resettlement and need for addressing significant land tenure, gender, and other issues. In Beles, there are a number of ethnic groups that live very traditional lifestyles. There are serious public health concerns in these areas from malaria and other water-related diseases.

*Environmental***:** There is high climate variability that impacts the livelihoods both through droughts in the sub-basins and floods (especially around Lake Tana). During the 2003 drought, the already shallow lake level (avg. depth 9m) dropped 2m and lake area was reduced by 35 km^2, exacerbated by hydropower generation demands. In 2006, more than 15,000 ha was inundated and 10,000 people were displaced, 2500 domestic animals swept away, and many houses demolished. Future climate change is expected to exacerbate this variability and adds to the uncertainty that currently impacts livelihoods and investments. Lake Tana also faces significant water and natural resources degradation problems, including degrading catchments resulting in high erosion (upwards of soil loss of 100 t/ha/year) and sedimentation problems (including substantial deposition in downstream rivers and near inflowing river deltas), impacting on flood damages, lake turbidity, fisheries, and navigation. Although the tropic state of the shallow Lake Tana is still good, there are increasing signs of stress – local algal blooms and local fish kills induced by pollution, unsustainable fishing practices, and conversion of Lake Shoreline wetlands for settlement, urban development and rice farming. The combined impact of increased sediment loads and deposition and conversion of wetland that provide the natural capacity to filter sediment and contaminant loads is reducing the lakes' natural buffering capacity to deal with such stresses. Eco-tourism assets such as the Tis-Issat falls are vulnerable to the operation of water infrastructure and climate variability. There is a need for significant investments for watershed development, sustainable agriculture, wetlands protection, as well as mechanisms to reduce the vulnerability, especially in the lakeshore to frequent and devastating floods. Overall, environmental stresses on the Lake can result from the following parts of its system: (a) Lake's sub-basin: from water use and water infrastructure operation (the Chara-Chara weir, Tana-Beles hydropower tunnel - proposed to be shortly operational, and proposed dams/irrigation in the sub-basin), point and non-point source pollution, (b) Littoral zone: from conversion, destruction, and encroachment of important natural buffers (shoreline wetlands) for commercial, residential and tourist construction, and from (c) Within the Lake: unsustainable fisheries practices, pollution from within the Lake and from its islands (e.g. untreated wastes, fuel/oil spills)

Economic: The area has not lived up to its potential in terms of economic growth based

[5] The data in this section is sourced from presentations by the Amhara and Benishangul BoFEDs during the World Banks preparation teams visit to the regions in 2006.

on its promising land, water, cultural, and human resources and location. The economy is very vulnerable to climate risks. Agricultural productivity from the largely rain fed and few smallholder irrigation systems is low. All-weather transport access is poor is many parts of the sub-basins. There are an increasing number of largely ad-hoc investments. Several public investments in the Tana sub-basin are underway, including a significant diversion tunnel that is being constructed from the western shores of Lake Tana to the Beles basin to provide hydropower (460MW installed capacity), diverting most of the current outflow. Other public investments have been made in irrigation infrastructure (small and large-scale), agricultural extension, upgrading of trunk roads, protection of natural habitats and cultural assets, food/cash transfers to food insecure populations in the highlands and associated public works (mostly watershed development) through the productive safety net program – and further investments particularly in large scale storage based irrigation, hydropower and road/air connectivity are planned. There are a number of other private investments, primarily in agriculture, agro-industry, hotels, tourism, and micro-enterprises that are underway around Lake Tana. About 700 ha on Lake Tana shores have been allocated for export-oriented floriculture to replicate this industry's success around Addis Ababa. The investments planned around Lake Tana contribute to stimulating growth in the region. Yet, they are implemented in a fragmented manner without a clear coordination mechanism for integrated development. There are also a number of investments planned in the Beles basin, primarily related to commercial irrigated agriculture.

Institutional: There are a number of institutional challenges for both management and development of the Tana and Beles sub-basins. There is an urgent need to improve the management of Lake Tana in particular and the Tana and Beles sub-basins in general to meet the emerging challenges described above. There is a need to build enabling institutional arrangements and capacity for improved "shared vision" water and natural resource planning and management to balance multi-sectoral interests with the sustainability of the resource base in a sub-basin context. The planning needs to optimize the major environmental, social, and economic objectives of the management of the sub-basins and their assets (including the ecologically-fragile Lake Tana). Currently, there is also a lack of an adequate knowledge base (including on basic hydrologic information due to an ineffective hydrologic network and information system), analytical capacity, and stakeholder forums for effective management of the sub-basin and its resources. Economic growth for sustainable development of the sub-basins requires substantial investments from the public and private sector facilitated by effective institutional arrangements for sustainable development of the sub-basins. This includes adequate capacity to promote, facilitate and regulate private sector investments in the sub-basins that are targeted to stimulate economic growth while ensuring resource sustainability. There is also a need to strengthen and improve coordination among various government agencies (e.g. across regional bureaus and with the federal level) and improve synergistic partnerships with other institutions (e.g. academia) to better develop a synergistic set of public and private investments. There is a need for an enabling policy framework and strong institutional capacity (with appropriate skill base, knowledge base, tools, and partnerships) to create enabling co-located infrastructure (e.g. water storage, irrigation development, feeder roads, international airports, energy generation, tourism development) and enabling policies (e.g. relating to land reform, private sector investment facilitation, technology modernization, etc.) to address problems of weak private sector capacity, lack of effective public private partnership models, and poor product and financial markets.

These issues are all interlinked in direct and more subtle cascading ways. For example, climate variability impacts both livelihoods and economic performance (by impacting hydropower generation). The 2003 drop in lake levels caused significant impacts on navigation (suspended for 3 months), tourism, fisheries, and on the lake's littoral zone, adversely impacting livelihoods for associated communities. The poor economic performance could reduce investments in social sectors and private sector interest in scaling-up much-needed investments. It is clear that these environmental, social, economic, and institutional issues need to be addressed in an integrated and well-planned manner.

Opportunities

The Lake Tana sub-basin has significant water resources in the lake and surrounding areas, and has rich cultural and natural assets, relatively developed urban centers, basic infrastructure and telecommunications to support economic activities (good roads and air connectivity, industrial zones, efficient administration), and dense settlements. The basin has a potential for growth in multiple sectors with strong employment and income multiplier effects, including more intense and diversified agricultural produce, agro-industry and exports, tourism, fisheries and energy.

The Beles sub-basin, given on-going hydro-power development with diversion of water from Lake Tana, also has exploitable water resources plus productive land that is currently under-utilized. In addition, Tana- and Beles are located on a possible transit route between Sudan and Djibouti. Trade with Sudan has been growing however given the potential for trade; it is still low but is expected to keep on growing significantly. Currently, direct exports from regions through Port Djibouti are low, and so is the transit trade from Sudan, but they both could grow significantly as the roads linking the area with the border has been upgraded.

Much of the natural endowments and potential in the sub-basins are already in use, but there are large efficiency gains and opportunities to expand production in the growth corridor. Efficiency gains and expansion of production could be obtained through an appropriate combination of improved basic infrastructure (water supply, watershed management, irrigation, hydropower, and roads), market development and connectivity, institutional development, promotion of investment, and incentives/opportunities for farmers to shift out of subsistence agriculture into surplus/commercial agriculture and non-agricultural activities[6]. For instance,

[6] This regional dynamics between investments, institutional rules, and incentives would be consistent with the choice by the Government of Ethiopia in PASDEP to promote growth zones that group together complementary investments where there is potential for accelerated growth. The Water Resources Strategy for Ethiopia also points to the need to strengthen synergies between investments in

development of medium/large scale irrigated agriculture, in addition to the ongoing hydropower development, through private sector investment and stronger linkages between the two sub-basins, could provide the impetus for higher and better quality supply of agricultural inputs, which could prompt a take-off in agro-processing in the Tana area.

In exploring the prospect for growth along the above lines, the following opportunities are highlighted: (i) availability of shared water resources in the two sub-basins that can serve as a basis for hydropower, irrigated agriculture and fisheries development, (ii) suitability of both sub basins for agricultural production, (iii) opportunities for manufacturing in Tana area with two large urban centers (Bahir Dar and Gonder), growing private investment and major transport linkages, (iv) the availability of a large labor force within the Tana area and current migration from the Tana to Beles sub-basins, (v) fisheries potential, estimated, up to 18,000 tons of fish production per year as compared to the current level of about 750 tons production, (vi) potential for tourism and recreation with emphasis on eco-tourism which is currently considered as one of the priority sectors – based on the historical heritage of the area and its natural resources (including the lake, wildlife, bird and fish species, dramatic landscapes and hot springs).

Challenges

However, there are strong constraints, affecting: (i) the stock, maintenance, and renewal of the endowments - a fragile ecology in the Tana area (a shallow lake and associated wetlands) with concerns of high erosion in the highlands, water quality/biodiversity issues in the lakes environs, and recurrent droughts/floods; inadequate knowledge of the Lake's hydrology, high rates of land degradation; (ii) productivity and effective integration of economic activities in themselves, and with geographical markets - limited use of modern technology in agriculture, fragmented land holdings, limited public irrigation and energy generation, enabling infrastructure not always in-par with emerging and dynamic needs, weak product and financial markets, limited private sector capacity and public private partnerships; and (iii) an effective institutional oversight - poor planning and management of water resources for multi-sectoral and often competing uses, lack of coordination among the various regional and federal sector institutions with responsibilities over water resources, scarce attention to environment impact of proposed diversion of large volume of water from Lake Tana to Beles system for hydropower development.

Indicative Growth Scenarios

One scenario for growth is that growth in and around the Tana and Beles area will be driven by higher productivity and production from small holder agriculture with tourism and agro processing as an additional source of growth. Better management/development of the water resources in this area (irrigation, drainage and flood control) and the transformation of agriculture from its current subsistence orientation to high-input, high-output, commercially oriented production would allow for growth in agriculture. However, given ecological considerations, conflicts with fisheries development and wildlife conservation as well as competing demands for the water resources by tourism and hydro power, a clearer understanding of the

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water and market infrastructures to better leverage their growth potential.

potential for agricultural growth is necessary.

Growth in agro processing a complementary source of growth would be at a relatively slow pace; following on the agricultural growth envisaged. The priority for investment under this scenario would be water resources development in the Tana and Beles sub basin and the promotion of private sector investment farming and agro-processing that is partnered with small holders; e.g., out grower schemes. Current plans (and on going investments) on development of the Nile basin (irrigation and drainage, watershed development, flood preparedness and early warning projects) correspond to this growth scenario.

A second scenario is given opportunities observed in the two sub-basins and the Government of Ethiopia's strategy for rapid private sector-led economic growth and rural development, the primary engine of growth for the Tana area is agro-processing/manufacturing in the three urban centers: Bahir Dar, Gonder and Debre Tabor. Commercially oriented and irrigated small holder agriculture focusing on high value crops as well as tourism would complement growth in manufacturing but are not considered as the primary growth engines. For manufacturing to take off, it would need to build on a large and consistent supply of agricultural inputs. It is expected that development of medium/large scale irrigated agriculture (in addition to the ongoing hydro power development) in the Beles sub basin would provide the necessary supply of agricultural inputs on which manufacturing in the Tana area could develop.

Under this scenario, the priority investments would be the promotion of irrigated agriculture in the Beles sub basin, the establishment of effective linkages (through development of road networks, market infrastructure, etc) between the two sub-basins, promotion of private investment in manufacturing within the Tana sub-basin; and, the development of linkages with international markets. The *"Growth Corridor for Tana and Beles Regions: Endowments, Potentials and Constraints"* study currently underway will be responsible for developing a scenario through rigorous analysis.

Well-planned interventions in the Tana and Beles Sub-basins will bring substantial benefits; inaction, on the other hand, will likely result in significant environmental, social, and economic costs. The Tana sub-basin requires urgent action in the short-term to help manage the current and emerging threats from resource degradation and competing claims for water among different uses. The Beles area also does face some short-term emerging issues in the form of adapting to the expected increase in flows from the Tana-Beles Hydropower diversion, as well as longer-term issues of development in a setting of low-density population.

The Tana & Beles Integrated Water Resources Development Project

However, given the scale and complexity of the challenges it is clear that a single project will not be sufficient to undertake all key activities required for sustainable development and management of the sub-basins to stimulate economic growth and alleviate poverty. Realizing the potential will require a phased approach- as a series of projects with subsequent projects building on the previous ones, starting with this project that lays the foundation for effective sub-basin management and development. This would include addressing the challenge of institutional arrangements and capacity for integrated water resources planning and management in the Tana and Beles sub-basins, public and private investment facilitation, and initiating on-the-ground actions to improve the management of the resource base, focusing on watershed and flood management. A phased approach is proposed in which the current project would be the first of several "shared vision" investments that facilitate the creation of an enabling environment for subsequent investment and capacity-building activities. The World Bank with support from Government of Finland have recently concluded an agreement with Government of Ethiopia for an initial project (the Tana & Beles Integrated Water Resources Development Project- project cost: $70m) to establish institutions and initial investments to move forward in the realization of growth potential of this area.

The Project Development Objective of this project is *"to develop enabling institutions and investments for integrated planning, management, and development in the Tana and Beles Sub-basins to accelerate sustainable growth"*. The mechanisms include *institutional* strengthening, *instruments* and *information* tools for water planning/regulation, and *investments* in the Tana sub-basin on watershed and flood management. The objective is planned to be achieved by (i) establishment/strengthening of targeted institutions to bring about effective and coordinated planning, development, and management of natural resources of the sub-basins; (ii) immediate investments in sustainable watershed development and community based flood preparedness in the Tana Basin; (iii) establishment/strengthening of relevant growth promoting institutions; and (iv) preparation of a set of investments for promoting growth in the sub-basins underpinned by land and water resources to be implemented in successive projects. Targeted institutions include existing and evolving institutions including the Tana Sub-basin organization, Beles Sub-Basin Organization, existing regional bureaus, related federal agencies, Abbay River Basin Authority and other evolving stakeholder entities and partners for shared vision sustainable planning, management, and development of the sub-basins. The emphasis is on working towards the use of the sub-basin's water resources for sustainable and accelerated growth.

The project seeks to balance critical institutional strengthening with essential investments to ensure sustainability of the natural resource base. This is necessary to create an enabling environment for the growth-oriented investments underpinned by the region's valuable land and water resources. The components for the $70 million project include (i) Sub-basin Resources Planning and Management; (ii) Natural Resource Management Investments; (iii) Growth-Oriented Investment Facilitation; and (iv) Project Management.

An agreement for project implementation was signed recently in June, 2008 and the project has been declared effective in October, 2008.

LAND USE GUIDED GROWTH CORRIDOR DEVELOPMENT APPROACH TO ENSURE SUSTAINABLE DEVELOPMENT. THE CASE OF OROMIA REGIONAL STATE

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Abstract

In mid-2006, the Oromia Regional State decided to implement a development corridor approach, which is in line with the Rural Development Strategy and PASDEP, to address its development objectives. Recurrent drought which is challenging the life of more than 1.5 million people of the region, the worsening poverty situation and the need for societal transformation forced the Regional Government to think strategically to address these issues. It is also imperative to bring about a reliable development in the coming few years as a basis for the fulfillment of the country's vision to be among the medium income countries by 2020. It is understandable that with the growth potential, the geographical location and the population it has, the role of Oromia is vital to attain this objective.

The first and foremost activity to test the growth corridor approach was to identify available resources to start with. The lowland parts of Oromia, which are hit by recurrent droughts, marginalized and unaddressed areas of the region, are found to be of good development potential if solutions to some very limiting factors are given. Experiences gained from the encouraging results from the lowlands led to an improved approach to address key problems of the Highlands of Oromia.

A steering committee led by His Excellency the Regional President and constituting active regional bureaus, was established at the initial stage to lead the overall process and aggressively start to bring a concrete strategy advanced for the intended paradigm development concept shift in order to change the existing scenario. It is believed that the so-called 'food insecure' areas can be changed to food surplus areas and even to development centers that relieve the pressure on the dwindling resources of the Highlands. In addition to this intervention in these areas, it is believed to ensure equity and balanced development in the region. Major problems in the Highlands of Oromia, which is linked with population pressure on limited resources, improper utilization, and management of the natural resources and lack of good governance, are taken as main areas of focus.

As a strategic advantage, the concept was first tested and exercised in the southeast economic development zone, and with experiences gained from this development zone the region was further classified into additional economic development zones based on their socioeconomic ties and agroecological settings, thereby bringing the total number of economic development zones to three. Further reclassification of the

zones into subzones was also made to facilitate various focused interventions.

The continuous communications made with all stakeholders is creating a huge mobilization of our human resources. Awareness has been created in efficiently using and managing our natural resources, particularly land and water. Impacts of the approach have only started to show in these past few years. There are remarkable and visible changes in people's attitude towards poverty and the life-saving projects have demonstrated the viability of the path towards sustainable economic development.

1. Introduction

In mid 2006, The Oromiya Regional State decided to implement a development corridor approach, which is inline with the Rural Development Strategy and PASDEP, to address its development objectives. Recurrent drought which is challenging the life of more than 1.5 million People of the region, the worsening poverty situation and the need for societal transformation forced the Regional Government to think strategically to address these issues. It is also imperative to bring about a reliable development in the coming few years as a basis for the fulfillment of the country's vision to be among the medium income countries by 2020. It is understandable that with the growth potential, the geographical location and the population it has, the role of Oromia is vital to attain this objective.

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2. Rational for the development Corridors Approach

Ethiopia is a country that suffered centuries of poverty and natural calamities, most of which are happening as a result of human error. Inadequate development policies have equally contributed to the problems the country is in.

In the country's rural development strategy growth corridor approach has been stated as key approach to bring fast and sustainable economic growth. The first attempt was to have few growth corridors at a larger scale that can bring fast development and catalyze the development of others. But the followings facts and believe lead the region to systematically implement a growth corridor approach to bring set objectives:

- There is life saving task to be given priority before embarking on the long term development objectives
- The natural resource base is either not well known/mismanaged/underutilized;
- Every piece of land has its own potential but some potentials are not easy to be seen; they need detailed study
- The biggest resources is the human resources and is not well utilized;
- The enormity of the socioeconomic problem facing the region demand huge mass movement to face it;
- There are areas with high potential for development but there is no detail plan to pick them as development corridor right away. Even if there are such potentials, starting with and focusing only on such few, high resource potential areas may not help to meet set development targets such as the MDG and reaching middle income level by 2020 ;
- Considering these few pocket fast growing areas as corridors and focusing on them don't bring the required fast overall socioeconomic transformation in the immediate future throughout the region and the conventional way followed to develop them doesn't bring huge mass mobilization;
- There is equity issue to be addressed: consideration of the marginalized lowlands suffering from repeated drought
- There is no area based development /spatial development plan to address spatial equity issues (e.g. Infrastructural development, service provision, etc…), and resources based development,
- Water is a key for development and must be taken as an entry point.
- Land use planning was considered as second limiting factor for development; in absence of detail land use planning it is difficult to make efficient use of the land resources and have sustainable economic development.
- Without having land use plan it is found difficult to identify growth corridors that exist throughout the region… at one go

3. Process of defining growth Corridors

As mentioned above it was found difficult to delineate pocket areas as growth corridor for the mentioned reasons. The first step followed was to see the prevalence of any socioeconomic linkage among various parts of the region. There are clearly seen but poorly defined/developed economic zone that can give way to the creation of growth corridors. Transforming these economic zones into economic development zones, focusing in their area of macro level potentials and opportunities, was the first step taken.

With this assumption three economic development zones (EDZ) (Fig.1) and sub-zones were identified based on their similarities in agro-ecological setups and socioeconomic following intensive one year long tour, by high-level regional government officials and professionals, in various parts of the region and undertaking consultations with various segments of the society.

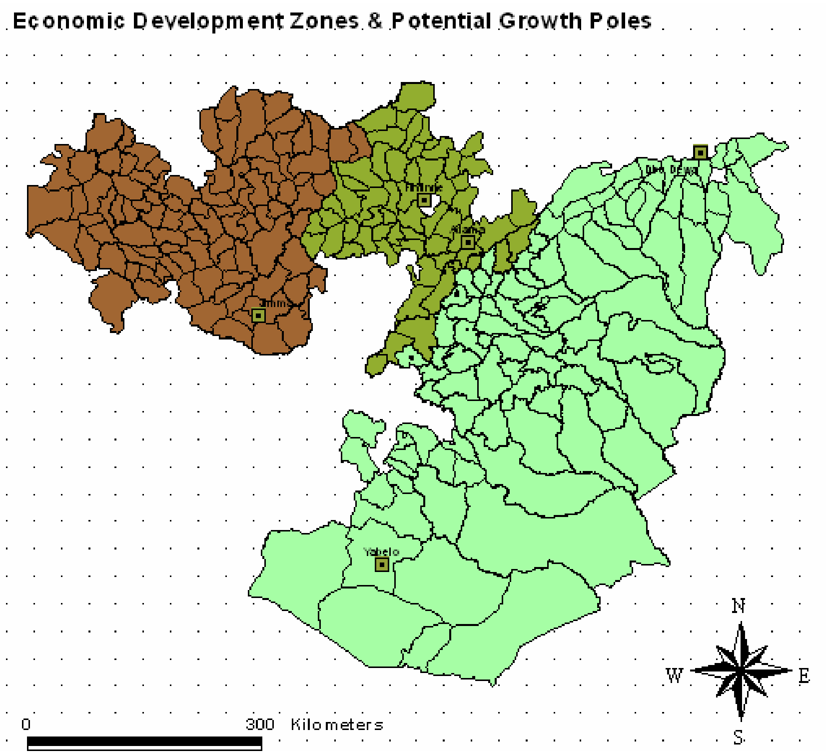

Fig. 1: Economic Development Zones and Potential Growth poles

Potential growth poles and numerous development centres have been identified in each zone. Selection of the growth poles is based on the availability of required infrastructure like well developed road network, airport, marketing system, access to export market, etc.

Further classification of the three economic zones into sub economic development zones is done to help to have a closer and focused attention based on specific potentials and development constraints of those areas. Further identification of growth corridors, growth centres and growth poles will be identified following the completion of land use planning which is being undertaken in various parts of the region (see fig 2).

In the process of implementing development **Corridor Approaches:**

- Development potentials and structural development constraints are identified
- Based on the potentials and constraints overall critical strategic issues are defined
- Implementation Strategy has been set
- Major interventions were identified
- Short and long term development plan is prepared
- Key Actors are defined

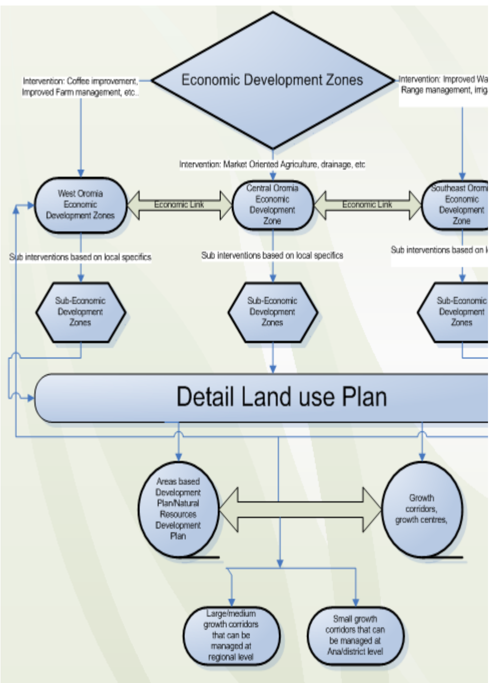

Fig.2: Conceptual Framework followed in the Process of Implementing Development Corridor Approach in Oromia

The overall procedure to be followed is defined as shown in the conceptual frame work given on fig. 2 above. The procedure followed may not be justified by development economics jargons rather it is problem driven and is based on the region's experience and existing socioeconomic conditions. According to the set framework spatial/area based development plan or Natural Resources Development Plan will be prepared based on results of land use planning which are done on water shade basis. It is from this plan that the identification of growth corridors and growth centres is going to be defined in a very systematic way. The completed detail land use plans have already helped to delineate growth corridors and growth centres and the possible interventions to be done.

Conclusions

The distance travelled so far has shown the possibility of societal transformation through appropriate and efficient use of the natural resources and mobilization of the human resource. With the prevailing determination and commitment it is possible to attain what were looking non-attainable in the past.

The new approach towards designing development projects has started paying back. Preliminary results have revealed that the approach works. In the process of implementing development programs the change in work culture has been observed, capacity is developing, and the public trust is increasing.

The successful completion of this objective requires the support and collaboration of all stakeholders. In this regard efforts are underway to engage as much stakeholders as possible. Among the support required assistance from the Federal Government is vital and the support from Bilateral and multilateral agencies, NGOs and the private sector is also expected to come and melt in a single pot.

HIGHLIGHTS OF IRRIGATION AND WATER SUPPLY POTENTIAL DEVELOPMENT INTERVENTIONS IN THE SPECIAL ECONOMIC ZONES OF RAYA-HUMERA PROJECT AREAS, NORTHERN ETHIOPIA

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Absract

As is the case in many parts of Ethiopia, Tigray's main economy is based on agriculture. The food requirement of the region is in a wider gap to production, due to the dependence of farmers in traditional rain-fed agriculture. Moreover, rainfall in the region is not dependable in amount, distribution and uniformity. In order to alleviate the existing problem of food shortage and to reach a level of food self-sufficiency, the Tigray Regional Government has given much emphasis to overall water-centered agricultural development interventions. To this effect the southern zone (Raya Valley) and the western zone plain area (includes Humera and Wolkait plains), which are believed to be potential areas for crop production and livestock development, are considered and delineated as special economic zones of the region. Therefore, the integration of rain-fed and irrigation development could play a major role in economic corridors for food self-sufficiency, security and for an agriculture-led industrial development program.
The Regional Government launching the Raya-Humera special economic zone has a paramount importance to utilize all the available water resource potentials in the economic zones. Therefore, based on the above and other available irrigation development options, the projected water resources development (potential) interventions by the water sector is hoped to be implemented in the near future to improve the lives of the people at both special economic zones and regional level. The major objective of the paper will be, therefore, to give highlights of the major available irrigation water potentials and other water harvesting mechanisms (groundwater, reservoirs, spates, etc.), in respect of their implementation approaches in the coming years to promote agricultural productivity and production in the special economic corridors of the region.

1. Introduction

The food requirement of the region is in a wider gap to production, due to the dependence of farmers in traditional rain-fed agriculture moreover rainfall in the region is not dependable in amount, distribution and Uniformity.
Southern Tigray Special economic zone is one of the potential areas for

agricultural development for its temperature, soil and social resource. Though double rain Belg" and " Mehere" is prevailing in the highland, the potential evapo-transpiration or crops water demand highly exceeds the effective rainfall, associated with its erratic nature, most crops suffer moisture deficiency in their growing season. Weed, disease and erosion problems are also incurring high yield losses of the crops.

Based on this facts the late Raya Valley or Southern Tigray Special economic Development corridor through an integrated rain fed and irrigation development programmers could pay a large dividend, and it may play a major role in the regional development programme for food self sufficiency, security and for an agricultural led industrial development programme.

2. Background

Agriculture is the major economic activity of the population of Tigray. The same sector contributes to the food supply, job opportunity and incomes of the rural population.

The agricultural system which is under practice by Tigray farmers is mainly characterized by rain fed crop production by small scale farmers at traditional and subsistence level, low-input low-output production system has contributed to the low trend of the agricultural growth in the region. .

In the region, the total cultivated land is estimated to be a little less than 1.2-million hectares. During 1997/98 e.c a total crop production of about 13.5 million quintal was obtained from about 1.04-million hectares. The regional peasant agriculture has been affected by low rainfall, poor soil and pest problems. The average regional crop yield was at around 10-12 quintals level much lower than the national averages. The region has a structural food deficit of about 0.3 -0.5 million quintals.

Irrigation in the region is not yet developed. Out of the total 300,000 hectares irrigation potential the existing irrigation practices is on less than 27,000 hectares mainly on traditional irrigation systems.

In the Raya Valley, crop production is carried out by peasant farmers under traditional and backward conditions. In spite of the available potential in improving the rain fed and irrigated agriculture in the valley the peasant agricultural sector is still found at low productivity level. In the recent years, crop production was carried out on about 87718 hectares and only 727,798 quintals were collected with only 8.3 quintals per hectare.

Irrigated agriculture in the valley is not yet developed. Spate irrigation is the major practice in the valley, which is not yet supported by better managements.

The regional government initiative in launching of the south special economic zone (Rava valley) have paramount importance so as at near by to execute and realize all the available water resource potentials (ground water, reservoir/dam) in the valley.

Therefore based on the above and other available irrigation development options; the projected water resource development (potential) interventions by water sector is hoped to be implemented in the near future to improve the life of the people both at the south special economic zone and regional levels.

3. Objectives

3.1General

The major objective of the paper will be to assess and identify major available irrigation water potentials and other water harvesting mechanism (ground water, reservoir, spate, etc) with respect of their implementation approaches in the coming two to three years so as to promote agricultural productivity and production in the South Special Economic Zone.

3.2. Specific

Irrigated crop production may expand in the Valley through different water harvesting mechanisms among which area are spate, groundwater and reservoir.

Here, it is worthy wise to consider that the water harvesting systems should be assessed exhaustively in all part of economic zone including the high lands. Since the valley by large has exploitable groundwater potential and a rich experience of spate irrigation system, in the short & medium term, explorations of the on going groundwater irrigation as well as improvement of the existing spate practice having low cost techniques has to be given priority as prime specific objective. However the high cost reservoir interventions of previously identified dams especially with respect of construction should be postponed as long term specific target after catchment's healing tasks have been done. Therefore in the coming 2-3 years catchment treatments of the five (5) proposed dams, in the mid and lowland have to be given focus as short term specific action plan. These areas are Harosha, Oda, Hayya, Dayu and Tengogo catchments.

4. Methodology

Irrigation development as an essential component of the water resource sector, to assess and gather the necessary available information with respect of water development potential and furthermore to propose appropriate irrigation interventions in the southern Tigray special economic zone (Raya valley) the following methods have been employed.

- Reviewing study documents done on the valley and adjoining areas.
- Discussion with relevant staff members' of Tigray Water, Mine and Energy Bureau.
- Previous and existing visual field level observation.

5. Overview of the Economic Zone

5.1. Location

The development area is situated in the southern zone of the Tigray region between Latitudes 12016' and 12° 55' N and longitudes 30° 53' and 39° 53' E. The valley is some 600km away from Addis Ababa and around 150 km from Mekelle, and bordered by Afar region to the east, Amhara region to the south, part of Ofla & Endamehoni woredas to the west, and some part Alaje & Hintalo woredas of Tigray to the north , (as indicated on the Figure1 at the annex).

The valley is divided in to three development areas based mainly on altitude. These are:-

- Highland Irrigation Agricultural development area (HIADA)
- Midland Irrigation Agricultural development area (MIADA)
- Lowland Irrigation Agricultural development area (LIADA) however all have not been delineated yet.

The total area of the project is 243000ha. The dominant topographic feature is lower plain and followed by mountains and small plateaus out of the total area only 69052 ha (28.4%) is currently under cultivation. On the other hand, however, the land use development study has indicated that there is an additional potential of 39747ha that can be put under production.

5.2. Climate

The seasonal distribution of rainfall in the project area is associated with the annual progression of the Inter Tropical Convergence Zone (ITCZ). The area characterized by bimodal rainfall pattern with a short rainy season (Belg) from February to March and a long rainy season (Kirmet) from June to September with a peak in August. The annual mean rainfall in the lower flat plain of the Valley varies from 650mm to 750 mm. The mean daily temperature of the area is 250c.

5.3. Agro Ecological Zones / Agro Climates

a) Dry Kolla Flat plains AEZ

A small unit, this zone in the Raya Valley is located in the Alamata, Mehonni flat plain specifically, in the central part of the study area from Waja to around Kukuftu. The extent of this zone is 36,220.0 ha which about 14.91% of the total study area is. The altitude of this AEZ is below 1500 m.a.s.l and the mean annual rainfall varies from 500mm in the east to 700mm in the west. The soil types are mainly vertisols (clay texture and Fluvisols (loamy textured). The highest temperatures and Potential Evapotranspirations (PET) are recorded in this AEZ because of its low altitude; due to this the Length of Growing Period (LGP) is expected to vary from 80 to 120 days.

b) Dry to Moist Woina Dega Flat plains, Hills and Mountains AEZ.

Being the largest unit, this AEZ is located in the east, in the north and in the west parts of the study area. The latitudinal range of this AEZ is from 1500 m to 23 00 m. a. s. l and the mean annual rainfall varies from 450 mm in the east and north to 700 mm in the western part. The general physiography of this AEZ is flat plain in the north and hills and mountains in the east and west part. As compared to the Dry Kolla flat plain AEZ this AEZ the temperatures and the potential Evapo-transpiration (PET) are lower, but within this AEZ, elements vary from place to place with altitude variation. In the Raya Valley the extent of this AEZ is 164,367.0 ha of land which is about 67.64% of the total study areas. The LGP in this AEZ varies from 90 to 150 days.

c) Moist Dega Mountains AEZ

In the Southern Tigray specific economic zone (Raya Valley) the altitude of this AEZ is above 2300 m.a.s.l and it is found and located in the western mountains of the proposed development areas. Here the rainfall amount is better and it is evenly distributed as compared to the above two AEZs. On the contrary, the best agricultural land is located where the rainfall amount is low and variable. Because of high altitude, the temperatures and the potential evapo-transpiration in this AEZ are even much lower as a result the LGP is high ranging from 120 to 150 days. This AEZ comprises 42,413.0 ha of land which is about 17.45% of the total probable development areas (the late Raya Valley).

5.4. Geology and Soil

The dominant geological formations found in the proposed development areas are poorly compacted sedimentary basic fill. The frame is mainly composed of Tertiary Volcanic Rocks (for detail refers Geology feasibility report of Raya valley).

The Regional geology indicates that most of the area covered with a trap series of the Ashengi group. Dominantly they are alkaline olivine basalts and tuff, rare rhyolites from fissures and dissected by dikes and hills.

Normally there are different soil types in the projected area. The major soil types exhibit a general relationship with altitude. The soils in the Raya area are developed on recent alluvial colluvial sediments derived from the adjacent mountain ranges.

In general in the zonal area and in particular in the lowland flat plains two major soil types have wide area coverage. These are vertisols and Fluvisols. Vertisols are black clay soil with better water holding capacity. Fluvisols are medium textured soils. The clay vertisols are predominately found in the flat plains and loam Fluvisols are located in the mountains & hill foot slopes. Shallow Leptosols is the dominant soil type in the mountain & hill sides of Raya valley. Soils in the plateau terraces are moderately deep soils, in the flat plain are deep and moderately deep and are suitable for irrigation. Soils in the highlands are low in soil fertility (Low N, P & OM content) as compared with the soils in the valley bottom will have better fertility status. (Refer the details on Soil Report).

5.5. Water Resources

5.5.1. Surface Water Resources

The surface water resources in the area mainly depend on streams and perennial rivers, which originates from the highland areas, characterized by lower dry season flow, so it is only of interest for small-scale irrigation through small storage reservoir or flood harvesting or spate irrigation diversion weirs in conjugation with ground water. Assuming 75 % dependable run-off, the total annual volume of exploitable surface water is estimated to be 100 million cubic meters.

5.5.2. Groundwater Resources

Ground water resource is believed to be the huge water resource in the development area, dominant ground water flow directions are north south and west east. The depth of ground water varies from less than 20 m in Waja and Adis Kigni areas to over 60 m in the northern part of the area. The average ground water recharge in the project area is estimated to be 85.6 million cubic meters per year and the static ground water reserve estimated at 7150 million cubic meters. However, the total exploitable quantity of ground water per year in the valley is about 130 million cubic meters.

5.6. Land Use

According to the study of late Raya Valley Agricultural Development project, the total land in the project area is estimated to be 243,000ha. It comprises of spatially diversified land resources including physiographic, soils, and climate and farming systems.

Rainfall (rain fed) crop production is the dominant land use practice in the project areas. The land use survey results indicate that crop productions is conducted in the high, mid and lowland areas with respective areas covers of 10517, 39645 and 18888 hectares of land.

The existing land use cover under crop production area also stratified by level and intensity of cultivation practices. Accordingly, intensively cultivated land holds the major area coverage in all the high, mid and lowland areas.

The average land holding in the development area is estimated to be 0.7 ha, 1.4ha and 1.6ha per household in the highland, midland and lowland projected area respectively.

Mixed farming is practiced in the project area with crop production being dominant. Single cropping system is common in the midland and lowland project areas. However double cropping system is mainly adopted in the highland areas during Meher and Belg growing season. The detailed information on land use systems is available in the land use report.

5.7. Socio-Economic Conditions

In the valley the total population is about 286,613 according to the census made during the late 1997. The total rural house holds is estimated to be about 51,045. The average population density in the project area is about 118 persons per square kilometer. The average family size in the study area is about 4.1 persons per house hold.

In the valley five different ethnic groups are found. These are Tigray, Amhara, Oromo, Agew and Afar with a respective share of 81.1, 14.9, 3.2, 0.6 and 0.3% of the total population.

In the valley areas, three different religions are found with a respective total population coverage of Christian (80,4%), Islam (19.2), Protestants and Catholic (0.3%). The literacy rate in the Raya valley is estimated to be about 26.0% of the eligible age groups.

The availability of labor in the Raya valley area is about 2.9 adult per family. This estimation was made by excluding age groups below 15 and above 64 years. However, quite essential labor contribution by children in farm practice and livestock management is not uncommon. The annual labor time is in the range of 53-168 days. Fast and feast days which are observed mainly by orthodox Christians have substantially contributed to the presence of limited or lower annual labor days in the area. The details information will be available on socio-economics report.

6. Existing Crop Production System

The development area having varied type of climatic zone (different temperature, rainfall intensity and distribution) many types of crops are currently produced, though their yields are low due to several reasons, the major one being moisture constraints. All types of cereal crops, pulses, oils seeds, Horticultural crops (vegetables and orchards), and stimulant crops are found in the study area at varying degree of production.

6.1. Crops Grown in the Area

The dominant crops produced in the area are mostly cereals, Pulses and oils seeds. The rest are grown on a minor scale especially in areas where there is spring perennial rivers to supplement the crops with irrigation water. Thus the crops grown in the south Tigray special economic zone or area can be listed as follows:

A. Cereals - Sorghum, Teff, Maize, Barley, Wheat, Finger millet, etc.

B. Pulses - Horse Bean, Field peas. Chick pea. Lentil, Vetch, "Dekoko",

C. Oil crops - Linseed, Niger seed, Sunflower, Sesame, Castor Bean, Mustard, Rapeseed,

D. Vegetable - Potato, Tomato, Onion, Cabbage, Spinach, beet root,

E. Spices - Chili, Garlic, Red pepper, Cumin, mustard, Fenugreek,

F. Fruit crops - Guava, Mandarin, Lemon, Orange, Banana, prickly pear (wildly grown), papaya, peach.

G. Fibber crops - Cotton, Sisal.

H. Stimulants - Coffee, Hop, Chat.

6.2. Farming System

The farming system in the proposed economic zone both in high land and low land is sedentary mixed farming system in which farmers practice both livestock production and crop production giving more emphasis to the latter. Farmer in the Raya valley area pursue different crop enterprises in order to secure their family food supply and also satisfy various cash needs.

Sorghum, Teff, Barley, Wheat, Maize and Pulse crops are the major crops grown by farmers. The livestock enterprise also plays an important role in the farming system of the study area. Its major objective is to satisfy food and cash needs. Cattle make the highest proportion in both high land and low land areas followed by small ruminants and camels. Cattle are kept primarily as a source of draft power for land preparation. Sheep, goats and poultry are kept mainly and/or as insurance when there is food shortage due to crop failure.

6.3. Cropping System

Cropping systems used in the valley is limited due to moisture limitation, less knowledge of the farmers and poor extension services to use other types of cropping system. The two most commonly used cropping systems are double cropping and single cropping.

Double cropping is the growing of two crops on the same plot of land per year. Such practice is undertaken in the study area due to the bi-modal nature of the rain. The farmers produce their first crop during the short rainy season in February/march and harvest it in June/July and take the second crop in June/August to he harvested in October/November. This practice enables the success of growing and harvesting at least one crop in normal years, two crops in good years and even nil in drought years as it happened in the past. The extent of double cropping is very low in the low land areas due to very short growing period and uncertainty of rain fall during the short rainy season. Similarly the area used for double cropping on the highland areas is also very low as compared to the single cropping land area.

Single cropping is grooving of only one crop in a year. Most of the cropping system in the expected area is single cropping in which farmers only grow one crop during the long rainy season.

The type of crop produced though dependent on the preference of the farmers, in high land areas the dominant crops are barley and wheat and in the low land sorghum and Teff are the major ones.

In the low land areas in fact the monoculture system is prevalent in which case the farmers produces Sorghum crops every year in succession as it is the staple food crop of the area. The disadvantage of this monoculture practice is it increases pest and weed infestation which reduces yield at the same time it exhaust the fertility status of the soil.

6.4. Cropping Season

Depending on the rainfall pattern which is bi-modal there are two distinctive cropping seasons traditionally used by farmers of the area? The type of crops produced during these two cropping season vary between the high land and low lands. The cropping season are termed as "Belg" and "Meher" cropping season.

6.4.1 Belg Cropping Season

This cropping season begins as soon as the short rainy season rain starts. Normally in the high land areas land preparation for Belg cropping starts as soon as the last harvest of the Meher crop is over which is usually in January and February. The normal time of Belg cropping or sowing starts during the month of February/March as soon as the first few rains enabled the soil to be moist enough for germination. The crop sown during this time is harvested during the month of June or early July enabling to use the land for Meher/Tsedia planting. The crops grown are Barley, Wheat and Pulse crops like field pea and Lentil.

In lower altitude planting is done at the same time with the highland except harvesting is a little earlier which is in may and early June due to short grooving period of the crop taken and higher temperature. The crop mostly taken for Belg in this area is Teff.

6.4.2. Meher Cropping Season

This cropping season is during the locally known season kiremit which starts during the month of July and extending up to September/October. However, the long season crops (Sorghum and Maize) are sown during the short rainy season in April and May and reach for harvest in October/November. These crops are locally termed as Azemera crops to differentiate it from the late sown crops in July/August. As Maize is more susceptible to moisture stress than Sorghum, most of the land is covered or allotted for Sorghum.

The short season crops usually sown in July/August and be harvested in October/November are locally termed as "Tsidia" crops. Almost all small grained cereals, Pulses and oil crops are sown during this time except sorghum and Maize. Thus Tsidia crops could be the second crops in the double cropping system. The three distinct sowing times have given the farmers to secure at least some yield in a particular year despite the shortage and unreliability of moisture to guarantee the rain fed agriculture.

When the Belg crops fail due to insufficient moisture farmers are able to sow "Azmera" crops in April and May. There is still another chance for farmers to take a new crop in "Tsidia" when the "Beig" or "Azmer" crops fail. Moreover, due to early withdrawal of "Meher" rain farmers in the lower altitude divert the flood water that comes from the highland areas and flood it in their field and save the crop from drying.

This practice is done by farmers who are located in the flat valley areas but crops sown on the rest of the area always suffers from shortage of rainfall especially at the latter stage of crop development.

7. Major Constraints of the Economic Zone

The existing crop production system in Raya valley is dominantly characterized by rain fed peasant agriculture where crop production is carried out by small scale farmers at subsistence and traditional level. The existing production system has been severely, affected by multi- natured environmental, technical & socio-economic constraints which separately and/or collectively contributed to low and declined crop yields eventually to recurring food shortage. The major constraints are briefly described below.

1) Low and unreliable rainfall condition

Rain fed crop production is repeatedly affected by low rainfall conditions. Moreover, uneven distribution of the available rainfall, late on-set of the rainy season, early withdrawal of the rains as well as short crop growing periods have continuously contributed to poor and low crop yields.

2) No successful effort was made yet in full utilization of the available spate potential in the special economic zone.

3) The existing spate experience is under back ward and traditional level so as to up grade and use efficiently, it needs system improvement.

4) The lately constructed existing modern spate irrigation infrastructures almost all are none functional, or are not working in full capacity, therefore requests to review of the pervious study and deign work to be under reconstruction again in the future.

5) Low level effort with regard to exploration and utilization of the existing huge potential of ground water for irrigation development (in the South Tigray Special economic development corridor).

6) Poor management of ground and surface water, on the existing on farm, irrigation system.

- In almost all the irrigation scheme, the design command areas are not in full function mainly duty poor management irrigation water and related problems (shallow-well & dam).

7) Lack of consistent operational maintenance and management service.

In the south Tigray specific economic zone, the existing irrigation schemes are not working in full capacity among quite a lot of reasons was lack of premedical supervisory work to under take maintenance and management service on the existing schemes.

8) Lack of implementing ground water policy and development.

The Ethiopian government have enumerated and declared the "Ethiopian water resource management policy (1998)" which envisages comprehensive and integrated water resource management including water for agriculture, energy, drinking, domestic use, sanitation, mining, aquatic resource etc however such policy elements lacks implementing policy with regard to ground water resource development. Such policy may also help to establish and develop norm, standard and general guidelines for sustainable utilization and rechargeable management, and clear policy on (well) ownership with reference to future expansion of ground water in the special economic corridor of south Tigray.

9) Lack of, water resource development, institutional sustainability.

10) Low level of soil fertility in the existing and under operation irrigation schemes.

The fertility of the soil has declined because of continues practices. Furthermore soil erosion, marginal practices of traditional soil fertility management practices such as absence of following, poor crop rotation, lack of applying farm yard manure have contributed to poor soil conditions especially in the high and mid altitude.

11) Use of Local Crop Varieties in the irrigated area.

Farmers in the irrigated area widely use local land races as source of planting materials. Local varieties are low yielding and repeatedly affected by various pests. The use of low yielding local varieties which are neither cleaned, chemically treated nor improved have contributed to the current low crop production in the valley.

12) Backward and Traditional Irrigation Crop Husbandry Systems.

Cereal mono -culture is a growing trend which is widely under practice in the irrigated area. This has hampered the development of crop diversification. The existing irrigated crop husbandry systems are entirely backward & undeveloped. Poor land preparation, late planting, and improper plant population, delayed & inefficient harvesting & threshing and inadequate storage practices have hampered the healthy and productive growth of peasant irrigated agriculture.

8. Development Opportunities

In view of the fact that the existing production system is neither productive nor sustainable it is crucial to look for alternative development potential and option for the area. The following potential are envisage reversing the present alarming trend and improving rural life in Raya valley.

1) Improving the Rainfall Agriculture.

There is quite huge potential and opportunity to improve crop production in Raya valley. Crop yields of rain fed agriculture could be substantially improved through the use of external inputs such as fertilizers, improved seeds and agrochemicals. The existing backward production system could be replaced by improved crop husbandry practices which the latter have immense potential to increase yields. Effective extension & other support service have to be developed & strengthen in line with provision supplementary irrigation as major inputs using ,different on and off farm, water harvesting mechanism in order to safeguard crop failure especially at time of shortage of rains furthermore with these to increase crop yields per unit area of rain fed cultivated land,

2) Developing dry Season Irrigated Agriculture (Potential for Irrigation development)

Dry season full irrigation could be developed in the mid and lowland areas in Raya valley. Irrigated agriculture allows farmers to double cropping intensity. Crop yields under irrigation could be easily doubled & even improve further for the major production constraint (water) is alienated under this system. Moreover wet season supplementary irrigation also will consider for rain fed crop to supply additional water at time of shortage through spate irrigation.

Generally the Potential for Irrigation development may include : a total No. of 32 irrigation schemes (13 spate, 5 reservoir and 14 ground water) were proposed to develop 13,214 ha of land for 52,810 beneficiaries during the dry season and an additional 7,780 ha in the wet season (annex table 4, pp).

3) Wide agro ecology and soil resources to intensify and diversify crops and cropping systems.

In the irrigated project area different agroclimates such as Dega, Woinadega and Koall are found in varying area coverage. Moreover, the soil resources are also wide and different in physical & chemical properties.

Both resources allow farmers to grow introduce wide range of potential irrigated crops and improve the existing unproductive irrigated cropping system.

4) Available Working Labor

More labor intensive development works could be undertaken using the huge labor force in the area. The existing labor productivity could be further improved through minimizing non-working days such as converting cultural, religions & social holidays into working days.

5) Growing Markets for Agricultural Product

Currently there are potential markets to several agricultural products in the area. The presence of food shortage, growing demands for farm production since the region is in its economic take-off. More accessibility to local & regional markets could be properly utilized. However, there is an opportunity also in the near future to create and develop efficient marketing services to grains, industrial & horticultural crops in the medium & long term periods through technical assistance of integrated work of the farmers' cooperative and the regional marketing agency.

6) Encouraging Regional & Nation Development Polices and Strategies

The current development & agricultural polices of both the regional and the federal Governments are rural based and oriented towards developing agricultural development led industrialization (ADLI). Therefore, the envisaged development efforts in the project area could be the beneficiaries of such a conducive Regional Sectoral Policy and Strategy conditions. Therefore, it is quite certain & inevitable that the proposed development interventions could be smoothly and effectively implemented in order to increase crop production both under rainfall & irrigated conditions.

9. Development Strategies /Options

The existing crop production system is the study area is severely affected by wide range of complex constraints such as environmental, technical and socio-economic problems as stated in the constraint section of this report.

To this effect, it was quite pertinent issue that the various resources of Raya valley to put into more productive and sustainable development program in order to improve the life of the people without further ecological degradation.

Hence, within the context of the available development potential as well as by addressing well-known existing gab related with irrigation development resource, 3 basic development options and 7 technical interventions or irrigation support service are identified.

These are:-

9.1. Ground Water Irrigation Development.

9.2. Improvement of Spate Irrigation System.

9.3. Reservoir Irrigation Development.

9.4. Swamp area management and reclamation (Waja, Gerjellee and tumuga swamped areas, 1900 ha).

9.5. Maintenance and operation of the existing irrigation structures in the valley.

9.6. Detail design work of the 20 Waja springs.

9.7. Establishment of clear policy related with water resource management.

9.8. Review and appraisal in allocation of irrigable land holding system (equitable/reasonable distribution of irrigable land).

9.9. Study and assessment of appropriate on & off farm water harvesting structure and technologies, above all in the high lands.

9.10. Capacity building and training need assessment in management of irrigation water resource.

9.1. Ground Water Irrigation

The ground water irrigation was designed to appropriately utilize the ground water resources through drilling boreholes in 14 identified well fields, among which, one well field (WF8) is conjugate of Waja Springs. Drilling of 11 boreholes with an average design discharge of 30 l/s, in the mid land and 25 l/see in the Lowland areas was planned in each well field.

Accordingly, 6,711 ha of land in dry and 5,697 ha in wet season were proposed to 33,555 beneficiaries

(assuming 0.2 ha per household) through developing the 14 well field (154 boreholes) and Waja Springs both on Mid & Low land areas that include:
Five well fields (55 boreholes) in the mid land to irrigate 2,465 ha in dry season & 1,795 ha in the rainy season namely: WF9, WF10, WF11, WF12, and WF13.

Nine well fields (99 boreholes) in the Low land to irrigate 4,246 ha in dry season & 3,902 ha in rainy (wet) season namely: WF0, WF1, WF2, WF3, WF4, WF5, WF6, WF7 and WF8 and spring.

Table 1.Ground Water Irrigable Land Potential of the Valley

No	Location WFS'	Area Ha		Total Area Ha	Quantity / No		Remark
		Dry	Wet		Well Field	Bore hole	
1	Midland	2465	1795	4260	5	55	
2	Lowland	4246	3902	8148	9	99	
	Total	6711	5697	12408	14	154	

Source: Raya Valley Irrigation Agronomy Feasibility Report (REST, 1997)

In ground water the major intervention to be undertaken in the coming 2-3 years may based on and include the recently on going feasibility study out put ,therefore the following activities are expected as action plan focus of both in low and mid land (Alamata and Raya Azebo woreda) ground water potential:

- Feasible well field verification and bore hole site selection
- Measure and estimate yield of test wells in already drilled and labeled (test well fields) such as TW1, TW2, TW3 and TW 4 etc.
- Bore hole drilling (45-52 drilled out of the total proposed 154 bore holes).
- Surveying of the irrigation area.
- Irrigation system design (39 bore holes)

The TOR proposed to execute a detail design work for 45 boreholes already drilled in western zone of Mohoni and Alamata sub-basin. However, the current report of Tekeze drilling company (REST) shows the total number of newly drilled boreholes is 52, among which seven are private, one is damaged by farmers, 2 are dry, and 3 failed due to formation collapse.

Therefore, the plan of the design work in the first phase will be 39 instead of 45 wells. Furthermore, the report shows the location, yield, and static level of the new boreholes. However, the field assessment revealed that further study on hydrogeology through group pump test would be necessary to confirm the potentials of these wells before any design executed. (See hydrogeology report for detail).

- Construction and installation of the irrigation system infrastructure.
- According to the TOR, Hydro geological Study in the central and Eastern zones of Mohoni will be carried out in phase two of the projects to determine the potential of ground water for irrigation side by side the above major intervention. Because this part of the valley was not exhaustively assessed in the previous studies.

9.2. Improvement of Spate Irrigation System

Rain fed agriculture in the lowland & midland areas could be improved through better spate irrigation practice. Under spate irrigation quite substantial area could be covered by undertaking the existing already verified potential area indicated below per scheme. Furthermore, yields per unit area of land could be increased as compared with rain fed condition through supply additional water to crops through spate irrigation. Generally the spate irrigation lowland & midland areas will suppose to be implemented in 13 different spate schemes and cover an area of 4420ha. When the project is fully implemented, it is expected to benefit 8940 farmers.

Low land Spate Irrigation: will be implemented in the low land with altitude range of below 1500 meters above sea level. The intended project will be conducted in 4 spate irrigation schemes (Table 2). Hence, with an average land holding of 0.5 ha, about 2196 farmers will /can be the direct beneficiaries of the proposed irrigation schemes in the coming 2-3 years if the venture /plan is fully implemented.

Mid land Spate Irrigation: will be implemented in 9 different irrigation schemes with in the mid lands. These schemes are located in Ashiya, Tirike, Beyru, Fokissa,Guguf, MayAkino, Baro, Burqa and Fage areas.The area coverage of the prospective mid land spate irrigation schemes are indicated in Table 2.

Likewise, with an average land holding of 0.5 ha, about 6644 farmers will /can be benefited from the proposed irrigation schemes in the coming 2-3 years if the undertaking above plan is fully implemented

Table 2 .Spate Irrigation Schemes & Potential Irrigable Land

No	Scheme Name	Lowland	Midland	Remark
		Area (ha)	Area (ha)	
1	Bufe	228		
2	Ual-Ula	202		
3	Hara	414		
4	Ula	254		
1	Ashiya		72	
2	Tirike		380	
3	. Beyru		626	
4	Fokissa		562	
5	Guguf		856	
6	Baro		152	
7	MayAkino		204	
8	Burqa		280	
9	Fage		190	
Total		1098	3322	4420

Source: Raya Valley Irrigation Agronomy Feasibility Study Report (REST, 1997)

9.3. Reservoir Irrigation Development

The reservoir irrigation was designed to utilize the seasonal surface runoff through providing water storage by constructing appropriate dams and irrigation infrastructures. Accordingly, on 2,083 ha of land and for 10,415 beneficiaries (Assuming 0.2 ha per household), reservoir irrigation was proposed on five rivers both on mid & Lowland areas that include:

- 4 dams in the mid land (1,603 ha) namely: Harosha, Tengego, Haya & Oda.
- One dam in the Lowland (480 ha) which is Dayu.

Table 3: Reservoir Irrigation Schemes & Potential Irrigable Land

No	Dam Name	Lowland Area (ha)	Midland Area (ha)	Remark
1	Dayu	480	-	0.2 ha/household
2	Harosha	-	490	
3	Tengego	-	447	
4	Haya	-	550	
5	Oda	-	116	
	Total	480	1603	2083

Source: Raya Valley Irrigation Agronomy Study Feasibility Report (REST, 1997)

The reservoir irrigation scheme proposed is very expensive to implement with in short period and can be considered as feature potential of the project. Siltation was one of the major problems identified on these projects during previous studies. Therefore, it is advisable to implement catchments treatment works with in the coming 2-3 years (physical and biological) which will reduce the siltation, increase the project life & benefits 10415 when implemented in the future

9.4. Swamp area management and reclamation

Waja, Gerjellee and tumuga swamped areas with respective area coverage of 1000ha, 300ha & 600 ha should be considered in the coming 2-3 years.

9.5 Maintenance and operation of the existing irrigation structures in the valley

- River diversions / micro dams
- Spate infrastructures almost all
- Ground water pressurized irrigation infrastructures

9.6. Design work of Waja springs

To design the irrigation systems for 20 (secured 13) Waja springs in Alamata sub basin in the coming 2-3 year.

9.7. Establishment of clear policy related with water resource management.

Lack of clear policy on ownership of wells, exploration of Ground Water (by both the farmers & private sector),

9.8. Review and appraisal in allocation of irrigable land holding system (Equitable irrigable land).

Land holding on irrigation plots, which ranges 0.2 to 2ha and is beyond their capacity for some of the farmers. The need for reallocation of land is quite necessary.

9.9. Study and assessment of appropriate on & off farm water harvesting structure and Technologies in the high lands.

- Site specific and feasible water harvesting irrigation structures /technologies.

9.10. Capacity building and training need assessment.

- In the coming 2-3 years periodical training arrangement related to irrigation water management has paramount importance.

10. Conclusion

The South Tigray special economic zone (late Raya Valley) irrigation agriculture development includes three intervention areas namely: High land, mid land & Lowland agricultural development based on altitude ranges of the contours of 1,500 m.a.s.l. and 2,300 m.a.s.l.

The current crop production system in the Raya Valley is characterized by mixed farming system where by peasant farmer undertake both crop and livestock production at subsistence and traditional levels. Crop production by small scale farmers is mainly carried out under rain fed condition using backward and traditional farming systems. Irrigation system is not fully yet developed. The existing irrigation practice is mainly conducted in the low land areas where by farmers use rain water coming from upland areas to supplement their rain fed crops.

In general, in the special economic zone (Raya Valley) three types of irrigation was identified (spate, reservoir & ground water), which includes 6 area specific irrigation projects such as Mid land spate, Low land spate, Mid land reservoir, Low land reservoir, Mid land ground water and Low land Ground water which were proposed as option for development.

Therefore, using the above available potential 32 irrigation schemes (13 spates, 5 reservoirs and 14 ground waters) it is possible to develop 13,214 ha of land to support 52,910 beneficiaries during the dry season, as well an additional 7,780 ha in wet season.

Table 4.The Available Total Potential Irrigable Land (Spates, Reservoirs and Ground Water) and Beneficiaries in the S.Tigrsay Economic zone

Type of Irrigation Schemes	Low Land			Mid land			Total			Remark
	Area (Ha)	Scheme (No)	Farmer (No)	Area (Ha)	Scheme (No)	Farmer (No)	Area (Ha)	Scheme (No)	Farmer (No)	
Ground Water Development	4246	9	21230	2465	5	12325	6711	14	33555	0.2 Ha/ house hold
Improvement of Spate Irrigation	1098	4	2196	3322	9	6644	4420	13	8940	0.5 Ha/ house hold
Reservoir Irrigation Development	480	1	2400	1603	4	8015	2083	5	10415	0.2 Ha/ house hold
Total	5824	14	25826	7390	18	26984	13214	32	52910	13214 Ha is only during Dry season but additional in wet-season cover to supplement 7780 Ha

Source: Raya Valley Irrigation Agronomy Feasibility Report (REST, 1997)

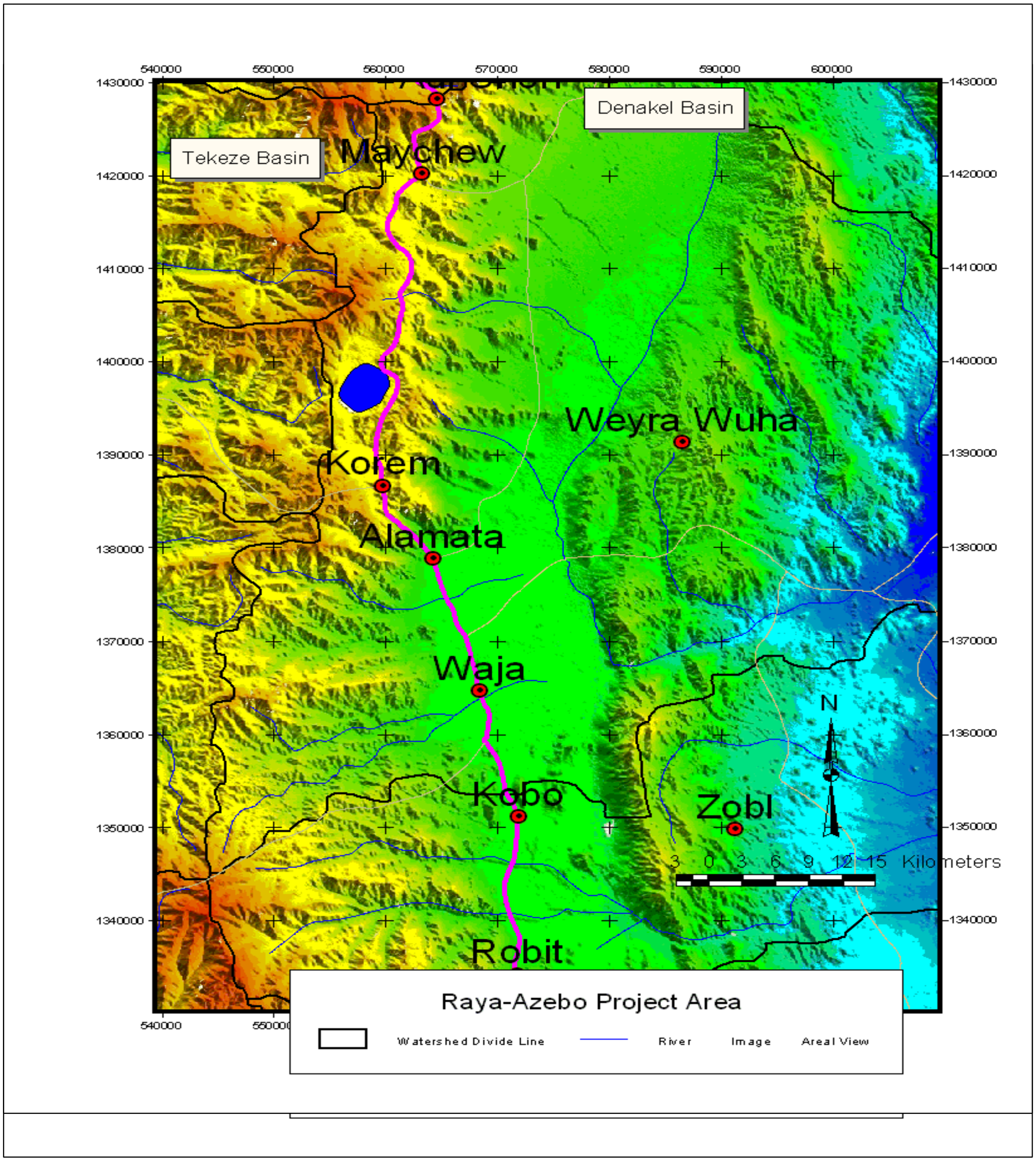

Figure 4.1 Location map of Raya-Valley projected area

Four rivers/creeks flow into the project area beginning from Tekeze basin

Divide line crossing the Robit-Alamata road.

WESTERN TIGRAY SPECIAL ECONOMIC ZONE

1 Introduction

Special economic zone in the western Tigray comprises the Kafta-Humera, Wolkait and Tsegede Woredas. The area has an elevation which ranges from 600-2800 masl. Due to variation in elevation the annual rainfall reaches 1600 mm in the highlands and decreases to 600mm per year in the west part of the Sudanese border.

Tekeze and Angereb rivers are the major surface water potentials that are found in the area. There are also few perennial intermittent streams, which are originating from the area and join the Tekeze and Angereb rivers.

2 Background

2.1 Kafta- Humera

The first study of the Humera area was made by the consultant TAMS, commissioned by the Ministry of Agriculture in the early 1970s. The potential for rain fed agriculture was recognized at that stage and has since been developed to a certain extent. With respect to irrigation development the study was made recently during the Tekeze basin integrated master plan study. The Tekeze River Basin was studied in 1998 at master plan level under the Tekeze River Basin Integrated Master Plan Study Project by NEDECO. The Humera irrigation project was studied at pre-feasibility level during the master plan study.

Based on previous studies in the area, the total area approximately 70,000 ha exists in Humera area, and excluding about 20,000ha which is expected to be unfavorable topography, big natural drainage courses etc. Therefore, gross area of about 50,000 ha can be left for irrigation.

2.2 Wolkayit

The Wolkayit irrigable area was not identified as a potential irrigation site during the Tekeze River Basin Integrated Master Plan Study. However, areas around this project was studied at reconnaissance level in which some parts of the area was considered to be more than 60 % highly suitable and the rest Moderately and marginally suitable for rain fed agriculture

Based on estimates from Global top maps and orthophotos, potential irrigable land of Wolkayit area is approximately 40,000 ha gross.

3 Climate

3.1 Rainfall

The source of rainfall of the Project area is the Tropical Atlantic, which results in the main July-September rainy season (Sileshi .1996). There are two meteorological stations in the project area, the Humera and Adiremetse stations.

The pattern of rainfall is classified as uni-mods, normally occurs from May to October. Due to its or graphic nature, the rainfall generally decreases form East to West. The mean annual rainfall reach about 1300mm in the eastern highlands of Wolkait and Tsegede woredas and Decreases westward where it reaches about 600 mm per year at Humera.

4 Water Resources Potential

4.1 Surface Water Potential

The Western economic zone of Tigray includes Tekeze and Angereb River sub-basins. The Tekeze River flows in deep gorges with a depth of 200-300 meters for most of its length up to the Ethio-Eritrea border. In the last reaches of the river, it comes out Of the gorge and flows in a flatter course. The main tributaries of Tekeze River are Zamra, Tserari Gheba and Won in upper reaches and Zarma, Lama and Sebeta in the lower reaches. The main tributaries of Angereb River are Kaza and Mekezo. The major tributaries of Tekeze, which originates within the economic zone, are: Royan, Zerbabit, Degawakum, ldris, etc. Due to the construction of the Tekeze hydropower dam, the Tekeze River will be fully regulated. The reservoir simulation study of the Tekeze Hydropower project shows that the mean regulated outflow will be minimum of 85 m^3/sec in the month of February to a Maximum of 231 m^3/sec in the month of August. On the average there will be 90m3/sec of regulated water from the dam.

Previous studies conducted in western zone indicate there are about 100,800 ha of potential irrigable land that will be developed by diverting water from Tekeze River at Kafta-Humera and Wolkait. Besides l065ha, 2500 ha and 500 ha of land will be irrigated conventionally and traditionally by different water abstraction methods at Kafta-Humera, Tsegede and Walkait Wereda respectively.

The existing traditional irrigation includes pump diversion, gravity diversion from perennial and intermittent rivers and the using of springs and ground water as sources of irrigation development.

4.2 Ground Water Potential

Several boreholes have been drilled to tap groundwater for supply of the newly established settlement centers. Major urban centers such as Humera, Danash and Baker are getting water from drilled wells. Springs are commonly used in the Wolkite Tesegede high land and escarpment areas. A number of dug well were dug along major river courses such as Kaza. Currently groundwater is used mainly for domestic water supply. The coverage of water supply is, in general, low; a typical example suffering form lack of adequate water supply is Adiremetse town. The groundwater resource development is hampered by absence of detailed groundwater study and financial constraint to develop the resource.

Although many wells were drilled by Tigray Water Development Bureau, Tigray Water Works Construction Enterprise and other private contractors, drilling data have not been compiled, interpreted and converted into meaningful hydro geological information.

Although the Geological Survey of Ethiopia has mapped hydrogeology of Adiremetse sheet at
1:250,000 scale; it doesn't give clear and detailed distinction of the various aquifers that may occur in the area.
In general there exist quite a lot of valuable groundwater data, but not thoroughly interpreted.

5 Development Potential

5.1 Large Scale Irrigation

5.1.1 Humera

Irrigation potential is available in the Humera and Wolkait Woredas However, the water need to be lifted up from the gorges to the plateau from where water can be supplied by gravity. The best site available to lift and divert the water is, on the reaches of the river that bordering Ethiopia and Eritrea. However, because of the current border problem it is not possible to construct off take structure on this river reach. Suitable sites on the river reaches with in Ethiopia require large intervention, which requires further studies and investigations.

5.1.2 Upstream of the Bridge Of Sheraro-Humera Road

The site is located immediately upstream of the bridge on Tekeze near Sheraro. The preliminary studies shows that this site, which is named as Shiraro site, is suitable for construction of a dam up to 150 meter height, The Reservoir water can be lifted either by pump or through tunnel up to the plateau and Then by gravity to Humera. The best option however is to convey water from the reservoir by tunnel. In order to supply water for Wolkait water can be pumped from near to the tail of the reservoir, to the Wolkait irrigable area.

5.1.3 Upstream of the Bridge near Embamdrie

There is possible dam site upstream of the bridge near Embamdrie. The method of abstracting of water from the reservoir is same as above. However this site is too far from the command area, which incurs higher conveyance cost. The Tekeze River Basin Integrated Master Plan Project prepared by the Netherlands Engineering Consultants, Medico, shows the water resource potential of the entire Tekeze basin. The Humera Integrated Agricultural Development study prepared by Alemayehu Mengiste, et al, 1999 has studied the water resource potential of the area and identifies possible water development interventions.
The Feasibility studies conducted for the Tekeze Medium Hydropower

5.1.4 Tekeze at Adi-Mehamedai

This site is located in between the above two identified sites. The abstraction method suitable for site is to lift the water by pump and then to convey the water through open canal, which will be aligned along the ridges. However, the preliminary investigation does not favor this option as the canal involves a lot of cross drainage structures.
The best option among the above three options is the first option, i.e., to construct a dam on Tekeze upstream of the Shiraro bridge which could supply water for both Hurnera and Wolkait

irrigable areas. Further studies focuses on the Shiraro Dam site.

5.2 Small Scale Irrigation Projects

The area considered for irrigation with its traditional and small scale is mostly found along the rivers. Irrigation from the rivers and wells by pumping has a long history in the three woredas. Based on the data obtained from the three study Woredas 992ha, 44ha and 620ha is currently under irrigation in Kafta Humera, Welkait and Tsegede respectively as depicted in the following tables.

The sources of water for irrigation are;

1. Rivers (off-streams and perennials)
2. Ground water (springs)
3. House-hold level water harvesting structures.

Table 1: Potential Irrigable Areas considering water resource availability at various levels with methods of Application

S.no	Wored a	Potential Irrigable Area			Remark
		Small(ha)	Medium(ha)	Large(ha)	
1	Wolkai t	1387	2500	20000	Surface
		2500	4500	20000	Pressurized
2	Tseged e	-------	2500	-------	Surface
		--------	4500	--------	Pressurized
3	Kafta-Humera	4154	2500	53750	Surface
		7500	4500	112750	Pressurized
4	Totol	5541	7500	73750	Surface
		10000	13500	132750	Pressurized

6 Major Problems

Traditional irrigation systems are supplied by pumping, springs and gravity diversion. Besides labor resource and accessibility limitations, the followings are major problems for the prevailing and future irrigation development activities of the three Woredas.

1. Resource limitation mainly water for irrigation except Tekeze regulated flow,
   a. Lack of improved technology
   b. Lack of capacity in utilization and managing the resources
2. Accessibility
3. Labor scarcity
4. Malaria in some parts

7 Recommended Activities for the Coming Years

1. Upgrading the technical capacity of the staffs engaged in the water resources management and utilization Practice.

2. Conduct detail studies and researches on the indicated development options
3. Expansion and intensification of new irrigation development practice by integrating the maximum possible usage of the resources with modern technology.
    - Introduce spate irrigation practice in the foot hill plain areas of the economic zone
    - Introduce pressurized irrigation systems like drip.
4. Upgrading the existing irrigation systems that are managed in the economic zone
    - Improve and upgrade the existing traditional diversion structures.
    - Introduce new water harvesting techniques and upgrade the existing small scale water harvesting techniques.
    - Improve the water management practice currently used by the local farmers

5. Introduce appropriate Ground water recharges techniques and ground water utilizations

PART TWO –WATER SUPPLY

1 Background

In most Eastern and western low lands of Tigray clean and sufficient drinking water is not made available for the larger population of the area, this has made the development efforts difficult and complicated, without supplying sufficient drink water for human and animals of these areas any positive intervention is impossible.

In the past several years there were efforts to address the problem, but, due to a number of problems what have been attained is low, still the water supply coverage of these areas is below regional average, If we see the water coverage some of woredas in these two zones; Endamokone 38%, Alaje 37.72%, Ofla 35.40%, Raya azebo 45%, Kafta humera 32.46%,Wolkayte 20.39% Tsegede 40.09%, and Alamata 53.33%.due to this low drinking water coverage the people and livestock of the area are facing serious problems.

2 Major Problems

Most of the water supply schemes around Raya were constructed before many years. These schemes are in need of major maintenance and rehabilitation works, large percentage of these schemes has become non- functional. In some woredas the figure is as large as 50% of the total. In Kafta humera 52%, Alamata 50%, Wolkayet 24.4% and Raya azebo 8% of the shallow wells are not functional.

- Lack of spare parts, cranes and rehabilitation rigs.
- Lack of skilled technicians
- Poor water management of the community.

- Poor financial and information management of the water committee.
- Less private sector involvement.
- Uncontrolled settlement. /scattered settlement areas and settlement expansion to source areas/
- Contamination hazards from intensive agricultural inputs.

3 Opportunities and Potential

Studies conducted by the Raya valley shows the existence of good ground water potential in most of low land of the area a total exploitable quantity of ground water, the potential is estimated about 130mcm per year, and the boreholes dug for irrigation purpose have verified this. The depth of ground water varies from less than 20m in Waja to 60m in the north part of the project area. In the mid and high land areas there are some potential springs and rivers. According to the classification different water supply schemes have been suggested in the five-year plan.

In this area the local people ability to pay for the service is better than other areas existence of Strong local administration chain up to bottom including water sector representative, Expansion of schools, technical institutes, and health centers.

For western zone studies conducted by concert engineering has indicated the ground water potential in the area, according to this study the geological formation in Humera area are grouped into four hydrological potential classes;

3.1 High potential aquifer consisting of sand stone and alluvial aquifer, in these areas the yield of bore holes in the sand stone is generally grater than 5 l/sec the ground water level is usually 10 to 45m bellow the surface.

3.2 Moderate potential aquifer the lower basalt adjacent to the Wolkaite- Tsegede escarpment with mild slope has moderate ground water potential yield of wells developed in these aquifer is about 1-5 l/sec the ground water level is 6-30m below the surface.

3.3 Low potential aquifer these aquifers occur in the Wolkaite –Tsedede high lands and the surrounding escapement areas, because of its steep and dissected topography, it is considered as low potential aquifer, however locally good potential aquifers can be found.

3.4 Very low potential aquifer This consisting of fractured metamorphic rocks that occur in Tekeze low lands, the depth of fractured aquifer zones is generally not more than 50-70m below the surface.

4 Development Options

4.1 Southern

In Raya low lands deep wells are better than any other options, so more motorized schemes should be constructed to increase the coverage.

In this area large maintenance and rehabilitation work is important.

In Maichew, Alaje, Bora, Ofla high lands shallow boreholes, springs development and pumping river water with small-scale treatment plant can be used.

Multi village water supply schemes can be used in some high potential areas.
Surface and ground community ponds can be used for small villages in the high land areas.
For Schools, Health institutions, and governmental offices roof catchments can be used in the high land and low lands.

4.2 Western

According to several assessments spring development can be practiced in the high lands and drilling borehole is appropriate in the sand stone, basaltic and hard rock aquifer.
In Humera area boreholes can be drilled safely between 70-100m for drinking water use.
Development of aquifer in basement is possible by digging of shallow wells and drilling deeper wells in Tekeze valley, it is possible recommended drilling to depth of 30-70m yield of 0.5-1 l/sec in this area
In the inaccessible areas of wolkaite Tsegede spring development is more appropriate, ponds with small treatment plant can also be used where springs are not available.
Pumping and treating Tekeze river water should be considered as long-term option for Humera and near by towns, since the population is increasing with the new investment and market option.
For Schools, Health institutions, and governmental offices roof catchments can be used in the high land and low lands.

5 Conclusions

- In this hot semi arid areas before any major development activity, clean and sufficient drinking water should be supplied, some towns of these low lands are attractive investment areas, the flow in investment is creating additional water demand, so to make these areas conducive for economic activity the drinking water problem should be addressed primarily in sustainable manner.
- One of the major problems of water supply in these areas is lack of timely maintenance and rehabilitation, in most woredas the number of non-functional schemes is increasing from time to time, unless strong local maintenance crews are formed and the zonal workshops strengthened for these areas the effort to increase drinking water coverage would be meaningless.
- Ground water is scarce resource that should be exploited with care, unless over exploitation could lead to severe disaster, to avoid such disaster recharge mechanisms and water shade development intervention is vital.
- Regular monitoring and regulating system should be in place to monitor the over exploitations of ground water and to avoid contamination hazards.
- Artisans should be trained from the local community.
- Strong operation and maintenance centers should be opened at all levels.
- Community water management training should be given to users.

GROWTH POLE CENTERS AND DEVELOPMENT CORRIDORS IN SNNPR

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Abstract

It is known that starting from the year 1994, the Southern Nations, Nationalities, and People's Region (SNNPR) had started implementation of different development programs. These development programs/interventions had brought significant economic and social changes in the region. Even though encouraging results were achieved in the past, they did not meet the actual development demand of the Regional State/people as a whole.

In order to resolve the above-mentioned problem, serious discussions had been carried out by the Regional Cabinet. The point of discussion mainly focused on how to make maximum utilization of the regional potential and enhance regional as well as national economic growth. After several serious discussions, consensus among members was made on the key existing constraints for development and then solutions were proposed to alleviate those prominent development challenges.

Based on the consensus made by the Regional Cabinet, the direction for implementing activities was stated, complementing the existing national and regional development policies and strategies. The main directions laid down are identifying growth pole centers, areas, zones and corridors. To achieve activities based on the above directions, there was a need to establish the regional steering and technical committees. The steering committee comprised of regional bureau heads (cabinet members), whereas members of the technical committee comprised of experts from the bureaus of Agriculture and Rural Development, Finance and Economic Development, Water Development, Investment Agency, Trade and Industry and Office of the President. After establishing the technical committee, there was a need to provide the tasks and objectives that had to be achieved, and then this was carried out through the steering committee.

Introduction

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The steering committee consists of Regional bureau heads (cabinet members), where as members of the technical committee are experts from bureaus of Agriculture and rural development, Finance and economic development, Water development, Investment agency, trade, industry and Office of the president. After establishing of the technical committee it was a need to give the task and objectives to achieve, and then it was done through the conscious of steering committee.

Objectives

The objectives given to the technical committee were: Identifying regional potentials in spatial dimension, grouping and demarcating those administrative localities (Woreda or Zones) which have similar economic potentials and development constraints based on the similarities of agro ecology, farming systems and other socio economic situations, and then selection of growth pole centers, identification and demarcation of development zones/areas and in the mean time locate development corridors.

Methodology used for the activities that were conducted:

1. Proposed tentative activities, discipline charters, action plans and estimated budget for the committee,
2. Regrouping the committee members according to the proposed activities,
3. Assessing all relevant documents for better accomplishment of the task, and made clear understanding of the job among the committee members. Understanding of terminologies and reviewing literatures were made by group discussion. The best experiences were reviewed from internet, journals and books, were read, fully utilized all relevant basins' master plans, industrial project service study documents, reports brochures other relevant documents from the concerned bureaus and orientation was given to the technical committee on the subject by experienced bodies.
4. Identifying similar potential, opportunities and development constraints in every administrative zones and woredas, based on the data's taken from all relevant basins master plans, and other useful documents,

5. Grouping all similar administrative zones or woredas to one development zone and areas,
6. First briefing of the reached result to the steering committee and regional cabinet already conducted,
7. Identifying growth pole centers based on proposed selection criteria,
8. Second time briefing of the reached result to steering committee and then to regional cabinet was done,
9. Prepared first draft of two volume documents: The first focused on regional potentials, development constraints and the other focused on development zones/areas, growth pole centers and identifying tentative development corridors,
10. Documents were distributed to all relevant stakeholders at the regional and federal levels in order for attaining constructive comments, suggestions, views as well as critiques,
11. Conducted two level workshops: one was done with the representatives of higher officials of all zones and special woredas, the other was conducted with representative from the concerned Ministerial offices, universities, colleges, bureaus and agencies in the region and at federal level.
12. Updating the documents based on the outputs gained from the workshops conducted twice,
13. Prioritization of all development zones based on the proposed criteria was achieved,
14. Identification of development corridors was conducted,
15. Produced final two volume documents in Amharic language,

Volume one: Regional natural and built up resources or potentials and development constraints

It has three main sub sections:

1. Introduction part

This shows the relevance of the study, the main and specific objectives of the study, scope of the study and the methodology how the study is conducted and documents prepared.

2. Features of the region ,

In this sub-section well stated geography, climate, relief, other natural resources, geology, soil, and population, current situation of the region economic and social status.

3. Potentials and Development Constraints of the region,

In this sub section, in each administrative zones and woredas well discussed the their own potentials and development constraints based on the existing valuable documents such as basin based master plans study documents (Omo gibe, Rift valley lakes, Baro okobo, Genale dawa), and other relevant materials.

Volume two: Regional development zones/areas, growth pole centers and corridors

The document has the following chapters:

2. Introduction part
3. Concept on Regional development planning,
4. Alternative choices of development panning and the need for a new type of development planning,

a. The existing development planning procedures,
b. New approach to development planning

5. Development zones/areas, Growth Pole centers, and Development Corridors… definition in the context of the SNNPRS.
   a. Principles and criteria for selection and determination of development zones/areas, Growth pole centers and Development Corridors,
   b. Development zones/areas, Growth poles centers in the SNNPRS,
6. Anchor and supplementary projects in each identified development zones,
7. Description of potentials in each development zones by Woreda,
8. Prioritization of Development zones based on their own endowed natural and human resources,
9. Selection of the three most economically effective and potentially bestowed development zones
10. Identification of three main development corridors, and two sub-ordinates and feeder of the three main.
16. The last briefing were done to the steering committee and the cabinet, and
17. Finally, to start up the program based on the agreement and consensus reached on the workshop held on last May 2007 at Ghion Hotel And also based on the direction given from the MoARD and MoFED and expected financial support to be obtained from the UNDP, estimated budget proposal was submitted to MoFED for the following two essential issues:
    i. For further feasibility study of endowments of the prioritized development zones and related development corridors and
    ii. For translation of the main two main documents to English version.
18. As mentioned above, even though our regional Government has made a significant effort to carry out the above mentioned development program, due to unclear reasons we were not able to get the proposed financial support.

Conclusion

It is believed that growth poles and development corridors type of development strategy with in the focus of spatial development planning can give advantages to impulse the regional as well as the national economy to high level of status.

Growth poles, In the form of attraction it can promote best urban-rural linkages, will be promoting more agricultural products from the development zones to near by pole centers (towns) for further adding values on the agricultural products and prepare for sell as commodities.
The centers apparently seen as the nucleuses of development corridors, and can be connected each other by roads, air ways and other means of communications for interchange both inputs and out puts from or to the areas.
In this regard the SNNPR identified nine development zones among them the

most three are prioritized as high rank zones, 18 growth pole centers and five economical important corridors are highly praised,

And now for the way forward, The SNNPRG look for to have one more further feasibility study on its highly ranked development zones and identified corridors, in this study should be well discussed how to develop those prioritized development zones and identified corridors, the way and how the implementation should be gone will be suggested, how be appear inter regional linkage and national frame work on the issues of "Growth pole and Corridors", how and on what issues be done intra nations (countries) agreement? And the like issues will be proposed for further decisions by the Regional and Federal Government.

The region will go through the above mentioned issues as far as the available finance source is gained. In this aspect if any funds available to support such development initiative, we appreciate it and any one can contact the regional government any time and we will submit projects proposal in return.

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Recent Development of Irrigation and Government Policy

IRRIGATION DEVELOPMENT IN AMHARA REGION AND THE CHALLENGES ON "IRRIGATION AND WATER FOR SUSTAINABLE DEVELOPMENT"

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Abstract

The Amhara National Regional State is known to have a high potential of water and land resources, but people live below the poverty level because these resources are not properly used for food production except in the case where traditional methods are used. Therefore, bringing highly fluctuating water yields as close as possible to a steady state should be one of the major objectives of water resources development. Doing this will allow systematic and steady regional development. 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. As stated in the MoWR 15-year Water Sector Development Program, the 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 chemicals in the water, and depth of groundwater level; the case is true for the region as well. Second, the estimated potential land area available for large- and medium-scale irrigation in the region is about 650,000-700,000 hectares, and for small-scale irrigation it is about 200,000-250,000 hectares (of which less than 10% has been developed). This indicates the magnitude of water and land resources available for development. Based on the potential availability of resources, the overall goal of the National Water Resources Management Policy is to enhance and promote all national efforts towards the efficient, equitable, optimum utilization of the available water resources of the country for significant socioeconomic development on a sustainable basis, of which irrigation development is one.
The extent of regional water use for irrigation is at a rudimentary stage. Modern small-scale irrigation projects constructed by the Government of Ethiopia and NGOs until 2007 are about 197 schemes covering about 16,000 hectares of land area. All these small-scale irrigation projects are using surface water only, i.e., baseflow of streams and harvesting runoff. There is one modern pressurized (drip and sprinkler) irrigation project, Kobo-Girana Valley,

which uses groundwater. The proposal indicates, about the irrigable area, that the potential exists to supply for 3,600 hectares of land; at this time, the installation covers only 250 hectares of land. Irrigation development requires planning, design, construction, and operation and maintenance facilities to control, protect and utilize water efficiently for the economy of the country as well as the well-being of the generation. Institutional instability, less community participation in these processes, poor skills in water management, impacts on the environment, and absence of strong and holistic applicable regulations could be mentioned as important challenges for the region's irrigation development, which is still in its infant stage.

Introduction

The Amhara National Regional State is known with high potential of water and land resources, but the people are suffered from famine year after year because of draught. Even though the reports of last two years indicated that there are increases in crop production and the income of the farmers are increasing, there is still the indication that a single shock of climatic changes affecting the rural people. For instance due to absence of the Belg rainfall in most of Eastern part of the Region there were people affected and are exposed for food support. The main reason for this is the available potential resources are not properly managed and utilized (it is under traditional and extensive system of farming) to play the role in alleviating the paradoxical phenomena of the region. Therefore, to bring highly fluctuating water yield as close as possible to a steady state, should be one of the major objectives of water resources development, since doing so will allow systematic and steady regional development.

The main objective of this paper is to introduce the situation of ANRS irrigation development in relation to management and the impact one upon the other. Hence it comprises the water resource potential, extent of its use for irrigation, challenges and finally conclusions.

2. The Region's water resource potential

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^3 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^2 (*MoWR*, *2003)*.

An indicative point of the wealth of the region's undeveloped water and land 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.

The recharge, in Abbay basin for example, expressed as an average continuous flow ranges between 250 and 300 m^3/s *(BCEOM, 1999).* However, the present boreholes are yielding an average of 5 l/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 $179Mm^3$, 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, Dembia, 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 650,000ha - 700,000ha and for small-scale irrigation is about 200,000 - 250,000ha (of which less than 10% has been developed), indicates the magnitude of water and land resources available for irrigation 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.

Table1. The water resources of basins that the region has major shares

No	River basin	Catchment area (Km^2)	Annual Runoff (Bm^3)	Groundwater (Bm^3)
1	Abbay	199,812	52.6	1.23
2	Tekeze	89,000	7.63	0.18
3	Awash	112,700	4.6	0.13
4	Danakil	74,000	0.86	0.00
Total		**475,512**	**65.69**	**1.54**

Source: ESP, National Water Supply & Sanitation Master Plan Framework, 2003

3. The current government policy and strategies on water resources development

3.1 The Policy

The overall goal of the water resources policy is to enhance and promote all national efforts towards the efficient, equitable optimum utilization of the available water resources of country for significant socio-economic development on sustainable basis *(MoWR).*

The general policies are to:

1. Enhance the integrated and comprehensive management of water resources that avoids fragmented approach.
2. Recognize that water resources development, utilization, protection and conservation go hand in hand and ensure that water supply and sanitation, irrigation and drainage as well as hydraulic structures, watershed management and related activities are integrated and addressed in unison.
3. Recognize water as a scares and vital socio-economic resource and to manage water resources on strategic planning basis with long-term vision and sustainable objectives.
4. Ensure the integration of WRD and utilization with Ethiopia's overall socio-economic development framework and be guided by those socio-economic development objectives at the federal and Regional level of government. Ensure that WRM is compatible and integrated with other natural resources as well as river basin development plans and with the goals of other sectoral developments in health, mines, energy, agriculture, etc.
5. Recognize and adopt the hydrologic boundary or "basin" as the fundamental planning, studies, programmes and development domain.
6. Ensure that all planning, studies, programmes, and development projects in the water sector include protection and conservation, operation and maintenance as well as replacement activities and budgets.
7. Promote and encourage that conservation of existing water systems and efficient utilization of water as feasible at development of new schemes.
8. Promote and advocate for institutional stability and continuity in water resources management and ensure smooth transition during times of change.
9. Promote and enhance traditional and localized water harvesting techniques in view of the advantages provided by the schemes dependence on local resources and indigenous skills.

Specific policy related to institutional framework;

1. Promote appropriate linkage mechanisms for the coordination of

water resources management activities between the Federal and Regional Governments.

2. Establish water resources management institutions for sustainable development and management of the water sector.
3. Avoid or minimize institutional instability in order to maintain sufficiently skilled manpower and as appropriate, to enhance a coherent institutional framework that allows the necessary flexibility and accommodates continuity in times of change.
4. Foster the participation of user communities in water resources management by supporting the establishment of appropriate institutional framework from regional to the lowest administrative structure and promote decentralized management.
5. Establish phase-by-phase Basin Authorities, for efficient, successful and sustainable joint management of the water resources of the basins through concerted efforts of the relevant stakeholders.
6. Put in place conducive situations for the establishment and sustainability of appropriate Federal level agencies for study, design, and engineering and construction supervision.
7. Create conducive environment for the enhancement of linkages and partnership between the Federal and Regional states on the basis of the constitution for the realization of efficient, sustainable and equitable water resources management.

3.2 Strategies

The Regional state establishes the watershed base Integrated Water Resources Management ***(IWRM)*** committee led by the Chief Administrator of the Region at Regional level. This committee is also established up to Kebelle level. The primary objective of IWRM committees is to play role in poverty alleviation campaign in the region by undertaking integrated water resource development based on using local people knowledge, labor, skills and money. However, since 2005 it is not functional as it was planned to work.

The national water sector strategies related to irrigation states that:

- Carry out water resource assessment studies that will undertake inventory of the quality and quantity of available surface & groundwater in time and space;
- Assess and evaluate the existing hydrological and meteorological network, station, and data compilation; standardize observation methods, instruments and procedures for data compilation, processing and analysis and develop data base management;
- Undertake periodic review and updating of the master plans;
- Harvest rainwater through the construction of water harvesting structures to meet domestic water supply and irrigation needs at local level;
- Undertake surveys on the extent of existing water transport facilities and on the future needs for improvement and development;
- Devise and implement demand management measures, such as pricing, improved extension services; public awareness and regulatory measure that improve efficiency and conserve water
- resources;
- Undertake watershed treatment measures that reduces soil erosion and reservoir siltation;

- Encourage and promote local community participation in watershed management and water conservation measures and practices;
- Enforce legislative mechanism and penalties to prevent indiscriminate discharges of toxic materials into water bodies;
- Prevent discharges of industrial effluents without adequate treatment into watercourses and issue regulations to ensure their strict enforcement;
- Asses the impact of disposal systems on local water sources, when the disposal system discharge to the nearest water course such as a stream, river of Lake by carrying out detailed surveys and studies;
- Assess treatment proposals, effluent quality and quantity, in particular from industries and the probable impact on receiving water, raise awareness among managers of industries as how to minimize the effect of industrial wastes on water quality;
- Recycle waste water when it has been found to be safe for health & the environment;
- Promote improvement of environmental sanitation in urban centers
  and rural areas and protect water bodies from being polluted and contaminated.
- Establishing tariff structures for water services based on site specific characteristics of the schemes, and ensure that water price lead projects to full cost recovery based upon users payment capacities and appropriate technologies;
- Establish financial management rules and feasible arrangements of resource allocation, cost sharing and accessing fund for demand driven water supply systems, promote local self financing programs & projects, based on the overall Socio-economic development condition of communities, and through appropriate incentive mechanisms.

4. The Status of Irrigation Development and Management

4.1 Categories of Water Resources use for Irrigation

The water resources of the region are large enough to supply water for different economic sectors. There are four categories of irrigation schemes in Ethiopia, namely, traditional (less than 100ha), modern communal (from 20 to 200ha), modern privet (from 0.5 to 200ha) and public irrigation (greater than 3000ha), *MoWR, 2002*.

4.2 Irrigation

The extent of regional water resources use for irrigation is at rudimentary stage. Modern small-scale irrigation projects constructed by GoE and different NGOs until 2007 are about 197 schemes covering about 16,000ha of land. All these SSIP are using surface water only, i.e., streams base flow and harvesting runoff. There is one modern pressurized (Drip and sprinkler) irrigation project, Kobo-Girana valley, which uses groundwater. The project proposal indicates, about the irrigable area, that the potential could supply for 3600ha of land; at this time the installation covers only 250ha of land.

Currently small-scale irrigation is highly favored by Government as a means of bringing about household food security, reduced dependence on food aid and economic growth. Hence, the traditional irrigation schemes both at communal and household levels are now in a better position from the point of land coverage and having proper ownership. The practice includes diverting small streams and springs, constructing ponds to harvest runoff, and shallow wells. However the coverage and ownership is there, concerning the management practice, it is not yet improved as the practice is still traditional. The inventory conducted in 2004 on irrigation development schemes in the region shows that the overall land coverage of modern irrigation schemes were working below 50% of their planned capacity, *Table2*. The assessment made on sample modern irrigation schemes in November, 2008 indicated that most of them are forced to cover more than the planned area to be covered, i.e., almost doubled. For instance, Sewur, Guanta, were planned to cover respectively ------- ha, but are now covering respectively -------- ha.

Irrigation development in Amhara Region

Table 2 Comparisons between planned and used area of irrigation schemes

Administration Zone	Planned (ha)			Used (ha)			Percentage		
	Dam	**Diver.**	**Total**	**Dam**	**Diver.**	**Total**	**Dam**	**Diver.**	**Total**
N/gonder	130	610	***740***	41.76	248.4	***290***	32	41	***39***
N/shoa	20	1092	***1112***	2.83	774.3	***777***	14	71	***70***
N/wollo	70	2126	***2196***	54.83	1440	***1495***	78	68	***68***
S/Gondar	75	400.5	***476***	0.17	125	***125***	0	31	***26***
S/Wollo	200	1197	***1397***	178.3	677.2	***855***	89	57	***61***
Waghimra	121	148.4	***269***	8.97	24.23	***33.2***	7	16	***12***
Awi	0	1336	***1336***	0	1024	***1024***	0	77	***77***
E/Gojam	0	880	***880***	0	433.4	***433***	0	49	***49***
Oromia	0	580	***580***	0	279.2	***279***	0	48	***48***
W/Gojam	0	1287	***1287***	0	315.5	***316***	0	25	***25***
Total	***616***	***9655***	***10271***	***286.8***	***5341***	***5628***	***47***	***55***	***55***

Source: Amhara region Irrigation Land and water resources Inventory Draft Report, 2004

The draft report for the region's irrigation land and water potential inventory indicates that, until June 2004, from the total 250,000ha irrigable land suitable for small-scale irrigation 76,130ha of land was covered by traditional (*65,859ha*) and modern (*10,271ha*) irrigation practices, *Table 3*. The annual report of Bureau of Agriculture and Rural Development (BoARD) of the year 2007/08 indicated that the total area covered by irrigation including both modern and traditional is about 287,000ha.

Table 3: The number of modern and Traditional SSIP and area coverage by zone of the region up to 2004

Zone	Diversions		Micro earth dams		Modern Total (ha)	Traditional Total (ha)
	No of Schemes	**Command area (ha)**	**No of schemes**	**Command area (ha)**		
N/Gonder	9	610	2	130	***740***	***3356***
S/Gonder	11	401	1	75	***476***	***6142***
N/wollo	14	2126	1	70	***2196***	***7534***
S/Wollo	16	1197	1	200	***1397***	***8002***
N/Shoa	10	1092	1	20	***1112***	***12664***
Waghimra	6	148	2	121	***269***	***182***
Awi	5	1336			***1336***	***13814***
E/Gojam	5	880			***880***	***3493***
W/Gojam	5	1287			***1287***	***8813***
Oromia	7	580			***580***	***1859***
Total	**88**	**9655**	**8**	**616**	***10271***	***65859***

Source: Amhara region Irrigation Land and water resource Inventory Draft Report, 2004

Under the 15 years (2002-2016) Water Sector Development Programme[7] "…a total of 329 small-scale irrigation schemes [totaling 30,461ha and benefiting 46,607 households] are planned to be implemented mainly for the provision of food requirements, another 28 medium- and large-scale irrigation projects [amounting to 228,392ha] are planned to contribute to regional economic growth and poverty alleviation." Koga, Ribb and Megech pump irrigation projects are part of these large-scale projects currently under construction, when completed planned to supply irrigation water for about 7,000ha, 14,290ha, and 5300ha of land respectively. Gilgel Abay, Jemma and Gummara are under study and design stage.

5. Challenges of Irrigation sub sector

Water resource development requires planning, design, construction, operation and maintenance facilities to control, protect and utilize water efficiently for the economy of the country as well as the well-being of generation. Irrigation sub-sector is one the most important sector for the region with unreliable rainfall and the water resources development is not led in well organized system.

Institutional instability, less participation of community, poor skill of water management impacts on environment and absence of strong and applicable regulation could be mentioned as important challenges for the irrigation development of the region stay at infant stage.

5.1 The Challenge of Institutional Instability

Avoiding institutional instability is considered as part of strategy of national

[7] *MoWR, Water Sector Development Program (2002-2016), Irrigation Development Program part II*

water management to achieve the growth. However the region is experiencing frequent restructuring and reorganization without studying the existing and the future conditions is a challenge of water resources development and managements especially irrigation sub-sector. The most important effects are; lack of coordination of various stakeholders in the irrigation and other sectors activities, inconsistency of irrigation development and related resources data so that no coordination for proper data collection and distribution, capacity limitations to implement and manage the irrigation development, lack of enabling environment to undertake integrated irrigation schemes management, and frequent skilled manpower turnover is the result of restructuring and reorganization. Besides, it affects the design and construction quality, and management of the schemes after handing over to the beneficiaries are poor resulting with less return in production as the professionals are less experience due to turnover.

In the region since the time of irrigation sub-sector started to implement, there are about five restructuring. The first was under Ministry of Agriculture (after delegated) irrigation development Team, which was responsible at for construction of irrigation schemes after the design is completed at Federal level, next it is replaced by the same Team under Natural Resources and Environmental protection Bureau for a single year. Thirdly well organized and functions for Ten years, Co-SAERAR. This institution was responsible for study, design and construction and to some extent for the establishment of irrigation water users association of completed schemes. Due to this suitable institutional set up the region is become to do the design and construction work by its own staffs. Next to Co-SAERAR, the irrigation development division under Bureau of Water Resources Development (BoWRD) was established by proclamation. But most of the staffs from Co-SAERAR were not willing to go with the new institution (BoWRD). However there are better efforts to improve the skill of experts through short term and on-the-job trainings with the support of different foreign organizations like SWHISA, the design work become poor in quality and amount. After the new principle is emerged to reengineer the institutions throughout the country accordingly at regional level, the irrigation sub-sector is reorganized in better condition that can contribute more for the improvement of irrigation schemes. The organization is structured in such a way that it can include all activities of irrigation from the need identification, study, design, supervise the construction, IWUAs establishment and up to management. However this is suffering from lack of well experienced experts and unstable institutional capacity.

In all of these, being the irrigation sub-sector is by large important for the country's economic growth through the development of agricultural sector development, there was no chance given to the sub-sector so that organized as independent as it is in other sectors.

5.2 The Challenge of Poor Participatory Approach and Lack of Skilled Manpower

Participation of community at every level of water and other economic sectors development and management activities is the most important to have sustainable economic development. The existing improvement of the region irrigation development, due to lack of participatory approach, is at very low level; hence it is a challenging issue for the sub-sector.

As Gashaye mentioned for one of the Region's old irrigation schemes called Geray, the number of beneficiary households that own irrigable land was 790 out of which 400 of them were members of the WUA and the rest 390 are not members. In the irrigation project, there is no any rule or restriction on the farmers about what type of crop to produce. Any individual farmer has the right to choose what type of crop to produce as long as s/he feels that the crop is profitable, household consumable and that the water allocation is adequate to produce the selected crop.

Continuing the discussion on the findings on the canals and related structures, majority of the drop and other canal structures were not well functional. There were a number of illegal water abstraction points and canal breaching. The secondary and tertiary canals' water was partly flowing through the canal and partly out of the canal since the embankment was not functional. Majority of the tertiary canals which did not correspond to the currently distributed land boundaries were not in operation. At the research time the amount of area being irrigated was less than 50% (215 ha out of 454 ha) land that would have been irrigated. This is generally absence of ownership and the result of poor participation from the beginning to the end. Had that no be the case, after some discussion made with the beneficiaries, would not change their attitude after cleaning the sediment deposited in the pond for long times which affects the capacity of water. The beneficiaries were concluded that there is shortage of water so that need not continue producing on the whole of the irrigable area due to there is no sufficient water for the crops at critical seasons.
In other observations, absence of ownership on the schemes, lack of irrigation system services, lack of implementation of water management regulation and insufficient farmer training are important factors that undermine successfulness and sustainability of SSIP. For instance; on most modern SSI projects farmers at the upstream are practicing irrigation by covering area of land out of the designed command area in dry season allowing downstream beneficiaries to grow crops with deficit moisture, *Figure 1;* and on the other hand because of selfishness and/or lack of knowledge about efficient water utilization, water logging problems are observed, which could result in abandoning the farmlands with in the command or out of the command area, *Figure 2.* The effect of both poor management activities reflected directly on crop yield reduction and quality, *Figure3.* Since irrigation schemes are working under inefficient and ineffective condition, their contribution to the food self-sufficiency as well as economic growth of the region is forced to be insignificant.

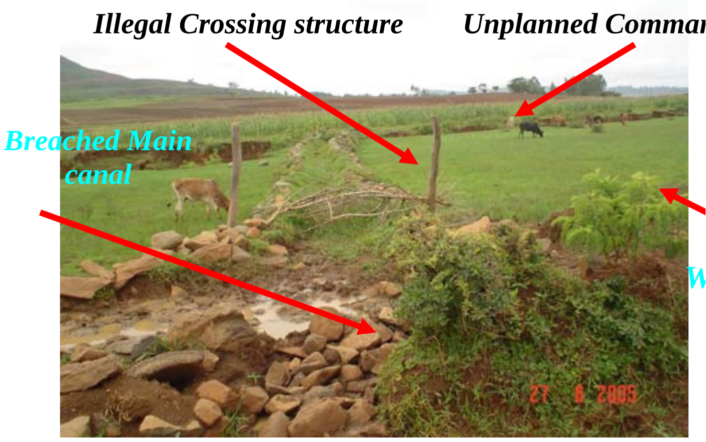

Figure1: Jedeb SSIP, Breached Canal and Diverted Water to the Unplanned Land

In addition water born diseases favored by the swampy farmlands and poorly managed canals, *Figure 2.* Although farmer-training centers established in all Peasant Associations, they have few teaching aids and there is no organized training and closed supervision on the irrigation schemes. Most of the woreda experts and Development Agents who are assigned in the water resources team of the woreda Agriculture and Rural development offices and around irrigation projects respectively do not have irrigation management background and most woredas do not have even appropriate experts. This may account in part for no irrigation water management activities are very common in all SSI schemes of the region.

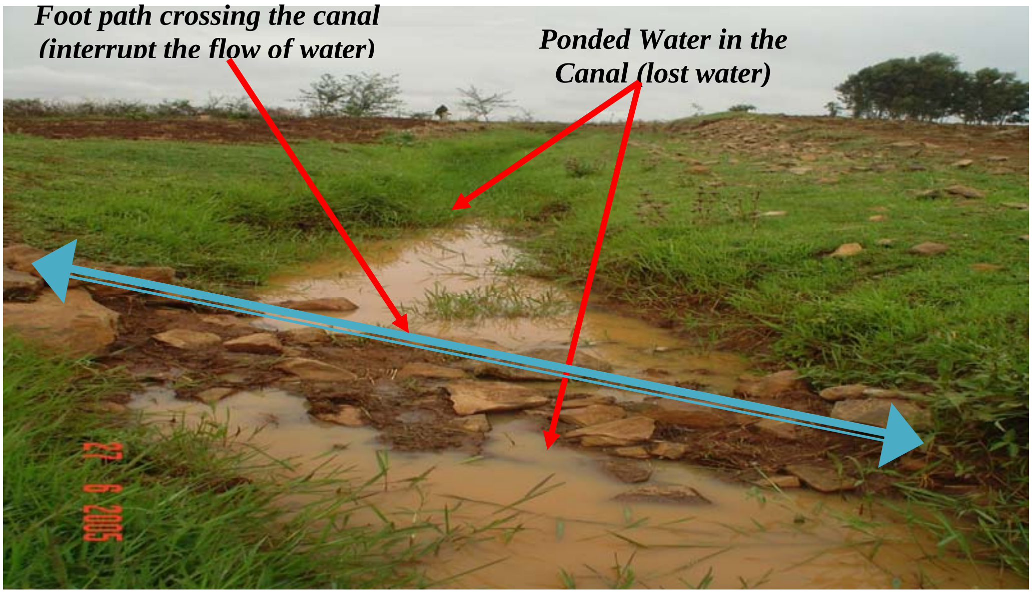

Figure 2: Jedeb SSIP Existing Condition of MC

On account of the surplus of management and technical problems, the predicted crop yields and economic returns expected from the irrigation schemes are not yet materializing in full. Successive reports have been showing that progress is being measured primarily by the area of land covered by irrigation, rather than by the extent to which farmers make effective use of irrigated land and the consistency and sustainability of the irrigation system put in place and increase yield per unit area. The effect of poor water management on potato for example can be observed from the pictures in *Figure 3*.

Figure 3: potatoes with high level of different problems from poor irrigation water management (Baiyel, 1990)

5.3 The Challenge of Poor Watershed Treatment

Better utilization of water resources for different purposes requires constructions of structures that can control the water flow effectively. The main structure is often the headwork (in the case to control the flow of water along the rivers) that divides the environment into upstream side including; catchment, reservoir and the dams or diversion structures and the downstream side including; the command area and water distribution system.

However the region's water resources are adequate, utilization of the resources as to their respective benefits is at lower stage. If there are few, they are not in the condition to provide the expected productions.

The challenges of irrigation development activities lie with in the upstream or downstream or both environments. In irrigation schemes using run-of-river diversions or small dams, upstream or up-slope soil erosion is a major hazard, rapidly blocking intakes, filling reservoirs, and silting up canals. These problems could be mentioned as some causes for low level of benefit from the high water and land potential resources of the region. Of all micro earth dams constructed in the region at this time Zana-1 and Bati (Bira) MED outlets are blocked by sediments and no water is able to supply for irrigation. In the contrary alike the beginning of project life, the beneficiaries are more understand the importance of irrigation development now but no water is coming from the dams.

The region's agricultural soils have suffered from generations of erosion and degradation ("nutrient mining"), it is agreed that the main causes of sedimentation problem. The former is obvious in visible gully-and sheet-erosion, and the omnipresent "chocolate rivers", *Figure 3*, while the latter is evidenced in stagnant or declining crop yields (*Richard CC & Danert, 2004*).

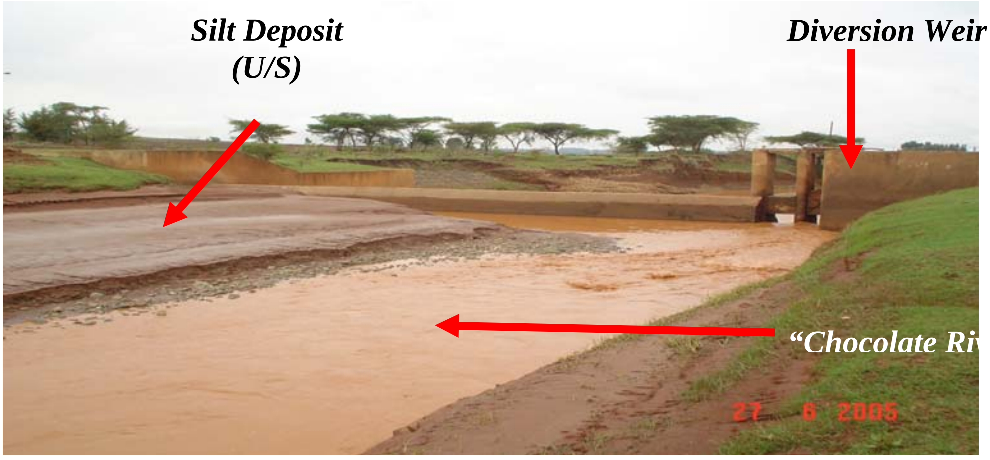

Figure 4: One of the region's heavily silt-laden (Jedeb)

The actual soil losses because of erosion in a basin are difficult to estimate. But based on a review of the literature supported by stream sediment data (assuming a 10% annual delivery rate to the stream) it is estimated that an average of at least 100t/ha/yr is being eroded from cultivated fields *(BCEOM, 1999)*. The effect of soil erosion is three fold; first every drops of rainfall on the catchments instead of infiltrate into the soil and keep soil moisture rich or after deep percolation recharge groundwater will be lost being runoff; second after high soil erosion land become out of production; and third the eroded soil is transported and redeposit in to natural and/or manmade reservoirs resulting on shortening the service life of manmade structures and affect the capacity and aquatic life of natural reservoirs.

For this reason in the processes of irrigation projects planning, study and design (especially for micro earth dams) practices, estimation of sediment load was considered as one component of the study. However, some of the projects are facing problem of sedimentation. Therefore, for the irrigation development to play role in the region's as well as the country's economy, searching solutions for the identified problems (the problem may be from estimation, or the formula used to estimate or lack of catchment treatment, or the designers decisions on the dam and structures in relation to the estimated values of sediment load) is very essential. Besides, most of the region's rivers, springs, and boreholes flow are declining from time to time resulting shortage of water for domestic water supply and irrigation. The main reason, even though not further investigation was undertaken, could be linked to deforestations, over grazing and inappropriate farming practices that generally lead to increase the flood in the watersheds.

5.4. Challenges of Inadequate Implementation of Water Resources Management Regulation

Concerning the overall goal of the Water Resources development and management strategy it is stated as there will be enhancement and promotion of all national efforts towards the efficient, equitable and optimum utilization of the available water resources of the country for significant socio-economic development on a sustainable basis. It is well articulated in this aspect; based on this the development part implementation is going relatively in good statues as the development for irrigation, water supply, and hydropowers are on the truck. However, any development with out effective management would not result the set objective, as in the water strategy, "… towards the efficient, equitable and optimum utilization of the available water resources".

The management of irrigation sub-sector will reinforced by the implementation of established regulations, however not yet touched. The main reasons for this might be due to the regulation it self is not well articulated in such a way that it can address the country situations. The articles in the regulation are on the water resources utilized after permits, but in reality use after permit are not in place except for the "packed water". The real understanding of water, by the rural people using for irrigation, is not as economic good rather is considered as social good. Hence, there is no room to bring efficient utilizations, dispute resolutions between up stream and down stream users, and with in the scheme it self. This may be effective first by creating the knowledge about the water management policy, strategy and regulations, second by establishing proper water users associations.

Regulation No. 115/2005 in relation to irrigation management especially for the establishment of Water Users Association (WUA), "Water User's Cooperative Societies (WUCS)" is included. Part Seven, Article-29, Sub-Articles 1-3 states that registration of WUA (WUCS) for medium and large scale irrigation and for small scale irrigation schemes shall be the responsibility of the 'Supervising body' called Ministry of water resources and an 'organ established by law at regional or city administration level' respectively. Irrigation schemes at this time are not functioning properly, so that the yield expected from them is not achieved. The problems related to this are first the farmers are not fully owner as the established institutions are not proper that allow all the beneficiaries be member of the institutions; second, may be continuation to the first, the operation and maintenance is not properly managed as the beneficiaries are not consider the schemes their own property. These are with small scale irrigation schemes but in the case of medium and large scales, however they are soon to start functioning at small holders' level in the region, the responsibility to register is for the 'Supervising body'. In practice even this body is not ready to handle this responsibility.

Considering the above challenges the region, through the study of Business Reengineering Process, able to establish an institution with responsibility to handle the whole aspects related to irrigation be it small or medium or large, *Figure 5* shows the structural arrangement.

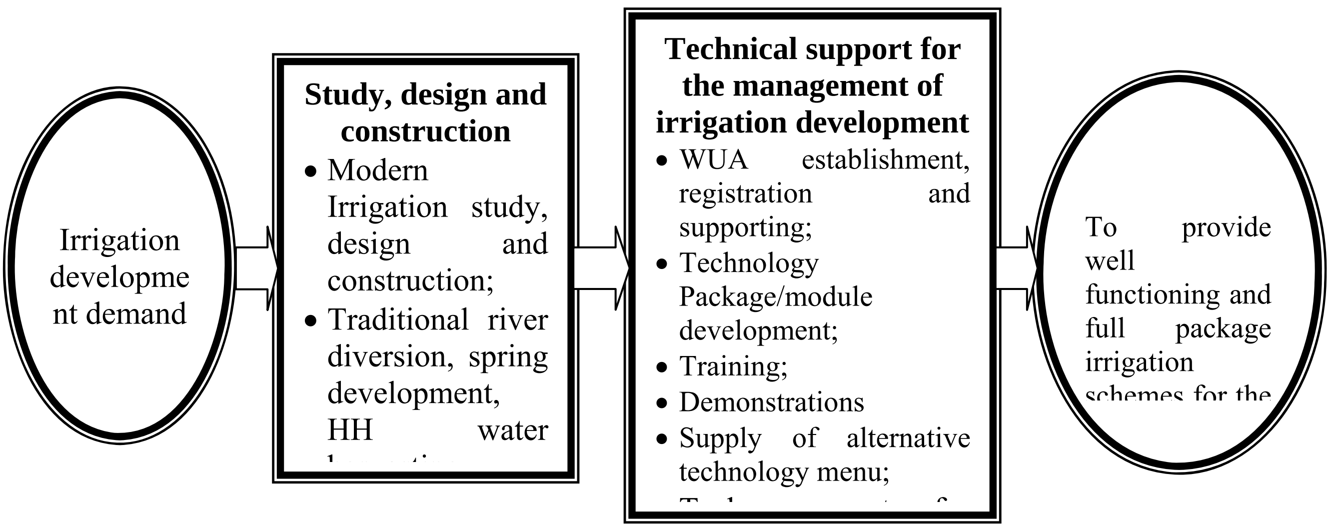

Figure 5: Irrigation and Drainage Development Process of the Region

6. Conclusions

The potential of water resource to be used for different purposes is available in the region either in the form of surface or subsurface water. The total estimated annual renewable potential of surface water is about 35Bm3 fresh water. Although no comprehensive survey of groundwater resource has been undertaken, observations show that the presence of considerable potential of shallow groundwater in the region alluvial deposits of flood plains; such as Fogera, Kobo-Girana, Borkena and Chefa plains. The region is not only the owner of water potential; also it is owner of the enormous amount of cultivable land using either irrigation or rain fed.

The existing country water resources management policy and strategies are good indicatives that the government is focusing on the use of these rich resources for the country's economic development.

However, the extent of the region's water resources use for irrigation is at rudimentary stage. Modern small-scale irrigation projects constructed by GoE and different NGOs until 2007 are about 197 schemes covering about 16,000ha of land and the traditional irrigation covers about 250,000ha. All these modern SSIP are using surface water only and some traditional irrigations use water from shallow groundwater. The traditional irrigation practices both at communal and household levels are now in a better position with respect to land coverage and having ownership. The practice includes diverting small streams and springs, constructing ponds to harvest runoff, and shallow wells.

Factors that hamper the region's irrigation development include; institutional instability, less community participation, lack of water management skill, environmental degradation and inadequate implementation of water management regulations. To overcome the challenges and then control, protect and utilize water efficiently for the economy of the country as well as the well-being of generation; irrigation development requires fulfillment of planning, design, construction, and operation and maintenance facilities. These are realized mainly by the establishment of suitable and sustainable institution for the irrigation sub-sector and integration among institutions for different activities to bring complementary effect.

The existing situation of the region's irrigation schemes management, due to lack of participatory approach at each level, is very low; hence it is a challenging issue of the sector. According to the recent observations absence of ownership on modern irrigation schemes, lack of irrigation system services and insufficient farmer training is an important factor undermining successfulness and sustainability of SSIP. The result of lack of ownership and management skill is less irrigation efficiency (below 40%), therefore the production and quality of crop yield is highly affected.

The effects of poor watershed management are; every drops of rainfall will be changed into runoff, insufficient groundwater recharging, land become out of production because of loss of fertility, and the eroded soil is transported and redeposit in the reservoirs resulting on shortening their service life. Therefore, for the water resource development activity to play better role on the regional as well as the country's economy, seeking solutions for the identified problems is very essential.

In conclusion, for the above mentioned challenges to be solved practicing well organised and integrated water resources management is essential. The focus areas to improve irrigation management practices could be;

Establishing functional institution with clear duties and responsibilities up to kebelle level, so that could work together with the concerned organisations, and allow the organisation to work at least one strategic plan season (five years), the existing irrigation and drainage development process is good example;

Create clear understanding on the regulations of water resources management and properly implement, delegate the regional line institutions;

To undertake research on the watershed of existing irrigation schemes, water user's associations, and water management practices in the command areas, and

To conduct demonstrations in the appropriate irrigation command areas by assigning well trained and sufficient expertise at Woreda and kebelle level.

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STRATEGIES AND IRRIGATION DEVELOPMENT POTENTIAL AND EXISTING CHALLENGES IN TIGRAY REGIONAL STATE

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Abstract

The State of Tigray is located in the northern part of Ethiopia, has an estimated area of 56,000 square kilometers (km^2), and has an estimated total population of 4,334,996, of which 3,519,000 (or 81.2%) are estimated to be rural areas dependent on subsistence agriculture, while 816,000 (or 18.8%) are urban areas.

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Tigray Regional State is relatively dry, and the distribution and availability of water is erratic in both space and time. Hence, despite abundance in some parts of the Region, it is highly water scarce due to lack of water control infrastructure. The problem of water scarcity in the region is attributed to either low rainfall availability or an uneven distribution of water throughout the crop-growing season or a combination of both. This makes rain-fed agriculture risky or unreliable. Use of untapped sources of water for irrigation is, therefore, mandatory to increase agricultural productivity and provide a sustained or reliable economic base. This is to be realized through the adoption of different water harvesting techniques.

1. Introduction

The state of Tigray Region has an estimated area of 56,000 km^2 and has an estimated total population of 4,334,996, of which 3,519,000 or 81.2 percent of the population are estimated to be rural areas depending on subsistence agriculture, while 816,000 or 18.8 percent are urban (CSA 2005).

Though Agriculture is the dominant sector, most of the Tigray Region cultivated land is under rain fed agriculture. Due to lack of water storage and large spatial and temporal variations in rainfall, there is no enough water for most farmers to produce more than one crop per year and hence there are frequent crop failures due to dry spells and droughts which have resulted in a chronic food shortage currently facing the region as well as the country.

Tigray has an extremely varied topography. The complex geological nature that began millions of years ago and continues, accentuates the unevenness of the surface; a highland complex of mountains and bisected plate aux characterizes the landscape. Interspersed with the landscape are higher mountain ranges and cratered cones.

2. Strategies and Irrigation Development of Tigray Region

Irrigation is the means by which agricultural production can be increased to meet the growing demands, to the Region for reliable and sustainable by food security. Irrigation development is expanding through various scales as small, medium & large scales, through construction of dams, water harvesting structures, river diversions, etc.

2.1 Five Year Strategy Plan of the Region

Tigray Regional state is relatively dry, and the distribution and availability of water is erratic both in space and time. Hence, despite abundance in some parts of the Region is highly water-scarce due to lack of water control infrastructure. The problem of water-scarce in the region is attributed to either low rainfall amount or uneven distribution throughout the crop growing season or a combination of both. This makes rain-fed agriculture a risky or non-reliable therefore to increase agricultural productivity and provide reliable economic base, the Government of Tigray National Regional State Water Resources, Mines and Energy bureau has a five year Irrigation development strategy plan and the region is designing a better strategy plan for the Agricultural sector for Irrigation development

2.1.1 Assessment of Potential Irrigable Land from Preliminary Studies

A desk work is made to estimate the available potential irrigable area in the region. This does not include the large scale projects which are included in the 5 year irrigation development plan of the Ministry of Water Resources (MOWR)

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Table 1: Summary of potential irrigable land

S. No.	Estimated Potential Command area (ha)	No of Identified Schemes	Total Estimated Commendable area (ha)	Remarks
1	<100	23	1610	
2	100 - 200	5 - 8	750	
3	200 - 300	3 - 5	750	
4	300 - 400	3 - 4	1050	
5	400 - 500	5	2250	
6	> 500	10	10,000	
Sum		**49-55**	**16,410**	

2.1.1.1 By Tigray region water Resources Mines and Energy Bureau and Woreda (Own Force)

Schemes with a command area of less than 350 ha are considered to be implemented by own force.

Table 2: Five year Implementation plan (own force)

S.N	Year	Study & design			Construction		
		No. of SD Teams	No. of Schemes	Command area (ha)	No. of Schemes	Command area (ha)	Remark
0	2005/2006	2	2	140	-	-	
1	2006/2007	4	6	420	2	200	2 dams, 2 diversions, 3 spate
2	2007/2008	5	7	810	5	350	5 dams of 70 ha each + 1 spate + 2 diversion
3	2008/2009	5	5	950	6	740	**4 DAMS 50 HA EACH,** **2 DAMS 70 HA EACH**
4	2009/2010	5	5	1450	5	950	2 dams 250 ha each, 3 dams 50 ha each
5	2010/2011	5	5	2050	5	1450	2 dams 350 ha each, 3 dams 250 ha each
Sum			30	5820	25	3690	750ha spate supplementary Irrigation
Five year Implementation plan by Wored (own force)							
Pump				1360			
River diversion				1190			
Hand dug well				4250			
Sum				6800			
Total sum own force				12620			

Note: Out of the 30 schemes (5820 ha commendable area) studied, 23 dams and river diversions, which have a commendable area of 3690 ha, in addition to this 1190ha will be constructed at woreda level in river diversion.

Projects executed by Consultants & Contractors (out Source)

Relatively larger schemes with a command area of more than 350 ha are considered to be implemented by hiring consultants and contractors

Table 3: Projects expected to be implemented by consultants (out source)

Year		Study & Design		Construction		Remark
		Schemes	**Command area (ha)**	**No. of Schemes**	**Command area (ha)**	
1	2007	Suluh Hangoda	850 350	-	-	
2	2008	Edaga Hamus Kokay	1900 350	-	-	
3	2009	Debri Chelekot	1900 1000	2	1200	
4	2010	Womberta Kuen	780 500	2	2250	
5	2011	Adi-Atai	500	2	2900	
		9	8130	6	6350	

Note:

- ✓ Schemes studied in a particular specific year will be constructed one year after the following year. The following year is considered as a completion period for the studies and for the preparation of bid documents.
- ✓ 9 schemes with a command area of 8130ha will be studied
- ✓ 6 schemes with a command area of 6350 ha will be constructed.
- ✓ It should be kept in mind that some schemes may be dropped at the reconnaissance or feasibility level study due to social, technical or financial reasons or a combination of two or more of them. To compensate such sites, new sites will be identified in the North Western & Western as well as central zones where relatively better potential is expected in terms of:
  - ➢ Land & water availability (higher rainfall amount)
  - ➢ Better vegetation cover ∗ less risk of sedimentation
  - ➢ And so on

Table 4: Implementation Schedule of out source projects

S.No	Scheme	Activity	Year 2006	2007	2008	2009	2010	2011
1	Suluh-7(850) Hangoda (350)	➢ TOR preparation & bidding (study)	═══					
		➢ Study & design		═══	═══			
		➢ TOR preparation & bidding (const.)			═══	═══		
		➢ Construction				═══	═══	═══
2	Edaga Hamus (1900) & Kokay (350)	➢ TOR preparation & bidding		═══	═══			
		➢ Study & design			═══	═══		
		➢ TOR preparation & bidding				═══	═══	
		➢ Construction					═══	═══
3	Debri(1900), Chelekot (1000)	➢ TOR preparation & bidding			═══	═══		
		➢ Study & design				═══	═══	
		➢ TOR preparation & bidding					═══	═══
		➢ Construction						═══
4	Womberta (780) Kuen (500)	➢ TOR & bidding				═══	═══	
		➢ Study & design					═══	═══
		➢ TOR preparation & bidding					═══	═══
5	Adi-Atai (500)	➢ TOR preparation & bidding					═══	═══
		➢ Study & design					═══	═══

Note: 1. as shown above, the construction of Debri and Chelekot schemes will not be completed within the plan period (2011) but continues to the year 2012.

2. The construction of the other 3 schemes, i.e. Womberta, Kuen and Adi-Atai will not be commenced within the plan period.

Projects which are expected to be executed by Federal Government (MoWR)

In principle, implementation of **medium** (200-3000 ha) and **large** (> 3000 ha) scale projects is the mandate of the Federal MoWR. It is only to accelerate the pace of development that the region is planning to implement some schemes which fall in the range of medium scale projects with the involvement of consultants. It is, therefore, believed that the regional government shall convince the MoWR to include the **five medium scale and three large scale projects.** These are indicated in table 5.

Table 5: Projects expected to be implemented by the MoWR

S.No	Scheme	Command area (ha)	Remark
1	Dedebit	10,000	Tekeze River
2	Hadush Adi	2,500	Mereb River (Rama)
3	Tsahlo	4,000	Agulae River
4	Gasat	2,000	Giba River
5	Indaselassie	4,500	Giba River
Sum total		**23,000**	
1	Humera	42,965	Tekeze River
2	Mezega (Dedebit)	30,000	Tekeze River
3	Raya Valley	18,000	Groundwater
Sum total		**90,965**	
Grand total		**113,965**	

Note: In case the MoWR is not able to include these schemes in his 5-year plan, the region will assess other options to implement by its own.

2.2. Schemes Implemented by local NGOs

The major NGO involved in irrigation works in the region is REST. Catholic Church, Orthodox Church and World Vision are also involved in irrigation in some specific woredas. The 5-year plan of REST is given in the following table-6. The contribution of the other NGOs is not significant and can be considered in the woredas plan.

Table 6: Projects to be implemented by local NGOs

S.No	Intervention	No of schemes	Command area (ha)	Remark
1	***Full Irrigation***			
	➢ Micro-dam	38	850	
	➢ River diversion	22	200	
	➢ Percolation dam	4	20	
	➢ Pump irrigation	32	192	
	➢ Spring devt	51	76.5	
	➢ Hand-dug well with drip irrigation			
	• Household (0.05ha)	3325	166.25	
	• Communal (5-8ha)	50	300	
	• Communal (8-12ha)	28	280	
	• Check dam	18	270	
	Sum		**2354.75**	
2	Supplementary irrigation			
	➢ Small community pond	62	30	
	➢ Spate irrigation	13	315	
	➢ Underground tanker	2898	115.92	
	Sum		**460.92**	

Table 7: 5-Year Indicative Irrigation Development Plan Summary (Target in Hectares)

Type of intervention	Study & Design					Construction					
	Own force	**Consultant**	**MOWR**	**Woreda**	**Total**	**Own force**	**Contractor**	**MOWR**	**Woreda**	**REST**	**Total**
1. Full Season Irrigation											
Dam	5820	8130	113,965	-	127,915	3,690	6,350	113,965	-	850	124,005
Pump	-	5800	-	1360	7,160	-	5,800	-	1,360	192	6,100
G.water	-	375	-	-	375	-	375	-	-	-	375
R. Diversion	60	-	-	1190	1,250	60	-	-	1,190	200	1,450
Hand dug well	-	-	-	4250	4,250	-	-	-	4,250	746	4,996
Spring Dev't	-	-	-	-	-	-	-	-	-	76	76
Check Dam	-	-	-	-	-	-	-	-	-	270	270
Percolation Dam	-	-	-	-	-	-	-	-	-	20	20
Sum	**5,880**	**14,305**	**113,965**	**6800**	**140,950**	**3,750**	**12,525**	**113,965**	**6,800**	**2,469**	**138,334**
2. Supplementary Irrigation											
Spate Irrigation	750	-	-	-	750	750	-	-	-	315	1,065
Underground tanker	-	-	-	-	-	-	-	-	-	115	115
Sum	**750**	-	-	-	**750**	**750**	-	-	-	**430**	**1,180**
2011											

3. Challenges of the Region

In general the Region has the following challenges in order to achieve the five year strategy plan by taking the corrective measure of the following Challenges

- Lack of Financial Investment or budget constraints
- Lack of climatology data's
- Lack of Water Resources master plan
- Sedimentation problem due to land degradation
- Capacity limitation in skill professionals
- Lack of strong Integration between stack holders
- Due to improper management of water resources development

3.1 Lack of Financial Investment or budget constraints

One of the critical problems in the Region particularly in the sector is lack of adequate budget for implementation of projects, many project profiles have been strived due to lack of finance. Most of the time the bureau studied and designed projects in different localities of the region with out securing sufficient capital budget but in order to struggle famine and hunger financial budget is the crucial on to solve the problem.

3.2 Lack of climatology data's

The climatologic data has not enough coverage in quantity and quality through out the Region. At present, some surface water and meteorological data are collected and processed on a regular basis through existing hydro-meteorological networks stations.

3.3 Lack of Water Resource master plan

The optimum utilization of available water resource is the Water resource master plan due to lack of this the region face a problem to not use this master plan. . But, it is desirable that all major river basins in Ethiopia have an integrated development master plan study in national way only and their potential in terms of economic development be known.

3.4 Sedimentation problem due to land degradation

In Tigray Regional State the highly aggravation of degradation of the natural resource have aggravated the incidence of poverty and food insecurity by reducing fertility of the soil and increase sediment load in construction of dams in general especially in highly exposed areas of the highlands coupled with climate variability have aggravated the frequency of poverty and food insecurity.

3.5 Capacity Limitation in skill professionals

Currently the implementation capacity of the region (study and design as well as construction) is very low, particularly in terms of medium and large scale schemes.

So to execute the planned tasks, the first action to be taken shall be to strengthen the Study & Design as well as Construction Capacities in terms of professional manpower as well as machinery and equipment.

3.6 Lack of strong Integration between stack holders

Development effort will not be successful with out strong information with stake holders, all partners and stake holders should work together, if the project ideas are to be materialized, financial, material and human resources of this stake holder's integration is important, but, that is not the case when we look into the real projects around. Most stake holders role is limited to inactive participation during planning and implementation this lack of integration has led to unsuccessful project implementation most of the time.

Due to Improper management of Water resource development

Water management is one of the basic requirements for Irrigation development, to use water resource efficiently, for this crucial issue to manage the resource of the Region as well as the country water management is the important one to make decisions also.

Water resources management for agriculture includes both support for sustainable production in rain-fed agriculture and irrigation and should be soil protection and maintaining soil fertility.

4. Conclusions

This workshop makes awareness to all stack holders the Regional States, NGO's, and the Governmental officials. If we have Water Resources master plan, availability of climatology data's, availabilities of previous studies, Skill of professionals and financial capital investment every body distinguish that Irrigation development is the back bone of the country economy to reduce famine and poverty.

Based on the above affirmation the five year strategy plan coverage will be increase from 7 percent to 43.4 percent in Irrigation development sector.

Experience and Impact of Irrigation in Ethiopia

INVENTORY, SUITABILITY ASSESSMENT, AND UPSCALING OF BEST AGRICULTURAL WATER MANAGEMENT PRACTICES

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Abstract

It is the belief of many analysts that agrarian countries like Ethiopia that depend on rain-fed agriculture are significantly vulnerable to rainfall variability, the risk which tends to aggravate with global climate change. Consequently, it is believed that future increases in food supplies and economic prosperity depend heavily on effective agricultural water management. It is with this in mind that the use of low-cost technologies for rainwater and runoff control, storage, water lifting, conveyance and application have become more widespread in Ethiopia since the recent drought of 2002/2003. A range of technologies are currently used with varying levels of impacts. This paper outlines an inventory, characterization, suitability and upscaling aspects of Agricultural Water Management Technologies (AWMT) in Ethiopia. Particular characteristics of each of the technologies, their suitability for a given environment, and the necessary conditions for their successful adoption and scaling up are identified. Furthermore, a variety of combinations of technologies used for control or storage, lifting, conveyance and application of rainwater are documented. Suitability of a technology in a particular environment depends on many factors, such as, the nature of technical complexity, the existing institutional and individual capacity to implement, the costs and benefits, etc. Technical considerations include implementation (set up), operation and maintenance, affordability and environmental impact. The results of a ranking exercise of the technical complexity of a given technology are presented. Concerns related to waterborne and water-related diseases due to stagnation, water quality and possibility of mosquito breeding are discussed.

Households in some parts of Ethiopia, who have practiced improved agricultural water management suitable to their local conditions, have managed to diversify their incomes through beekeeping, livestock, intercropping cash crops with food crops and setting up shops, hotels and flour mills in the nearby towns or villages. Therefore, AWMT at smallholder level meet the intended purpose, provided that they are suitable and adaptable to the local circumstances. The question is which of the technologies are suitable to which area under what socioeconomic conditions?

Introduction

Ethiopia covers a land area of 1.13 million km^2, with a population of 77 million at 2007 estimate. The physiographic is characterized by complex highland mountains and plateaus. The agricultural potential is largely unexploited; with less than 40% of the arable land currently under cultivation. Rainfall is generally greatest (around 2200 mm per annum) in the southwest highlands and decreases to around 600 mm per annum in parts of the northeastern highlands. Much of the rainfall in the country occurs between June and September only in the southern and eastern highlands, there are pronounced bimodal rains with the first peak in April and the second in September. Rainfall variability generally increases as rainfall itself decreases and is thus generally greatest in the lower rainfall areas of the north and northeast highlands. The mean daily temperature in the highlands during the growing season (May to December) is 21.3^{o}C, and drops by 0.6^{o}C for each 100 meters increase in altitude (Goebel, 1983).

The cultivable land is about 13.2 million ha, or 12% of the total land area (FAO, 1998). But agricultural productivity remains very low partly due to limited access to agricultural technologies, limited possibility to diversify agricultural production, underdeveloped infrastructure, and weak or sometimes lack of access to agricultural markets and to technological innovations (S.B Awlachew et al., 2005). As a consequence the rural dwellers in the country are among the most vulnerable to poverty as they entirely depend on agriculture for their livelihood. The agriculture sector is highly dependant on rainfall, thus the amount and temporal distribution of rainfall and other climatic factors during the growing season have an important influence on crop yields. When rainfall variability increased across the country, average food production per capita has also declined in the past years, and the country has become increasingly dependent on imported food. Presentation made on Impact of Irrigation on Poverty and Environment (IIPE) Symposium (S.B. Awlachew, 2007) confirms that the performance of Ethiopian economy is directly linked to rainfall variability (Figure 1). It is estimated that in Ethiopia, one drought event in 12 years lowers GDP by 7 to 10% and increases poverty by 12 to 14 percent. This calls for use of effective and efficient agricultural water management technologies to mitigate its negative impacts. At the same time, the country is endowed with surface and ground water that can be used for boosting agricultural production sustainable.

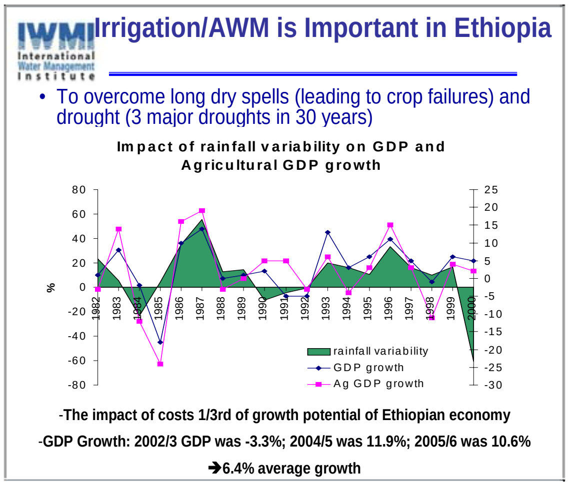

Figure 1: IIPE Symposium presentation, S.B. Awlachew (2007)

Water resources and AWMT

The country is faced with a rapidly growing population and an agricultural production which in most years, falls short of the food requirements mainly because of rainfall variability. The total mean annual flow from all the river basins is estimated at 123 BMC. Only about 200,000 ha has been developed using irrigation and yet more land has to come under irrigation to feed the fast growing population and combat the effect of drought. Different types of irrigation have been used in different parts country, ranging from small scale traditional methods to large-scale commercial farms.
There are twelve river basins twenty lake bodies, four crater lakes and over twelve major swamps or wetlands. Irrigation in Ethiopia is classified as large with a command area greater than 3000 ha, medium with a command are between 200 and 3000 ha; small scale with a command area less than 200 ha. The small scale irrigation (SSI) schemes are managed by the community. The estimated 48,000 ha is under modern small scale irrigation (S.B. Awulachew et.al, 2005) and the traditional irrigation estimate is about 13,820 ha. However, if it were not because of lack of proper inventory, the total area irrigated using modern and traditional methods exceeds this amount.

Recently, rainwater harvesting and use for agricultural production has become common to many areas. Harvesting runoff during the rainy season can supplement irrigation development and fill the gap during the drought season in rain fed agriculture. Massive program was planned by the government during the period 2001 to 2005 and implemented by individual households. Farmers have continued adopting these technologies and have continued benefiting in areas where it has become successful. The use and adoption level of the different types of technologies differs from place to place. However, water management efficiency and production level of agricultural outputs has remained a question in many of the places even in areas where there is successful adoption.

Objectives

The overall objective of the AWMT project is to contribute to improving the lives of rural poor through improved and sustainable agricultural productivity and generation of incomes for smallholder farmers in Ethiopia. Specifically, this study aims at assessing suitability of AWMT and identification of promising technologies for scaling up.

Methodology

The method of collecting data and information included literature review from both local and international sources, key informants interviews and discussions at all levels including federal, regional and in some instances at zonal and woreda levels. In addition, a questionnaire was designed and distributed to relevant experts in various institutions (GO, NGO, UN agencies, private, etc) to capture diversified information on agricultural water management practices, ranking of technologies and suitability including the constraints that exist (**Annex 1**). Where conditions favor site observations were made and discussion with individual farmers were also held.

Limitations

This study was based on a one time field visit to regional capital of Amhara, SNNP, Tigray and Eastern and Western Hararghe zones of Oromia regional state where most agricultural water management technologies are practiced. Few promising technologies were also visited during the field trip. In view of the broad scope of the study, which covers the entire country and the diversity of technologies, the time allocated to the project was not adequate. In addition, farmer's involvement in the study was not adequate. However, the information through the various tools is believed adequate to present the general overview of agricultural water management technologies in Ethiopia.

Depending on the topography, agro-climatic conditions and the farming systems, different types of AWMT are used in different parts of Ethiopia. There has been no exhaustive inventory of modern as well as traditional AWMT in Ethiopia. Therefore, the first part of this study "identification and characterization of AWMT" is the first of its kind in documenting a wide range technologies all together in one. More than 50 agricultural water management technologies practiced in Ethiopia were identified through the inventories. The information made available through this study can serve as a reference for further investigations. Annex 2 provides summary of these technologies, their advantages and constraints in brief.

Rainwater harvesting for crop production, if successfully implemented within a social and hydrological catchment, will have many interacting implications on biophysical, economic, and ecological systems, suggesting that a systems approach needs to be considered when promoting Rain Water Harvesting (RWH) (Rockstrom, 2000). Water harvesting structures built without consideration of the whole catchment have faced serious problems like siltation, water shortage, conflict of interest, etc. The suitability of AWMT depends very much on the specific environment and local conditions of a particular area. Some of the conditions broadly include agro-ecology, infrastructure, socioeconomic conditions (market, cultural, etc).

While altitude, temperature and rainfall determine the range of cropping possibilities, the actual patterns of cropping that predominate are determined primarily by the lengths of growing periods and by socio-economic considerations. Other physical conditions such as soils are also important in influencing potential for plant growth. Crop management practices such as cropping systems, fertilizer, and weed and pest control also determine the efficiency of agricultural water use. Intercropping cash crops with food crops is practiced in some areas to maximize the production from a limited farm size of a water harvesting structure and may ultimately contribute to the success of the technology. In consideration of the above, the high and low potential cereal zones and high potential perennial crop zones have been classified by Ethiopian Highland Reclamation Study as shown in Annex 3.

One of the main constraints in the scaling up of any conservation measures is non ownership of asset by farmers. Livelihood is a pressing day to day question to farmers and as a result farmers often fail to focus on long term objectives but rather they need early return to any investment. As a result, interventions with long term gestation period are not generally favored by farmers. The dwindling land holding size of farmers where they can not afford to allocate portion of their plot to be used for conservation structures is also another bottleneck to scaling up of agricultural water management technologies.

Technology suits in practice

There are different combinations of technologies that are used from the source up to delivery of water to crops. Affordability, experience, availability, lack of awareness is among the factors that influence these combinations. The commonly adapted combination of agricultural water management suits are shown in Annex 4. However, the choice, adoption, suitability and success of AWM technologies were not clear. Out of the results of the 2006 symposium and other sources of information, it has become clear that some technologies are working very well in some parts of the country and fail in others. **Annex 5** presents the location of these technologies where they are widely adopted and practiced.

Conditions of suitability for agricultural water management technologies

The appropriateness micro-catchments to specific agro-ecological conditions is crucial to the success of technological interventions. In drought-prone semi-arid areas, the introduction of rainwater harvesting is generally successeful, although fluctuation in the amount of rainfall remains to be a major constraint. For example, half moon is implemented in areas receiving rainfall less than 500 mm. It is suitable in areas with sandy and sandy loamy soils affected by low fertility levels and thin surface crusts that inhibit infiltration and increase runoff. On the other hand, Fanya Juu is well adapted in areas where the rainfall ranges between 500 to 1400mm. It is widely practiced in Dega, Woina Dega agro-climatic zones, dominated by heavy soils and where erosion problem is critical.

The suitability of technologies depends also on the specific site conditions, such as slope, soil depth, cropping pattern, erosion level, etc. According to L. Desta, et al., 2005, the measures listed from **Annex 6 to 9** are broad indications of suitability of soil and water conservation interventions based on agro-climatic conditions and land use. For example in cultivated land and homestead areas, measures like soil bunds, stone bund, fanya juu, BBF, etc. are appropriate. Flood control and drainage measures like vegetative or stone paved waterways are suitable for grazing lands. Stone faced soil bunds and cut off drains are more suitable for forest areas with steep slopes where as level bunds are better suited in gently sloping and moderately sloping areas. In general, conservation technologies are varied and their appropriateness is agro-ecology based and purpose oriented.

Open ponds are suitable where unskilled labor is abundantly available, evaporation loss is relatively low, when efficient water conveyance and application technologies are used, when there is limited capital to invest but, unsuitable where there is severe shortage of land and where favorable conditions exist for malaria proliferation. Underground cisterns are suitable where skilled labor is available, evaporation and seepage loss is relatively high, there is severe water scarcity, when higher water quality is required and in areas of free grazing.

In situ technologies are most suited to conserve soil, water and increase vegetation cover and when there is a need to increase ground water recharge for shallow well exploitation. Shallow ground water and spring development are suitable when good quality and dependable source of water is required. Shallow well is less functional in loose soils due to likely construction difficulties.

Practitioners agree that if technologies are to become successful series of chain of measures are required. Production of crops have to be linked to cooperatives, this in turn linked to processing plants, again linked to market, etc. A system approach would involve different biophysical disciplines within a watershed and linkages between the agro ecological system and rural society, and between production and marketing, among others (Stephen N. Ngigi, et. al 2003).

Rainwater harvesting techniques can be applicable in all agro climatic zones. However, it is more suitable in arid and semi arid areas. These are areas of average annual rainfall <800mm (rarely exceeding 800mm). Rain may not come on time and in such environment, rain fed crop production usually needs to be supplemented with rainwater harvesting.

According to Oweis T., D. Prinz and A. Hachum. 2001, generally water harvesting is advantageous in the following circumstances:

- In dry environment, where low and poorly distributed rainfall normally makes agriculture production impossible
- In rainfed areas, where crops can be produced but with low yields and a high risk of failure. Here, water harvesting systems can provide enough water to supplement rainfall and increase and stabilize production.
- In areas where water supply for domestic and animal production is not sufficient
- In arid areas suffering from desertification, where the potential for production is diminishing, due to lack of proper management. Providing water to these lands through water harvesting can improve the vegetative cover and can help to halt environmental degradation.

In country experiences and lessons drawn from other countries indicate that adoption of new technology becomes more effective if supported by applied research and demonstration sites.

Furthermore, a guideline shown in Annex 7 can be used for selecting water harvesting techniques depending on the soil type, topography, land cover and other socio-economic considerations (Oweis, T., D. Prinz and A. Hachum, 2001).

The performance of technologies in terms of implementation, operation and maintenance, affordability, gender sensitivity, environmental impact, etc., has also been assessed through a questionnaire. Suitability depends on the nature of technical complexity, the existing institutional and individual capacity, the investment capital and operation and maintenance cost, and benefit. Therefore an elaborated suitability criteria has been developed, and has been integrated into the questionnaire to get experts feed back. The summary of the performance of technologies as per the feed back obtained from four regions has been presented in Annex 10.

Promising technologies

Earlier inventories carried out by different institutions for different purposes provide indicative information on the type of technologies used and the level of their utilization. Tables 1 below indicate the type of technologies and extent of their adoptability and usage in three regions. In SNNPR, based on the available information almost all small scale irrigation development comes from river diversion.

Table 4: Commonly practiced AWM technologies in Amhara Region

Technologies	Amhara Region coverage (%)	Oromia Region irrigation coverage by water source (%)	Tigray Region coverage (%)
River diversion	95	69	75
Micro dam	0.1		6
Pump	1.1		
Hand dug shallow well	3.5		12.7
Deep wells			0.2
Pond	0.3	2	6.03
Spring development		21	
Spate irrigation			0.07
Lake		8	
Total	100	100	100
Source BoWR, Amhara; Regional Irrigation Land and Water Resources Inventory, 2005		Based on Water Resources and Irrigation Development in Ethiopia, 2007	Evaluation of water harvesting schemes in Tigray, 2004

From Table above, it is evident that *river diversion* plays a critical role in the development of SSI followed by *shallow wells*. River diversion is widely used in all the regions visited. *Shallow wells and spring development* are attractive for household level agricultural development. In areas where shallow ground water potential exists it is exploited by communities. Water pumping, farm ponds, deep well exploitation are relatively new technologies and hence were not widely used among communities in the past.

Micro dams are more important in areas where there are less perennial rivers and river flows run during few months of the year. It is mostly practiced in the northern regions of Ethiopia.

Annex 11 to 14 elaborates details of the ranking exercise; technical performance such as easiness of implementation, skill manpower requirement, financial requirement, etc of micro catchment RWH structures and groundwater exploitation; water lifting and water application technologies; and micro catchment technologies respectively. The technologies adopted by the regions were also ranked in terms of their technical complexity and financial requirement for implementation; the result is summarized (Table 2). Accordingly, *trapezoidal pond, hand dug shallow well and spring development* ranked better among water harvesting and ground water exploitation technologies. The most promising SSI technologies are runoff diversion (spate irrigation), upgraded traditional irrigation and river diversions when site conditions are favorable with out considering the cost–benefit analysis. This can also been witnessed from the extent at which they are used in the different regions of the country. Among the few water lifting technologies practiced in the country; treadle pump and motorized pump (small) are the most preferred ones based on technical and capital considerations. Although not widely practiced the limited information obtained show that wind mill is less complex to use where potentials exist.

Table 5: High ranking promising technologies

Source	Technology
Water harvesting	*Trapezoidal pond,*
Ground water	*Hand dug shallow well*
	Spring development
Runoff diversion	Spate irrigation
River diversion	Upgraded traditional irrigation system
	Modern irrigation system
Water lifting technologies	Treadle pump
	Small motorized pump

The result is reasonably in line with the outcomes of the discussion made with key informants in the four regions. It was observed that promising technologies identified by experts in the respective regions (Table 3) are adopted by farmers in a greater scale because of their suitability to the local conditions i.e. addressing farmer’s needs, capacities and the service that are realistically available. As indicated in the ranking exercise these technologies are found to be technically simple to set up, operate and maintain; low investment, operation and maintenance costs compared to other technologies. Conservation activities are considered as complementary to ex-situ activities and therefore, they are not considered in the prioritization. It was observed that institutions particularly NGOs through their long experience have specific technologies to promote in their program area. However, there is a general consensus that upgrading traditional irrigation schemes, shallow well development and runoff diversion (spate irrigation), and river diversion are the most promising technologies, and hence can be considered for scaling up depending on the specific conditions of the respective region (Table 3).

Table 6: Most promising technologies by Region

Region	Technology	Justification
Amhara	Upgrading traditional schemes from spring/ river	high level of ownership feeling as they are originally built by the farmers themselves, better operation and maintenance or scheme management; improving structures and make them permanent; high discharge with large command area and hence benefits many farmers
	Shallow well development	where shallow ground water is available provides reliable water; good water quality may have multiple uses including domestic water supply
	Water harvesting	Trapezoidal ponds in suitable agro-ecology with evaporation mitigation measure and availability of market
Oromia	Upgraded traditional irrigation	Shortage of water source could occur and u/s-d/s conflict might be created; established farmers organizations and working procedure;
	Shallow well	Where opportunities exist they are reliable source of water; could be easily constructed with locally available material; can be managed by individual households.
	Runoff diversion/ spate irrigation	In low land semi arid areas traditional runoff harvesting can be done with farmers knowledge and labor
SNNPR	Upgraded traditional irrigation from river	Because of simplicity in operation and maintenance; low cost ; farmers have long irrigation experience
	Shallow well	In high land agro-ecological zones, high value horticultural crops in homestead areas can be grown. At house hold level where potential exist shallow wells, spring development have priority over other technologies.
	Water harvesting structures (Ponds)	Can be constructed with family labor,
Tigray	Modern river diversion	• It can irrigate large area and easy to manage • No sedimentation problem unlike dams except in canals
	Micro dam	• Stores water during wet season including from non perennial rivers to supply water during long dry season • It has a capacity to hold larger amount of water
	Shallow well	• It is possible to irrigate using shallow well during dry season • It provides irrigation water sustainable during dry season unlike other technologies

The impact of these technologies on poverty alleviation; the cost and benefit has been analyzed (Fitsum Hagos et.al. 2008), but the results are reported separately.

Some case studies

Small Scale Irrigation

The topographic map developed by the Ethiopian Mapping Authority (1:50,000) is far less than sufficient for assessment of SSI potential in the country. A more accurate assessment tool needs to be employed to know the potential for small scale irrigation. Existing modern as well as traditional schemes are also not accurately known in number. A more accurate assessment of SSI including traditional schemes can be done through use of higher resolution satellite imagery. Thus, in order to overcome the above-mentioned limitations and provide a benchmark data on irrigation sub sector, IWMI, NBEA has developed a data base for the modern schemes for the use of all stakeholders.

There are different typologies of small scale irrigation that include traditional, spate, upgraded traditional, and modern. Small scale irrigation by and large is community managed or is under private holding. Communities are required to participate at all stages of the development process and they are expected to contribute at least 10% of the capital cost in the form of labor and material. There are good success stories of small scale irrigation overall the country where communities have benefited, but definitely this is not with out difficulties (Box 1).

Box 1: Farmers of Mogdullar Irrigation Water Users Cooperatives are expanding the command area with their own initiative

In Alem Tenna PA the Mogudulla Small Scale Irrigation Cooperative uses river diversion to irrigate their land since year 2005. The cooperative has an estimated 240-300 ha of potentially irrigable land of which about 30-50 ha can be cultivated at any future time. There are about 70 beneficiaries who hold between 0.25 and 0.75 ha of irrigated land individually. Outside the command area there is also a communally owned pump scheme expanded with the initiative of the cooperative. The pump rental rate is about 700 birr/month which is paid by the cooperative and farmers are required to work on the farm, and in case of shortage of labor they also hire extra labor. The farmers reported that the pump scheme is profitable despite its high rental cost. Most of the irrigation is served by a diversion; the main canal is concrete lined and the rest is earthen. At field level furrows are used to apply water to the field with spades being used to guide the water. Canal maintenance is done once in a year by the community themselves.

There are two crops per year in addition to the rainy season. The crops grown include maize, potato, cabbage, onion, tomato, haricot bean, etc. Among these, most profitable crops are onion and sugar cane. RWH technologies are integrated into irrigation development; ponds are used for seedling rising later to be transplanted in to the irrigable land. The rain fed and irrigated crops are grown for both home consumption and for market; with the dry season crops being more market oriented than the rainy season crops. Several organizations like Food and Agricultural Organization (FAO) and Lay Volunteers International Association (LVIA) trained farmers in the use of water management technologies. There is a committee for water scheduling which is guided by bylaws. During dry season there is disparity in water availability between head and tail reach. This is experienced mostly during the flowering stage of crops, where the water demand is high. There are experiences else where in the country where such problems are mitigated by conjunctive use of ground water. Water related disputes are resolved through team leaders established for the purpose. Farmers report that the water quality is generally good for most crops except for paprika. There is a problem of sediment load which can best be dealt with through integrated watershed management which involves the upstream and downstream users.

They also reported that lack of market and unfair price set by middle men traders for their produce are among the major problems. They have proposed as a solution that farmers cooperative should have a shop in town (collective marketing) for selling agricultural produce. It is reported that at the moment, cooperatives are instrumental to get credits, inputs market for the agricultural produce. It was learnt during the study that farmers had difficulty in getting market for the silk they produced which IPMS-ILRI has helped; one of its objective being improving market conditions to farmers. The food for the Silkworm (castor plant/ *Ricinus communis* and strawberry) is grown in the irrigated area. They are able to sell their produce through the cooperative in which the cooperative assess market alternatives as whole sale. Profit sharing is based on the percentage of share they hold in the cooperative after deductions are made for the services they get. The women explained the benefits of irrigating horticultural crops for their daily cash requirement and provision of better nutrition to their family.

Meeting with Stakeholders at Mogdulla village

According to experts supplementary irrigation is getting increasing acceptance among farmers compared to rain water harvesting with concrete structures because of factors such as cost, water lifting requirement, etc

The problems encountered in SSI include both operation and maintenance. Seepage, collapse of structure, canal crossing, gully expansion, clogging of out lets, lack of maintenance in diversion schemes, sedimentation of reservoirs,, water shortage are some of the problems mentioned. Leakage through diversion structures, field water management, collapse of structures and gully expansion are some of the typical problems under traditional irrigation. Due to weak farmers' organization, operation and maintenance on SSI is generally weak. Farmers are organized as cooperatives. One of the principles of cooperatives is voluntary membership. While the scheme is a single system, exclusion of non volunteer farmers from the organization has created problems in operation and maintenance as well as in water management practices with the scheme. Another severe constraint is lack of provision of irrigation extension service due to lack of conducive organizational arrangement and lack of qualified personnel to provide the necessary service to farmers with regard to irrigated agriculture.

Micro dam

Dams store water during rainy seasons to be used during dry seasons for different purposes. As it is capital intensive and, requires technical designs as well as high operation and maintenance costs, the small scale farmers do not have the capacity to implement by their own. Besides, reservoir sedimentation is a critical issue in dam technology, which makes external technical, managerial and financial support necessary. Occasionally, there are also conflicts arising from resettlement caused by dam construction (Box 2)

Box 2: Tsebayina micro dam in Atsbi (Tigray) provides year round water to farmers

The dam was built to store water from springs located within the reservoir area. Significant amount of water leaks through the dam foundation. This together with other springs along the river is used to irrigate the land in the downstream and on the banks of the river. Crops grown include cereals (barley, wheat), legumes (beans, peas) pasture for livestock, seedlings (apple, olive tree). The average land holding of a house hold is about 0.5ha. Those who use irrigation benefit from three cropping seasons. Usually, cereals are grown during the rainy season while vegetables (potato, tomato, onion, etc.) and other cash crops during dry season using irrigation. Farmers report that pest; especially for beans is the major problem in the area for the last three years. The local bureau of agriculture is supplying improved seeds obtained from seed agency. However, some farmers tend to recycle their own seeds, which results in low productivity and less disease resistant. The extension services are provided by 4 to 6 DAs with different disciplines (agronomy, livestock, natural resource and cooperative) assigned to each PA.

Some farmers pump water directly from the reservoir and river channel to irrigate adjacent farms. Farmers group themselves in 3 to 10 per group to get credit to buy pumps. The pump commonly used in the area has a capacity of discharging 900lit/min, which is expected to irrigate up to 5ha. Among the group, individual farmers who can afford to buy one on their own will leave the group with amicable settlement of their account with the rest of the group.

They have established water users association (cooperatives) and developed bylaws to resolve any conflicting issues among themselves. There is a prevailing conflict over land redistribution, indicating the lack of clear policy directive on land redistribution on the irrigation command areas.

There are also good success stories where land has been amicably redistributed. In some PAs (for instance in Hayelom) with SSI there are Water User's Associations (WUA) which have bylaws and function properly perhaps lessons could be learned from these PAs and applied to others where conflicts exist. On other schemes farmers agreed to remain with their original holding. Those who own large plots rent or share crop (50% each) to others who do not have sufficient land.

A micro dam in Tigray

Ground water exploitation for agriculture

There is no exhaustive ground water assessment carried out in the country except some localized studies for water supply purposes. This and lack of information regarding its sustainable use result in shortage of water in some instances. Ground water exploitation in the country is generally low, but provides good source of water for irrigation and other purposes. There are numerous places where ground water emerges on the surface. In those areas, springs provide a good option for agricultural development. The other source of water for agriculture is deep well. In high land areas like Chencha shallow well development have become good source of water for growing high value crops like apple. Deep wells are usually sunk for domestic water supply. But with increasing development of floriculture in the country deep wells have become part of the agricultural development.

In some areas of SNNPR ground water recharge is increasing with the increase of conservation activities. A vivid example is Humbo Tebela where ground water recharge has increased with the intensive conservation activities in the area. In these areas springs have become potential sources of water for downstream use. Farmers in upstream watershed who recognized this fact are now demanding payment for water. Intensive soil and water conservation works are being implemented in most parts of Tigray which has helped in ground water recharge. Fore example, in Atsbi the community is mobilized at least 20 days per year to do soil and water conservation activities. Gergera watershed is one of the degraded watersheds where the communities were food insecure. Since year 2000 the watershed was protected from human and livestock interference and hence is gradually regenerating. Farmers have started benefiting from the catchment through beekeeping, cut and carry was introduced for fodder to their livestock including increased ground water recharge. However there are still constraints that are encountered during the process of shallow well development. Lack of proper ground water investigation and determination of well yield and spacing have negative consequences (Box 3).

Box 3: Over pumping from shallow wells in Haramaya might have contributed in Lake drying up

Past A shallow well owned by a farmer with five household members was visited in Gende Guto area. It was observed that he grows vegetables such as potato, cabbage, carrot, salad, beet root, onion, etc using water from the shallow well (Box 4) inherited from his forefather. The well was dug in a telescopic shape with diameter about 10m at the top and narrows down to about 2m at the bottom. The well digging is in a stepped manner to avoid caving in as there is neither concrete ring nor masonry lining at the top of the well. In some instances, the wells are found very close to each other as close as 50m radius with overlapping sphere of influence. According to the development agent (DA) The total number of wells in the PA (809 square kilometers) is about 210, which is considered highly dense however, needs to be verified with testing. Intensive pumping from these wells coupled with catchment degradation might have contributed in drying up of Haramaya Lake. Lucrative market in Djibouti has motivated farmers to increase their farm land. This in turn calls for increased water demand and therefore, such development needs to be accompanied by sustainable ground water exploitation studies.

Horticulture development in Haramaya using shallow well

Other constraints include; collapse of the well during excavation in lacustrine environment where the formation is dominantly sand. In such areas excavation should proceed in a telescopic manner (wider at the top and narrower at the bottom) in order to avoid caving in of wells. In vertisol areas such as Becho and Kuyu, wells collapsed soon after rain due to the swelling nature of the soil. It is believed that well capping with concrete ring or masonry may alleviate the problem. There lack of appropriate water lifting technologies is another problem. Water lifting is usually done with rope and bucket but farmers want to have improved and easier technologies. In some instances wells do not have wellhead and manhole cover that expose the well to flooding and contamination

Water harvesting technologies

Given the constraints of lack of funding for small scale irrigation it is important to explore other options that can be implemented at household level to meet the food requirement. It is increasingly recognized by policy makers that due to shortage of capital for large dams and irrigation projects, water harvesting tanks and ponds at village or household levels can be considered as option to improve the lives of rural people with limited external support. The introduction of water harvesting technologies is especially relevant to regions where the problems of environmental degradation, drought and population pressures are most prevalent. Ponds are generally used where other sources of water (GW& Surface water) are short. The adoption of ponds depends on availability of other options. For example in areas where there are alternative livelihood means (coffee, chat growing areas) the adoption level is low.

Some farmers combine two ponds in one to optimize the use of plastic lining. Because of the ponds, farmers able to grow three times per year including the rainy season. The purpose of constructing ponds was to promote supplementary irrigation. However, in areas where there is shortage of water (for example, in Raya), ponds serve for multiple uses – livestock watering, domestic use and supplementary irrigation. The most dominant crops grown using the ponds include; potato, tomato, pepper, onion, cabbage, green maize, and garlic. They are grown principally for cash, but also contribute to household nutrition. According to experts, the income per pond ranges from 3000 to 6000 birr in Gursum, however this is dependant on the market demand of a specific crop in specific area.

Water management is one of the biggest challenges in irrigated agriculture because of non efficient water application methods. Family drip kit and sprinkler irrigation can be used to improve water use efficiency. They are among the most efficient water application technologies that are practiced. Some farmers use multiple drip kits to maximize the area irrigated (Box 4). The cost of one FDK is 801 Birr and credit is available for those who want to buy. In both cases, water free from sediments should be used so that the emitters may not be clogged.

Box 4: Farmers innovations on the use of family drip kits in Haramaya woreda

Some farmers wanted to irrigate larger area and have tried to maximize the capacity of family drip kits (FDK) with their own innovations. Normally, One FDK has three laterals, irrigates only 300 square meters. A farmer near Haramya town installed seven laterals in opposite sides of a tanker to irrigate about 2100 square meters as it is reported by the woreda experts. Initially, the storage tank was being filled with a treadle pump. However, the capacity of the pump was not adequate to meet the needs and hence they had to resort to small motorized pump. In some instances the predetermined spacing of FDK emitters does not match with the spacing of plantation (ex, chat) because of these farmers suggest having the emitter and the puncher to come independently so that they could make the drippers that fits their requirements. It is generally recommended that farmers use optimum spacing of crops that they opt to grow.

There are also areas where failure has been noted. There were ponds without water due to in appropriate site selection or seepage loss; ponds floated due to ground water rise. Experts agree that it has been a learning process where both farmers and experts have acquired a lot of experience in the process of implementation in the past few years. In semi arid areas water loss from ponds through either seepage or evaporation is a major problem. Farmers build grass hatched hut over the ponds in order to reduce evaporation loss. Mud mortar is a pond lining technology to reduce seepage loss where caolinite dominant red clay soil (locally called kuisa) is mixed with cement in 1:6 ratios. Soil type is among the dominant factor for the success or failure of this technology. Generally, in areas where there are sandy soils or vertisoils, the chance of success is less.

In dry areas with high evaporation loss, dome shaped structures are often successful. Dome and Hemispherical concrete structures are found Kobo and Woldia (Guba lafto) areas. In these areas, water is used to irrigate cash crops and domestic water supply. Farmers in Kobo area sell their harvested water for domestic uses at about 2 birr/20 liter according to experts.

Spate Irrigation

In Ethiopia, spate irrigation is mostly practiced in East Tigray, East Hararghe, around Konso and Jinka areas. Oromia Region has in recent years adopted a policy of promoting spate irrigation. Oromia Irrigation Development Authority (OIDA) is embarking on a massive spate irrigation development, which involves upgrading of traditional and development of new ones in the entire Region. This is because spate irrigation is considered to be easily adoptive by farmers as it is cheaper. Upgrading of traditional spate irrigation was underway in Fedis areas, but farmers were impatient to wait for the official handover of the modern system that they have started to use it. In Gursum woreda, currently site selection, study and access road construction by farmers have been completed for Ariro 750 ha, Samkala 1500ha, Harobati 200 ha awaiting budgetary allocation for the commencement of construction during the coming new year. Farmers in Dodota used to experience repeated crop failures due to recurrent drought in the region. In response to this effect the 5000 ha Boru Olloo spate irrigation development in Arsi was started around mid-2007 and is now well in progress. During the field visit those farmers who got water reported that their crops have survived the dry spell of this year because of the project (Box 5).

Box 5: Boru Ollo modern spate irrigation relieves farmers in Dodota from climate variability problems

Boru Olloo spate irrigation located in Arsi, Dodota Sire woreda was started in mid 2007. The long term plan of the project is to provide water to farmers in Dodota area who commonly suffer from frequent drought so that they can irrigate about 5000 ha. In the short term it will provide supplementary irrigation to 3000ha. Farmers in the area use wild flooding to irrigate crops with out proper water management practices, which implies their limited experience in on farm water management. There is a need for further soil investigation to understand salinity conditions before and after introduction of irrigation. It is advisable that farmers get in field water management and sufficient extension support to maximize the benefit from the planned spate irrigation. Further investigation sediment yield of the river catchment and its impact on the project may be required to look for timely measure. In the long term there is a plan to transfer water from Keleta River to Boru River to change the scheme from spate irrigation to diversion scheme that could benefit farmers all year round.

Modern spate irrigation in Boru Olloo previously rainfed, Oromia

Soil and Water Conservation technologies

Most highlands of the country are highly degraded through deforestation, overgrazing, improper farming practices which lead to food insecurity. This situation has been further aggravated by frequent drought. Rehabilitation of marginal lands through appropriate soil conservation measures is increasingly recognized so that it contributes to agricultural production. Promoting sustainable farming by adopting suitable soil and water conservation technologies may enhance food security. Some soil and water conservation technologies have been traditionally practiced by the community since antiquity where as others are introduced in recent years. Promotion and adoption of new technologies and lessons of good practices are important to the sustainable use of the land.

Experience shows that issues of land degradation require holistic approach rather than individual interventions. Although individual based technologies generally show better success, soil and water conservation measures generally require community actions. Soil and water conservation has been a tradition to communities like Konso, where hill side bench terraces are widely used. Soil and water conservation is embedded in farming practices in Tigray, where most areas have been well terraced.

Up scaling and sustainability of technologies

Consultations with experts have revealed that, there are some constraints to scale up the promising technologies identified. Some of these constraints are summarized in Table 4.

Table 7: Summary of constraints to scale up promising technologies

Technology	Constraints for scaling up	Recommended measures	Remark
Upgrading traditional schemes	Technical and financial capacity, water scarcity due to increased area, poor water use efficiency		Poor agronomic practices, pest management
Shallow well development	Poor site selection, poor construction methods, lack of suitable water lifting mechanism.	Techniques of well digging, appropriate water lifting techno,	Crop water management
Runoff diversion/ spate irrigation	Can only be used where there is an opportunity		
Water harvesting structures	Seepage, evaporation, sedimentation, estimation of catchment yield		
Modern river diversion	Lack of strong farmers organization, limited support services		
Micro dam	-Lack of capital to scale up to wider communities -Sedimentation of the reservoirs, -Conflict due to land reallocation -Lack of skilled manpower for operation and maintenance		
Water lifting (treadle & small motorized pump)	-Motorized pumps are too costly to farmers, -difficulty in availability of spare parts		

In addition to the technical constraints, there are also institutional and policy related issues that are affecting the scaling-up of agricultural water management technologies. These include lack of promotion works, affordability of the technologies, access to market for input and outputs, institutional issues, policy environment, technical challenges, socio-economic, environment and health related issues outlined below need to be attended.

Promotion

In order for people to perceive the benefit of a new technology, they should have detailed information not only on the benefits but also on the constraints. The problem that hinders dissemination of information on water harvesting is insufficient documentation. WOCAT-Ethiopia is currently doing a commendable job of building a database mainly on soil and water conservation practices. However, simple manuals, booklets, brochures, and posters on promising technologies are in need. These can be used to enhance awareness among the farming community, experts and policy makers. They can also be used by development agents to implement the technologies with minimum external support. These may require building of synergies among various stakeholders in research, policy, advocacy and development partners to facilitate development of the above tools. Such synergies could be achieved by enhancing collaboration, networking, partnership and information sharing. The Ethiopian Rain Water Harvesting Association (ERHA) is endeavoring to play such a role

Affordability

Some technologies are some times are beyond the financial and technical capacity of farmers. In such circumstances, external interventions either from the government or NGOs are required to support the farmers both technically and financially. However, farmers can contribute in kind such as construction material and labor. Public-private partnership is also vital in successful adaption of water harvesting technologies.

Most farmers have little capital to invest and this limited resource should only be spent on a proven technology. When conditions allow farmers prefer to employ their labor rather than invest their capital on any infrastructure therefore, technologies that require more labor investment will have preference over those capital intensive ones. For example, dome shape cistern is the most expensive type of water harvesting structure where the labor contribution is only about 20%. Hand dug shallow well is the cheapest where the labor contribution is more than 35% (Table 4). In some instances ponds are beyond the capacity of individual households to construct– in terms of labor, land, and other resources. For example, construction of pond (size 12*12) requires labor, land and cash. In some instances, ponds occupy productive land and because of this farmers are uncomfortable. Price escalation of construction materials like cement and other factory products are beyond the purchasing power of farmers to scale up technologies including traditional ones like flood diversion/spate irrigation.

Based on the cost build up shown in Table 5 the percentage cash and labor contribution for construction of house hold water harvesting structures is shown in Table 4. Although the cost of water harvesting structures are given in Table 5 below from one region it could provide cost comparison of different water harvesting structures with other regions.

Access to market

Access to market is a critical precondition for success of any technology. If there is no market it is discouraging to farmers to grow more. Because of varying local conditions and changes in the road network differing market opportunities exist in different locations. According Rebeka (2007) the benefit found from the high value and perishable commodities due to RWH depends on market and infrastructure accessibility, and diversification in the types of the crops. Thus, efforts should be made to assess various agricultural commodities as well as giving emphasis to marketing extension, especially in facilitating markets to farmers.

Market becomes a problem where there is no major urban center in the area. During our field visit market constraints have been reported in many localities of the country including schemes around Debrezeit, Atsbi, Alamata, Fogera, etc. Even though farmers report that their livelihoods have improved through water harvesting measures, they face market constraints while growing vegetables and other crops in sufficient quantity. Sometimes due to lack of market information farmers tend to grow similar crops beyond the limits of the market demand. The level of demand and the extent of availability in a particular area determine the type of crop and the price setting. Hence availability of information to high value crops in a particular area is an important input to farmers. For example, vegetable farmers in Haramaya area have widely adopted shallow well technology because of the lucrative market in Djibouti and the same is true for other areas too.

Farmers also complain that they are being exploited by middle men and feel that they do not get what they deserve. These middlemen are giving very exploitative and unreliable terms at the same time; they are in a position to dictate the market. Normally, for larger produce farmers sell on credit basis to middle men and get their money after it is sold. It is important that farmers get what they should deserve and in this regard absence of strong cooperatives in most schemes visited is a disadvantage to farmers.

Institutional issues

The responsibility of WH implementation, supervision and monitoring is divided among different government organizations and NGos. Strong coordination among these institutes is a paramount importance. The institutional set-up and accountability issues on WHT vary from region to region and they are not generally stable. Frequent institutional restructuring and staff turn over are the most critical problems for sustainable development of the sub-sector. As a result, there is confusion on mandate, resulting in some cases of scheme failure due to lack of accountability in provision of operation and maintenance and other services. In most cases, the participation of the private sector in provision of services is generally poor. Creating the enabling environment for the private sector and providing the necessary capacity will motivate the private sector to play its role in increasing agricultural water productivity.

Policy environment

Land tenure was found to hamper promotion of RWH, where land users invest minimal resources on the land for fear that it may be reallocated to others. In some PAs there are conflicts still arising from land redistribution that occurred when dams are constructed and command areas are developed. Farmers lost land when dams were constructed and there are no clear compensation mechanisms in place. The situation may become much worse with the growing realization of the benefits of WH especially for resource poor small scale farmers. Such conflicts may adversely affect promotion and adoption technologies. Absence of land use policy in the face of dwindling farm size is a critical problem for success of WHT. Currently, conflict resolution on land re-distribution very much depends on farmers will and ability to resolve the issue.

In some areas of Northern Ethiopia land certification is being piloted. Land Certification requires farmers to conserve the natural resources available with in their holding. If farmers don't comply with conservation measures, the land will be confiscated. In some of the pilot areas like in Amhara Regional State the main challenge lies in implementation of the certification, which may require putting in place detailed enforcement guideline in order to reverse the natural resources degradation condition. Incentive mechanism such as prize award is another means to encourage farmers to embark on conservation measures. Land certification is an encouraging attempt towards enforcing conservation activities. However, comprehensive policy framework guiding the promotion, development and adaptation WH systems in the country is generally lacking.

Downstream-upstream conflicts could also be reduced if upstream users harvest water allowing adequate water to reach downstream users. However, upstream water harvesting may also lead to reduced river flow, which could also cause conflict with downstream users. During dry season there is disparity in water availability between head and tail reach of an irrigation scheme. Upgrading an irrigation scheme usually increases irrigation command area which may result in water shortage; and competition for water could cause conflict among communities. In view of ensuing competition and conflicts over limited water resources urgent policy attention is needed.

Technical challenges

AWM technologies offer tremendous opportunities for improved agricultural productivity and increased household income. However, there are a lot of technical and management challenges and threats reported in the literature as well as by experts affecting the sustainability of AWMT. These technical challenges include feasibility of technologies, the management challenges that farmers face with the introduction of new technologies, operational and maintenance problems; lack of availability of spare parts, environmental problems such as public health and pests.

Poor workmanship and inadequate technical skills could negatively affect technology promotion and adoption. A case in point is ponds constructed on black cotton soil in Ada' woreda with out any lining material have negatively affected the adoption of ponds in the entire area. All the water contained was drained while the soil was cracking. Similarly, there are incidents where under ground tanks have failed due to leakage caused by cracking, unable to with stand uplift pressure from ground water level rise. The performance of many WH structure is also low due to inadequate maintenance

From our fieldwork, we have observed that there are serious shortages of lining material in areas where ponds are well received. On the other hand, we have also witnessed plastic lining material being forced on farmers and are being used for other purposes like roofing material as shown in the Fig.2.

Figure 2: Geo-membrane used as roofing material, Alamata

Socio-economic factors

It is important that the beneficiaries participate at every stage of project implementation. Unless communities are involved actively starting at early stage of planning, the success of the program becomes unlikely. They should be consulted about their priorities and their needs should be taken into account. Indigenous knowledge developed and improved over time through accumulated experience are found to be more sustainable to the locality. Examples of such practice are hillside terracing and spate irrigation found in northern Ethiopia and else where in the country.

We have witnessed ponds constructed in high rainfall areas being abandoned; more ponds have been constructed than required because of the need for more food aid. Problem of water logging in hillside trench due to soil type and resistance of farmers at the initial stage of the program implementation are among the noted problems. The reluctance of farmers to invest in permanent water harvesting structures on land that will not remain in their holding for long is hindrance to acceptance.

To mention some of the general draw backs that hinder acceptance of conservation measures is that they are labor demanding, loss of productive land, financial requirement and lack of access to market. Family labor is sometimes hampered by in adequate food supply; hiring labor in many cases is difficult due to economic status. In such cases less labor and capital intensive technologies could be more suitable. For example construction of underground tanks like dome, bottle shaped, etc are not easily made by poor farmers without a strong credit service because of the high investment cost.

Although the Water Resources Policy advocates full cost recovery it is not yet realized in most irrigated schemes. However, some have managed to recover the cost of operation of maintenance like Mogudulla small scale irrigation cooperatives in Alaba.

Environment and health

In general water harvesting systems are environmentally friendly, but there are some minor concerns such as increased mosquito and snails, soil erosion along inlet channels, reservoirs, poor water quality, and risks of drowning, among others. Though positive environmental impacts outweigh the outlined concerns, they should not be ignored. Improved environmental conservation activity is required in terms of reduced soil erosion, improved soil fertility, agro-forestry and afforestation of hill slopes.

Table 8: Cash and labor contribution of water harvesting structures

WH structure	Cash contribution (%)	Labor contribution (%)	Relative cost
Hemisphere	82	18	7.2
Dome	80	20	14.7
Geomembrane	68	32	4
Pond	-	100	2.5
Hand dug well	65	35	1

Source: Based on table 5

In roof water harvesting technologies flush diverters need to be provided in the delivery system to divert the first runoff at the beginning of each rain. Cleaning tanks, say annually, improves water quality provided any remaining disturbed sediment is allowed to resettle for several days before the tank is used again.

Runoff is taken from the road, where livestock droppings, excrements and garbage are common. Without proper education and extension work, ponds can create serious health problems (Rami, 2003). This is very important because households use water harvesting structures such as ponds as source of domestic water exposing them to water related diseases.

Studies show that the experience with water harvesting is limited, environmental side effects such as salinity of the soil is not observed (Yazew et al., 2007). However, the same study recommends that farmers using wells would have to implement necessary measures to minimize effect of salinity including irrigation schemes with storage and river diversion facilities.

Table 9: Construction cost of water harvesting structures

WHSs	Proposed Volume in m^3	Total No. constructed in 2003 & 2004*	Cost of construction a structure				Remark
			Cash cost	Labour cost	Cost/structure (cash + labour cost)	Total cost	
Hemisphere	60	6468	3000	646	3646	23582328	Labour cost was assumed according to the norm.
Dome	60	401	6000	1467	7467	2994267	Information on labour cost was as to the farmers
Geomembrane	60	10114	1380	646	2026	20490964	Labour cost was assumed according to the norm.
Pond	118	45508	-	1270	1270	57795160	The size of ponds varies from 60-540m^3
Hand-dug Well	-	173949	320	176	496.00	86278704	The volume was totally varied from place to place
Total						191,141,423	

N.B.

1. The norm for person/day was 0.5-0.75m^3. Thus, the average was assumed to be 0.65m^3
2. Labour cost (person/day) was assumed to be Birr 7.00.

Source: Y.Afework, 2006; EPLAUA

Table 10: Labor requirement of soil and water conservation measures

Activity	Unit	Work norm
Soil bund	Km	70 pd/km
Stone bund	Km	150 pd/km
Fanya juu	Km	250 pd/km
Water way	Km	800 pd/km
Cutoff drain	Km	400 pd/km
Gulley plugging	Km	
Gabion checks	Km	1 pd/km
Loose rock checks	Km	1 pd/km
Brush wood checks	Km	1 pd/km
Sand/soil bag check	Km	1 pd/km

Source: Proposal to accelerate the integrated watershed management implementation in Koga Watershed; MoWR, 2002

Social equity: Gender sensitive water development technologies can significantly enhance the productivity if women are involved through out the process. In practice, Women farmers working on irrigated land mostly share cropping, or hire labor and usually lack capital to invest on their land. An evidence of such practice is Chelecot drip irrigation in Alamata where all female headed households share-crop their farm plot.

Proper irrigation development endeavor is generally location specific, capital intensive and the service can not be provided to all sections of the society. Regassa E. Namara (2007) confirms that income inequality among households with access to irrigation is worse than that of those with out access. In contrast, household level water harvesting structures are simple, can be constructed by family labor and therefore can generally be done when individual farmers are ready to have it with minimal external support.

It is generally recommended multiple use approach should be adopted that preferably can target women and the poor to stimulate productive water use and technologies that favor IWRM principles. For example when ponds are located near the homestead, easy for women to manage and water can have multiple uses; can generate cash from horticultural crops.

Extension and inputs

Farmers feel that the current system of input delivery for irrigated agriculture is unsatisfactory and, acts as a severe constraint on their production. Timely delivery of input will play one of the most decisive roles in the success or failure of the WH effort in the country. As observed at all WH and irrigated sites and from discussions held with experts, the agricultural extension aspect is very weak and lags far behind the development. Provision of poor extension service is attributed to lack of qualified personnel (for example only one trained irrigation agronomist in the entire SNNPR) to provide the necessary service to farmers in the all the regions visited; DAs are not well trained in relation to irrigated agriculture to enter-face between experts and the farmer. This coupled with high staff turn over; those trained as DA or higher level being transferred to some other task has made the situation worse.

The extension media like demonstration, training, etc in most cases are non existent even if available they are not appropriate. Water harvesting structures such as trapezoidal ponds could not be scaled up due to low technical know how of DAs, farmers dependency syndrome and shortage of geo-membrane in areas where it is well received.

The DA will remain the pivotal interface between Government and farmer, but the Office of Agriculture has to be in a position to support DAs with emphasis to WH technologies. In the longer term, reform of the extension service with respect to irrigation and drainage is to be commended. Training of agricultural staff and DAs in irrigated agriculture and strengthened irrigation extension services to the farmers are very decisive.

Training and capacity development: Farmers reported that they receive training once or twice in a year and this is not sufficient. They need training particularly on how to grow vegetables, water management and strengthening the capacity of WUA, since most of these technologies are new to the farmers. Marketing, operation and maintenance and how to reduce post harvest losses, pest management are very important in improving crop productivity. Training materials in product marketing, irrigation extension, cooperative financial book keeping/auditing and monitoring are all important.

Capacity of Woreda experts at zonal and regional level needs to be improved in terms of number and qualification. Some of the training requirements include:

- Introduction (Agronomy with emphasis on horticultural crops, water management, marketing);
- Site selection (runoff estimation, specific site selection locally available materials - soil type and crop water requirement, and estimating potential irrigable area);
- Training of Trainers (Woreda experts, DAs, farmers) on construction methods of WH structures should be carried out so that they go back and the training program is wide spread at all levels.
- Reporting

Monitoring and Evaluation system: M&E system should also collect information and compile reports on a monthly, quarterly and annual basis at all levels. The M&E system should be established with the following objectives:

- Improve productivity of AWMTs
- Improve water use efficiency of AWMTS
- Ensure repay and recurrent investment for water harvesting system

In most places visited there are no M&E systems; even if there is monitoring and evaluation system is biased toward civil works. There should be a system to identify veritable and measurable impact indicators that are foundations of an effective monitoring system. Institutionalizing the M&E in the respective water related institutions should be considered in order to make it a routine exercise. In order to be effective and make the monitoring system workable, a simplified record keeping system should be introduced to WUAs on each scheme.

In conclusion, lessons that can be drawn from the above for scaling up of promising technologies include awareness creation among communities, inter regional cross visits where good practices exist, upgrading technical skills through training, demonstration of benefits of technologies before initiation of program implementation; and improvement of access to market are issues that require due attention.

Conclusions and recommendations

In practice, many technologies were seen successful and few with out success. From lessons learnt in conducting this study the following general conclusions and recommendations can be made.

1 AWM technologies are generally successful in areas where there is low rainfall to increase household agricultural production for food, cash crops, and livestock production.

2 Adoption of small pumps by farmers is increasing at an alarming rate. The use of pumps can significantly contribute to food security at household level. Such use can be further enhanced if cost of pumps is lowered through tax exemption or create an enabling environment for local manufacturing. Provision of electricity to rural areas with affordable price will also enhance the use of motorized pumps.

3 In areas where there is a potential for shallow well development it has preference over other technologies and found to be more sustainable if supported with

watershed conservation activities. In areas where the water source is less than 6 meters, treadle pumps offer potentially suitable technology to adopt in conjunction with storage structures.

4 There are evidences that success and adoption of technology is highly linked to market. Therefore, it is important that physical infrastructure is developed and farmers get up to date market information to enhance their access to market. In this regard, strengthening the capacity of farmer's organization is critical in order to protect farmers from being exploited by middle men.

5 Monitoring and evaluation of positive and negative socioeconomic impacts, assessing cost-effectiveness, piloting of technologies before program implementation, and sharing lessons learned among stakeholders needs to be strengthened which is currently almost non existent.

6 Nexus between conservation activities and water harvesting and its integration to a catchment approach is generally missing due to fragmented institutional responsibilities; although there are changes still requires some improvement. An integrated approach that includes soil and water conservation, crop and livestock management system together with other income generating activities.

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POVERTY IMPACTS OF AGRICULTURAL WATER MANAGEMENT TECHNOLOGIES IN ETHIOPIA

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Abstract

Farmers in rural Ethiopia live in a climate-related shock-prone environment. The major source of climate shock is the persistent variation in the amount and distribution of rainfall. The dependence on unreliable rainfall increases farmers' vulnerability to shocks while also constraining farmers' decisions to use yield-enhancing modern inputs, exacerbating the vulnerability of households to poverty and food insecurity. As a response, the Government of Ethiopia has embarked on massive investment in low-cost agricultural water management technologies (AWMTs). Despite these huge investments, their impact remains hardly understood.

The main focus of this paper was to explore whether access to selected AWMTs, such as deep and shallow wells, ponds, river diversions and small dams, has led to a significant reduction in poverty and, if they did so, to identify which technologies have higher impacts. The study also calculated the net present value of the selected AWMT, to assess which of the AWMTs are worth investing in given that they have the promise of reducing poverty. In measuring impact we followed different approaches: mean separation tests, propensity score matching and poverty analysis. The study used a unique dataset from a representative sample of 1,517 households from 29 Peasant Associations (*Kebeles*) in four regions of Ethiopia. Findings indicated that the estimated average treatment effect on per capita income was significant and amounted to USD 82. Moreover, there was 22% less poverty incidence among users of AWMTs compared to non-users. The poverty impact of AWMT was also found to differ by technology type. Accordingly, deep wells, river diversions and micro-dams have led to 50, 32 and 25%, respectively, reduction in poverty incidence compared to the reference, i.e., rain-fed systems. Although, the selected AWMTs were found to contribute to poverty reduction, we found that ponds, deep wells and small dams were not attractive from a social cost-benefit analysis perspective, implying that choices need to be made

considering their relative financial viability and poverty reduction impacts compared to other available options that could improve rain-fed agriculture. Finally, our study identified the most important determinants of poverty, on the basis of which we made policy recommendations: i) build assets (AWMT, livestock, etc.); ii) human resources development; and iii) improve the functioning of labor markets and access to these (input or output) markets for enhanced impact of AWMT on poverty.

1. Introduction

Farmers in rural Ethiopia live in climate related risk-prone environment. The major source of climate risk is the persistent fluctuation in the amount and distribution of rainfall (Awulachew, 2006; Namara et al., 2006). The dependence on highly variable rainfall increases farmers' vulnerability to shocks while also constraining farmers' to use yield-enhancing modern inputs. This exacerbates household's vulnerability to poverty and food insecurity. Poverty in Ethiopia has, in fact, mainly rural dimension. Small-scale farmers are the largest group of poor people in Ethiopia (MoFED, 2006). As a response, the government of Ethiopia has embarked on massive investment in low cost Agricultural water management technologies (AWMTs). Lately the focus has been on development of small-scale micro water harvesting schemes. This wide range of technologies collectively referred to as "smallholder water and land management systems," attempts to create opportunities for the poor and small landholders in accessing water, rain or ground water, which in turn leads to increased production and income. These technologies are reported to be particularly suited to small, poor and even landless households as the costs self-select the poor and have a strong land and water-augmentation effects (Hussain et al. 2001).

In this line, thousands of shallow wells and dozens of deep wells have been developed since 2002/2003 in Ethiopia. In Amhara and Tigray Regional states alone a total of approximately 70,000 ponds and tanks were constructed in one fiscal year (Rämi, 2003). There are currently an estimated 56,032 ha of modern small scale irrigation schemes in Ethiopia, comprising micro dams and river diversions (Awulachew et al. 2007) and larger areas under traditional irrigation. The development of these systems has required huge financial input from the government, whose food security budget has increased from year to year, a major chunk of which is used to promote different types of small scale water and land management systems (FDRE, 2004). Despite these huge investments, their impact remains hardly understood, save the anecdotal evidences gathered here and there (Rämi, 2003).

The Comprehensive Assessment of Water Management in Agriculture (IWMI, 2007) states that "improving access to water and productivity in its use can contribute to greater food security, nutrition, health status, income and resilience in income and consumption patterns. In turn, this can contribute to other improvements in financial, human, physical and social capital simultaneously alleviating multiple dimensions of poverty" (P.149). FAO (2008) also argued that well-targeted, local interventions in water can contribute to rapid improvements in livelihoods of the rural poor in SSA and help attain the Millennium Development Goals of eradicating extreme poverty and hunger. In fact, FAO (2008) identified better management of soil moisture and investment in water harvesting and small storage as two promising interventions in view of their poverty-reduction potential.

While evidence on the impact of irrigation on poverty from Asia, be it from large and small systems, is plenty (Hussain, et. al.2001; Hussain, et. al.2006; Hussain, 2005; Hussain, 2007; Huang, et al., 2006; Namara, et al., 2007b) and the research findings consistently indicate that irrigation development alleviates poverty in rural areas of developing countries (Hussain and Hanjra, 2003). Hussain and Hanjra (2004) reported that irrigation is productivity enhancing, growth promoting, and poverty reducing. The poverty impact of AWMTs in Asia is also viewed in the same positive light. Hussain et al. (2001) reported that there has been an upsurge in the adoption of irrigation technologies for smallholders such as low-cost pumps, treadle pumps, low-cost bucket and drip lines, sustainable land management practices, supplemental irrigation, and recharge and use of groundwater and water harvesting systems. Of the many studies that documented the poverty reduction impacts of micro-irrigation in Asia, Namara et al., (2007a) and Narayanamoorthy, A., (2007), both from India, reported that micro-irrigation technologies result in a significant productivity and economic gains. Shah et al. (2000) reported that treadle pump technology has had a tremendous impact in improving the livelihoods of the poor in Bangladesh, eastern India, and the Nepal Terai, South Asia's so-called "poverty square."

As far as sub-Saharan Africa is concerned, although there are specific country evidences that support the poverty reduction impacts of irrigation development (Van Koppen et al., 2005; Namara et al., 2007; Tesfaye et al., 2008; FAO, 2008), a report by AfDB, FAO, IFAD, IWMI, and the World Bank (2007) documented that irrigated cropping in the region continues to be characterized by low productivity and hence low profitability with serious implications for poverty reduction and growth.

There is an emerging literature, although still very scanty compared to the evidence in Asia, on the impact of small scale agricultural water management technologies on poverty in Africa. Just to mention few: Evidences from Tanzania, suggest that acquisition of treadle pump enabled households to double their income (Van Koppen et al., 2005). Similarly, adoption of treadle pumps by farmers in Niger has resulted in significant positive impacts, in terms of improvement of labor efficiency, increase in area under cultivation, cropping intensity and production volume, and increase in farm income. The same study also showed that in Nigeria, the use of low cost petrol pumps had a positive effect on its direct beneficiaries and slightly improved their situation in terms of income derived from irrigated fadama farming (Van Koppen et al., 2005). Adeoti, et al., (2007), exploring the impact of use of treadle pump in Ghana, West Africa, found that adoption of treadle pumps reduced poverty as measured by household income with positive impacts on human capital, i.e. children schooling and health.

The current study also aims to contribute to the emerging literature by measuring the poverty impacts of selected agricultural water management technologies in Ethiopia. This study has at least four novel features compared to earlier studies in the field. First, it makes a systematic documentation of the so-called promising technologies/practices in Ethiopia before measuring their poverty impacts. Hence, the paper quantified the effect on poverty of successfully adopting selected AWMT. In doing so, welfare indicators such as per capita income and expenditure per adult equivalent were used to measure these improvements. Second, it considered all aspects of agricultural water management technologies ranging from in-situ to ex-situ AWM technologies and practices while also considering the different suits used to control, withdraw, convey and apply water. Third, to explore the impact of adoption of AWMT on poverty we used a variety of simple and complex statistical techniques (to test robustness of results) ranging from mean separation tests, standard poverty analysis to estimation of average treatment effects using propensity score matching. In quantifying the poverty impacts, we made sure that we created comparable groups of households from those having access and those without access to AWMTs, which is critical in assessing impact of interventions. As part of explaining the role of access to AWMTs on poverty, we also identified correlates of poverty using a multivariate regression model. Last but not least, the study calculated the net present value of the selected AWMT to see how much each of these technologies cost households, even if the full costs for accessing these technologies are not fully borne by the households. This is important in the light of assessing which of the AWMTs are worth investing in given that they have promises to reduce poverty.

The study used a sample of 1517 farm households from 29 Peasant Associations (Kebelle)[9] in four regional states in Ethiopia, where the selected technologies are widely practiced. The survey was conducted during Oct.-Dec. 2007. The paper is organized as follows. In section two we describe the data used and the study sites followed, in section three, by brief outline of the methodological approaches used in this paper to measure impact. In section four we present the major findings of the including mean separation test results of important socio-economic variables; the estimates of the average treatment effects for the treated; the poverty estimates and their decomposition by different socio-economic variables, and some stochastic dominance tests and the determinants of poverty analysis from a multivariate regression model. Section five presents the results of a simple cost benefit analysis of the selected AWMTs. The final part concludes and draws policy recommendations.

2. Data and study site description

This study is part of a comprehensive study on Agricultural Water Management Technologies in Ethiopia. The study includes inventory of

[9] A Kebelle on average covers 800ha of land and is the lowest rural administrative unit in Ethiopia. It is also known as a peasant association.

Agricultural Water Management Technologies and Practices in Ethiopia and assessment of the poverty impacts of most promising technologies, the focus of this study being on the latter. The study was conducted during October - December 2007 and was implemented by the International Water Management Institute (IWMI) with support from USAID. The socio-economic survey data, on which this study is based, is gathered from a total sample of 1517 households from 29 Peasant Associations (PAs) in four Regional states (see Fig. 1). The PAs were selected based on the presence of the identified promising technologies. This selection was based first on the identification of promising technologies through key informant interviews (see Loulseged, et al. 2008). Then households from each PA were selected randomly, once the households in each PA were stratified into those with access and without access, following a non-proportional sampling approach. Details of the sample households by type of technologies from the four regions are given below in table 1. The data was collected for the 2006/2007 cropping season.

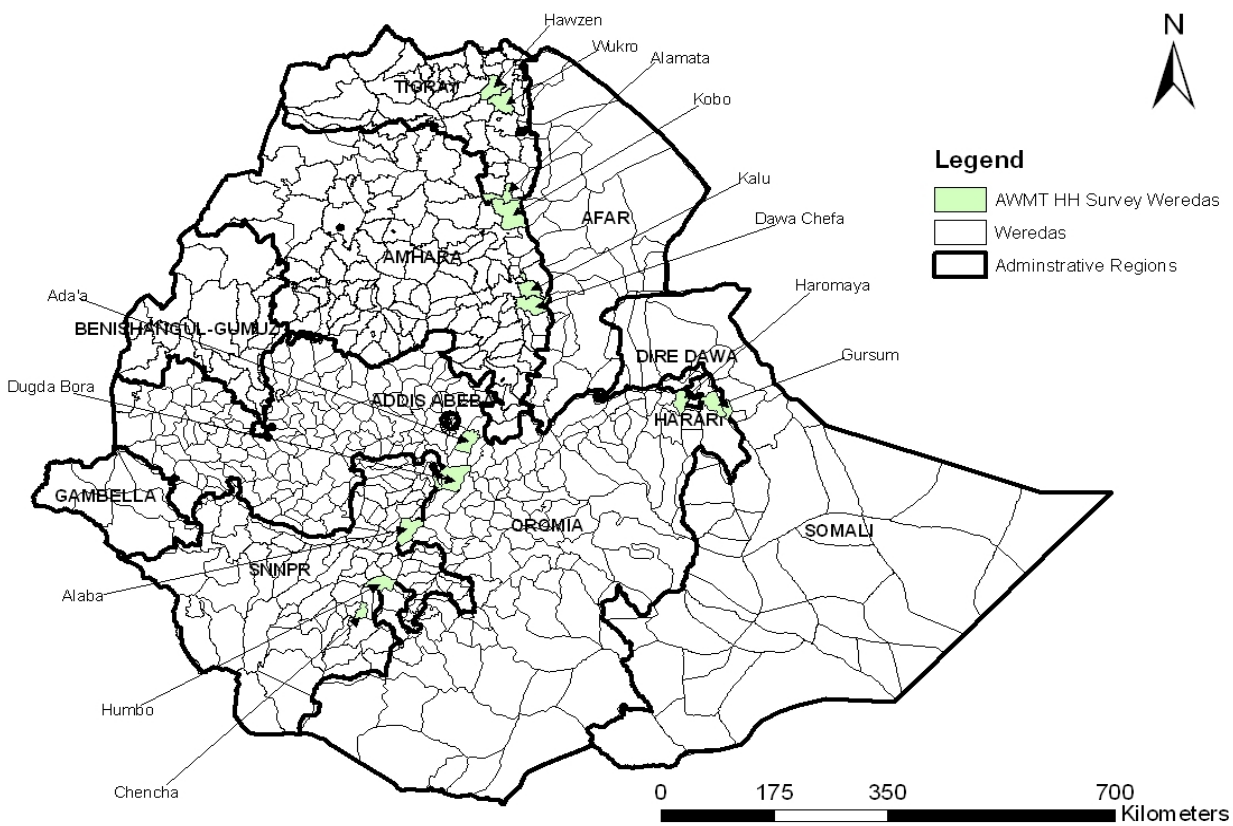

Figure 1: Location of the study sites

The poverty impacts of AWMT were assessed first using simple mean separation tests on key variables (per capita income, expenditure per adult equivalent, income from cash crop sales, perceived changes in food security, farm input use and asset holding). We then examined the impact of AWMT on household wellbeing, where wellbeing is measured as per capita household income, using matching econometrics to establish whether access to AWMT has unambiguously led to significant increase in agricultural income which is expected to be translated to other welfare outcomes, for instance to higher consumption expenditure which we used for poverty analysis. Finally we undertook poverty analysis using standard poverty analysis techniques to explore whether those with access to AWMT have relatively higher consumption expenditure per adult equivalent compared to those without access. We briefly present the analytical methodology used for doing so below.

Table 1: Summary of sample households

Region	**Agricultural water management technologies**						
	Purely rainfed	Pond	Shallow wells	Deep wells	River diversion	Micro dams	others
Amhara	281	8	45	10	28	13	5
Oromia	219	12	23	68	68	1	2
SNNPR	217	68	55	0	14	25	0
Tigray	143	47	91	1	40	35	18
Total	688	829					

3. Analytical approaches

Here below we present the analytical approaches used in the paper to measure impact.

Propensity score matching

One of the problems of assessing impact is to find comparable groups of treated and control groups, i.e. users and non-users of AWMT. Matching econometrics provides a promising tool to do just that while estimating the average treatment effects (Ravallion, 2004).

Matching is a method widely used in the estimation of the average treatment effects of a binary treatment on a continuous scalar outcome. It uses non-parametric regression methods to construct the counterfactual under an assumption of selection on observables. We think of having access to AWM technologies as a binary treatment, income per capita as an outcome, and households having these technologies as treatment group and non-user households as control group. Matching estimators aim to combine (match) treated and control group households that are similar in terms of their observable characteristics in order to estimate the effect of participation as the difference in the mean value of an outcome variable. In this case, we used observable household characteristics (such as characteristics of household head, land, livestock and labor endowment, access to credit, etc.) and village level covariates that may influence choice of participation in the intervention (e.g. choice of AWMTs) but not necessarily influenced by the intervention.

Following the literature of program evaluation, let Y_1 is the per capita income when household i is subject to treatment $(C=1)$ and Y_0 the same variable when a household is exposed to the control $(C=0)$. the observed outcome is then

$$Y = CY_1 + (1-C)Y_0 \quad (1)$$

When $C=1$ we observe Y_1; when $C=0$ we observe Y_0. our goal is to identify the average effect of treatment (using AWMT) on the treated (those households who have access to the technologies) (ATT). It is defined as

$$ATT = E(Y_1 - Y_0 | C=1) = E(Y_1|C=1) - E(Y_0|C=1) \quad (2),$$

The evaluation problem is that we can only observe $E(Y_1|C=1)$; however, $E(Y_0|C=1)$ does not exist in the data, since it is not observed. A solution to this problem is to create the counterfactual $E(Y_0|C=1)$ (what would have been the income of households with access to AWMT had they not had access (or the converse)), by matching treatment and control households. As discussed by Heckman (1998) a critical assumption in the evaluation literature is that no-treatment state approximates the no program state[10]. For matching to be valid certain assumptions must hold. The primary assumption underlying matching estimators is the Conditional Independence Assumption (CIA). CIA stated that the decision to adopt is random conditional on observed covariates X. in notation,

$$(Y_1, Y_0) \perp C | X \quad (3)$$

This assumption imply that the counterfactual outcome in the treated group is the same as the observed outcomes for non-treated group

$$E(Y_0 | X, C=1) = E(Y_0 | X, C=1) = E(Y_o | X) \quad (4)$$

This assumption rules out selection into the program on the basis of unobservable gains from access. The CIA requires that the set of X's should contain all the variables that jointly influence the outcome with no-treatment as well as the selection into treatment. Under the CIA, ATT can be computed as follow:

$$ATT = E(Y_1 - Y_0 | X, C=1) = E(Y_1 | X, C=1) - E(Y_0 | C=1) \quad (5)$$

Matching households based on observed covariates might not be desirable or even feasible when the dimensions of the covariates are many. To overcome the curse of dimensionality, Rosenbaum and Rubin (1983) show that instead of matching along X, one can match along $P(X)$, a single index variable that summarizes covariates. This index is known as propensity score (response probability). It is the conditional probability that household i adopts AWMT given covariates:

$$p(X) = pr(C=1)|X \quad (6)$$

The ATT in equation (5) can then be written as

[10] Here the assumption of no contamination bias or general equilibrium effect is important.

AT

$$E(Y_1|P(X),C=1)-E(Y_0|P(X),C=1) \quad (7)$$

The intuition is that two households with the same probability of adoption will show up in the treated and untreated samples in equal proportions. The propensity score (p score) is estimated by a simple binary choice model; in this paper a binary Logit model is used. Once the p score is estimated, the data is split into equally spaced intervals (also called common support) of the p score. Within each of these intervals the mean p score and of each covariate do not differ between treated and control plots. This is called the balancing property. For detail algorithm of p score matching see Dehejia and Wahba (2002). If the balancing property is not satisfied higher order and interaction terms of covariates can be considered until it is satisfied. Since p score is a continuous variable exact matches will rarely be achieved and a certain distance between treated and untreated households has to be accepted. To solve this problem treated and control households are matched on the basis of their scores using nearest neighbor, kernel and stratification matching estimators. These methods identify for each household the closest propensity score in the opposite technological status; then it computes investment effect as the mean difference of household's income between each pair of matched households. For details of these methods we refer to Becker and Ichino (2002) who also provide the STATA software code we use in this paper. One limitation of the matching based on observables is that endogenous program placement due to purposive targeting based on unobservable will leave bias (Ravallion, 2001). However, there is hardly reason to believe that these interventions are purposively placed as the feasibility of the technologies is conditioned more by natural factors (e.g. availability of water, topography, etc.) than by socio-economic preconditions.

Poverty analysis

When estimating poverty following the money metric approach to measurement of poverty, one may have a choice between using income or consumption as the indicator of well-being. Most analysts argue that, provided the information on consumption obtained from a household survey is detailed enough, consumption will be a better indicator of poverty measurement than income for many reasons (Coudouel et al. 2002). Hence, in this paper we estimate poverty profiles using expenditure adjusted for differences in household characteristics.

Constructing poverty profiles

We used the Foster-Greer-Thorbecke (FGT) class of poverty measures to calculate poverty indices (Foster et al., 1984). The FGT class of poverty measures have some desirable properties (such as additive decomposability), and they include some widely used poverty indices (such as the head-count and the poverty gap measures). Following Duclos et al. (2006), the FGT poverty measures are defined as

$$\mathrm{P}(z;\alpha)=\int_0^1\left(\frac{g(p;z)}{z}\right)^{\alpha}dp$$

Where z denotes the poverty line, and α is a nonnegative parameter indicating the degree of sensitivity of the poverty measure to inequality among the poor. It is usually referred to as poverty aversion parameter. Higher values of the parameter indicate greater sensitivity of the poverty measure to inequality among the poor. The relevant values of α are 0, 1 and 2.

At α=0 equation 8 measures poverty incidence or the head count ratio. This is the share of the population whose income or consumption is below the poverty line, that is, the share of the population that cannot afford to buy a basic basket of goods, food or non-food or both depending on which one is interested in.

At α=1 equation 8 measures depth of poverty (poverty gap). This provides information regarding how far off households are from the poverty line. This measure captures the mean aggregate income or consumption shortfall relative to the poverty line across the whole population. It is obtained by adding up all the shortfalls of the poor (assuming that the non-poor have a shortfall of zero) and dividing the total by the population. In other words, it estimates the total resources needed to bring all the poor to the level of the poverty line (divided by the number of individuals in the population). Note also that, the poverty gap can be used as a measure of the minimum amount of resources necessary to eradicate poverty, that is, the amount that one would have to transfer to the poor under perfect targeting (that is, each poor person getting exactly the amount he/she needs to be lifted out of poverty) to bring them all out of poverty (Coudouel et al. 2002). At $\alpha = 2$ equation 1 measures poverty severity or squared poverty gap. This takes into account not only the distance separating the poor from the poverty line (the poverty gap), but also the inequality among the poor. That is, a higher weight is placed on those households further away from the poverty line. We calculated these indices using STATA 9.0 and tested for difference between poverty profiles between groups following approaches suggested by Kwakani (1993) and Davidson and Duclos (1998).

Dominance tests

Poverty comparisons can, however, be sensitive to the choice of the poverty line. The important issue in poverty analysis is that the poverty line yields consistent comparisons (Ravallion, 1994). Stochastic tests used to check the robustness of ordinal poverty comparisons prove to be useful in poverty analysis (Atkinson, 1987). The idea of standard welfare dominance is to compare distributions of welfare indicators in order to make ordinal judgment on how poverty changes (spatially, inter-temporally or between groups) for a class of poverty measures over a range of poverty lines (Ravallion, 1994; Davidson and Duclos, 2000). Hence, we need to undertake ordinal poverty comparisons using stochastic dominance tests and check the robustness of the poverty orderings. The idea here is to make ordinal judgments on how poverty changes for a wide class of poverty measures over a range of poverty lines.

Determinants of poverty

An analysis of poverty will not be complete without explaining why people are poor and remain poor over time. Within a microeconomic context, the simplest way to analyze the correlates of poverty consists in using a regression analysis against household and demographic factors, specific individual/household head characteristics, asset holdings, village level factors, and access to services (markets, credit, AWM technologies, extension, etc). Let the welfare indicator W_i be gives as:

$$W_i = Y_i / Z \qquad (9)$$

Where Z the poverty is line and Y_i is the consumption expenditure per adult equivalent. Denoting by X_i the vector of independent variables, the following regression

$$LogW_i = \beta' X_i + \varepsilon_i \qquad (10)$$

This could be estimated by ordinary least squares (OLS). In this regression, the logarithm of consumption expenditure (divided by the poverty line) is used as the left-hand variable. The right hand variables in the regressions include: (a) household head characteristics, including sex, level of education (using five tiered categories), primary occupation of the household (farming vs. non-farming) and consumer worker ratio; (b); asset holding: oxen holding, livestock size (in TLU[11]) and farm size, adult labor (by sex) all in per adult equivalent terms; c) access to different services and markets: credit, non-farm employment, access to market proxied by distance to input markets, seasonal and all weather roads, distance to major urban markets; and d) village level characteristics mainly agro-ecology.

The β coefficients in equation (10) are the partial correlation coefficients that reflect the degree of association between the variables and levels of welfare and not necessarily their causal relationship. The parameter estimates could be interpreted as returns of poverty to a given characteristics (Coudouel et al., 2002; Wodon, 1999) while controlling for other covariates, the so-called ceteris paribus condition. We used regression techniques to account for the stratified sampling technique and, hence, adjust the standard errors to both stratification and clustering effects (Deaton; 1997; Wooldrige, 2002) and thereby to deal with the problem of heteroskedasticity. We also tested for other possible misspecifications (e.g. multicollinearity) using routine diagnostic measures.

In summary the analysis of poverty and inequality followed six steps. First, we have chosen household consumption expenditure as welfare measure and this was adjusted for the size and composition of the household. Second, the consumption poverty line was set at 1821.05 Birr (1USD=9.2 Birr), an inflation-adjusted poverty line of the official baseline poverty line of ETB 1075 set in 1995/96 as measure of welfare corresponding to some minimum acceptable standard of living in Ethiopia (MOFED, 2006). We also used an inflation-adjusted poverty line of 1096.03 as absolute food poverty line based on the corresponding 1995/96 official food poverty line. These lines were chosen to enable meaningful comparison of poverty levels in Ethiopia between various groups and over time (in reference to earlier studies). The poverty line acts as a threshold, with households falling below the poverty line considered poor and those above the poverty line considered non-poor. Third, after the poor has been identified, poverty indices such as head count, poverty gap and poverty gap squared were estimated. Fourth, we constructed poverty profiles showing how poverty varies over population subgroups (example users Vs non-users) or by other

[11] We used livestock less oxen in Tropical livestock units.

characteristics of the household (for example, level of education, age, asset holding, location, etc.). The poverty profiling is particularly important as what matters most to policymakers is not so much the precise location of the poverty line, but the implied poverty comparison across subgroups or across time. Furthermore, we undertook ordinal poverty comparisons using stochastic dominance tests to check the robustness of the poverty orderings. This is important because the estimation of the poverty line could be influenced by measurement errors. Lastly, we explored the determinants of poverty using multivariate regression analysis. We analyzed the correlates of poverty against household and demographic factors, specific individual/household head characteristics, asset holdings including adoption and use of AWM technologies, village level factors, and policy related variables (access to services). By doing so, the marginal impact of access to AWM technologies on poverty was assessed while controlling for other possible covariates.

4. Results and discussions

In this section, we report the results of the statistical summary of important variables for users and non-users, including their test statistics, matching estimates of the average treatment effects, poverty profiles of users and non-users and decomposition by various socio-economic variables to identify who the poor are and results of the dominance tests and correlates of poverty.

Summary and separation tests

This statistical test result could serve as some indicative measures of the differences in important variables between users and non-users, which may be considered as indicative measures of the impact of access to AWMT. However, we will be required to do a more systematic analysis of impact before we could draw definite conclusions on impact of access to AWMT. Accordingly, we found statistically significant difference in mean values of important variables (Table 2).

As could be seen from the mean separation test, there is statistically significant difference ($p < 0.000$) in agricultural income (both crop and livestock) among users and non-users of AWMT. Those with access to AWMT were found to use higher farm inputs and have significantly higher share of their produce supplied to the market ($p \leq 0.000$) implying increased market participation. Accordingly, the value of fertilizer, seed, labor and insecticide used and the size of loan received from microfinance institutions were significantly higher for users of AWMT compared with non-users. This may imply that because of access to AWMT, there is increased intensification of agriculture. This is expected to have wider effects on the economy e.g. on input and factor markets. Not surprisingly, users were also found to have significantly higher asset endowments such as male adult labor, oxen, livestock (in TLU) and land holding, which may imply that those with access to AWMT have managed to build assets. On the other hand, it may also mean that households with better resource endowments may be targeted by the program (or due to self-selection) secured access AWMT, an issue we may not be able to tell in the absence of baseline data. However, the mean separation test indicated that there is no significant difference in mean consumption expenditure per adult equivalent, incidence of food shortage and size of non-farm income between those with access to AWMT and those without access.

Table 2: mean separation tests of some important variables of households with access and without access to AWMT

Variable name	Non-user of AWMT (n= 641)	User AWMT (n= 876)	p-value*
	Mean (SE)	Mean (SE)	
Value of fertilizer used	274.9 (27.0)	399.5 (32.7)	0.0053
Value of seed used	272.1 (31.1)	698.1 (204.1)	0.0762
Value of labor used	600.9 (34.7)	1114.3 (67.6)	0.0000
Value of insecticide used	19.6 (3.1)	75.4 (19.7)	0.0161
Loan size (cash)	1293.4 (108.0)	1688.9 (102.5)	0.0083
Crop income	302.3 (16.4)	682.5 (57.0)	0.0000
Livestock income	51.6 (5.37)	67.3 (4.25)	0.0201
Agricultural income	352.9 (7.2)	749.7 (57.2)	0.0000
Non-farm income	63.7 (4.36)	67.0 (4.95)	0.6276
Consumption expenditure per adult equivalent (monthly)	39.2 (4.46)	40.8 (3.71)	0.7739
Face food shortage	0.373 (0.019)	0.354 (0.016)	0.4475
Market share	0.07 (0.01)	0.15 (0 .012)	0.0000
Oxen units	1.18 (0.047)	1.71 (0.055)	0.0000
Livestock units (in TLU)	3.27 (0.113)	4.64 (0.15)	0.0000
Land holding in (timad)	5.12 (0.163)	7.143 (0.19)	0.0000
Labor endowment (adult labor)	2.961 (0.059)	3.054 (0.051)	0.2340
Labor endowment (Adult male)	1.4456 (0.039)	1.568 (0.035)	0.0209
Labor endowment (Adult female)	1.496 (0.037)	1.476 (0.029)	0.6650

* Two-sided test of equality of means

Average treatment effects

The problem with such mean separation tests is non-comparability of the two sub-samples and that we did not control for the effect of other covariates. Hence, we will systematically analyze if access to AWMT has led to significant effects on income and poverty using matching (by creating comparable groups) and standard poverty analysis techniques respectively in the subsequent sections**.**

Table 3: Results of matching method to measure impact of AWMT on household income (bootstrapped standard errors)

Treatment (n)	Control (n)	ATT		t-test
Kernel Matching method				
699	394	788.674	(218.78)	3.605***
Nearest Neighbor Matching method				
699	247	760.048	(255.73)	2.972***
Stratification method				
699	394	785.326	(227.53)	3.451***

*, **, *** significant at 10, 5 and 1 percent level of significance

he matching estimates where the treated and control households were matched on the basis of their scores using nearest neighbor, kernel methods and stratification matching estimators, show that there is significant effect on household income from owning AWMTs. Important to note is that out of the 1517 households only about 947 are comparable (see Table 3). The estimated average treatment effect for the treated (ATT) is also positive in all the cases and is about ETB 780 (equivalent to USD 82). This indicated that access to AWMT technologies has lead to significant increase in per capita income. We now turn to poverty analysis using consumption expenditure per adult equivalent.

Poverty profiles and decomposition

Using the absolute overall poverty line of ETB 1821.05, about 48 percent of the individuals in user households have been identified as poor. On the other hand, about 62 percent of the individuals in non-users were identified as poor. The test results also show that there is significant difference in poverty levels between users and none users. Our calculation shows that there is about 22% less poverty incidence among users compared to non-users. In other words, individuals with access to AWMT are in a better position to meet their consumption requirements, food and non-food. There is also significant difference in poverty gap and severity of poverty among users and non-users, implying that access to AWMT are effective instruments to narrow the poverty gap and inequality (see Table 4). However, this also implies that the level of poverty has increased compared to reported official overall poverty of about 39 % in 2004/05 (MoFED, 2006; p. 23) calculated based on poverty line of ETB 1,075. However, we feel that this seemingly significant increase in poverty has to do with the failure to adjust the poverty line to account for price changes in the cited document.

We disaggregated users by the type of AWMT to measure the poverty impact of specific technologies. As could be seen from the reported results, all ex-situ technologies considered in this study were found to have significant poverty reducing impacts. However, deep wells, river diversions and micro dams seem to have higher poverty impacts compared to ponds and shallow wells perhaps largely due to scale benefits. In this case, deep wells, river diversions and micro dams have led to 50, 32 and 25 percent reduction in poverty incidences compared to the reference, i.e. rain fed system. On the other hand, use of in-situ AWMT was found to have no significant poverty reducing impacts. On the contrary, those using in-situ AWMT are found to have higher poverty levels in terms of the head count, poverty gap and severity of poverty indices. We do not have any a priori reason for this seemingly counter intuitive result. However, it may be mentioned that in-situ technologies have been used as mere soil conservation measures with little immediate impact on productivity growth; and at the same time they may divert labor from direct agricultural crop production.

We also considered disaggregating poverty levels by type of water withdrawal and application technologies. The most common withdrawal and application mechanisms include gravity flooding (63.3 %), manual (33.7 %), treadle pump (6.7%), and motor pump (8.4%). Sprinkler (0.20 %) and drip (0.20%) are hardly practiced although there are signs of households picking up these technologies gradually.

Table 4: The effect of irrigation on incidence, depth and severity of poverty (poverty line = ETB 1821.05)

Category	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	value	SE	Value	SE	Value	SE
Access to AWMT						
Users (n= 876)	0.478	0.017	0.198	0.009	0.1110	0.007
Non-users (n= 641)	0.623	0.018	0.282	0.011	0.167	0.009
z-statistic*	-484.2***		-381.6***		-282.0***	
Types AWMT[12]						
Pond (n= 196)	0.561	0.035	0.218	0.017	0.107	0.011
z-statistic[13]	-193.5***		-170.8***		-146.2***	
Shallow wells (n= 251)	0.565	0.031	0.266	0.019	0.168	0.016
z-statistic	-233.0***		-172.3***		122.1***	
Deep wells (n=93)	0.312	0.048	0.113	0.021	0.0550	0.013
z-statistic	-109.2***		-107.8***		-98.0***	
River diversion (n= 291)	0.403	0.029	0.1440	0.013	0.071	0.009
z-statistic	-258.0***		-235.5***		-189.0***	
Micro-dams (n= 63)	0.484	0.063	0.1910	0.032	0.101	0.022
z-statistic	-71.6***		-63.0***		-53.3***	
In-situ technologies						
Users (n= 368)	0.614	0.025	0.253	0.014	0.141	0.0110
Non-users (n= 373)	0.521	0.0148	0.2300	0.008	0.134	0.007
z-statistic	-296.2***		-220.9***		-150.5***	
Water application technologies[14]						
Flooding (n= 533)	0.429	0.021	0.159	0.010	0.079	0.007
Manual (n= 284)	0.567	0.029	0.274	0.018	0.171	0.015
Water withdrawal						
Treadle pump (n=101)	0.524	0.049	0.183	0.023	0.088	0.014
z-statistic	-111.0***		-103.4***		-63.4***	
Motor pump (n=127)	0.228	0.037	0.068	0.0135	0.027	0.007
z-statistic	-155.7***		-172.7***		-171.0***	
Water input						
Supplementary (n= 270)	0.56	0.030	0.262	0.18	0.16	0.15
z-statistic	-245.0***		-24.5***		-17.4***	
Full irrigation (n= 579)	0.437	0.020	0.16	0.009	0.077	0.006
z-statistic	-322.7***		-287.0***		-231.7***	

*, **, *** significant at 10, 5 and 1 percent level of significance

[*] The z-statistic is derived using Kwakani's (1993) formulae to test for equality of poverty measures. The critical value for the test statistic is 1.96 (applicable for all tests in Tables 4-6) at 5% level of significance.
[12] We compared those using different AWMT against non-users.

[14] We compared those using different water application technologies against non-users.

Accordingly, those using motor pumps were found to have significantly lower poverty incidence, compared to treadle pump users. In fact, as a result of using motorized pumps, there is more than 50 percent reduction in the incidence of poverty mainly due increased water availability and scale benefits. As far as, water application technologies are concerned, households using gravity were found to have significantly lower poverty incidence compared to those using manual (using cans) applications. Furthermore, we disaggregated poverty by the type of water use that is whether water is used for supplementary or full irrigation. Our results show that those who use AWMT for full irrigation have significantly lower poverty incidence compared to those using supplementary and non-users. This implies that supplementary irrigation could contribute to poverty reduction; a significant contribution comes, however, from full irrigation. System reliability and scale benefits seem to be the most important drivers of poverty reduction. This will have an important implication on technology choice for an effective poverty reduction.

We also estimated poverty profiles using an absolute food poverty line of ETB 1096.02. Accordingly, 23 percent of the users and 34 percent of the non-users respectively are identified as food poor. These indices could be taken as food security indices. This implies that the level of food security has increased compared to 38% in 2004/05 (MoFED, 2006; p. 27) calculated based on poverty line of ETB 647.8. However, we feel that the food poverty line used should have been adjusted to account for price changes to make meaningful comparisons.

When disaggregated by type of AWMT, as in the case of overall poverty, deep wells, river diversion and micro dams have relatively higher impact on reducing food poverty. Ponds and wells, although have led to significant reduction (compared to non-users), they have relatively lower poverty reducing impacts. However, in-situ AWMT have not led to significant reduction to food insecurity. On the contrary, those using in-situ AWMT are found to have higher poverty levels in terms of the head count, poverty gap and severity of poverty indices.

Furthermore, households using AWMT for full irrigation have relatively lower food poverty compared to those using water for supplementary irrigation. We also conclude that the mentioned comparative advantages are linked to reliability and adequacy of water supply as well as availability of labor for water management.

Who are the Poor?

We tried to gain additional insights into the question of who the poor are by decomposing poverty profiles of households by other socio-economic variables. We used variables such as sex of the household head, education status of the head, asset holding (mainly labor, farm and oxen holding) and access to services like formal credit and location dummies (in this case regions). We tested for differences in poverty across socio-economic groups using statistical tests. The results are reported in Table 6.

The regional decomposition of poverty shows that users of AWMT in Oromia and Amhara have significantly lower poverty levels in incidence, depth and severity of poverty compared to users in Tigray and SNNPR. This may show the successful use of AWMT in Oromia and Amhara having significant impact on poverty reduction. Not surprisingly, poverty seems to be closely related to asset holding, most importantly land holding.

Table 5: The effect of irrigation on incidence, depth and severity of poverty (poverty line = ETB 1096.02)

Category	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	value	SE	Value	SE	Value	SE
Access to AWMT						
Users (n= 876)	0.2340	0.015	0.086	0.007	0.049	0.005
Non-users (n= 641)	0.349	0.018	0.137	0.009	0.081	0.007
z-statistic*	-286.4***		-231.3***		-181.8***	
Types AWMT						
Pond (n= 196)	0.275	0.032	0.071	0.011	0.028	0.006
z-statistic[15]	-116.2***		0.00		-144.9***	
Shallow wells (n= 251)	0.311	0.029	0.143	0.017	0.094	0.014
z-statistic	-137.0***		0.0		-69.7***	
Deep wells (n= 93)	0.151	0.037	0.0380	0.0130	0.017	0.008
z-statistic	-3.8***		0.0		-73.2***	
River diversion (n= 291)	0.158	0.021	0.047	0.008	0.023	0.006
z-statistic	-179.6***		0.0		-128.9***	
Micro-dams (n= 63)	0.234	0.053	0.081	0.022	0.039	0.014
z-statistic	-47.0***		0.0		-39.7***	
In-situ technologies						
Users (n= 368)	0.302	0.024	0.111	0.012	0.062	0.009
Non-users (n= 373)	0.279	0.013	0.109	0.007	0.064	0.005
z-statistic	-156.7***		-117.2***		-85.1***	
Water application technologies						
Flooding (n= 533)	0.176	0.016	0.056	0.006	0.027	0.005
Manual (n= 284)	0.341	0.028	0.144	0.015	0.091	0.0128
Water Withdrawal technologies						
Treadle pump (n=101)	0.227	0.042	0.062	0.013	0.020	0.005
z-statistic	-490.7***		0.1		-104.6***	
Motor pump (n= 127)	0.0470	0.019	0.014	0.007	0.006	0.003
z-statistic	-490.8***		0.0		-149.3***	
Water input						
Supplementary (n= 270)	0.333	0.028	0.138	0.016	0.086	0.013
z-statistic	-496.6***		0.1		-75.8***	
Full irrigation (n= 579)	0.174	0.0158	0.053	0.006	0.025	0.004
z-statistic	-490.7***		0.1		-155.8***	

*, **, *** significant at 10, 5 and 1 percent level of significance

* Critical statistics

[15] We compared those using different AWMT against non-users.

Households with operated farm holding greater than the mean holding, depicted lower poverty levels than those having farm holding less than the mean. On the other hand, households with oxen holding greater or equal to the mean holding (1.5 oxen units) displayed significantly higher poverty levels, perhaps indicating owning more than two oxen may not contribute to poverty reduction. Female-headed households have apparently higher poverty levels in terms of the incidence, depth and severity of poverty.

Table 6: Poverty decomposition by other socio-economic variables (users only and poverty line = ETB 1821.05)

Variables	Incidence ($\alpha = 0$)		Depth ($\alpha = 1$)		Severity ($\alpha = 2$)	
	value	SE	Value	SE	Value	SE
Tigray region (n= 244)	0.606	0.031	0.215	0.015	0.102	0.009
z-statistic	-230.5***		-202.0***		-179.3***	
Amahra region (n= 273)	0.329	0.028	0.117	0.012	0.056	0.008
z-statistic	-258.7***		-2.42.8***		-198.9***	
Oromia region (n= 190)	0.258	0.032	0.081	0.012	0.036	0.007
z-statistic	-205.2***		-216.0***		-193.4***	
SNNPR region (n= 169)	0.810	0.030	0.446	0.026	0.301	0.023
z-statistic	-205.6***		-115.4***		-78.6***	
Female-headed (n= 81)	0.568	0.055	0.205	0.028	0.107	0.020
Male-headed (n= 768)	0.463	0.018	0.191	0.009	0.106	0.007
z-statistic	-67.9***		-55.4***		42.8***	
Education level of head						
Illiterate (n= 787)	0.59	0.175	0.27	0.011	0.162	0.008
Informal education (n= 239)	0.47	0.03	0.174	0.015	0.085	0.009
z-statistic	-56.9***		-127.4***		-0.2***	
Primary complete (n= 327)	0.49	0.027	0.203	0.015	0.119	0.012
z-statistic	-62.8***		-165.9***		-125.3***	
Junior complete (n= 119)	0.48	0.046	0.20	0.024	0.106	0.017
z-statistic	-45.3***		-76.9***		-57.3***	
10 & above complete (n= 29)	0.44	0.094	0.187	0.055	0.121	0.046
z-statistic	-18.0***		-17.4***		-13.7***	
Primary occupation						
Farming (n= 834)	0.48	0.017	0.195	0.009	0.11	0.006
Non-farming (n= 33)	0.57	0.087	0.28	0.049	0.158	0.034
z-statistic	-35.7***		-31.5***		-25.7***	
Land holding						
Below average (n= 1054)	0.55	0.15	0.247	0.009	0.147	0.002
Above average (n= 463)	0.52	0.02	0.212	0.012	0.113	0.009
z-statistic	-93.1***		-253.7***		-235.3***	
Oxen holding						
Below average (n= 691)	0.48	0.02	0.18	0.009	0.092	0.006
Above average (n= 826)	0.59	0.17	0.28	0.011	0.174	0.008
z-statistic	-89.6***		-390.3***		-343.4***	
Labor holding (male)						
Below average (n= 568)	0.64	0.02	0.29	0.012	0.175	0.010
Above average (n= 949)	0.48	0.016	0.202	0.008	0.113	0.006
z-statistic	-352.5***		-264.2***		-183.8***	
Credit access						
With access (n= 447)	0.52	0.023	0.226	0.003	0.131	0.010
Without access (n= 1070)	0.55	0.015	0.240	0.008	0.139	0.006
z-statistic	-355.1***		-620.8***		-211.6***	

*, **, *** significant at 10, 5 and 1 percent level of significance

Education was also found to have significant effect on poverty levels of users. Accordingly, households with heads that have informal training or higher educational attainment have lower poverty levels compared to illiterate heads. There is also a significant difference in incidence, depth and severity of poverty depending on whether households have access to formal credit. This may have to do with the fact that households with access to AWMT may use credit to purchase farm inputs. Perhaps surprisingly, households whose primary occupation is farming have significantly lower poverty in terms of the incidence, depth and severity of poverty compared to those having non-farming as their primary occupation, which signifies agriculture is the most paying occupation in rural Ethiopia. The later group mainly constitutes landless farmers who make a living mainly from off/non-farm employment though they are also engaged in agricultural by renting in/sharecropping in land.

Dominance test results

Comparing the head count ratios between users and non-users of AWMT, the different orders of stochastic dominance tests established unambiguously that poverty is significantly lower among users compared to the non-users (Figure 2). This confirms that the incidence of poverty is significantly lower among users compared with non-users.

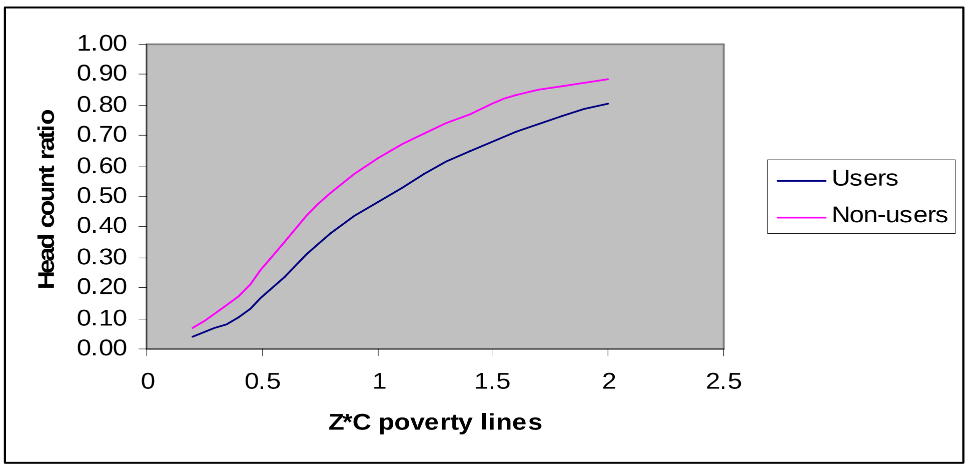

Figure 2: First-order stochastic dominance

Similarly, in terms of the depth and severity of poverty, the second and third order stochastic dominance tests showed that there was a significant difference in poverty gap and severity between users and non-users (see Figures 2 and 3). The results are robust for the different poverty lines considered. Hence, we could conclude that access to AWMT has led to significant reduction in poverty. More interestingly, AWMT are not only poverty reducing but also inequality reducing, as could be seen from the third order stochastic dominance.

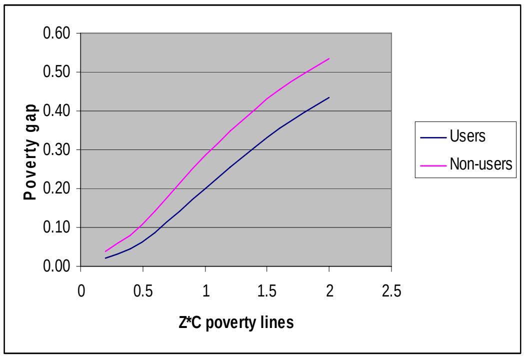

Figure 3: Second-order stochastic dominance

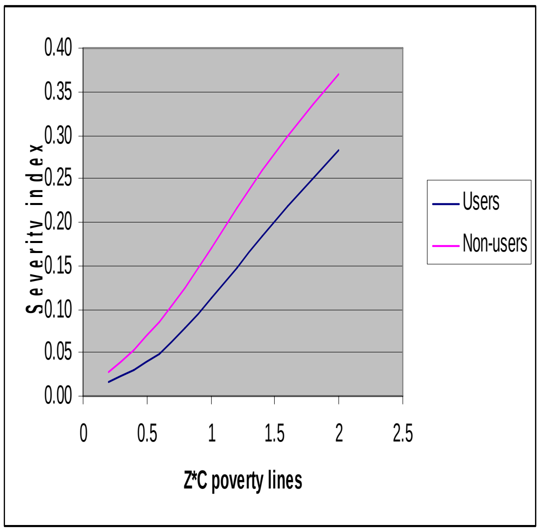

Figure 4: Third-order stochastic dominance

Poverty correlates

The results of the regression analysis on correlates of poverty are reported below. The F-test results indicate that the hypothesis of no significant β coefficient (except the intercept) is rejected (p < = 0.000); the coefficients are jointly significantly different from zero. As could be seen from the results in Table 7, most of the coefficients are significantly different from zero. The goodness of fit measure indicates that about 25 percent of the variation in the model is explained by the chosen model. Given the data used is survey data, this measure is not atypical.

Reporting on the significant variables, water input from AWMT has a significant effect on household welfare. Particularly, households that use AWMT as supplementary or full irrigation have significantly better wellbeing compared with those who depend on rain fed agriculture. This result corroborates the evidence we found earlier on the positive and poverty reducing impact of AWMT in Ethiopia.

While controlling for all other variables, households with more asset holdings are found to have significantly higher wellbeing (i.e. less poverty). This is particularly true with oxen holding and other forms of livestock holding. On the other hand, households with more adult labor endowment, both male and female, are found to have significantly lower wellbeing. This could be indicative of the high level of rural unemployment prevalent in Ethiopia and the poor functioning of the labor market.

Access to services is also found to have significant effect on household wellbeing. In this line, distance to input (fertilizer and seed) markets have a significant negative (at 1 percent level of significance) effect on household wellbeing while controlling for all other factors. Distance to water source has also a negative and significant effect on household welfare which may imply that those with access to water closely to home are better off. This underlines the fact that access to water for productive and consumptive uses, poverty reduction and sustainable livelihoods for rural people are all intimately linked (IWMI, 2007). Accesses to credit markets also have a significantly positive effect on household welfare, albeit at 10 percent level of significance. On the other hand, households distance to all weather roods has a significant and positive effect on wellbeing. The result is counter intuitive; one possible explanation could be households who are able to produce for the market transport their produce to distant but more attractive markets (Hagos et al., 2007).

Few household level covariates and agro-ecology (a village level covariate) were also found significant in explaining household wellbeing ceteris paribus. Accordingly, age of the household head has a negative effect on household welfare and this effect increases with age as we could see from the non-linear age coefficient. Our results also show that households with more dependents (compared to producers), i.e. higher consumer-worker ratio, are worse off. Education attainment of the household head has also a positive and significant effect on household welfare. Accordingly, compared to illiterate household heads, household with informal education (church and literacy program) and primary complete have a significantly positive effect on household wellbeing. The coefficients for junior high and high school complete have also the expected positive sign but were not significantly different from zero. Contrary to usual expectation, we did not find a significant difference between male-headed and female-headed in terms of welfare while controlling for all other relevant factors. Agro ecology, which could be a good proxy of the agricultural potential of geographical area, was found to have a significant effect on poverty. Accordingly, households located in highland (dega) were found to have higher poverty compared to lowlands. This could be indicative of the suitability of AWMT in relatively low land compared to highlands.

Table 7: Determinants of poverty (Regression with robust standard errors)

Dependent variable: log(welfare)

Variable name	**Coefficient**	**Standard error**	**t-value**
Household characteristics			
sex of head (Male-headed)	-0.045	0.077	-0.59
Age of head	-0.025	0.009	-2.81***
Age squared	0.0002	0.0001	2.48***
Informal education (reference illiterate)	0.162	0.056	2.90***
Primary complete(reference illiterate)	0.111	0.063	1.77*
Junior high complete (reference illiterate)	0.119	0.108	1.10
Secondary and above (reference illiterate)	0.195	0.198	0.99
Framing (reference non-farming)	-0.063	0.129	-0.49
Consumer-worker ratio	-0.096	0.031	-3.14***
Asset holding			
Number of male Adult labor	-0.077	0.030	-2.54***
Number of female Adult labor	-0.148	0.032	-4.63***
Land holding per adult equivalent	-0.0002	0.035	-0.01
Oxen per adult equivalent	0.160	0.079	2.02**
Other forms of livestock per adult equivalent (in TLU)	0.118	0.038	3.10***
Agricultural water management technologies (reference= rain fed)			
Supplementary irrigation	0.171	0.074	2.31**
Full irrigation	0.281	0.050	5.59***
Other uses (livestock and domestic)	-0.120	0.127	-0.95
Access to factor markets			
Off-farm employment	-0.048	0.049	-0.99
Credit access	0.088	0.051	1.71*
Distance to input distribution center	-0.002	0.001	-3.17***
Distance to all weather road	0.002	0.001	2.55***
Distance to local wereda center	0.001	0.001	1.28
Distance to water source	-0.003	0.001	-4.81***
Village level factors			
Agro-ecology (Weina Dega)	-0.058	0.047	-1.23
Agro-ecology (Dega)	-0.700	0.116	-6.05***
_cons	1.114351	0.273	4.07***

Number of obs = 1421
F(25, 1420) = 15.45
Prob > F = 0.0000
R-squared = 0.2517
Number of clusters = 1421

*, **, *** significant at 10, 5 and 1 percent level of significance

5. AWMTs: Benefits versus costs

In the light of assessing which of the selected AWMTs are worthwhile investing in, given that they have promises to reduce poverty, we run a simple financial cost-benefit analysis (for details see Hagos et al., 2008) of the selected AWMTs yielding mixed results.

We collected establishment cost data mainly from secondary sources and data on production cost and crop revenue from the household survey. Establishment and operation and maintenance (O & M) costs, and the assumed life span of these technologies are reported in Table 3 below. Assuming a discount rate of 8 % we calculated a net present values (NPV) of project worth to assess their social and private financial worth16. Assuming that farmers cover all investment, operation & maintenance and production costs, the corresponding net present values (NPV1 in Table 8) of all technologies, except river diversions, are negative even at 5 percent of social discount rate showing that these technologies are not financially viable from social financial cost-benefit analysis perspective. We even calculated NPVs by excluding the opportunity cost of labor (while still investment repayment and O & M costs are accounted for) to see if they become worthwhile of investing, as farmers do usually use family labor and does not involve direct cost (except the forgone income opportunity or leisure time). The calculated values (NPV2) show that only shallow wells and river diversions are financially viable.

Currently, the government, with donor and NGO involvement, is responsible for promoting most of these technologies.

In areas where the ground water potential is found to be high, the government is promoting deep wells by covering the total establishment costs while farmers are expected only to cover the operation (e.g. electricity costs) and maintenance costs. River diversions and small dams are also usually provided by the government and farmers are expected to cover operation and maintenance costs. However, in the case of ponds and shallow wells, after initial introduction with strong government support, farmers are expected to cover full cost of establishment. The government promises only technical support to farmers who would like to introduce these technologies besides providing, at cost, valuable water withdrawal and application inputs. This implies that the private cost of accessing these technologies is very low although provided at high social costs. Hence, it is interesting to assess the private financial viability of these technologies by excluding investment costs and only accounting for operation and maintenance costs and production costs.

Instead of the baseline scenarios (NPV1 and VPV2), we estimated NPV values by considering, first, that the opportunity cost of labor and O & M (ruling out investment recovery) in the calculation and latter all investment repayment cost, O & M and opportunity cost of labor are excluded. If opportunity cost of labor and O & M is only considered in the calculation (NPV3), ponds and small dams are not still financially viable while shallow and deep wells and river diversions are financially viable. In this case, unless establishment costs are considered as sunk costs, the financial returns of ponds and small dams, given current production and market conditions, are not promising. In the extreme case where all investment repayment cost, O & M and opportunity cost of labor are excluded (NPV 4), a very unrealistic scenario, all

[16] 8 percent is the current banking lending rate for long–term investment loans in Ethiopia (Tesfay, 2008).

technologies except ponds become financially viable implying that ponds are not financially viable under any of these circumstances. This needs to be taken into account while making the choice what to invest on.

Table 8: Cost-benefit estimates of selected water harvesting structures (in ETB/ha or unit)

Type of technologies	Establishment costs	Operating cost	Life span (# years)	O & M cost 10%	Production cost ETB/ha	Crop value ETB/ ha	NPV 1 ETB /ha	NPV 2 ETB /ha	NPV 3 ETB /ha	NPV 4 ETB /ha
Pond	5980[±]	-	10	388.8	5901.0	7861.0	-28864	-10354	-23532	-5022
Shallow wells	9343[+]	-	12	584.2	3531.2	4467.0	-2246	8347	6083	16677
Deep well/ha	94292[♣]	2500	25	2841.8	2616.2	9843.4	-28082	-19346	56438	65174
Small dam/ha	50000	-	25	5000	2919.4	12,070.8	-47244	-28918	-2662	15663
River diversion/ha	50000	-	25	5000	1629.3	2867.5	53131	50999	97713	95581
Rainfed (reference)					1804.0	2894.4	-			

<u>Source:</u> Tesfay (2008) and own calculation

± Includes costs of pond construction, geo-membrane plus treadle pump.

+ Includes costs of well construction and for purchase of generator pump.

♣ The cost stream include system installation cost (ETB 53,253.75 per hectare), electricity installation (ETB 2,543 per hectare), construction of generator house (ETB 356 per hectare), and electro mechanical works (ETB 9,722 per hectare).

From social financial cost benefit analysis perspective ponds, deep wells and small dams are not fully financially viable (if investment recovery option is considered); the most important implication of these findings is that, a widespread adoption of these technologies could not be expected without continued government support in proving these technologies. The reverse side of the story is if the government is to institutionalize investment cost recovery schemes, farmers operating particularly deep wells and small dams may not be able to pay unless some thing changes in the profitability of these systems. Hence, it is important to seek ways to improve the performance of these technologies through promotion of profitable cropping patterns and improved marketing conditions. This will have serious implications for poverty reduction and growth, because as a report by AfDB, FAO, IFAD, IWMI, and the World Bank (2007) argued without profitability the necessary income gains cannot be achieved and without profitability there is unlikely to be economic viability. However, there are even reported cases where farmers use ponds successfully (not only the other promising ones) to grow cash crops, and these farmers consider ponds as promising technologies. Exploring under which circumstances the different AWMTs work and what are the determinants of successful adoption of each of these technologies is critical beyond doing simple and dirty cost benefit analysis.

6. Conclusions and recommendations

AWMT have been identified as important tools to mitigate adverse effects of climatic variability and to reduce poverty. Huge resources are being allocated to develop and promote diverse low cost technologies in many developing countries including Ethiopia. In the last few years, thousands of low cost AWMTs have been developed for use by smallholders. In spite of these huge investments, their impacts remain unknown. The main objective of this paper was, hence, to explore whether adoption of selected AWMTs has led to significant reduction in poverty and if so identify which technologies have relatively higher impact. Moreover, the study aims to assess the financial viability of these technologies and its implication for poverty reduction. The importance of such study is to identify technologies that are promising for future investments.

Our results show that there was significant reduction in poverty due to adoption and use of AWMTs. In fact, our calculations show that there is about 22% less poverty incidence among users compared to non-users of AWMT. We found the poverty orderings between users and non-users are statistically robust. Furthermore, from the poverty analysis (severity indices), we have found that AWMT are not only effectively poverty-reducing but also equity-enhancing technologies. Equitable development is good for the poor and for better performance of the economy (Ravallion, 2005).

The magnitude of poverty reduction is found to be technology specific. Accordingly, deep wells, river diversions and micro dams have led to 50, 32 and 25 percent reduction in poverty incidences compared to the reference, i.e. rain fed system. This may imply that there is a need to promote more micro deep wells, river diversions and small dams for higher impact on poverty. Use of modern water withdrawal technologies (treadle pumps and motorized pumps) were also found to have strong poverty reducing potential. Households using of motorized pumps were found to have led to more than 50 percent reduction in the incidence of poverty. Similarly, households using gravity irrigation were found to have significantly lower poverty levels compared to those using manual (using cans) applications because of scale benefits. This implies that promotion of modern water withdrawal and application technologies could enhance poverty reduction.

The choice of between these technologies has to be made considering their relative financial viability (from cost-benefits analysis perspective) and poverty reduction impacts compared to other available options that could improve rain fed agriculture. This is especially important because farmers are not made to bear the full investment costs of these technologies as the government is the major provider of these technologies. In this line, assuming that establishment costs are disregarded from the computation, shallow and deep wells and river diversions were found to be financially viable technological options while ponds and small dams were not. Furthermore, given the poverty reduction impacts of ponds and small dams are relatively modest compared to deep wells and diversions, it is important to consider whether they are worthwhile of investment. On the other hand, deep wells are not also financially viable (if investment recovery option is considered); the most important implication of these findings is that, a widespread adoption of these technologies could not be expected without continued government support in proving these technologies. The reverse side of the story is if the government is to institutionalize investment recovery scheme, farmers operating deep wells and small dams may not be able to pay unless some thing changes in the profitability of these systems. Hence, it is important to seek ways to improve the performance of these technologies through promotion of profitable cropping patterns and improved marketing conditions.

While poverty analysis techniques do not have in-built mechanisms of creating comparable groups, and hence, could lead to attribution bias16, our results from the propensity score matching, however, indicated that the average treatment effect of using AWMT is significant and has led to an increase in per capita income which amounts to average income of USD 82.

While access to AWMT seems to unambiguously reduce poverty, our study also indicated that there are a host of factors that could enhance this impact. The most important determinants include asset holdings, educational attainment, underutilization of family labor and poor access to services and markets. To enhance the contribution of AWMT to poverty reduction, there is, hence, a need to: i) build assets; ii) human resource development; and iii) improve the

[16] The baseline situation of users and non-users is not known, one could argue that the difference in estimated poverty levels may have to do with differences in initial conditions.

functioning of labor markets and access to markets (input or output markets). These areas could provide entry points for policy interventions to complement improved access to AWMT in Ethiopia. Moreover, care is needed in choice and promotion of technologies that are not only reliable and have scale benefits but are also financially viable and resilient to climate change and variability.

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GROUP DISCUSSIONS AND FINDINGS

One of the most important parts of the Forum was the group discussion section, its plenary presentations and discussions. The group discussions and presentations focused on the following three themes:

Group 1: Recent development of irrigation subsector policy, strategy and investment
Group 2: Water-centered growth corridor, concepts and innovations
Group 3: Experience and impact of irrigation development in Ethiopia

The lead questions for the three groups were the following:

Group 1: POLICY, STRATEGIES AND INVESTMENTS

1. What are the key points summarizing the policy and strategies in Ethiopia in relation to water resources and irrigation development?
2. Identify policy gaps, if any, that constrained irrigation development in Ethiopia.
3. Revisit the existing strategies and identify implementation difficulties and bottlenecks as well as suggest mechanisms to overcome these difficulties.
4. Identify major constraints for private sector participation in irrigation development and roles of the government to encourage investment in irrigation.
5. Research gaps/issues needing further research.
6. Way forward.

Group 2: WATER-CENTERED GROWTH CORRIDOR

1. How do you see the concept of water-centered growth corridor?
2. What opportunities, constraints and challenges will be faced in the implementation of the growth corridor?
3. Is there a gap between the concept of the growth corridor and the current exercise by various bodies?
4. What are the study needs or research gaps/issues needing attention?
5. Way forward.

Group 3: EXPERIENCE AND IMPACT OF IRRIGATION

1. What are the key points summarizing AWMT and irrigation development in reducing poverty, promoting market-oriented production and its contribution to the economy?
2. Suggest measures on how on-farm water management can be improved and how farmers can best benefit from their produce (market).
3. Challenges and viable options for effective service (extension, technology, credit, improved seed) delivery to small-scale irrigation development.
4. Suggest measures for effective implementation of monitoring and evaluation (M&E) system.
5. What are the study needs or research gaps needing attention?
6. Way forward.

Participants were divided into three groups based on the above themes. The groups made extensive discussions and have come up with a list of suggestions and recommendations in the presence of HE the Minister of Water Resources. The summary contents of the discussion results and recommendations of each group are as shown below.

Group 1

The following are major conclusions of the Group 1 discussion:

- SSI is under MoARD; medium- and large-scale irrigation in the MoWR. The current institutional arrangement (extension, market, WUA, etc.) preferably to be put under the Ministry of Agriculture and Rural Development is to be reviewed and come up with an appropriate institutional arrangement from the apex to the grassroot level.
- Coordination, harmonization of federal, regional and local offices in terms of planning/management.
- Irrigation classification is based mainly on an area basis, but technological aspects requiring high capital, dam height, storage capacity, management aspects of the scheme need to be considered.
- Water and land rights enforcement (natural resources belong to the government). As a result, land is an impediment to irrigation development; land redistribution on command area; experience of the Amhara Region could be of benefit.
- Irrigated agriculture mainly focuses on high-value crops but it should also include food crops for food security.
- WUA is currently organized on the basis of cooperative directive, but they should be legally instituted for the purpose of water management.
- Marketing aspect should have special emphasis with regard to infrastructure development, information to farmers and value chain approach.
- Ecohydrology approach needs to be considered.
- Information and database is generally insufficient.
- Integrated approach should be followed in irrigation development, with more attention on social factors.
- With increasing awareness of water use; conflict between upstream and downstream users is increasing, hence clear regulatory framework and implementation may require more attention.
- Lack of capacity to implement the water policy.
- Private sector involvement in the sector should be supported by policy with clear incentive mechanisms in place.
- In view of the potential for groundwater use in agriculture; an accurate assessment of the potential is important.
- Harmonization of other sectoral policy that affect irrigation development such as environmental policy.
- Agricultural/water management-related research needs to be enhanced and, therefore, an independent water research agenda is proposed.
- Agreement on transboundary rivers needs to be expedited in order to implement bankable projects.
- Cost recovery principle should be implemented in order to enhance ownership of users.
- Foreign investment is constrained in land acquisition, telecommunication and energy provision.

Discussion

Presenter: **Makonnen Loulseged**

It was reported that the group comprised of participants from multidisciplinary and multiple institutions. The presentation focused on policy and strategies that the group thought are necessary for the envisaged development efforts to succeed. Among the issues raised:

- The need for irrigation institution.
- Classification of irrigation should not only focus on the size of command area but also consider the management aspects.
- The importance of a centralized database was appreciated, and it was suggested that information and database should be strengthened, but did not say who should take the responsibility for this.
- The group recommended strengthening of Agricultural Water Management Research, and suggested establishment of an Independent Water Research Group for the country.

Group 2

The concept of growth corridor understanding

- Based on the old basin/river master plans.
- Growth stimulating/poverty and food insecurity alleviation tool (Oromia experience).
- Geographically identified area that links effective natural potential and market area to accelerate growth: value chain approach.
- Catalytic planning and investments.

Characteristics

- It can be transnational/regional/zonal…, not limited to certain areas.
- It should be multifaceted; should be flexible and dynamic.
- It could be used to lift an economically depressed area or enhance a naturally endowed area or with both purposes, however, this has to be articulated initially.
- Growth corridors should be seen as a basic framework, and given a spatial context.
- Different from regional planning (physical planning): Growth corridor is a bit elastic, clear in forward and backward economic linkages in time framework. PASDEP proves that growth corridor is viable direction.
- No concerned regions should be left out.
- The regional growth corridors may/can/will be unique.
- Among other things, the growth corridor is a realigning/streamlining planning and synergetic implementation tool.

Challenges of growth corridor

- Concern for limitation of the growth corridor planning in the major regions.
- Piloting a growth corridor involves implementing the entire growth corridor and is, therefore, costly.
- Limited background knowledge on concept and enabling policies.

The way forward

- Iterative planning process.
- Taking stock of past policies.

- Creating comprehensive background information on the growth corridor concept.
- Knowledge sharing of ALL policies at ALL political and technical levels.
- Integrated interregional activities in growth corridor identification and development.

Discussion

Presenter: **Berhanu Adenew**

The group discussed the concept and implementation of the growth corridor.
It was suggested that no region in Ethiopia should be left out in the growth corridor approach for development.
Some challenges and limitations of growth corridor planning in the major regions have been discussed.
In the way forward, it was suggested to consider the following:

- Iterative planning process.
- Taking stock of past policies.
- Creating comprehensive background information on the growth corridor concept.
- Knowledge sharing of all policies at all political and technical levels.
- Integrated interregional activities in growth corridor identification and development.

Group 3

Consensus

- Development of irrigation in Ethiopia has a positive impact on the livelihoods of the people and the system.
- How could we increase the beneficial effects of irrigation while minimizing the negative environmental and social effects?

Key recommendations for various clients

Environmental impacts must be equally considered

- Negative impacts (e.g., salinization, water quality, resettlement of people).
- Positive impacts (rehabilitating upper watersheds, collective action, local capacity).
- Weak institutional capacity to monitor and evaluate the positive and negative impacts.
- The potential role of the Environmental Protection Authority (EPA).
- Who should monitor small-scale irrigation systems (regions?), and medium- and large-scale systems - MoWR?

Develop and maintain a reliable database

- Soil quality, fertility, salinity.
- Groundwater recharge.
- Microclimate studies.
- Land use change.
- Baseline data (Site characterization/socioeconomic data).

Improve water use efficiency of crops, farms and systems

- Water pricing? Economic vehicles.
- Access to infrastructures/investment.
- Agronomic efficiency.
- Subbasin planning/coordinated water resources development.

Improved extension services for irrigated agriculture

- The need for particular science/recommendations.
- Economic assessment in choosing enterprises.
- Moving towards private extension? Whether it will attract them? Would farmers be able to pay?

- Strengthening public extension.
- Learn from good practices.
- Need for practical training, communication be a priority.

Research gaps

- Water requirement of crops.
- Profitable enterprises.
- Marketing strategies.
- Improved design of schemes.
- Institutional learning and filtering good practices.
- Strategies to link producers with markets and other services.
- Coordinating actions on the ground, extension and marketing.

Discussion

Presenter: **Tilahun Amede**

The group was convinced that irrigation has a significant positive impact in Ethiopian agriculture and economic development. Therefore, the discussion focused on how to make irrigation more effective, efficient and sustainable. A strong extension service focusing on irrigation was recommended to be provided through the public extension system. The group agreed that continued monitoring of irrigation projects for their impact on environment should be taken seriously. It was suggested that the MoWR take the responsibility for medium- and large-scale irrigation projects, while regions can monitor small-scale irrigation projects. Similar to group 1, this group also felt the need for a strong centralized database and research support for irrigation projects to attain the desired goal of sustainable agricultural development; and several issues seeking research were suggested.

CLOSING REMARKS

H.E. Ato Asfaw Dingamo
Minister of Water Resources

Dear participants of the symposium
It is indeed my great pleasure to be here with you today on the occasion of the conclusion of your two days deliberation on an important subject, “Irrigation and Water”. Irrigation and water are indeed very important at a time when our growing population is increasingly food insecure and poverty has become prevalent among our people. The economy of Ethiopia is significantly agricultural based and is greatly affected by climate variability. During the drought seasons the agricultural GDP is lowered significantly; sometimes up to 40%. Poor environmental management and rapidly rising population are threatening the socioeconomic livelihoods of our people. Watershed degradation has negatively affected water resources infrastructure which has resulted in dams that were built in the past have acted as siltation basins, and as a result power generation and agricultural production have reduced significantly. Among other factors, capacity building at all levels stands as a key factor to implement water infrastructure and use them sustainably. I also believe that knowledge sharing among practicing professionals, and sharing of national, regional and international experiences can greatly contribute towards expediting our development needs in the water sector. In this regard, this Forum, which brought together practitioners from the government, NGOs, the private sector, international organizations, donors, researchers and farmers, with particular emphasis on the management of irrigation and drainage systems is a timely event and highly appreciated. When we act together we can make a difference!

Ladies and Gentlemen
The Ministry of Water Resources is committed to water infrastructure development and the government investment in irrigation and drainage has significantly increased during the past few years. Accordingly, 487,000 hectares of land are planned to be irrigated during the PASDEP period (2009/2010), in addition to the existing one. Some of these projects are ready for detailed design and construction, and some are already under construction. Of course, there are issues to be addressed and constraints to be overcome if investments in water infrastructure are to achieve viability and sustainability. I am sure during your deliberation you have given due emphasis to some of these issues and provided sound recommendations. At this juncture, I would like to reiterate the commitment of the Ministry of Water Resources to look seriously into your recommendations and work closely with all the stakeholders.

Finally, I would like to thank MoARD, USAID, IWMI, JICA and others who have played a lead role and for taking the initiative that they have taken in support of agricultural water management in Ethiopia. The Ministry of Water Resources would like to reiterate its commitment to collaborate and closely work with all stakeholders who are interested in promoting and developing the water resources of this country. Finally, for those of you who came from outside of Addis, I wish you a safe journey back home. I now declare the Forum closed!

God bless you!

APPENDICES

Annex 1: Questionnaire

INTERNATIONAL WATER MANAGEMENT INSTITUTE

INVENTORY OF AGRICULTURAL WATER MANAGEMENT TECHNOLOGIES RELATED TO RAINWATER HARVESTING, MICRO IRRIGATION AND SMALL SCALE IRRIGATION:

Respondents: Key Informants (experts, technology suppliers, implementers, development agents, researchers)

Questionnaire ID___________ Suite Number: ___________

Name(s) of respondent: ____
Organization: ____
Position in organization: ____
Phone number: ______________________Region/ woreda: ___________________________
Date of interview: ___________________ Interviewer: _____________________________

1. Description of Agricultural Water Management technology suite

1.1 Common name of AWM technology
……………………………………………………………………………………………..

1.2 Local or other name of AWM technology
……………………………………………………………………………………………..

1.3 Provide a summary of the technology with its main characteristics (description, purpose, maintenance)

Description
……………………………………………………………………………………………..
Purpose (what are the uses of the technology)
…………………………………………………………………………………………
……………………………………………………………………………………………..

Establishment (how it is constructed, implemented, setout)
……………………………………………………………………………………………..

Maintenance (how it is maintained e.g using oxen energy to maintain soil bund/ human labour to clear sediments from ponds etc)
……………………………………………………………………………………………..

2. Provide photographs/slides showing an overview and details of the technology. If digital photograph is available provide file name/reference number using the suite name

Explanation/ description of photo: ……………………………………………………………………………………………..

Location………………. Region…………….. Zone………………Woreda……………...

Photo taken by………………… Date………………………

3. Provide a technical drawing:
As a supplement to your photographs (question 2), please provide a drawing of the AWM technology and indicate technical specifications, measurements, spacing, gradient, capacity etc. in the box below.

Explanation/Description: of drawing:
……………………………………………………………………………………………..
…………………………………………………………………………………………

Location………………. Region…………….. Zone………………Wereda……………...

Drawn by………………… Date………………………

4. Locate/circle the wereda in which the technology is practiced in the attached list.

5. Type of technology

5.1 Which agricultural water management measures does the technology consist of? Underline if they are listed or provide your own

Micro catchment on farm systems	☐	contour bund, contour ridges, semi circular bunds, Negarim, contour bench terraces, small pits, runoff strips, ridge and furrow, broad bed and furrow, trash line,…………………………………………………
Micro catchment roof top systems	☐	Above ground tanks, under ground tanks……………………………….
Macro catchment river flow harvesting systems	☐	Small dams, diversion…………………………………………………..

Macro catchment runoff harvesting/farming systems	☐	trapezoidal ponds, hemispherical ponds, dome shape ponds, water spreading bunds, spate irrigation , river bed cultivation/recession agriculture, ……………………………………………………………………….....
Water well	☐	Deep, shallow wells…………………………………………………
Agronomic measures	☐	zero tillage, minimum tillage, mulching, ……………………………
Irrigation application and lifting kits		drip, sprinkler, treadle pump, motorized pump, hand pump, ………………………………………………………………………
Other (specify) ………………………	☐	………………………………………………………………………..

5.2 Which of the following goals does the technology purse? Possible to tick more than one box

		Crops
Supplementary irrigation	☐	………………………………………………….
Full irrigation	☐	………………………………………………….
Runoff storage in soil profile to enhance rain fed crop production	☐	…………………………………………………..
Domestic water supply	☐	
Animal feed production /watering	☐	……………………………………………………
Other (specify) ……………………………………… ……………………………………….	☐	……………………………………………………… ……………………………………………………….

5.3 How does the technology supply/apply water to crops?

Control of dispersed runoff (retain/trap, impede/retard)	☐
Control of concentrated runoff (retain/trap, impede/retard, drain/divert)	☐
Increase of infiltration	☐
Increase/maintain water stored in soil	☐
Water spreading	☐
Improvement of ground water recharge	☐
Storage in above or under ground structures latter to be used as supplementary or full irrigation	☐
Store in small reservoirs with dam later to be used as supplementary or full irrigation	☐

Water is supplied using surface irrigation (furrows, border, basin) ☐

Water is supplied using pressurized means to the crops (sprinklers, drip) ☐

Other (specify) ☐

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………..…………………

5.4. Specification of technology

If you have described the technology as micro-catchment on farm system, micro catchment rooftop systems, macro catchment river flow harvesting systems, macro catchment flood water farming systems and water well in question 5.1 fill out the following section other wise go to section 5.4.2 or 5.4.3

5.4.1 Type and alignment/layout of structures micro/macro catchment and water well technologies

Structures	Material E, S, W, C, R*	Between structures		Dimensions of each structure					
		Vertical Interval (m)	Spacing (m)	Ditches/pit/dams/furrow			Bunds/banks/others		
				Depth (m)	Width/diameter (m)	Length (m)	Height (cm)	Width (cm)	Length (cm)

*E: earth, S: stone, W: wood, C: concrete, R: crop residue

5.4.2. Specification of irrigation application and lifting kits.

Irrigation kit	type	Discharge (l/hr)	Working pressure/ head* (m)	Operating power (kw)	Between spacing	
					Laterals (m)	Sprinklers/ Drippers (m)

* For pumps indicate total dynamic head

5.4.3 Specification agronomic measures

Agronomic measures		Crops/ other materials	Land preparation (e.g herbicide type, rate/ time of application	Weeding (e.g herbicide time, rate, time of application)
Conservation tillage	☐	…………	……………………….........	…………………………
		…………	……………………….........	…………………………
		…………	……………………….........	…………………………
		…………	……………………….........	…………………………
Mulching	☐	…………	……………………….........	…………………………
		…………	……………………….........	…………………………
		…………	……………………….........	…………………………
		…………	……………………….........	…………………………
Other (specify)	☐	…………	………………………...	…………………………
		…………	………………………..	…………………………
………………		…………	………………………...	…………………………
………..		…………	…………………………	

5.5 Is the performance of the technology affected by sedimentation? ☐Yes ☐no
If yes comment
……
………………………………………………………………………………………

5.6 Is the technology affected by water quality? ☐Yes ☐no
If yes comment
……
………………………………………………………………………………………

6. Status

6.1. Is the AWM technology?

New to the area (introduced in the last 10 years) ☐
Mainly new, including indigenous/traditional elements ☐
Mainly indigenous/traditional, including new elements ☐
Indigenous/ traditional, used for generations ☐
Other (specify) …………………………………………….

Number year since its introduction……………..................

6.2. Where did the technology come from? ……………………………………………..
…………………………………………………………………………………………

6.3. Who provided the technology?
☐ GO ☐ NGO ☐ Private sector ☐ other (specify)

Name of provider …………………………………………………………………..
………………………………………………………………………………………

6.4. Which of the following best describes the technology?

- Experimental ☐
- Program/project implemented/ promoted ☐
- Traditional/indigenous/existing/local ☐

6.5 Is the technology modified to fit local conditions at the start?

There has been modification☐ no modification ☐ modification in some location ☐

If modifications have been made at the start, what were these modifications?
………………………………………………………………………………………
………………………………………………………………………………………
If modifications have been made over time, what were these modifications?
………………………………………………………………………………………
………………………………………………………………………………………
Are further modification /improvements required? Yes☐ no ☐
If yes what are they?
………………………………………………………………………………………
………………………………………………………………………………………

6.6 Is the technology still widely used? Yes☐ no ☐

Comment
………………………………………………………………………………………
………………………………………………………………………………………

7. Bio physical features of the area where the technology is implemented

7.1 Average annual rainfall (mm)…………………………………………………………

7.2 Agro-climatic zone

- Humid ☐
- Sub humid ☐
- Semi-arid ☐
- Arid ☐

7.3 Average annual maximum and minimum temperature…………………………………...

7.4 Altitude (m.a.s.l)…………………………………………………………………..

7.5 Landforms

- Plateau/plains ☐
- Ridges ☐
- Mountain slopes ☐
- Hill slopes ☐
- Foot slopes ☐
- Valley floors ☐

7.6 Slope on average

- Flat (0-2%) ☐
- Gently sloping (2-6%) ☐
- Sloping (6-13%) ☐
- Moderately steep (13-25%) ☐
- Steep (25-55%) ☐
- Very steep (>55%) ☐

7.7 Major soil type on which the technology is applied

Local name……………………………….FAO classification……………………………

7.8 Number of growing season per year

One ☐ Two☐ Three☐

Growing period (in terms of moisture availability)	Length in days (approximately)	From which month to which month:
Longest	……………………..	…………………………………………………….
Second longest	……………………..	…………………………………………………….

8. Type of cropping system of the area where the technology is implemented.

8.1 What kind of production system is practiced?

- Subsistence (own consumption) ☐
- Mixed (subsistence and commercial) ☐
- Commercial/market ☐

8.2 What is the land cultivation method?

- Manual labor ☐
- Animal traction ☐
- Mechanized ☐

		major cash crop	major food crop	other
Annual cropping	☐	…………………. ………………….	…………………. ………………….	…………………. ………………….
Perennial (non-woody) Cropping	☐	…………………. ………………….	…………………. ………………….	…………………. ………………….
Tree/shrub cropping	☐	…………………. ………………….	…………………. ………………….	…………………. ………………….
Mixed	☐	…………………. ………………….	…………………. ………………….	…………………. ………………….

8.3 Types of cropping system and major crops (see attached list for clarification)

8.4 What kind of water supply/management is used for crop cultivation?

Rain fed☐ mixed rain fed-irrigated☐ full irrigation☐ other ☐…………

8.5 Type of cultivation

Continuous cropping ☐ shifting ☐ fallow☐ ley ☐

8.6 Is intercropping practiced? no ☐ yes☐

If yes which crops? ……………………………………………………………………….

Describe cropping system (e.g sequence of crops, cropping intensity, time of planting, etc)
…………………………………………………………………………………………………
……………………………………………………………………………

8.7 What are the major constrains to crop production? Score (1= most important)

		Comments
Pests	☐	……………………………………………………
Disease	☐	……………………………………………………
Market (Distance, non-existence)	☐	…………………………………………………….
Soil fertility	☐	…………………………………………………….
Soil erosion/degradation	☐	…………………………………………………….
Labor	☐	……………………………………………………..
Insufficient moisture/		

rainfall shortage or variability ☐ ……………………………………………………
Infrastructure
(road, water supply) ☐ ……………………………………………………
Other ☐ ……………………………………………………

8.8 What is the size of cultivated land per household?

Comment

<=0.5ha ☐ …………………………………………………...
>0.5-1 ha ☐ …………………………………………………...
>1-2 ha ☐ …………………………………………………...
>2-5ha ☐ ……………………………………………………
>5 ☐ …………………………………………………..

9. Ease in set up, operation and maintenance

9.1 Is it possible to set up the technology easily?
(Score 1, 2, 3, 4, 5) 1-not easy 5-very easy

9.2 Does it require skilled manpower?
Operation (Score: 1, 2, 3, 4, 5) 1- requires 5- does not require
Maintenance (Score: 1, 2, 3, 4, 5) 1- requires 5- does not require

9.3 Is the operation labor intensive?
(Score: 1, 2, 3, 4, 5) 1- intensive 5- not intensive

9.4 Does it have high financial requirement?
Operation (Score: 1, 2, 3, 4, 5) 1- high 5- low
Maintenance (Score: 1, 2, 3, 4, 5) 1- high 5- low

9.5 In setting up does it require external technical support, for example for site selection, marking contours etc?
(Score: 1, 2, 3, 4, 5) 1- requires 5- does not require

9.6 Is maintenance material of the technology available locally ☐ no ☐ yes?

9.7 How many times the technology is maintained in a year?

☐One ☐two ☐ three ☐ other specify……………….

9.8. Is the system easy to maintain?
(Score: 1, 2, 3, 4, 5) 1- not easy 5-very easy

9.9. Does maintenance require skilled man power? ☐ Yes ☐ no

9.10 Does maintenance require daily unskilled labor? ☐ Yes ☐ no

9.11 What are the advantages of the AWM suite?
………………………………………………………………………………………...

9.12 What are the disadvantages of the AWM suite?
………………………………………………………………………………………...

9.13 What are the threats to sustainability?
………………………………………………………………………………………………...
………………………………………………………………………………………

9.14 What are the constraints to scale up?
………………………………………………………………………………………………...
………………………………………………………………………………………

10. Profile of beneficiaries

10.1 At what scale is the technology used?

☐ House hold ☐ community ☐ other……………………

10.2 Is this suite more commonly used by male headed or female headed households?

☐Mostly male headed ☐mostly female headed ☐no difference

10.3 Who uses this technology most commonly? (In terms of labor, cash, and materials)

☐Mostly by resource rich ☐mostly by resource poor ☐no difference

10.4 Are there capacity limitations of the users in using the technology? ☐ yes ☐ no

If yes, what kind of limitations?

☐ Financial ☐skill ☐other (specify)………………………………

10.5 Do the users require training? ☐ Yes ☐ no

If yes, what are the training needs?
………………………………………………………………………………………………...

11. Role of institutions

11.1 State names of organizations involved in promoting this technology suite
………………………………………………………………………………………………...

11.2 What specific support is provided in technology promotion and dissemination?

☐Financial …………………………………………………………………….....
☐Equipment ……………………………………………………………………..
☐ Training …………………………………………………………………….....
☐Other………………………………………………………………………...

11.3 Who provides this support?

☐GO. ………………………………………………………………………….
☐ NGO………………………………………………………………………….
☐Other (specify) ……………………………………………………………….

11.4 What additional support is needed by the farmers?
………………………………………………………………………………………………

11.5 Is the support still ongoing or withdrawn?

…………………………………………………………………………………………………
…………………………………………………………………………………

11.6 How is the coordination among input providers, GO's, NGO's, community?
(1, 2, 3, 4, 5) 1- low 5 – high

11.7 What is the role of each stakeholder?
GO's……………………………………………………………………………………….NGO
's………………………………………………………………………………………Research
…………………………………………………………………………………
Input providers…………………………………………………………………………..
…………………………………………………………………………………………

11.8 What is the level of farmers' participation in introduction and installation of the technology?
(1, 2, 3, 4, 5) 1 low 5 high
…………………………………………………………………………………………

11.9 Is there monitoring and evaluation? ☐Yes ☐no

If yes at what level? And how does it work
…………………………………………………………………………………………………
…………………………………………………………………………………

12. Environmental impact of the technology (both positive and negative)

12.1 What is the impact of the technology on soil (quality, erosion, drainage, water logging, salinity, organic matter…)?
…………………………………………………………………………………………………..

12.2 Is there any change on water availability and quality after the use of the technology?
☐Yes ☐no
Comment
…………………………………………………………………………………………………..

12.3 Do you think the vegetation cover is affected due to the technology?
☐Yes ☐no
Comment
…………………………………………………………………………………………………..

13. Health Impacts of the technology.

If you have described the technology as micro catchment rooftop systems, macro catchment river flow harvesting systems, macro catchment runoff harvesting systems and water well in question 5.1, fill out the following section

13.1 Do you think people are affected by malaria due to the use of this technology?
☐Yes ☐no

Comment:……………………………………………………………………………………
……………………………………………………………………………

13.2 Do you think people are affected by Schistosomiasis due to the use of this technology?
☐ Yes ☐ no
Comment:
……………………………………………………………………………………………
…

14. Gender sensitivity
14.1 Is the technology convenient/ easily accessible to women? ☐Yes ☐no
Comment:
…………………………………………………………………………..………………
……………………………………………………………………………………

14.2 Is there particular benefit to women (cash/nutrition, etc)? ☐Yes ☐no
……………………………………………………………………………………………………
……………………………………………………………………………………

15. What are the costs of establishment and maintenance of the technology?

Establishment
……………………………………………………………………………………………………
Maintenance
…………………………………………………………………………………………………

Annex 2: Description of AWM technologies practiced in Ethiopia

Technology	Description	Advantage	Disadvantage	Region mostly practiced
Irrigation and drainage				
River diversion (modern)	Provides the necessary head for gravity water supply through canal system to the command area. In some instances barrages together with pumps are used to supplement less water demanding crops (legumes) during shortage of rainfall. Water application is dominantly by flooding followed by furrow, basin and border methods	Dependable water supply, efficient water use,	Intake structures and canal systems are affected by sediment	A, O, S, T
Earth dam	To store water from non perennial rivers during wet season for dry season use	Store water during wet season for dry season use	-Sedimentation of reservoirs -Negative environmental and social impacts	A, O, T
River diversion (traditional)	Divert water from rivers with locally available material for gravity water supply to command areas	Low cost, does not require skilled labor, farmers have developed long experience in irrigation	Yearly maintenance of the head work, and canal system, inefficient water use, susceptible to flood damage	A, O, S, T
Traditional irrigation				
Flood diversion/ Spate irrigation	Flood resulting from rainfall in upper catchment is diverted from river beds and spread over large	Mitigates crop failure during drought, increase GW recharge Spate irrigation is more suitable for	Crop damage from unexpected floods,	A, O, S,

	farm land in low land areas.	arid/semi arid areas to supplement crops such as sorghum, maize and teff		T
Micro irrigation				
Drainage				
Ground water exploitation				
Deep well	Deep ground water extracted through motorized pumps	-Good water quality including domestic use -Increased yield and improve crop quality -Precise water and fertilizer application -Water saving and appropriate for water scarce area -Excellent water distribution and uniformity at low operation pressure -High sloping grounds (up to 13%) can be irrigated	-High capital cost -High operation and maintenance cost -Requires highly skilled labor -Spare parts are not easily available -Kit assembly for installation, operation and maintenance are not easy	A, O, S, T
Shallow well	Shallow ground water extracted through non motorized mechanism	-Good water quality including domestic use -Easy to construct with local artisans and the community -Locally available material is used -Sustainable water source is mostly guaranteed -Relatively low construction cost	-High labor requirement for water lifting -It can not maintained while collapsing -Caving in of soil during construction	A, O, S, T

		-Decrease travel time in water searching		
Spring development	Ground water emerging on the ground surface	-Good water quality including domestic use -Can be used both for domestic and agriculture purposes	-Shortage of water during drought seasons -Susceptible to flooding by rain storm	A, O, S, T
Water lifting technologies				
Small motorized pump	Pumps with 2” and 3” delivery pipe are commonly used. The discharge capacity is in the range of 1000 lit/hr.	Can be managed in small groups (3 to 10) of individual farmers who are willing to share cost.	Fuel is increasingly becoming expensive	A, O, S, T
Big motorized pump	Pumps with high discharge rate with high suction and delivery heads	Can irrigate large area	Cost of fuel is increasing from time to time	O, S, T
Treadle pump	Manual water lifting mechanism for 6m suction and 7m delivery head	Can be operated by an individual,	Availability of spare parts, skilled manpower for maintenance, requires strong and continuous human power	A, O, S, T
Wind mill	Are wind driven water lifting devices which works on continuous basis as the capacity is very low	-Wind energy is free of charge -There is no negative environmental impact -Requires less frequent maintenance	-It depends on the natural wind speed of the area -Less human influence incase of shortage of water on non windy days as a result crops will not get sufficient water	S
Rope and bucket	Water lifting mechanism with a rope tied on bucket and lifted manually	-Locally available material can be used	-Can lift only in small quantity -Labor intensive	A, O, S, T

Water application technologies				
Family drip kits (FDK)	Water application mechanism for small area where by water is trickling into the root zone of plants	-High water use efficiency		A, O, S, T
Drip irrigation	Water application mechanism for large area	-High water use efficiency	-Initial investment cost is high -Requires skilled labor for O&M	A, O, S, T
Sprinkler	where by water is trickling into the root zone of plants	-High water use efficiency	-Initial investment cost is high -Requires skilled labor for O&M	A, O, S, T
Ponds and cisterns				
Community ponds	Large volume pond constructed by communities mostly for livestock watering	-Increased milk production as a result of water availability for livestock consumption -Reduce livestock travel distance searching for water -Reduced runoff resulting from reduced soil erosion -Increased ground water recharge -Increased farmers productive time mostly women who are responsible for livestock watering	-Collective management problems -Lack of preventive maintenance -Sedimentation of the pond	A, O, S, T
Trapezoidal ponds	Earthen ponds constructed at	-Increase of agricultural production by	-High labor requirement for	

	household level for small scale agricultural development	minimizing crop failure -Better nutrition status -Decrease of runoff and soil erosion in to rivers -Can be implemented where ever there is water scarcity -Livestock watering in areas of water scarcity -Increase in groundwater recharge	excavation -Non durability of the lining material unless handled with great care -Difficulty in construction of shade to reduce evaporation loss -Reduces farm land -Water born diseases may occur	A, O, S, T
Hemispherical ponds	Hemispherical concrete/masonry cistern with a ranging capacity	-Drought buffering to produce cash crops -Easy access to livestock -Relatively durable and easy maintenance	-High construction cost in view of farmers ability to pay -water lifting is difficult -Risk of children drowning -Requires semi skilled labor both for construction and maintenance -Not suitable for areas where there is shortage of land	A, O, S, T
Dome shaped ponds	Dome shaped concrete cistern with a capacity ranging ---	-Evaporation and seepage loss are minimal -Relatively better water quality and can be treated with chemicals -Important source of water for domestic and livestock watering in arid areas -Women fetch water for domestic use	-Capital intensive -The tanker is difficult to maintain -Construction is complex; if more than 2m difficult to implement High risk of collapsing	A, O, T

		without walking long distance -Women can grow horticultural crops both for own consumption as well as for sale -Saves space		
Roof water harvesting	Water from top of roof collected into a tank	-Water availability for domestic and agriculture -Reduced work load for women -No negative environmental impact	-High financial requirement -Requires skilled labor for maintenance	A, O, S, T
Conservation technologies				
Hillside terrace	A physical structure constructed along the contour to reduce the length of the slope, and thereby reduces soil erosion and enhances moisture conservation.	-Runoff control and erosion -Maintenance cost can be reduced if controlled grazing and cut and carry system is adopted. -Spring/river discharge increases and new springs start emerging -After one rainy season vegetation cover of the hill slope increases	-Labor intensive and costly	A, O, S, T
Farm terrace (soil and stone bunds)	Reduces the length of slope which in turn reduces the soil erosion. Stone faced soil bund is reinforced soil bund in one or on	-To combat soil erosion -To conserve moisture -Soil gradually builds up behind the bunds to	-Labor intensive -The bunds take productive land -Breakage of bunds can lead to	A, O, S, T

	both sides	form bench terrace	gulley formation	
Trench	Rectangular and deep pits constructed along the contours with the main purpose of collecting and storing rainfall water to support the growth of trees, shrubs cash crops in moisture stressed areas.	-Collects and stores considerable amount of runoff water thus vegetation grows faster and vigorous -Contributes to ground water recharge and increase in spring discharge and well yield -Improves the organic content and water holding capacity of the soil	-It is labor intensive -It requires about 50cm top soil to be applied	A, O, S, T
Fanya Juu	An earth embankment constructed across the slope were cut soil is heaped upward to make the ditch/basin at lower side. It reduces slope length, reduces runoff velocity, mitigates soil erosion by retaining runoff and conserves moisture.	-Bench formation can be made with in short time (about two years) -High moisture and soil retention -Improves soil fertility when combined with biological measure -Ground water recharge and	-Productive land could be occupied by the structure -Ditch fills by sediment frequently in high erosion areas -Dwindling farm size -Structure easily gets damaged where there is free grazing	O, S

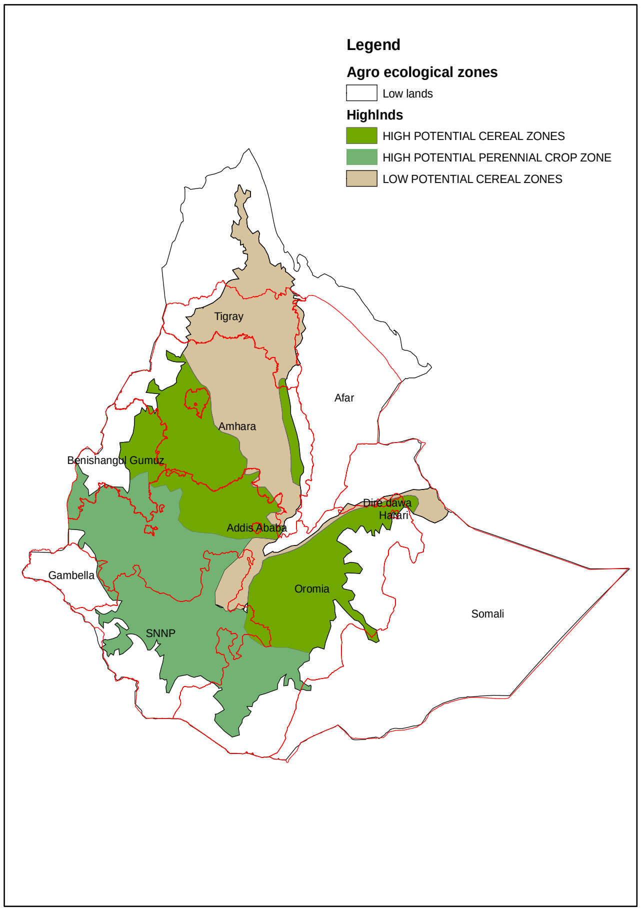
Trash line	Sorghum main stalks are laid on the ground in lines that make 2 to 4 square meters basin. The purpose is to increase moisture content in the soil by delaying the runoff, reduces soil erosion, and adds organic matter to the soil when it decomposes.	-Easy to construct with minimal labor -Minimal cost	-Harbors stalk borers -	S
Tie ridge	Rectangular series of basins formed within the furrow of cultivated fields. The purpose is to increase surface storage and to allow more time for rainfall to infiltrate into the soil.	-Increase soil moisture -Allows more time for infiltration	-Contouring and alignment is difficult -Used on gentle slopes and flat lands only	A,O
Level/contour bund	An embankment structure along the contour made of soil and/or stones with a basin at its upper side. The purpose of the bund is to reduce the velocity of overland flow, increase infiltration and consequently decrease soil erosion, increase moisture availability	Can be easily constructed by farmers	-Takes more productive land -It is not convenient to Plough -Can be easily destroyed during ploughing -Farmers want to use the fertile soil accumulated behind the bund and as a result the bund is destructed while ploughing	A, O
Bench terrace	A structure where a sloppy land is converted in to a series of steps with a horizontal cultivated area on the steps and steep risers between the two steps. Its	Once established easy to maintain.	labor intensive and not so easy for farmers to construct	S

	purpose is to retain water on the benches and provide sufficient time to infiltrate into the soil.			
Water harvesting for plantation purpose				
Herring bone	Small trapezoidal structures for tree planting to help rehabilitate degraded land; to plant trees and other species.	-Good potential to improve degraded areas -Improve watershed rehabilitation, biomass production and the recharging of water tables -Increases ground water recharge	-Layout is demanding -Requires maintenance if not well constructed and stabilized	A, O
Zai pit	Systems of small pits dug along approximate contour lines that allows cultivation of crops on degraded lands	-Possible to cultivate on graded land	-Labor intensive	A
Micro basin	Shallow basins surrounded with stone paved/sodden soil structures of moon shape, constructed in a staggered manner across the slope.	-Collect water that would other wise flow down the slope	-Labor intensiveness and can not easily be mechanized	A, S
Eye brow basin	Larger circular and stone faced structures for tree and other special planting combined with water collection basin placed side ways or in front of	Runoff and erosion decrease in degraded areas and increasing spring discharge	-Requires rigorous maintenance if not constructed properly and stabilized well.	A, O

	plantation pits depending on soil type.			
Percolation pit	Rectangular pit dug on any marginal land with pervious soil, with the objective of enhancing agricultural production through improved water availability in the soil profile.	Improved water availability in the soil profile	-Potential soil salinity where shallow ground water table is found	A
Improved pit	Square shaped water collection pits constructed along the contours with a plantation pit in front of the main water storage pit to support the growth of trees.	-Acceptable to the farmers -They harvest additional moisture to support growth of plants	-For higher slopes it must be supported by other structures	A, O
Nagrims				
Gulley stabilization				
Check dam	A structure built across the bottom of a gully or a small stream to reduce the velocity of runoff and prevent the deepening and/or widening of gullies.	-Controls soil erosion and gulley formation	-Foundation usually not well constructed -Require regular follow up and maintenance	A, O, T
Sediment storage dam	Water harvesting and conservation systems with stone faced earth dams constructed across medium/large size gullies to trap sediments behind the structure. The purpose is to collect and divert excess runoff; convert unproductive gulley areas into productive use.	-It changes unproductive land to productive land -It huge potential to accommodate landless and households with less land	-Requires intensive labor -Needs careful design and construction quality	A, S

Sediment storage dam	A dam built with wooden and earthen material on gullies and creeks of a fragile land			S
Farm land drainage				
Broad bed and furrow	Is a surface drainage system to evacuate excess water from vertisols to advance the planting date? It consists of 80cm wide bed and 20 cm wide furrows made using oxen driven implement called Broad Based Machine (BBM)	-Iincrease the length of growing period there by increasing productivity.	-Weed infestation due to early planting and sometimes fungal disease -May cause soil erosion	A
Cutoff drain				
Water ways				
Other agronomic practices				
Mulch				A, S
Compost				

Annex 3: Agro Ecological Zones Based on Ethiopian Highland Reclamation Study



Annex 4: Combination of Agricultural Water Management Technology Suits Practiced in Ethiopia

	Agricultural Water Management Technologies Mostly Practiced in Ethiopia							
Broad category	**ID**	**Suit type**	**Suit description and Practices**	**Control**	**Lifting**	**Conveyance**	**Application**	**Scope (see foot note)**
Macro catchment Technologies	1	**Trapezoidal pond**	Run-off water collected in a trapezoidal pond, lifted with a bucket and pulley and applied to the plots by hand with bucket.	Trapezoidal Pond	bucket/shadouf/pulley/Siphon	hand	hand	1
	2	"	Run-off water collected in a trapezoidal pond, lifted with a bucket and stored in an elevated drum, water from the drum flows by gravity to the drip system.	Trapezoidal pond	Bucket + storage drum	gravity	drip	1
	3	"	Run-off water collected in a trapezoidal pond, lifted with a treadle pump, conveyed by pipe and then linked to drip system	Trapezoidal pond	Pressure treadle pump	pipe	drip	1
	4	"	Run-off water collected in a trapezoidal pond, lifted with a treadle pump, conveyed by open ditch to irrigation plots	Trapezoidal pond	Suction treadle pump or rope and washer pump	Channel	flooding	1
	5	**Hemispherical tank**	Run-off water collected in a hemispherical tank, lifted with a treadle pump and stored in an elevated drum, water from the drum flows by gravity to the drip system.	Hemi-spherical tank (mortar)	treadle pump	Elevated drum	drip	3
	6	**Dome shaped tank**	Run-off water collected in a dome shaped tank, lifted with a treadle pump, conveyed through open channel to irrigation plots.	Dome shaped tank (concrete)	treadle pump	channel	flooding	3
	7	**Spate irrigation**	Water is diverted to the field by gully plugging and construction of bunds, etc. The system is applicable in the low land areas and valley bottoms where the land is flat	gully plugging + stone bund	gravity	Channel	water spreading	1
	8	**Roof top RWH system**	Rain from roof catchment is collected in a surface or under ground tank, lifted with a bucket and applied to the plots by hand with bucket.	surface/underground tank	Bucket	Hand	hand	1

	9	**Sub surface dam**	Sub surface flow in sandy river beds is checked and the stored in a dam where the water is pumped to a higher level to irrigate plots	Subsurface dam	motorized pump	Channel	flooding	3
	11	**Shallow well**	Water is collected from the well by bucket and transported to the storage drum where it is linked to a drip system	Shallow well	Hand	storage drum	drip	1
	12	"	Water from the shallow well, lifted with a treadle pump, conveyed by open ditch to irrigation plots	Shallow well	treadle	channel	furrow/ flood	1
	13	"	Water from the well is lifted with a motorized pump, conveyed by pipe and then linked to drip or sprinkler system	Deep well	Motorized pump	pipe	drip/sprinkler	1
	14	**Deep well**	Water from deep well is lifted either electric operated submersible pump or diesel operated pump. The pump is linked to high technology of water application systems like drip or sprinkler irrigation in order to maximize the use of water.	Deep well	Motorized pump	pipe	drip/sprinkler	
	14	**Pitcher irrigation**	Water is filled in a clay jar buried under ground and water is filled by hand daily or alternate day. Suitable for use by women	Pitcher irrigation	n/a	n/a	seepage	2
	15	**Small dams**	Water stored behind earth dam is released to a canal system to irrigation plots by flooding or furrow	Earth dam	gravity	Channel	furrow/ flood	1
	16	**Modern river diversion**	Water is diverted from a perennial river by concrete/masonry structure across the river and then in to a canal system to irrigated fields	Diversion weir	gravity	Channel	furrow/ flood	1
	17	**small scale pumped irrigation**	Water from the river is pumped to a higher ground and conveyed to a canal system to irrigated fields	River	Motorized pump	channel	furrow/ flood	1
	18	**Spring irrigation**	Spring water is collected and conveyed by gravity to a canal system to irrigated fields	Spring	gravity	Channel	flooding	1
	19	**Traditional diversions**	River water is diverted by constructing bunds with wooden logs or bunds across the river to irrigated field through a canal system without proper structures	Wooden logs/stone bund	gravity	Channel	flooding	1
Micro catchment Technologies	20	**Stone terraces**	Stone terraces are useful in areas with steep slopes but a high population density and scarce land. The terrace risers are made of stones collected from the land. The terraces themselves can be sloping or level. In the Konso area in southern Ethiopia, farmers form the terrace steps into a series of shallow pits, in which they plant several different crops.					1
	21	**Conservation tillage**	The purpose is to eliminate the need for hoeing or plowing to prepare the soil which cuts the labor requirement by half before planting and the need to weed almost completely by applying short lived herbicides. The practice also include leaving 30% the plant residue which helps the soil to retain more moisture and avoid the risk of soil erosion as the same time the decomposed mulch helps build and maintain organic mater in the soil which is good for soil health. In Ethiopia three major corps maize, wheat and teff were tested under conservation tillage (CT) by SG 2000. The input for the demonstration package include 30kg/ha (tef and maize), 150kg/ha (wheat) of seed; 100kg/ha of DAP; 100kg/ha of urea. Herbicides used include glyphosphate, alachlor atrazine and 2.4 D. The profitability analysis of CT versus non-CT practice doesn't generally show a significant difference between the non-CT plots also uses such inputs as improved seed and fertilizer. However, overtime it is apparent that CT technology gives farmer					2

	22	**Broad Bed and Furrow**	Traditional method to overcome water logging in vertisol of Ethiopia. First a seedbed is prepared by making 3-4 passes with the maresha (local ploughing equipment). In the middle of the rainy season, the seeds are broadcast and furrows are made with the maresha at an interval of 0.8 to 1m. Using family labour, the soil is then scooped up from the furrows and dumped on the beds. By using this method farmers establish a broad bed and furrow for drainage purposes	1
	23	**Ridge and furrow**	In areas with high rainfall it is common practice in the traditional system to make ridges and furrows. The ridges and furrows are made after broadcasting the seeds on the traditionally prepared seedbed using maresha. They are constructed by the maresha at an interval ranging from 40 to 60 cm. The height of ridge is 10 -15 cm.	2
	24	**Semi circular terraces**	Are earth embankments in the shape of a semi-circle with the tips of the bunds on the contour? Found to be effective in Ethiopia, Tigray coupled with other supplementary irrigation sources	2
	25	**Trash line**	Trash lines are constructed seasonally by the family members using maize and/or sorghum straws. It has multi purposes like water harvesting, soil trapping, soil fertility improvement, etc. It is common in gentle to steep slopes in semi-arid areas.	1
	26	**Cut off drian**	Its purpose is to protect the farm land below from runoff. A ditch is digged into the steep land, into the soil. The lower side is usually lays out with stones to raise the soil wall and to stabilize the ditch so the water won't break through.	2
	27	**Trench farming**	Trench farming is a variation of pitting, but the trenches are normally meant for incorporating large amounts of organic matter in the soil, and thus may end up being higher than the ground. The purpose is three-fold—to improve soil fertility, infiltration and moisture storage capacity. In the low rainfall areas in parts of southern Ethiopia, farmers have developed a highly specialized trench farming system. The land is prepared in multitudes of circular depressions (3 to 4 m in diameter and less than 1 m deep) where a variety of crops are inter-cropped. There is literally no runoff from the fields. In good years, all crops are harvested.	1
	28	**Stone bunds**	Stones are arranged in lines across the slope to form a strong wall, and since the lines are permeable, they slow down the runoff rate, filter it, and spread the water over the field, thus enhancing water infiltration and reducing soil erosion	2
	29	**Soil bunds**	Used to slow down and filter runoff, thereby increasing infiltration and capturing sediment.	2
	30	**Pearmeable rock dam**	A flood water farming technique where runoff waters are spread in valley bottoms for improved crop production. Developing gullies are healed at the same time. These are typically long, low dam walls across valleys	2
	31	**Negarim Microcatchments**	Closed grid of diamond shapes or open-ended "V"s formed by small earth ridges with infiltration pits	3
	32	**Tied ridges**	Tied ridges are among the popular soil moisture conservation measures in semiarid and sub-humid areas. They detain the rainfall in the furrows between the ridges where it infiltrates rather than being lost through runoff. Infiltration is improved by making ties or barriers in the furrows at a distance of between one and three meters. By growing the crop on the ridges, the method has the advantage of raising the crop's rooting zone above the impermeable layer or above the water table. Tied ridges are also suitable for Vertisols and other soils with high clay content and having drainage problems. Tied ridges have been found to be very efficient in storing the rain water, which has resulted in substantial grain yield increase in some of the major dry land crops such as sorghum, maize, wheat, and mung beans in Ethiopia. The average grain yield increase (under tied ridges) ranged from 50 to over 100 percent when compared with the traditional practice. This increase, however, will vary according to the soil type, sl	2

	33	**Qayder and Harro**	Natural ponds located on depressions or concave slopes. The small ponds are Qayder and the relatively bigger ones are the Harro. The life span of the natural ponds extends from one week to three weeks. When the ponds dry up grasses easily grow by the moisture residue and serves as a source of pasture	1
	34	**Balliyo**	Very old man made ponds so nobody knows when they are constructed. Small in number and found widely distributed in a range of 100 to 200 kms through out Degabour zone.	1
	35	**Earth dams**	These were dug in Somali region with the help of the government and some NGOs. Some of the natural ponds were excavated by machinery in a semi-circle form to form earth dams.	2
	36	**Berkas**	Ground tanks lined with stone and masonry used to collect and store runoff rainwater for human and livestock consumption. For example about 20,000 Birkas are found in 129 villages in the local administration of Gashamo. The are usually found in sloppy area, rocky and relatively far from village to minimize environmental pollution. they differ in size between 40 x 10 x 6 m and 20 x 7x 4m. Usually group of extended family or individual households owned the Birkas. The cost of Birka construction ranges from 30 million to 60 million Somalia shillings which is an average cost of 200 goats or 20 camels. They are usually constructed for self consumption and to generate income through water sale	2
	37	**Haffir dam**	Originally used to collect water for human consumption, but an NGO is continuing to modify the technology to expand it use for livestock uses. The dams built by machines serve both livestock and human being. The main dam and the silt trap were supplemented with out let canal attached to two shallow wells where water is pumped to elevated distribution cistern and further through gravity distributed to the livestock troughs and human collection points. The cost of construction an average haffir dam with a capacity of 60,000 cubic meters of water accounts about 1.4 million Ethiopian Birr.	2
	38	**Fanya juu terraces**	Are made by digging a trench about 60 cm wide along the contour, and throwing the soil upslope to form an embankment, which has a significant effect in reducing slope-length, and hence soil erosion from steep croplands. In some cases, enlarged embankments are made to allow ponding of harvested runoff and, therefore, the structure can be used in water harvesting systems having external catchments. The soil bund retains water and thereby, safeguards yields even during droughts. "Fanya juu" terraces are suitable on slopes with annual rainfall of 500-1,000 mm. Planting grass, trees and bushes along the terrace banks stabilizes the bunds, while contributing to productivity and biodiversity such as fodder, fuel and fruits. The bunds gradually become enlarged as soil is transported downwards and deposited upon them. Within a few years, a terrace is developed through natural processes of erosion and deposition	2

Scope **1** - practiced only in Ethiopia (indigenous)
2 - Practiced in Ethiopia and elsewhere (not indigenous but already available here)
3 - Not practiced in Ethiopia (source of new technologies that could be introduced here if appropriate

Annex 5: Location of technologies by woreda

Qid	Tecnotype	Nametech	Region	Woreda
1001	In-Suit	Tie Ridging	Amhara	
1002	In-Suit	Improved Pit	Amhara	
1003	In-Suit	Micro basin	Amhara	
1004	Ex-Suit	Ground water Pump (Drip) Irrigation	Amhara	Baher Dar
1004	Ex-Suit	Ground water Pump (Drip) Irrigation	Amhara	kobo
1005	In-Suit	Hillside terrace	Amhara	
1006	Ex-Suit	Community Pond	Amhara	lay Gayint
1006	Ex-Suit	Community Pond	Amhara	Machakel
1006	Ex-Suit	Community Pond	Amhara	Meket
1006	Ex-Suit	Community Pond	Amhara	Minjarna Shenchkora
1007	In-Suit	Level bund	Amhara	
1008	In-Suit	Sediment storage dam	Amhara	
1009	In-Suit	Bench terrace	Amhara	
1010	In-Suit	Trench	Amhara	Sayint, Sekota, Shebel Berenta, Simada, Tach Gayint, Tehuledere, Tenta, Wadla, Wegda, Wegera, Weldiya, Were llu, Werebabu, Zikuala,
1011	In-Suit	Eyeborow basin	Amhara	Kalu
1012	Ex-Suit	Earth dam	Amhara	
1013	Ex-Suit	Treadle pump	Amhara	
1014	In-Suit	Herring bones	Amhara	Addi Arkay, Ambasel, Bati, Ebenat, Farta, Kalu, Kemekem
1015	In-Suit	Vertisol pond	Amhara	Ambasel, Dejen, Ebenat, Enarj Enawga, Enemay, Hulet Ej Enese, Mekdela, Mojana Wedera, Moretna Jiru
1016	In-Suit	Dome shape cap pond	Amhara	Ambasel, Kalu, Kobo
1017	In-Suit	River/lake/spring/irrigation canal	Amhara	
1018	In-Suit	Traditional river divertion	Amhara	Achefer, Ankasha, Awabel, Banja, Baso Liben, Dera, Fagta Lakoma, Guangua, Guzamn, Hulet Ej Enese, Sekela
1019	In-Suit	Spring development	Amhara	
1020	In-Suit	Modern divertion weir & intake structure	Amhara	Kewet, Achefer, Addi Arkay, Adet, Alefa, Ambasel, Angolela Tera, Ankasha
1021	In-Suit	Traditional irrigation	Amhara	
1022	In-Suit	Hemisphiric cement pond/tan	Amhara	Bati, Gidan, Guba Lafto, Kalu, Kobo, Minjama Shenkora, Sekota
1023	In-Suit	Trapezodal Plastic Pond	Amhara	Bati, Berehet, Gishe Rabel, Kalu, Mama Midima Lalo, Minjama Shenkora, Simada, Tehuledere, Weldiya, Werebabu
1024	In-Suit	Hand dug water well	Amhara	Achefer, Ankasha, Awabel, Bahir Dar Zuna, Banja, Baso Liben, Dangila, Daga Damot, Dejen, Dembecha, Enarj Enawga, Enemay, Fagta Lakoma, Farta, Fogera, Guangua, Guzamn, Hulet Ej Enese, Jabi Tehnah, Lay Gayint, Machakel, Sekela, Siya Debima Wayu & Ensaro
1025	In-Suit	Flood water harvesting	Amhara	
1026	In-Suit	Cylindrical shap pond	Amhara	Ambasel
1026	In-Suit	Cylindrical shap pond	Amhara	Belesa
1026	In-Suit	Cylindrical shap pond	Amhara	Were Ilu
1027	In-Suit	Roof catchment water harvesting	Amhara	
1028	In-Suit	Traditional irrigation up grading	Amhara	Ebenat
1029	Ex-Suit	Drip irrigation	Amhara	Belesa
1030	Ex-Suit	Rainfall water harvesting	Amhara	Belesa
1031	Ex-Suit	River diversion irrigation	Amhara	Belesa
1032	Ex-Suit	Up graded traditional scheme	Amhara	
1033	Ex-Suit	Deep well /bore hole	Amhara	Ambasel, Dega Damot, Dembia, Enarj Enawga, Enemay, Fogera, Jabi Tehnan, Kalu, Kemekem
1034	Ex-Suit	Diversion weir (lined canal & earth canal & furrow (flooding)	Amhara	

1034	Ex-Suit	Spring development(earth canal, furrow(flooding)	Amhara	
1034	Ex-Suit	Pump irrigation(pipe delivery) flooding(motorized)	Amhara	
1034	Ex-Suit	Barrage (pump) flooding(mostly best for less water requirement crops)	Amhara	
1034	Ex-Suit	pond(rectangular &circular gated out let	Amhara	
1034	Ex-Suit	Up grading traditional schemes	Amhara	
1034	Ex-Suit	Treadle pump(river &spring)	Amhara	
1034	Ex-Suit	Shallow hand dug well lifted by pulley lined barrel	Amhara	
1035	Ex-Suit	Earth dam	Amhara	
1035	Ex-Suit	Modern diversion (weir intake)	Amhara	
1035	Ex-Suit	Traditional irrigation (traditional weir and intake)	Amhara	
1035	Ex-Suit	Up grading traditional schemes (weir & intake)	Amhara	
1035	Ex-Suit	Pump irrigation (ground water is pumped using hydro electric power)	Amhara	
2000	In-Suit	Broad Based Furrow	Oromia	Berahle, Dabat, Gonder, Dembia, Fogera, Pawe, Adet, Were Ilu, Enemay, Jama, Dejen, Hidabu Abote
2001	In-Suit	Tie ridging	Oromia	
2002	Ex-Suit	Micro dam	Oromia	Ada'a Chukala
2003	Ex-Suit	Spate Irrigation	Oromia	Dodatana Sire
2004	Ex-Suit	Hand dug wells & small motor pump	Oromia	Dugda Bora
2005	Ex-Suit	Dug-out trapezoidal pond & pedal pump &Geomembrance plastic sheet	Oromia	Adami Tulu Jido
2005	Ex-Suit	Dug-out trapezoidal pond & pedal pump &Geomembrance plastic sheet	Oromia	Kombolcha
2005	Ex-Suit	Dug-out trapezoidal pond & pedal pump &Geomembrance plastic sheet	Oromia	Boset
2006	Ex-Suit	Under ground tankers & treadle Pump	Oromia	Adami Tulu Jido
2006	Ex-Suit	Under ground tankers & treadle Pump	Oromia	Kombolcha
2006	Ex-Suit	Under ground tankers & treadle Pump	Oromia	Boset
2006	Ex-Suit	Under ground tankers & treadle Pump	Oromia	Dodotana Sire
2007	In-Suit	Water spreading bunds	Oromia	Dodola, Dodotana sire
2008	Ex-Suit	Shallow well & FDK	Oromia	Ada'a Chukala, Adami Tulu Jido, Dugda Bora, Lome
2009	Ex-Suit	River or spring diversion	Oromia	Lume, Dugida, Bora, Adami Tulu Jido, Kombolcha
2009	Ex-Suit	River or spring diversion	Oromia	
2010	Ex-Suit	Cistern	Oromia	Boke, Chiro, Darolebu, Kuni, Meiso
2010	Ex-Suit	Cistern	Oromia	
2011	Ex-Suit	Flood diversion	Oromia	Chiro
2012	Ex-Suit	Small scale irrigation	Oromia	Chiro, Kuni, Meiso, Tulo, Gamachis
2013	Ex-Suit	Traditional irrigation	Oromia	Boke, Chiro, Doba, Goba Koricha, Habro, Kuni, Mesela, Tulo
2014	In-Suit	Tie ridging	Oromia	Doba
2015	Ex-Suit	Pond, treadle pump	Oromia	Boke, Chiro, Darolebu, Doba, Goba Koricha, Kori, Mieso, Messala, Habro
2016	Ex-Suit	Treadle pump, Drip, deep well	Oromia	Chiro, Habro, Tulo
2017	Ex-Suit	Surface pond	Oromia	Chiro, Darolebu, Mesela
2018	Ex-Suit	Micro dam	Oromia	Boke, Chiro, Meiso, Tulo
2019	Ex-Suit	Spate irrigation	Oromia	
2020	In-Suit	Tie ridging	Oromia	Chiro, Doba, Meiso
2021	Ex-Suit	Surface pond & plastic sheet & treadle pump	Oromia	Kombolcha, Fedis, Golo Oda, Goro Gutu, Gursum, Jarso, Kersa, Malka Balo
2022	Ex-Suit	Hand dug well	Oromia	Babile, Fedis, Girawa, Kombolcha
2023	Ex-Suit	River or spring diversion(traditional)	Oromia	Kombolcha, Keresa, Haromaya, Girawa, Deder, Jarso, Goro Gutu
2024	Ex-Suit	Spate irrigation(flood irrigation)	Oromia	Fedis, Golo Oda, Malka Balo,

2025	Ex-Suit	Shallow well & motorized pump/treadle pump	Oromia	Haramaya, Kombolcha, Kersa, Jarso, Meta,
2026	Ex-Suit	Small scale irrigation (small dam or divertion)	Oromia	Deder, Girawa, Goro Gutu, Jarso, Kersa, Kombolcha
2027	Ex-Suit	Flood water harvesting	Oromia	Babile, Fedis, Gursum, Kombolcha
2028	In-Suit	Herring Bones	Oromia	Girawa, Kersa, Meta
2029	In-Suit	Hillside terraces	Oromia	Babile, Bedeno, Deder, Girawa, Goro Gutu, Jarso, Kersa
2030	In-Suit	Stone faced soil bunds	Oromia	Babile, Bedeno, Deder, Fedis, Girawa, Goro Gutu, Haro maya, Jarso, Kersa, Kombolcha, Kurfa Chele, Meta
2031	In-Suit	Level soil bund	Oromia	Babile, Bedeno, Deder, Fedis, Girawa, Golo Oda, Goro Gutu, Haro maya, Jarso, Kersa, Kombolcha, Meta
2032	In-Suit	Traditional Tie ridge	Oromia	Babile, Gurusum, Fedis, Golo Oda, Mayu Muluke
2033	In-Suit	Micro basins	Oromia	Babile, Bedeno, Deder, Fedis, Girawa, Goro Gutu, Jarso, Kurfa chele, Meta
2034	In-Suit	Eyebrow Basins	Oromia	Babile, Girawa, Goro Gutu, Kersa, Meta
2035	In-Suit	Trenches	Oromia	Babile, Deder, Goro Gutu
2036	Ex-Suit	Pond plus treadle pump & geomerps	Oromia	
2036	Ex-Suit	Cisternst & treadle pump & FDK	Oromia	
2036	In-Suit	Water spreading bund	Oromia	
2036	Ex-Suit	Spate Irrigation	Oromia	
2036	Ex-Suit	Hand dug wells & treadle pump& FDK	Oromia	
2036	Ex-Suit	Micro dam	Oromia	
2036	Ex-Suit	Small scale irrigation	Oromia	
2036	In-Suit	Traditional irrigation	Oromia	
3000	Ex-Suit	Ponds	Tigray	
3001	Ex-Suit	River diversion	Tigray	Adwa, Ahferom, Alamata, Ambalaje, Atsbi Wenberta, Degua Temben, Endamehoni, Enderta, Erob, Hawzen, Hintalo Wajirat, Kola Temben, Mereb Lehe, Ofla, Saesi Tsaedaemba, Samre, Tahtay Koraro, Tahtay Maychew, Tanku Abergele, werie Lehe, Wukro
3002	Ex-Suit	Water storage pond	Tigray	
3003	Ex-Suit	Spate irrigation	Tigray	Ambalaje, Raya Azebo
3004	Ex-Suit	Shallow well	Tigray	Atsbi Wenberta, Degua Temben, Enderta, Hawzen, Hintalo Wajirat, Saesi, Tsaedaemba, Wukro
3005	Ex-Suit	Water tanker / roof water harvest	Tigray	Degua Temben, Endamehoni, Enderta, Laelay Maychew, Samre
3006	Ex-Suit	Pumping from river	Tigray	
3007	In-Suit	Traditional diversion	Tigray	Enderta, Hintalo Wajirat, Wukro,
3008	Ex-Suit	Earth dam	Tigray	Adwa, Ahferom, Atsbi Wenberta, Degua Temben, Enderta, Hawzen, Hintalo Wajirat, Kola Temben, Laelay Adiyabo, Laelay Maychew, Mekele, Samre, werie Lehe, Wukro
3009	Ex-Suit	Spring development	Tigray	
3010	Ex-Suit	Bore hole	Tigray	Alamata, Raya Azebo
3011	In-Suit	Deep trench,hillside terrace & trench and percoletram tanks	Tigray	Adwa, Ahferom, Alamata, Atsbi Wenberta, Endamehoni, Erob, Genta Afeshum, Gulomahda, Laelay Maychew, Mereb Lehe, Mereb Lehe, Mereb Lehe, Raya Azebo, Saesi Tsaedaemba, Samre, Tahtay Adiyabo, Tahtay Maychew, Tanku Abergele, werie Lehe, Wukro
3012	Ex-Suit	Micro dam	Tigray	
3012	Ex-Suit	Modern diversion	Tigray	
3012	In-Suit	Traditional diversion	Tigray	
3012	Ex-Suit	Shallow well & treadle pump& drip	Tigray	
3012	Ex-Suit	Pond (trapezoidal) &treadle pump	Tigray	
3012	Ex-Suit	Roof water harvesting	Tigray	
3012	Ex-Suit	Spring & furrow	Tigray	

3012	Ex-Suit	River & motorized pump	Tigray	
3012	Ex-Suit	Bore hole & electric pump& drip/sprinkler irrigation	Tigray	
3012	Ex-Suit	Spate irrigation	Tigray	
4000	Ex-Suit	Traditional Irrigation	SNNPR	Amaro, Arba Minch Zuria, Awasa, Boloso sore, Burji, Daramalo, Dirashe, Gofa Zuria, Konso, Kucha, Meskanena Mareko, Sodo, Ubadebretsehay
4001	Ex-Suit	Spring development	SNNPR	
4002	In-Suit	Trenches	SNNPR	Damot Weyde
4003	Ex-Suit	Community pond/farm pond	SNNPR	
4004	Ex-Suit	Wind mill(Wind driven pumps)	SNNPR	Kuraz
4005	Ex-Suit	Small scale irrigation	SNNPR	
4006	Ex-Suit	River Divertion	SNNPR	Ajaba, Amaro, Angacha, Arba Minch Zuria, Arbe Gona, Aroresa, Awassa, Badawacho, Basketo, Bena, Bensa, Boloso Sore, Boreda, Burji, Chencha, Dale, Dalocha, Damot Gale, Damot Weyde, Daramalo, Dirashe, Dita, Enemorina Eaner, Ezha, Gelila, Gofa Zuria, Goro, Gumer, Hamer, Humbo, Kacha Bira, Kedida Gamela, Kemba, Kindo Koysha, Kochere, Konso, Kuraz, Lanfero, Loma Bosa, Melekoza, Meskanena Mareko, Mirab Abaya, Misha, Ofa, Omo Sheleko, Selti, Shebedino, Sodo, Sodo zuria, Soro, Surma, Ubadebretsehay, Wenago
4007	Ex-Suit	Drip irrigation	SNNPR	
4008	Ex-Suit	Micro earth dam	SNNPR	Damot Gale
4009	In-Suit	Level soil Bund	SNNPR	Alaba, Angacha, Boloso Sore, Bonke, Boreda, Bule, Chencha, Damot Gale, Damot Weyde, Humbo, Kacha Bira, Kedida Gamela, Omo Sheleko, Selti, Sodo Zuria, Yem,
4010	In-Suit	Eye brow basin	SNNPR	Damot Weyde
4011	In-Suit	Hill side terraces	SNNPR	Damot Weyde
4012	In-Suit	Bench terrace	SNNPR	Alaba, Konso
4013	In-Suit	Stone Bund	SNNPR	Alaba, Konso
4014	In-Suit	Tie ridge	SNNPR	
4015	In-Suit	Sediment Storage dam	SNNPR	Konso, Limu
4016	Ex-Suit	Water Lifting device	SNNPR	
4017	Ex-Suit	Hand dug well	SNNPR	
4018		Diesel pump	SNNPR	Hamer, Kuraz
4019	Ex-Suit	Trapezoidal Tank	SNNPR	Akililna Mohr, Alaba, Aleta Wendo, Alicho Woriro, Amaro, Angacha, Arba minch Zuria, Arbe Gona, Awasa, Badawacho, Basketo, Bena, Bensa, Boloso Sore, Bonke, Boreda, Burji, Cheha, Dale, Dalocha, Damot Gale, Damot Weyde, Dara, Daramalo, Dirashe, Endagagn, Enemorina Eaner, Ezha, Gazer, Gelila, Gena Bosa, Gofa Zuria, Goro, Gumer, Hamer, Humbo, Kacha Bira, Kedida Gamela, Kindo Koysha, Kokir Gedbano Gutazer, Konso, Kucha, Lanfero, Limu, Meskanena Mareko, Mirab Abaya, Misha, Ofa, Omo Sheleko, Selti, Shebedino, Sodo, Sodo Zuria, Soro
4020	In-Suit	Level Fanyajuu	SNNPR	Alaba, Boloso Sore, Bonke, Boreda, Chencha, Damot Gale, Damot Weyde, Humbo, Kacha Bira, Kedida Gamela, Konso, Omo Sheleko, Yem
4021	In-Suit	Trash line	SNNPR	
4022	In-Suit	Stone Check dams	SNNPR	
4023	In-Suit	Cut of drain	SNNPR	Alaba, Konso,
4024	In-Suit	Water ways	SNNPR	Alaba, Konso,
4025	In-Suit	Micro basin	SNNPR	Alaba, Arba minch Zuria, Boreda, Damot Weyde, Kedida Gamela, Konso, Yem

4027	Ex-Suit	River diversion	SNNPR	
4027	Ex-Suit	Micro dams/ponds	SNNPR	
4027	Ex-Suit	Pump (mainly diesel)	SNNPR	
4027	Ex-Suit	Drip irrigation	SNNPR	Hawasa
4027	Ex-Suit	Wind mills (wind driven)	SNNPR	
4027	Ex-Suit	Traditional irrigation	SNNPR	
4026		Physical and Biological Soil and Water Conservation measures	SNNPR	

Annex 6: Suitability of physical soil and water conservation; flood control and drainage measures

Physical soil and water conservation (SWC) measures

SR	Measure and work norm (MoA - 2000)	Main land use (*)	Suitability based on agro-ecology		
			Arid (*Kolla*) up to 500 mm	Semi-arid (dry *weyna dega*) 500-900 mm	Medium/high rainfall areas (*weyna dega*/*dega*) >900 mm
1	**Soil bunds** Work norm: 150 PD/km	Cu, Hcu, Gr	Suitable with large trenches	Suitable with trenches	In *dega* may need to be graded
2	**Stone bunds** Work norm: 250 PD/km	Cu, Hcu, Gr, FrSr, Ms	Same as above	Suitable +/- trenches	Suitable without soil fill on upper side of bund
3	**Stone faced soil bunds** Work norm: 250PD/km	Cu, Hcu, Gr, FrSr, Ms	Suitable with trenches	Suitable +/- trenches	In *dega* may need to be graded
4	**Fanya juu bunds** Work norm: 200 PD/km	Cu, Hcu, Gr	Not suitable	Suitable +/- alternate with trench soil bunds	Suitable in deep soils (>100 cm) – may be graded in *dega* zone
5	**Bench terraces** Work norm: 500 PD/km	Cu, Gr	Suitable with runon/ runoff system	Suitable	Suitable +/- may need excess water disposal structures

(*) Cu: cultivated land; HCu: Homesteads; Gr: Grazing lands; FrSr: forest/scrub land (usually steep slopes); Gu: Gully land, Ms (miscellaneous-degraded areas under multiple uses)

Flood control and drainage

SR	Measure and work norm (MoA - 2000)	Main land use (*)	Suitability Based On Agroecology		
			Arid (Kolla) up to 500 mm	Semi-arid (dry weyna dega) 500-900 mm	Medium/high rainfall areas (weyna dega/ dega) >900 mm
1	**Rock catchment water harvesting – runoff farming and ponding** Work norm: person days based on different activities	Based on site – below rock outcrops	Suitable	Suitable	Partially Suitable (specific conditions only)
2	Cutoff drains Work norm: 0.7 m³/PD	Based on site, below FsSr	Suitable	Suitable	Suitable
3	**Vegetative waterway** Work norm: 1m³/PD	Cu, Gr	Not suitable	Suitable combined with drop/apron structures	Suitable
4	**Stone paved waterway** Work norm: 0.75 m³/PD	Cu, Gr	Suitable	Suitable	Suitable
5	**Waterway Check & Drop + Apron structure (CDA)** Work norm: 3 CDA/PD	Support waterway construction	Suitable	Suitable	Suitable
6	**Flood water diversion using spreading bunds** Work norm: based on activities	Based on site	Suitable	Not Suitable	Not suitable
7	**Vertisols management – BBM (Broaded and furrow maker)** Work norm: not applicable (see requirements in Infotech)	Cu	Not suitable	Not suitable	Suitable (> 1000 mm rain – flat or slopes < 2% terrains)

(*) Cu: cultivated land; HCu: Homesteads; Gr: Grazing lands; FrSr: forest/scrub land (usually steep slopes); Gu: Gully land, Ms (miscellaneous-degraded areas under multiple uses)

Annex 7: Suitability of water harvesting and runoff management

Water harvesting and runoff management for multiple uses and irrigation

SR	Measure and work norm (MoA - 2000)	Main land use (*)	Suitability based on agroecology		
			Arid (Kolla) up to 500 mm	Semi-arid (dry weyna dega) 500-900 mm	Medium/high rainfall areas (weyna dega/dega) >900 mm
1	**Hand-dug shallow wells** Work norm: person days based on excavation, stone collection, and others.	Hcu, Cu, and Gu (below SS dams)	Suitable	Suitable	Suitable
2	**Low cost micro-ponds 60-150 m³)** Work norm: person days same as ponds	Hcu, Cu	Partially suitable	Suitable	Partially suitable
3	**Underground cisterns (20-40 m³)** Work norm: person days based upon soil excavation, lifting, and others.	HCu	Partially suitable (rare to find suitable soils)	Suitable	Suitable
4	**Percolation pits** Work norm: person days	Below FsSr, Ms	Suitable	Suitable	Suitable
5	**Pond (1500 – max. 5000 m³)** Work norm: 0.5 m³/PD	Based on site	Suitable (with preferred depth > 5 meters and seepage control)	Suitable	Suitable
6	**Spring development** Work norm: 1700 PD/spring	Gu, below FsGr	Suitable	Suitable	Suitable
7	**Roof water harvesting** Work norm: person days	Schools, buildings, and others	Suitable	Suitable	Suitable
8	**River bed dams** Work norm: person days for trench excavation, lining, filling	Based on site	Suitable (specific sites only)	Suitable (specific sites only)	Not suitable
8	**Stream diversion weir** Work norm: 3000 PD/weir	Based on site	Suitable	Suitable	Suitable
9	**Farm dam (min 5000 m³ and max 50,000 m³)** Work norm: 0.4 m³/PD	Based on site	Suitable	Suitable	Suitable
10	**Stone faced/soil or stone bunds with run-off/run-on areas** Work norms: same as for bunds	Cu, Gr, Ms	Suitable**	Not suitable	Not suitable
11	**Conservation bench terraces with runoff/runon areas** Work norm: same as bench terr.	Cu, Hcu	Suitable in areas with good soils	Suitable only for high value crops	Not suitable
12	**Tie ridges** Work norm: not applicable	Cu, Hcu	Suitable (slopes < 3%)	Suitable for specific crops	Not suitable
13	**Inter-row water harvesting** Work norm: person days	Cu, Hcu	Suitable for high value crops	Not suitable	Not suitable
14	**The zaï & planting pit system** Work norm: 1 PD/50 zaï pits	Ms, Gr	Suitable**	Not suitable	Not suitable
15	**Large half-moon structures staggered alternatively** Work norm: same as soil bund	Cu, Gr, Ms	Suitable **	Not suitable	Not suitable

(*) Cu: c*ultivated land; HCu: Homesteads; Gr: Grazing lands; FrSr: forest/scrub land (usually steep slopes); Gu: Gully land, Ms (miscellaneous-degraded areas under multiple uses)*

***This is a reclam*ation activity – applicable also in pastoral contexts

Annex 8: Soil fertility management and biological soil conservation

Soil fertility management and biological soil conservation

SR	Measure and work norm (MoA - 2000)	Main land use (*)	Suitability based on agroecology: Arid (*Kolla*) up to 500 mm	Semi-arid (dry *weyna dega*) 500-900 mm	Medium/high rainfall areas (*weyna dega dega*) >900 mm
1	**Contour cultivation** Work norm: not applicable	Cu, Hcu	Suitable with SWC measures and tie ridges	Suitable with SWC measures	Partially Suitable (specific soil conditions only)
2	**Compost making** Work norm: 10 PD/pit or 1 PD per linear meter (heap)	Hcu, Cu, Ms	Suitable (pit method) mostly around homesteads only	Suitable (pit method)	Suitable (pit or heap method)
3	**Efficient use of fertilizers** Work norm: not applicable	Cu, Hcu	Suitable only if integrated with additional water supply and conservation	Suitable only if integrated with additional water supply and conservation	Suitable if integrated with conservation, drainage control, and the like.
4	**Grass strips along the contours** Work norm: 30 PD/km	Cu, Hcu	Generally not suitable	Suitable only with drought resistant species and/or combined with conservation structures	Suitable
5	**Stabilization of physical structures** Work norm: 30 PD/km	Cu, Hcu, FrSr, Gr	Suitable with very drought resistant species	Suitable with drought resistant species	Suitable
6	**Vegetative fencing & stabilization (closures, gullies and farm boundaries)** Work norm: 40 PD/km	Ms, FrSr, Cu, Gu	Suitable with drought resistant species and support structures	Suitable	Suitable
7	**Strip cropping** Work norm: not applicable	Cu, Hcu	Suitable (supplemented by irrigation)	Suitable in benched areas	Suitable
8	**Ley cropping** Work norm: not applicable	Cu, Hcu	Not suitable	Suitable in fallows within areas treated with SWC measures	Suitable in fallows within areas treated with SWC and drainage measures
9	**Cover/green manure crops** Work norm: not applicable	Cu, Hcu	Suitable with drought tolerant legume crops	Suitable	Suitable
10	**Intercropping** Work norm: not applicable	Cu, Hcu	Suitable	Suitable	Suitable
11	**Sequential cropping using food crop** Work norm: not applicable	Cu, Hcu	Not suitable	Suitable for specific soils and with SWC	Suitable (specific soils and with SWC and drainage)
12	**Cropping using forage crops followed by food crops** Work norm: not applicable	Cu, Hcu	Not suitable		
13	**Relay cropping** Work norm: not applicable	Cu, Hcu	Not suitable unless under irrigation	Suitable	Suitable
14	**Mulching & crop residues management** Work norm: 250 PD/ha	Cu, Hcu	Suitable (mostly around homesteads)	Suitable (mostly around home-steads) and along conservation structures + compost	Suitable
15	**Crop rotation** Work norm: not applicable	Cu, Hcu	Suitable (crops with different rooting zones) combined with SWC and/or irrigation	Suitable	Suitable
16	**Choice of crops and plant population density** Work norm: not applicable	Cu, Hcu	Suitable (with SWC measures and based on moisture levels)	Suitable (with SWC measures and based on moisture levels)	Suitable (with SWC measures and drainage)
17	**Improved fallowing** Work norm: not applicable	Cu, Hcu, Gr	Generally not suitable	Suitable with other measures	Suitable
18	**Homestead technology (*)** Work norm: based on measures	HCu	Suitable (integrated with water harvesting and conservation measures)	Suitable (integrated with water harvesting and conservation measures)	Suitable (integrated with water harvesting and conservation measures/drainage measures)

(*) Cu: cultivated land; HCu: Homesteads; Gr: Grazing lands; FrSr: forest/scrub land (usually steep slopes); Gu: Gully land, Ms (miscellaneous-degraded areas under multiple uses)

Annex 9: Suitability of gulley control measures

SR	Measure and work norm (MoA - 2000)	Main land use (*)	Suitability based on agroecology		
			Arid (*Kolla*) up to 500 mm	Semi-arid (dry *weyna dega*) 500-900 mm	Medium/high rainfall areas (*weyna dega*/ *dega*) >900 mm
1	**Stone checkdams** Work norm: 0.5 m³/PD	Gu crossing various land uses	Suitable	Suitable	Suitable
2	**Brushwood checkdams** Work norm: 1 PD/3 linear meters	Same as above	Suitable only with dry resistant species combined with physical checkdam	Suitable	Suitable
3	**Gully cut/reshaping & filling** Work norm: 1m³/PD of earth cut and filling	Same as above	Suitable	Suitable	Suitable
4	**Gully revegetation** Work norm: 500 PD/ha	Same as above	Suitable with drought resistant tree/shrubs and SWC structures	Suitable with SWC structures	Suitable
5	**Soil Storage overflow dams (SS dams)** Work norm: (1) 0.75 m³/PD for earth and stone movement, excavation, filling (2) 0.5 m³/PD for spillway construction	Same as above	Suitable	Suitable	Suitable
6	**Soil Storage overflow bunds (SS bunds)** Work norm: 0.5 m³/PD for earth movement and spillway construction + work norm of brushwood for consolidation	Same as above	Suitable (smaller gullies than above)	Suitable (smaller gullies than above)	Suitable (smaller gullies than above)

(*) Cu: cultivated land; HCu: Homesteads; Gr: Grazing lands; FrSr: forest/scrub land (usually steep slopes); Gu: Gully land, Ms (miscellaneous-degraded areas under multiple uses)

Annex 10: Guideline for selecting water harvesting techniques in drier environment

Guidelines for Selecting Water-Harvesting

Technique	Crop	Soil Depth (1)	Soil Texture	Land Slope (2)	Land Vegetation (3)
Micro-catchments					
On-farm systems					
Contour ridges	range	variable	variable	med.,steep	poor,med.
	field	med.,deep	"	medium	poor
	trees	deep	med.,heavy	low,med.	poor,med.
	vegetable	med.,deep	"	"	"
Semi-circular bunds (trapezoidal triangular)	range	"	variable	"	poor
	field	"	med.,heavy	"	"
	trees	deep	"	"	poor,med.
	vegetable	"	"	"	"
Small pits	field	"	"	"	poor
	range	shallow,med.	"	"	poor,med.
Small basins (Negarim)	range	med.,deep	"	"	poor
	trees	deep	"	low	poor,med.
Runoff strips	range	variable	"	low,med.	poor
	field	med.,deep	"	"	poor,med.
Inter- row system (roaded catchment)	trees	deep	"	Low	poor
	vegetable	medium	variable	"	"
	field	"	"	"	"
Meskat (Khushkaba)	trees	deep	med., heavy	low,med.	poor,med.
	field	medium	"	"	poor
Contour bench terraces	trees	deep	"	Steep	"
	field	medium	"	"	"
Rooftops	drinking	na	na	na	na
	vegetable	variable	variable	"	"
Macro-catchments					
Wadi-bed systems					
Small farm reservoirs	all crops	variable	"	low,med.	variable
Wadi-bed cultivation	trees/ vegetable	med.,deep	med., heavy	"	poor
Jessour	trees	"	"	med.,steep	variable
Off-wadi systems					
Water spreading	field/trees	"	"	low,med.	poor
Large bunds	trees	deep	"	"	poor,med.
	field	medium	"	"	poor
	range	shallow,med.	variable	"	med.,dense
Tanks and hafair	*all crops*	variable	med., heavy	low	variable
Cisterns	drinking/ trees/vegetable	deep	rock	all slopes	poor,med.
Hillside runoff systems	field/trees	med.,deep	med.,heavy	low,med.	poor,med.

(1) shallow < 50 cm, medium: 50-100 cm, deep> 100 cm; (2) low < 4%, medium: 4-12%, steep > 12%; (3) poor < 15%, medium: 15-30%, dense > 30%; (4) lov
(7) low < 5 man-day/ ha, medium: 5-20 man-day/ ha, high > 20 man-day/ ha; na : not applicable.

Annex 10: Continued…

Techniques in the Drier Environments

Cover	Socio-economics				Storage type
Stoniness (4)	Farm size (5)	Capital (6)	Labor (7)	Skill	
low-med.	variable	low	medium	local/	soil profile
low	small,med.	"	"	training	"
"	"	"	"	"	"
"	small	"	"	"	"
low,med.	variable	"	high	local/no	"
"	small,med.	"	"	training	"
low	"	"	"	"	"
"	small	"	"	"	"
"	variable	"	medium	"	"
low,med.	"	"	"	"	"
"	small	"	high	"	"
"	small,med.	"	"	"	"
"	"	"	low	"	"
"	"	"	"	"	"
low	large	high	medium	local/training	"
"	"	"	"	"	"
"	med.,large	"	"	"	"
"	variable	low	"	local/no	"
"	small,med.	"	low	training	"
				"	
"	"	high	medium	external skill	"
"	"	"	"	"	"
na	small	"	medium	local/training	surface/
"	"	"	"	"	subsurface
					"
variable	med.,large	high	high	external skill	surface/ subsurface
Low	small,med.	medium	med.,high	local	surface/soil profile
variable	small	"	high	local/training	"
low,med.	variable	"	medium	external skill	soil profile
"	med.,large	"	"	local/training	"
low	medium	"	"	"	"
variable	med.,large	"	"	"	"
"	"	med.,high	"	external skill	surface/subsurfa
variable	small,med.	medium	high	local/training	subsurface
low	small,med.	"	high	local/training	soil profile

ow < 10%, medium: 10-25%, high> 25%; (5) small<5 ha, medium:5-25 ha, large> 25 ha; (6) low < $ 25/ ha, medium: $ 25-100/ ha, high > $ 100/

Annex 11: Summary of technical performance of micro catchments RWH structures and groundwater exploitation

Technologies	Easiness in set up	Skilled manpower requirement in O&M	Financial requirement in O&M	Easiness to maintain
Traditional pond	1	5	5	5
Trapezoidal pond	3.7	4.1	3.7	5
Hemispherical pond	2.25	2.5	2.1	3
Circular pond	3	2	1	3
Dome shaped pond	1	2.5	5	1
Cylindrical pond	1	3	3	1
Hillside ponds				
Roof water harvesting	2	1.75	2.5	2
Traditional wells (Ellas)				
Hand dug shallow wells	3.5	4.25	3.75	2.5
Deep boreholes	1	1	1.75	1
Spring development	4	3.75	4.5	4.5

Annex 12: Summary of technical performance of water lifting technologies and water application technologies

Technologies	Easiness in set up	Skilled manpower requirement in O&M	Financial requirement in O&M	Easiness to maintain	Remark
Treadle pumps	3	3	5	3	
Motorized pumps	1	1	1	1	Small size
Wind mill	4	1.5	2	1	
Family drip kit	1	4.5	3.5	5	
Drip irrigation					
Sprinkler					

Annex 13: Summary of technical performance of SSI technologies

Technologies	Easiness in set up	Skilled manpower requirement in O&M	Financial requirement in O&M	Easiness to maintain
Spate irrigation	4	4	3.5	4.5
Traditional irrigation	4	3.9	2.75	1.75
Upgraded traditional irrigation	3	1.5	3.5	3
River diversion	2.25	1.9	2.25	2
Earth dam	1	1.75	2.25	2

Annex 14: Summary of technical l performance of micro catchment technologies

Technologies	Easiness in set up	Skilled manpower requirement in O&M	Financial requirement in O&M	Easiness to maintain
Hillside terrace	3.5	3.5	4.5	4.5
Semi circle terrace	3	3.5	3	3.5
Level bund	3.5	4	4	3.5
Contour bund				
Semi circular bund				
Tie ridge	3	5	5	4
Traditional tie ridge	5	5	4.5	5
BBF	3	3.5	3.5	4
Fanya juu	3	3	3.5	3
Bench terrace	1	1.5	n/a	4
Nagarims				
Check dams	2	3	1	1
Sediment storage dam	1	1	1	1
Trench	3.5	4.25	4.5	5
Runoff farming				
Flood spreading				
Water ways	3	3	3	2
Cutoff drain	4	2.5	4	3
Trash line	5	4.5	5	4
Improved pit	5	4.5	5	5
Eye brow	3.5	4.25	1.5	4
Percolation pit				
Herring bone	3	3.75	4	1
Trench (deep)	3	3.5	4.5	2
Micro basin	4	3.5	3.75	5
Trench bunds				
Zai pit				
Gadaba				
Zugaa				
Soil multching				
Compost				
Multching				

Annex 15: Symposium and Exhibition program

December 15, 2008 (Monday)

Time	Activity	Reporter
8.30-9:00	Registration	Organizers
SESSION I: Opening Address		
9:00-9:30	Welcome address by organizers Opening remarks – Ato Sileshi Getahun, Chair of SC Opening by Chief Guest – *HE Ato Teffera Deribew, Minister, MoARD*	Dr. Seleshi Bekele Awulachew
SESSION II: Exhibition		
9:30-10:00	Opening of exhibition and visit to exhibition	Organizers
10:00-10:30	Coffee break	
SESSION III: Policy, Strategies and Investments		
10:30-10:45	Policy and strategies of irrigation sector in Ethiopia – *Dr. Markos Wijore*	Ato Alemayehu Mengiste/Dr. Fitsum Hagos
10:45-11:00	Federal large-scale irrigation projects: Opportunities and challenges they faced - *Ato Teshome Atnafie*	
11:00-11:15	SLM program with focus on irrigation and WSM – *Ato Sileshi Getahun*	
11:15-11:30	Federal small-scale projects-IFAD-supported - *Ato Dejene Abesha*	
11:30-11:45	Federal small-scale projects-AfDB-supported - *Ato Tessema Legeebbo*	
11:45-12:30	Discussion	
12:30-13:30	Lunch break	
SESSION IV: Water-Centered Growth Corridor		
15:30-15:40	Setting the scene – *HE Ato Hailemariam Desalegn*	HE Ato Shiferaw Jarso/ Ato Dejene Abesha
15:40-15:55	Water-centered growth challenges, innovations and interventions in Ethiopia - *Dr. Seleshi Bekele Awulachew*	
15:55-16:10	Water as a major entry point for agriculture and economic growth - *Dr. Berhanu Adenew*	
16:10-16:25	Socioeconomic development using growth pole/corridor with interface to river basin system - *Ato Alemayehu Mengiste*	
16:25-16:40	Creating irrigation extension service delivery, through PPP - *Dr. Belay Demissie*	
16:40-17:30	Discussion	
18:00-20:00	Cocktail	
SESSION V: Current Growth Corridor Case Study Examples		
8:30-8:45	*MoFED overall presentation Ato Getachew Adem*	Dr. Bayou Chane /Dr. Matthew McCartney
8:45-9:00	Tana Beles growth corridor – *Ato Michael Abebe/Ato Fekahmed N/ Mr. E. V. Jagannathan*	
9:00-9:15	Oromia growth corridor study – Ato Taye Alemayehu	
9:15-9:30	Tigray growth corridor – Ato Mulugeta Gezahegn	
9:30-9:45	SNNPR growth corridor – Ato Aseffa Chekol	

9:45-10:15	Discussion	
10:15–10:35	Coffee break	
December 16, 2008 (Tuesday)		
SESSION VI: Recent Development of Irrigation and Government Policy		
13:30-13:45	Oromia region irrigation development – *Ato Samuel Hussein*	Ato Seleshi Getahun /Dr. Tilahun Amede
13:45-14:00	Amhara region irrigation development – *Ato Muluken Lakew*	
14:00-14:15	Tigray region irrigation development – *Ato Zekarias G/Ananya*	
14:15-14:30	SNNPR irrigation development – *Ato Mitiku Bediru/Ato Amare Abate*	
14:30-15:00	Discussion	
15.00–15.30	Coffee break	
SESSION VII: Experience and Impact of Irrigation in Ethiopia		
10:35-10:50	Inventory of SSI in Ethiopia - *Ato Makonnen Loulseged/Dr. Seleshi Bekele Awulachew*	Ato Yacob Wondimkun/ Ato Gezahegn
11:15-11:30	Socioeconomic impact of SSI – *Dr. Fitsum Hagos/Ato Makonnen Loulseged/Dr. Seleshi Bekele Awulachew/Gaythri Jayasinghe*	
11:30-11:45	Performance and impact of irrigation projects in Ethiopia and elsewhere – Dr. Deborah Bossio/Dr. Seleshi Bekele Awulachew/Dr. Fitsum Hagos	
11:45-12:00	Horticulture and floriculture investment and promotion of out-growers concept – *Ato Tilaye Bekele/Tsegaye Abebe*	
12:00-12:15	Low pressure *drip irrigation systems* - Itamar Israeli/Tzahy Faybish	
12:15-12:30	Conveyance and drainage system in spate irrigation: A case of Boro Spate Irrigation - JICA Project - *Yohannes Geleta*	
12:30-13:00	Discussion	
13.00–14.00	Lunch break	
SESSION VIII: Group Discussion		
14:00-15:30	• Policy, strategies and investments • Water-centered growth corridor • Experience and impact of irrigation in Ethiopia	Ato Teshome/Ato Makonnen; Ato Dejene/Dr. Berhanu Adenew, Dr. Deborah Bossio/Dr. Teklu Erkossa
15:30–16:00	**Coffee break**	
SESSION IX: Group Report, Discussion and Recommendations		
16:00-17:00	Group 1 report Group 2 report Group 3 report Facilitated discussion Summary by the Chair	Ato Alemayehu Mengiste/Dr. Teklu Erkossa
SESSION X: Closing		
17:00-17:30	• Closing remarks • Closing speech – *HE Ato Asfaw Dingamo, Minister, MoWR*	