Assessment of Institutional Setup and Effect of Household Level Water Harvesting in Ensuring Sustainable Livelihood

Case study of Kobo, Almata and Kilte Awlaelo Woredas
in Amhara and Tigray Regions of Ethiopia

By Haile Tesfay

November 2007

DCG Report No. 52

Assessment of Institutional Setup and Effect of Household Level Water Harvesting in Ensuring Sustainable Livelihood

A Case study of Kobo, Almata and Kilte Awlaelo Woredas in Amhara and Tigray Regions of Ethiopia

Photos: Haile Tesfay

Haile Tesfay

DCG Report No. 52

November 2007

Drylands Coordination Group
TØRRLANDS-KOORDINERINGSGRUPPEN
GROUPE DE COORDINATION DES ZONES ARIDES

The Drylands Coordination Group (DCG) is an NGO-driven forum for exchange of practical experiences and knowledge on food security and natural resource management in the drylands of Africa.. DCG facilitates this exchange of experiences between NGOs and research and policy-making institutions. The DCG activities, which are carried out by DCG members in Ethiopia, Eritrea, Mali and Sudan, aim to contribute to improved food security of vulnerable households and sustainable natural resource management in the drylands of Africa.

The founding DCG members consist of ADRA Norway, CARE Norway, Norwegian Church Aid, Norwegian People's Aid, The Strømme Foundation and The Development Fund. The secretariat of DCG is located at the Environmental House (Miljøhuset G9) in Oslo and acts as a facilitating and implementing body for the DCG. The DCG's activities are funded by NORAD (the Norwegian Agency for Development Cooperation).

This study was carried out by the Relief Society of Tigray (REST) on behalf of the Drylands Coordination Group.

Drylands Coordination Group c/o Miljøhuset G9
Grensen 9b
N-0159 Oslo
Norway
Tel.: +47 23 10 94 90
Fax: +47 23 10 94 94
Internet: http://www.drylands-group.org

ISSN: 1503-0601

Photo credits: T.A. Benjaminsen, Gry Synnevåg, Haile Tesfay, and REST

Cover design: Spekter Reklamebyrå as, Ås.
Printed at: Mail Boxes ETC

TABLE OF CONTENT

ACKNOWLEDGEMENT .... **V**

ACRONYMS .... **VI**

EXECUTIVE SUMMARY .... **VII**

1. INTRODUCTION: OVERVIEW OF COUNTRY CONTEXT **1**

2. STUDY BACKGROUND **3**

2.1 RATIONALE OF THE STUDY 3
2.2 OBJECTIVE OF THE ASSESSMENT 3

3. STUDY AREA AND METHODOLOGY **5**

3.1 STUDY AREA 5
3.2 STUDY METHODOLOGY 5

4. OVERVIEW OF REGIONAL AND STUDY AREA CONTEXT **8**

4.1 REGIONAL CONTEXT 8
4.2 OVERVIEW OF AGRICULTURE IN THE STUDY WOREDAS 8
4.2.1 Climatic conditions *8*
4.2.2 Rainfall pattern *8*
4.2.3 Land use *9*
4.2.4 Production system *9*
4.2.5 Constraints to crop production *9*
4.2.6 Household level water harvesting strategy in Tigray and Amhara Regions *9*

5. FINDINGS AND DISCUSSIONS **11**

5.1 FARM HOUSEHOLD SAMPLE CHARACTERISTICS 11
5.1.1 Land holding *11*
5.1.2 Land tenure *11*
5.1.3 Household composition and labor availability *12*
5.2 TYPE AND CHARACTERISTIC OF WATER HARVESTING SCHEMES PRACTICED IN THE STUDY AREAS 12
5.3 WATER HARVESTING IMPLEMENTATION MODALITY 17
5.3.1 Implementation approach *17*
5.3.2 Role of community and institutions involved in the water harvesting implementation *17*
5.4 RULES AND REGULATIONS IN PLACE TO USE WATER IN THE STUDY AREAS 18
5.5 WATER USE EFFICIENCY OF HOUSEHOLD BASED PONDS AND SHALLOW WELLS 19
5.6 MAJOR ISSUES AND CHALLENGES FACING WATER HARVESTING IRRIGATION DEVELOPMENT 21
5.7 LINKAGE OF WATER HARVESTING WITH MARKETING 22
5.8 LINKAGE OF THE WATER HARVESTING HOUSEHOLD PACKAGE AND EXTENSION SERVICES 22
5.9 IMPACT OF WATER HARVESTING 23
5.9.1 Change in household months of food shortage *23*
5.9.2 Impact on household income *23*
5.9.3 Diversifying cropping pattern *24*
5.9.4 Changes in input use *25*
5.9.5 Impact on employment *26*
5.9.6 Household annual consumption expenditure *28*
5.9.7 Impact on reducing seasonal out migration *30*
5.9.8 Water harvesting impact on farmers' livestock holding *30*
5.9.9 Effects on drinking water for animals *31*
5.9.10 Effects on animal feed *31*
5.9.11 Impact on household assets holding *32*
5.9.12 Impact on average household diet diversity *32*
5.9.13 Gender dimension of the water harvesting *33*
5.9.14 Strengths, weaknesses, opportunities and threats (SWOT) analysis of water harvesting irrigation *35*

6. CONCLUSION AND RECOMMENDATIONS **37**

6.1 CONCLUSION 37

6.2 RECOMMENDATIONS 39
7. REFERENCES 41
8. ANNEX 43
ANNEX 1: KEY INFORMANTS 43

LIST OF TABLES

TABLE 1: THE STUDY AREAS COVERED AND NUMBER OF SAMPLE HOUSEHOLDS INTERVIEWED 5
TABLE 2: SELECTED WATER HARVESTING IRRIGATION TYPOLOGY FOR THE ASSESSMENT 5
TABLE 3: TOTAL LAND HOLDING OF SAMPLE HOUSEHOLDS (HECTARES) 11
TABLE 4: PROPORTION OF HOUSEHOLDS BY SIZE OF LAND HOLDINGS BY WOREDA 11
TABLE 5: DISTRIBUTION AND SIZE OF LAND HOLDINGS WITHIN THE STUDY AREA 11
TABLE 6: HOUSEHOLD DEPENDENCY AND LABOR AVAILABILITY CHARACTERISTICS OF SAMPLE HOUSEHOLDS 12
TABLE 7: LENGTH OF MONTH'S HOUSEHOLD CAN FEED THEMSELVES 23
TABLE 8: PROPORTION OF SAMPLE HOUSEHOLDS' GROWN VEGETABLE AND FRUITS BY IRRIGATION TYPE 24
TABLE 9: PERCENTAGE OF AREA COVERED BY DIFFERENT CROPS PLANTED DURING 2006 BY SAMPLE HOUSEHOLDS 25
TABLE 10: CROPS GROWN IN THE STUDY AREAS USING THE DIFFERENT IRRIGATION SYSTEM 25
TABLE 11: PERCENTAGE OF SAMPLE HOUSEHOLDS USING INPUTS BY WOREDA 26
TABLE 12: COMPARISON OF AVERAGE AMOUNT OF INPUT USE (KG) PER HECT 26
TABLE 13: PERCENTAGE OF SAMPLE HOUSEHOLDS REPORTING CHANGE IN USE OF FARM LABOR AFTER INTRODUCTION OF WATER HARVESTING SCHEME 27
TABLE 14: SUMMARY OF AVERAGE FAMILY LABOR (PERSON DAYS) USED FOR CROP PRODUCTION DURING 2006 PRODUCTION YEARS 27
TABLE 15: SUMMARY OF AVERAGE HIRED LABOR (PERSON DAYS) USED BY SAMPLE HOUSEHOLDS FOR DRY SEASON CULTIVATION 27
TABLE 16: SUMMARY OF THE AVERAGE ANNUAL FOOD AND CONSUMPTION EXPENDITURE PER CAPITA 29
TABLE 17: SHARE (%) OF HOUSEHOLD ANNUAL EXPENDITURE BY TYPE 30
TABLE 18: PERCENTAGE OF SAMPLE HOUSEHOLDS PURCHASED LIVESTOCK DURING 2006 30
TABLE 19: TRENDS IN PROPORTION OF SAMPLE HOUSEHOLD LIVESTOCK HOLDING 31
TABLE 20: PROPORTION OF HOUSEHOLDS OWNING FIXED ASSETS 32

LIST OF FIGURES

FIGURE 1: POND WITH GEO MEMBRANE LINING SHEET 14
FIGURE 2: POND COMPACTED WITH CLAY AND STONE RIPRAP 14
FIGURE 3: SAMPLE PONDS USED FOR HORTICULTURAL GROWING 14
FIGURE 4: SAMPLE SHALLOW WELL FROM ABREHA-ATSEBEHA KEBELLE 16
FIGURE 5: HOUSEHOLD UNDERGROUND TANKERS OF DIFFERENT SHAPE 17
FIGURE 6: THE TREADLE PUMP USED BY FARMERS 21
FIGURE 7: DRIP IRRIGATION USERS – ABREHA ATSBEHA 21
FIGURE 8: SHALLOW WELL WATER HARVESTING 21
FIGURE 9: SHALLOW WELL USER FROM ABREHA ATSEBE TABIA AND KELTE AELELO WOREDA. FARMER WORKING WITH HIS FAMILY MEMBERS 21
FIGURE 10: A TYPICAL POND AND A POND USER FROM KELTE AELELO WOREDA HARVESTING PEPPER FROM HER PLOT 33

ACKNOWLEDGEMENT

I wish to express my sincere gratitude and appreciation to the Drylands Coordination Group for financial support of this study. I further wish to express my sincere thanks to Ato Teklewoyni Assefa, Executive Director of REST for his support and the confidence he gave me to make this study a reality. Special thanks also go to Dr. Mulugeta from REST for his support during the preparation of the research proposal and the actual field research.

I am very grateful to the people of the study areas, especially the surveyed farmers, for their willingness to talk with the data collectors and the hospitality they offered us. A special word of appreciation goes to the data collectors and all those who read the drafts of this report, and provided useful comments and suggestions for improvement.

ACRONYMS

ADLI	Agricultural Development Led Industrialization
AIDS	Acquired Immuno Deficiency Syndrome
Belge	Short seasons
BoARD	Bureau of Agriculture and Rural Development
DAP	Di-Ammonium Phosphate
GDP	Gross Domestic Product
Ha	Hectare
HIV	Human Immuno-deficiency Virus
Kebelle	Smallest administrative unit
Meher	Long rain seasons
MoFaED	Ministry of Finance and Economic Development
MoA	Ministry of Agriculture
NGOs	Non Government Organizations
PCs	Producers' Co-operatives
PRSP	Poverty Reduction Strategic Plan
RWH	Rain Water Harvesting
SAERT	Sustainable Agriculture and Environmental Rehabilitation in Tigray
SAERAR	Sustainable Agriculture and Environmental Rehabilitation in Amhara Region
SPSS	Statistical Package for the Social Sciences
STATA	Statistical Software package
Woreda	District

EXECUTIVE SUMMARY

Drought is the most catastrophic natural event affecting food security and thus causing widespread periodic famine in many parts of Ethiopia. It affects many parts of the country on a regular basis causing extreme stress on coping mechanisms of the people. In order to alleviate the problem of recurrent drought and household food security, the government of Ethiopia has taken household level water harvesting ponds and shallow wells development as one strategy of the country's irrigation development. Ethiopians, however, debate on the worthiness of the recently introduced household level water harvesting program all over the country. This study, therefore, aims at establishing a better understanding and documenting the effects of the household level water harvesting irrigation development and its limitations.

The study was carried out in six villages through household level surveys, and discussions with various institutions and local authorities. The study focused on three household level water harvesting systems that include ponds, underground tankers, and shallow well irrigation.

Here are the major findings of the study:

Household ponds are characterized by small reservoirs located in irrigated areas that allow farmers to capture runoff water or to take water from nearby micro-catchments or gully or stream with a diversion structure and to store the water in the pond to be used when required. The pond is completely managed at the household level. The means of water lifting in the study area are mainly bucket and rope. Most households use this technology to lift water from the pond to irrigate their plots. Only very few households are observed using treadle pump as a means of water lifting from ponds. The land covered by different types of vegetation ranges from 0.001 to 0.25 ha depending on whether the harvested water is used for supplementary or full irrigation. With regard to the total cost of the construction, a pond covered with geo membrane plastic costs between 5100 to 5600 Birr while a pond without geo membrane plastic but compacted with clay soil and stone riprap costs between 3600 to 4000 Birr. Construction is usually completed in less than four weeks.

Shallow well is the other type of water harvesting structure widely promoted in Tigray and Amhara regions. Shallow hand dug wells have a circular shape. They are about 3-4 meters (m) in diameter with varying depths depending on the water level. In practice, however, the size varied with respect to land and labour availability. The source water is from shallow water table aquifers at depths between 3 and 16 meters and dug with human labour. The depth of a well ranges from 3 to 15 m. To prevent collapse of the ponds some farmers built masonry walls along all the sides of the pond. Many hand-dug wells in the study areas provide water for horticultural growing as well as for drinking for humans and livestock. The construction cost of a well ranges from 3000 - 10,000 Birr.

With regard to the planning process, it has been learnt that in all the study areas the planning process of the water harvesting program essentially used a top-down approach. Particularly during the first year of program implementation, numbers of water harvesting ponds and wells constructed were planned at regional levels with limited community consultation. This has made a significant negative impact particularly on the acceptance of pond water harvesting.

The majority of the sample households responded that their involvement in the identification, planning, and designing of the water harvesting program was low. Likewise, there was a lack of experienced technical people to run the construction work at site level which was one of the practical problems that affected the quality of the work. However, the participation of the beneficiaries in terms of labour and local material contributions during implementation was very high.

The study revealed that most of the constructed shallow wells definitely have promising potential positive impacts in terms of improving and diversifying household food security and income in the future if some of the witnessed gaps are addressed. This is likely to significantly impact particularly on the lives of women in terms of access to income and better nutrition opportunities for their families. Since the introduced water harvesting systems are being owned and managed at household level, this gives an opportunity for faster replicability and more efficient water use. In all study areas, the acceptance of the shallow well is high. However, the extraction of the ground water resource needs adequate follow-up in order to balance the water withdrawal with the recharge level.

Many shallow well users are now able to grow high value crops both for home consumption and local markets. It provides seasonal employment for family members. As a result of the massive introduction of household level shallow well harvesting many farmers have developed a commercial mentality.

The assessment results also indicate that the diversity of crops grown by households having wells has increased. From the household survey it is found that nearly 69 percent of the surveyed households owning wells have more than two types of crops on their plots. Many women expressed their appreciation for the shallow well irrigation by saying that they now manage to send their children to school, and can easily receive medical services with the income from growing backyard vegetables. The small-plot shallow well water harvesting irrigation has also contributed to gender equity by improving family nutrition, providing a source of independent income for women and creating opportunities for women to learn new skills.

On the other hand, the study has found that only a few pond water harvesting users have been able to grow vegetables. The study revealed that there is no significant difference between pond users and non users of water harvesting in terms of indicators like number of food self sufficiency months, productive assets holding, annual consumption expenditure per capita, effect on family and hired labour employment generation.

Many visited ponds are in poor working conditions since they are not properly designed and constructed. However, this does not mean that the pond water harvesting is not technically sound for supplementary or dry season irrigation; there are for instance a few farmers who are effectively using the pond water harvesting both for supplementary and horticultural production. This success has mainly taken place where the ponds are constructed in a proper way, have a sufficient micro catchment area to feed water to the pond and when the constructed pond is located near farmers' backyards.

In all the visited kebelles[1] lack of access to market information is an acute problem that has hindered the beneficiaries from fully realizing benefits from using the water harvesting well and pond irrigation.

Once limitations posed by institutional and managerial constraints are removed or at least minimized, the household level water harvesting, particularly the shallow wells irrigation systems, can be vital instruments to protect against the adverse drought effects and to switch from low-value subsistence production to high value market oriented production. In order to attain this goal, integrated efforts of different stakeholders and other relevant institutions are very important. Indeed, the development of water facilities by itself cannot bring about significant changes in the improvement of the livelihoods of poor farmers. To make successful the introduced household level water harvesting program, it is of paramount importance to consider the institutional and market issues as part of the program.

[1] *Kebelle* is equivalent to a peasant association (which is the lowest government administrative unit).

The study led to the following recommendations:

- It is technically sound and legitimate to develop household managed water harvesting for irrigation purposes, as this results in very little financial burden on the government to expend irrigation to many food insecure people in a short period of time and it requires little operation and maintenance costs. A bottom-up approach is ideal for household level water harvesting irrigation development that is treating farmers as "owners" and not as "beneficiaries". Thus, farmers should participate in the whole process i.e. in site selection, planning, implementation and monitoring phases. Furthermore, the existence of strong coordination of all relevant institutions involved in household level water harvesting irrigation development is important during planning and implementation. These development actors should coordinate their efforts to serve the community better and on a sustainable basis.

- Different water harvesting solutions should be available to the community that can be applied under different agro ecological, geological and social conduction.

- The overall evidence, suggests that in areas which have sufficient ground water, shallow well water harvesting is found to be an effective way of spreading benefits among wider target groups and have the potential to improve and diversify household food security and income in the future if some of the gaps are addressed.

- Many ponds are in poor working conditions (many have seepage problems) since they are not properly designed. The experience in all study areas was a blanket approach that demands farmers to construct a pond even without having interest to do so. This has led many community members of the study area to have a wrong perspective towards pond water harvesting indicating the need for alternative water harvesting schemes in areas where ponds are not technically feasible.

- Carefully designed water harvesting irrigation ponds are appropriate in areas which have sufficient micro catchments rainfall run off and construction materials.

- Pond and well users need considerable energy to lift water from the water scheme. The high labour required for lifting water from the well and pond is a challenging issue for effective utilization of the water from ponds and wells. Given that water is the most limiting factor in smallholder irrigation development in Ethiopia, efficient water saving systems should be expanded, so the current level of water utilization efficiency should be promoted through extending the usage of low cost water saving and lifting irrigation technology. Furthermore, strengthening of the local manufacturers to produce more efficient and affordable water lifting and saving technologies is also of paramount importance for future success of the household level water harvesting program.

- Training in water management, general crop production and marketing is important for all the water harvesting beneficiaries.

- In all study areas there is competition over limited underground water resources. If it continues like this there is anticipated fear of exceeding the carrying capacity of the groundwater potential due to over-use of wells. In order to regularize sustainable ground water use, a mixture of measures is required. The main measures are described below.

  - At village level there is an urgent need to formalize the importance of regulating water extraction /use permits (both from underground water and micro catchments water

harvesting). Therefore, a directive should be issued to all woredas to institutionalize the water permit prior to the start of construction of shallow wells or ponds. It is thus necessary to establish the relevant institutions and operational mechanisms, such as building a functional water permit system for groundwater exploitation by farmers.
- To control excess groundwater withdrawal; it is important to set up a groundwater monitoring system at woreda or village level.

- While the availability of irrigation water through wells enables farmers to increase their productivity, grow high value crops and use improved technologies, the market situation plays a critical role in enabling farmers to exploit those market-led opportunities. Hence, to realize the full potential of these interventions the following intervention areas need to be given priority:
  - Improve market information channels and coverage to improve market access for farmers;
  - Improve supply of seeds and seedlings at right prices and affordable packages;
  - Provide training to extension agents on marketing.

- Continuous monitoring of the constructed irrigation structure is necessary to provide feedback information that helps in the planning, implementation and management of future schemes.

1. INTRODUCTION: OVERVIEW OF COUNTRY CONTEXT

Ethiopia is one of the poorest countries in the world, with 80.7% of its 73.8 million people living on less than \$2 a day and ranking 170th out of 177 countries on the UNDP Human Development Index (2005). The same report indicated that income per head is \$86 per annum (which is equal to a Purchasing Power Parity ratio of \$711) and most indicators are significantly worse than the average for sub-Saharan Africa. For instance, life expectancy is as low as 47.6 years which is comparable to the high infant mortality and malnutrition levels. Adult literacy levels remain as low as 41.5% while only 22% Ethiopians have access to potable water facilities (UNDP Human Development Index, 2005). Relative poverty estimates for Ethiopia vary from one source to another, ranging from 31% to 45.5%.

According to MEDaC's report (1999), poverty is more widespread in all parts of the country, but is mainly higher in rural than in urban areas. Across the regions, the headcount ratio is higher in the drought prone regions of Ethiopia, which cover Tigray and Amhara, the densely populated region SNNP, part of Ormiyia, Somalia and Afar regions. Absolute poverty in Ethiopia also varies significantly among the regions. The report also indicated that the population living below the poverty line is highest (57.9%) in the Tigray region compared to the country figure (44%).

In Ethiopia, rain-fed agriculture is the main source of the GDP, and contributes ninety percent of export revenues. 85 percent of the labour force comes from this agricultural sector (MEDaC, 1999). However, food production in Ethiopia in the last three decades has never been sufficient to enable the rural population to be food secure.

The causes of food insecurity in Ethiopia are complex. Different studies suggested different reasons for the increasing trend of household food insecurity in the country. One of the major factors that has contributed to household food insecurity in Ethiopia is land degradation (Pender et al. 2002). They argued that poverty and liquidity constraints, which tend to increase rates of time preference, reduce incentives for investment and sustainable management of natural resources. Low productivity and the drive for survival led to severe degradation of the resource base reinforcing the negative environmental effects. This was exacerbated due to policy neglect of peasant agriculture and unreliable weather conditions. Gohen and Isksson (1988) also noted that recurrent drought and associated famines, land degradation, the civil war and wrong economic policy have contributed to the current food insecurity.

Helmut (1990) indicated that one of the major underlying factors for the current level of household food insecurity in Ethiopia is the over dependency of the farming community on erratic rainfed agriculture. There was little or no attempt to exploit the water resource potential of the country, contributing to the problem of a self-enforcing vicious circle of low productivity, land degradation and food insecurity (and poverty).

Equally important social factors are also causes of food insecurity in Ethiopia – like gender inequalities; increased prevalence of HIV/AIDS; limited access to social infrastructures, such as health, education, water, roads; governance factors that include misguided government policies and poor leadership, weak and inefficient markets (World Bank, .2000).

The Ethiopian Federal Food Security Bureau (2005) divided the food insecure population into two categories: (1) chronic/predictable and (2) acute/unpredictable. Chronic or predictable food insecurity is structural in nature and these households experience food deficits every year, even when the rain and market situation is good. Based on the Federal Food Security Bureau report, in Ethiopia at least 5 to 7 million people are categorized as chronic, and have been under food assistance for the last 7-10 consecutive years. The acute or transitory food insecure, are those who experience food deficits as a result of a ‘shock’ or ‘crisis’ such as drought. The total number of people in need of assistance rises dramatically in crisis years. This was the case in 2002/3, when the total number of people requiring emergency relief escalated to over 13 million people (21% of the total population).

Pursuant to the global initiative to reduce poverty[2], the government has now adopted a poverty reduction strategy that is primarily rural-centred. The goal of this strategy is sustainable increase in agricultural productivity through promotion of green-revolution type of technologies coupled with natural resources rehabilitation and conservation. Special emphasis is given to harness and develop the water potential of the country by promoting construction of micro dams, river diversions, ponds and wells. Irrigation development is regarded as the main pillar of the national food security strategy (FDRE, 2002a: FDRE, 2002b). The identified policy goals of the PRSP are to reduce poverty by half with the economy growing in real terms by 5.7% per annum until 2015 (MoFaED, 2000). The strategy paper stipulates that the bulk of the real GDP growth should come from agriculture. It, however, fails to quantify the contribution of irrigation development/water harvesting to increased agricultural productivity and poverty reduction.

The Government of Ethiopia has recognized the role of water harvesting-irrigation development as a key drought mitigation measure. Tremendous efforts have been made by the government in the area of irrigation development since the past 14 years. This study is, therefore, aimed at looking at the household level water harvesting impact and assessing its gaps and strengths in terms of institutional arrangement and market linkage.

The study report is organized into six sections and one annex. Section 1 describes the introduction part. Section 2 contains the rational of the study and research objectives; section 3 covers the study area and methodologies used; section 4 gives the general overview of agriculture in the study woredas, and section 5 provides a synthesis based on the fieldwork and secondary data. Section 6 summarizes the conclusions of the study and presents some recommendations. Lastly, the annex gives a list of key informants contacted in all study areas.

[2]The government’s poverty reduction strategy paper dubbed “Sustainable Development and Poverty Reduction Program (SDPRP)”.

2. STUDY BACKGROUND

2.1 RATIONALE OF THE STUDY

Drought is the most catastrophic natural event affecting food security and causing widespread periodic famine in many parts of Ethiopia. Drought affects many parts of the country on a regular basis causing extreme stress on coping mechanisms and the general health status of the people. The occurrence of repeated drought and dependence on rainfall which has been erratic and uneven in the regions over the past years has resulted in a widespread crop failure which in turn has brought a growing awareness of the importance of small scale water harvesting at both household and community levels. In Ethiopia, particularly in arid and semi arid areas of the country, irrigation development is considered therefore an absolute necessity and not an option and has been adopted as the frontline strategy to bring about sustained food security due to its profound role in boosting agricultural production and productivity in highly rain dependant agricultural farming systems. Farmers living in these drought affected areas are conscious of the central role played by water in their livelihoods and are able to clearly articulate the connection between water and their health, their ability to work and the likelihood of filling annual food gaps.

To avert the recurrent drought and crop failure, policymakers, researchers, NGOs and farmers are increasingly pursuing various innovations: technical, institutional and policy interventions to enable pro-poor, equitable and sustainable utilization of scarce water resources. As part of this strategy, in the past ten years, considerable resources have been allocated by the federal government, regional governments and non-government organizations to irrigation development efforts all over the country. As a result, considerable progress has been made in increasing the irrigable land by constructing many micro dams, and river diversion. However, since 2002, household level water harvesting irrigation development has attracted the attention of the policymakers due to the small initial investment, low government recurring cost, short development period, relative freedom of organization, and freedom from management difficulties. Due to this, development of smallholder micro irrigation development has been taken as one of the priority irrigation development strategies by the Government of Ethiopia. However, its impact on household livelihood as well as its market linkage and institutional strengths and weaknesses are not well documented.

Household level "micro-irrigation scheme" in the study refers to individualized small-scale schemes irrigating less than 1 hectare of land; using pond water harvesting, underground tankers and shallow hand dug wells. The operation and maintenance of such schemes are minimal and carried out by the users.

It is necessary to study the micro irrigation development (through ponds and wells) program implemented in the past years in Amhara and Tigray, as part of developing and implementing more effective irrigation development measures to improve household food security within the context of the poverty eradication program of the country.

Therefore, this study examines the strengths and gaps of the current water harvesting program in terms of its institutional setup and its impact on household food security.

2.2 OBJECTIVE OF THE ASSESSMENT

The overall objective of the study is to examine the strengths and gaps of the household based water harvesting program in terms of its institutional setup, market linkages and policy constraints and its impact on household food security. The specific objectives of this study are to:

- Know how beneficiaries/communities are involved in all phases of the water harvesting implementation;
- Examine the water rights of the community/beneficiaries by giving due attention to the rules, and regulations in place for using water;
- Explore the role of institutions involved in water management and conflict resolution;
- Examine current agricultural marketing opportunities and constraints; and
- Investigate the effect of different water harvesting approaches in reducing poverty in general and food insecurity at the household level in particular.

3. STUDY AREA AND METHODOLOGY

3.1 STUDY AREA

The study was conducted in three Woredas of two regions in Northern Ethiopia namely Alamata and Kelete Awelaelo Woredas from Tigray Regional State and Kobo Woreda from Amhara Regional State. The three Woredas were purposively selected for the analysis of the water harvesting program. In these regions, specific villages were selected on the basis of the presence and scale of work of the different household level water harvesting schemes. The list of the selected household water harvesting technologies studied and a summary of their details are given in Table 1 and Table 2, respectively.

Table 1: The study areas covered and number of sample households interviewed

Study area		No. of household samples				Total number of surveyed households
Region/Woreda	Village studied	Target- water harvesting beneficiaries			Control -rainfall	
		Pond	Underground tanker	Shallow well		
1. Tigray Region						
(i)Alamat Woreda	Lemat	25	-	10	35	70
	Selam Bekalise	27	-	36	63	126
(ii) Kilte Awlaelo Woreda	Abereha-weatsbeha	55	-	41	96	192
2. Amhara Region						
(i) Kobo Woreda	03 kebelle	11	22	16	49	98
	04 kebelle	-	-	7	7	14
Total		**118**	**22**	**110**	**250**	**500**

Table 2: Selected water harvesting irrigation typology for the assessment

Irrigation Typology	Irrigation technology used	Practiced in
Pond-with geo-membrane/plastic or with clay compaction lining	• Surface, • Few have household drip, • Some use treadle pumps for water lifting	Tigray and Amhara Regions
Underground tanker	• Surface water harvesting, • Many use treadle pumps for water lifting	Tigray and Amhara Regions
Shallow wells	• Few use household drip, • Many use treadle pumps for water lifting	Tigray and Amhara Regions

3.2 STUDY METHODOLOGY

To meet the study objectives, the researcher performed an assessment work based on the following methodologies. These include:

i) Household survey
In order to capture the direct impacts of the intervention on household as well as to identify problems encountered in relation to market and institutional support, an individual interview using structured questionnaire was developed.

The questionnaire covered socio-economic information, the division of labor in household crop production, participation in irrigation water management, and the impacts of irrigation. Enumerators were trained and checklists and questionnaires were pre-tested during pilot surveys undertaken in the study areas.

To select households for the interview, the population of the study area was first stratified into two groups based on ownership of irrigated plot. One group consisted of households who benefit from the different water harvesting irrigation (users of irrigation or target group) and the other group consisted of households who do not benefit from the household level irrigation (non-users of irrigation or control group).

The sample was drawn randomly from people in the 6 villages of the three woredas who are using the different water harvesting technologies and non users of well and pond water harvesting. Proportional sampling was used to determine the number of households to be interviewed from the different water harvesting system. Based on this, a total of 500 sample households[3] from the three study Woredas were selected: in Alamata (196), Kobo (112) and Kilte Awlaelo (192) were interviewed using structured questionnaires.

A balance of water-harvesting users and rainfed users was considered in the selection of the beneficiaries. The fieldwork was undertaken between June 16th 2006 and July 6th 2006. Useful information was also gathered through visits to the constructed ponds and shallow-well sites as well as to local market places. The market place could give vital information on what the local people produce, consume, and on how they live.

ii) Focus Group Discussion
Focus group discussions with beneficiary farmers (men and women) in selected *Kebelles (the smallest administrative unit)* of the study woredas were used to collect data on strengths and weakness, and opportunities in the water-harvesting program. The group composition was: a) elders and religious leaders; b) female-headed farm households; and c) young and middle-aged farmers. Each focus group consisted of three to seven people. The discussion was mainly focused on what supports they received from the program to implement water-harvesting structures; and major benefits obtained from such interventions and the changes in welfare and their food security status.

iii) Key Informant Interview
Key informant interviews were carried out with key informants who are knowledgeable about the program, which includes representatives of the Woreda leadership, representatives of water resources, Mines and Energy Development Office, Agricultural and Rural Development Office. Those involved in the planning, implementation and monitoring of these interventions were consulted in Kilte Awlaelo, Alamata and Kobo Woredas. The objective was to get adequate background information on what the main issues were on each individual irrigation technologies, so as to focus on these to fill the gaps in information left by the household level survey.

These discussions enabled the researcher to gain insights into the perspectives of the different stakeholders on the process of implementation and impact of these interventions and problems encountered and how the different stakeholders contributed in addressing these problems.

---

[2] This figure excludes the 100 households who partially filled the questioner, and avoided from the analysis.

iv) Literature review

Apart from data collected through the interviews of the farmers, the survey data was supplemented by gathering enormous amounts of secondary data pertinent to the assessment work, which were collected through extensive review of literature sources, annual reports of both Regional and National offices.

v) Analysis and write-up

The collected data were entered into SPSS statistical software and were analyzed using STATA statistical software.

4. OVERVIEW OF REGIONAL AND STUDY AREA CONTEXT

4.1 REGIONAL CONTEXT

Tigray and Amhara regions are two of the nine regional states in the country with an area of 250,150km^2 (Tigray 80,000 km^2 and Amhara 170,150 km2), which is estimated to constitute about twenty-three percent of the total area of the country (BOFED, 2007, SAERA and Consulting Enterprise P.L.C. 2003). Based on figures from the Central Statistical Agency of Ethiopia (2005), the populations of Tigray and Amhara regions were estimated to be over nearly 24 million people with 2.82% annual growth rate.

The livelihood of the farming communities in Tigray and Amhara regions primarily depends on agriculture, which is influenced by unreliable and erratic rainfall. The problem of food insecurity has increasingly become worse especially in the arid and semi arid areas of the two regions. Coping mechanisms of many people of these regions have become so fragile that minor irregularity in the rainfall distribution often results in drought of different magnitudes. Even though the amount of rainfall can be said to be enough for the seasonal crop production, the high degree of irregularity compounded with severe land degradation and high population density often leads to poor crop performance. Even at times when there is fairly good rainfall distribution, pockets of food shortage become evident in many parts of these regions. It is, therefore, necessary to develop and use water harvesting for agriculture.

The development of irrigation through household level water harvesting technology such as ponds and shallow wells irrigation have been followed by a number of conflicting opinions on their impact and sustainability. Little studies have been carried out on the institutional arrangement and its market linkage as well as its impact of such investments. Hence, this study is needed to fully equip policy makers and the general public on the strengths and weaknesses of the water harvesting program. It also attempts to derive lessons from past experiences for the planning of future water harvesting development interventions.

4.2 OVERVIEW OF AGRICULTURE IN THE STUDY WOREDAS

4.2.1 Climatic conditions

Alamata and Kobo study Woredas are located within kola (low land) agro-climatic zone, while Kilte Awlaelo study Woreda is located within weyna-dega (mid-highland) agro-climatic zone. All Woredas are characterized by a high evapo-tanspiration rate combined with low and erratic rainfall. Repeated rain failure is a common feature of all study Woredas. This makes farming in the Woredas quite uncertain. The unreliability of rainfall forces farmers to plant different drought tolerant and early maturing crops to meet their needs.

4.2.2 Rainfall pattern

The majority of farmers in the study areas are subsistence farmers who depend on rain and land for their survival. The rainfall distribution of the Kilte Awlaelo Woreda is characterized by a mono-modal distribution while Alamata and Kobo Woredas are characterized by bi-modal rainfall distribution (*Belg* and *Meher* seasons). The long rainy season is mostly from June to mid-September (*Meher*). The short rain season occurs mainly between March and April (*Belg*). The average rainfall of the study area of Kilte Awlaelo, Alamata and Kobo is 587.8, 720 and 609.4mm, respectively. Rainfall distribution in all parts of the study areas is very erratic including high intensity rainfall and characterized by storm, and the time when the rain starts and ends varies from year to year. The months of July and August together receive in the range of 54 to 71 % of the total annual rainfall.

The rainfall variability has a direct effect on root zone soil water availability, but also indirectly by causing runoff losses. Drought occurrence is common. But intra-seasonal, short periods of water stress (dry-spells) are even more so, hitting hard on crop yields - in particular if induced during critical growth stages such as stem-production and flowering.

Severe yield reduction of the crop in the study areas often coincides with water stress. Success in rainfed crop production is thus highly variable with farmers being unable to meet their food needs due to crop failure.

4.2.3 Land use

Presently land use in the surveyed Woredas is grouped into four categories. Cultivated land being the highest followed by non-agricultural land, such as grazing land, scattered vegetation, miscellaneous (hill, rivers, roads etc.) and settlement.

4.2.4 Production system

The agricultural production system of the study areas is subsistence farming with farmers practicing a mixed crop-livestock production system. This has been developed as a coping strategy to spread the risk in drought or disease outbreaks. In Alamata and Kobo Woredas farmers largely produce food grain crops mainly Sorghum, Teff, and Maize while Kilte Awlaelo Woreda farmers produce Barely, Millet, Teff, Wheat and Maize under rainfed cultivation. In both study areas vegetable crops like onion and tomato are commonly produced under irrigation cultivation. Irrigation is practiced in a few areas, and perennial water sources are few.

Livestock is an important part of the farming system and, as well as serving as sources of food and cash income, it is both an important draft power for ploughing and threshing and providing manure for crop production and fuel. Despite their relative large number, livestock productivity is very low and can be attributed to shortage of feed, disease and poor management. Crop residues provide the bulk of the feed resources base supplemented with grazing of natural pastures, valley bottoms and hills.

4.2.5 Constraints to crop production

The rainfall pattern in all study woredas is irregular both in quantity and distribution over the growing season. Irregular precipitation constrains efficient use of agricultural inputs, leading to either sub optimal or excessive use of some resources. In most cases, farmers are forced to adopt defensive low productivity production systems, such as sequential planting and low application of chemical fertilizer (particularly on soils with low moisture retention capacity) and have a preference for low value but low-risk crops - drought resistant. Water is, therefore, central for survival and development and water harvesting is hence the top priority of the targeted communities who are resource-poor farmers.

4.2.6 Household level water harvesting strategy in Tigray and Amhara Regions

Erratic rainfall in the many parts of Ethiopia over the past years has resulted in widespread crop failure and has brought a growing awareness of the importance of household level water harvesting. In an effort to address the problems of recurrent droughts and food insecurity the government of Amhara and Tigray Regional States has given priority to a variety of water harvesting programs to supplement rainfed agriculture of which the extensive small dam-based irrigation program initiated before ten years, within a major rural development program called Sustainable Agriculture and Environmental Rehabilitation in Tigray (SAERT) and Sustainable Agriculture and Environmental Rehabilitation in Amhara Region (SAERAR).

The Government of the two regional states realized that these structures require a huge amount of resources, technical capacity, and demand high maintenance and overhead costs. Moreover, it was observed that implementing limited water harvesting technologies alone would not enable to cover a wider area in a short period of time and that this was a slow process to reduce poverty. Besides, the overriding issue was that of the sustainability of the schemes.

Lately, there is a change in strategy with increased emphasis on water harvesting at household level. Emphasis has been given to use whatever opportunities available to exploit the available water resources. This led to focus on the construction of ponds, underground tankers and shallow wells. In the two regions, an extensive pond and shallow well construction have been in progress since the last four year in order to provide water for irrigation and domestic use at a household level.

The current water harvesting policy and strategy of the two regions is drawn from the national policy and strategy for irrigation development. In the strategy especial emphasis is given to micro and small-scale water harvesting technologies, particularly the construction of ponds and shallow wells, with the view to bring an impact on smallholder peasant agriculture and to ensure food security at the household level. Thus, most of the intervention structures are designed to be farmer managed.

Since 2003 household level water harvesting schemes have been expanding as an integral part of the two regions food security and extension programs aiming at breaking the cycle of famine by making water available to supplement rainfed agricultural areas during the critical stages of plant growth when rainfall is inadequate and to promote home garden development.

Water harvesting schemes like ponds and shallow wells were constructed to harvest water in order to reduce the risk of moisture stress by using the water for supplementary irrigation (pond) or dry season irrigations (shallow well) that productively at household level would increase. Therefore, household level water harvesting ponds and shallow well irrigation development in relation to food production in Tigray and Amhara regions is of interest to address the recurrent drought and famine.

Communal ponds are not new to the two regions and many communities have been harvesting water in ponds for human and animal uses during the extended dry period. What is new is the construction of household ponds on a massive scale for supplementary irrigation of the main season crops after the cease of the main rain in order to reduce the risk of moisture stress and for growing vegetable crops at the homestead.

5. FINDINGS AND DISCUSSIONS

5.1 FARM HOUSEHOLD SAMPLE CHARACTERISTICS

5.1.1 Land holding

Interviews and simple land holding exercises conducted during the household survey process revealed that households generally perceive the amount of land owned to be the main determinant livelihood, and this particularly applied to the amount of irrigated land owned. The average land holding sizes per household in the study Woredas were 0.75, 0.88 and 1.13 hectares for Kilte Awlaelo, Almata and Kobo Woredas, respectively (Table 3). Households in Kilte Awlaelo have relatively less land holdings than Alamata or Kobo Woredas

Table 3: Total land holding of sample households (hectares)

	Alamata	**Kilte Awlaelo**	**Kobo**
Mean (ha)	0.88	0.75	1.13
St.dev	0.57	0.37	0.66

Source: Household survey

Table 4: Proportion of households by size of land holdings by Woreda

Region/holding	**<0.5ha**	**0.5-2.0ha**	**>2.0ha**
Kilte Awlaelo	21%	79%	0%
Almata	22.7%	62%	15.3%
Kobo	16%	63.5%	20.5%

Source: Household survey

Table 4 shows that in all three study Woredas the distribution of land ownership is skewed with the majority of households (over 20 percent) having land holdings of less than 0.5 hectare.

Table 5: Distribution and size of land holdings within the study area

Holding size in ha	**Alamata**	**Kilte Awlaelo**	**Kobo**
	Cumulative % of households owning land	Cumulative % of households owning land	Cumulative % of households owning land
<0.5	22.7%	21%	16%
<2	84.7%	100%	79.5%
>2	15.3%	0%	20.5%

Source: Household survey

5.1.2 Land tenure

The majority of farming households in the study Woredas are land owners. Paying cash rent for the use of land was found to be rare. Sharecropping is common in both study Woredas and tends to occur when the owner of the land cannot cultivate by himself/ herself and the land is given for a temporary period (one season or one year or 2-3 years) to the cultivator on the basis of different crop sharing agreements.

5.1.3 Household composition and labor availability

Household size and composition are variables in determining the production and consumption in a particular population. The sample shows an average household size of 4.29 in Almata, 4.46 in Kilte Awlaelo and 4.51 in Kobo woreda. Household composition in terms of the proportion of adults engaged in farm work is similar across the three study areas. Kilte Awlaelo study area has a slightly higher proportion of older people who are at least partly dependent on family members. It is also noticeable that although most households include children less than 14 years of age, a high proportion (73.65 percent) report that children are regularly engaged in farm work.

Table 6: Household dependency and labor availability characteristics of sample households

Household members	Almata		Kilte Awlaelo		Kobo	
	Mean	Proportion	Mean	Proportion	Mean	Proportion
Family size	4.29		4.46		4.51	
Working age >14 years	30.47	22.50	31.15	22.30	30.96	22.50
Children age 9 to 14 years	11.3	17.60	10.98	20.27	11.49	17.25
Children age < or equal to 8	4.57	57.60	4.46	53.38	4.75	57.97
Old age >=60	66.71	2.49	67.07	4.05	66	2.28
% adults that do farm work	50.18		47.47		51.93	
Dependency ratio*	1:1		1.1: 1		0.94:1	
% of households with one or more children engaged in farm work	21.06		18.39		22.30	
%households adult working away	6.55		17.76		7.46	

* Dependency ratio is the number of children and non-working adults residing in the household per adult who performs farm work.
Source: Household survey

5.2 TYPE AND CHARACTERISTIC OF WATER HARVESTING SCHEMES PRACTICED IN THE STUDY AREAS

i) Household Ponds

Household pond is characterized by small reservoirs located in irrigated areas that allow farmers to capture runoff water or taken water from nearby micro-catchments or gully or stream with diversion structure and stored in the pond to be used when required; all manage at household level.

The great advantage of this storage system is the relative simple operation and maintenance structure. A typical pond water harvesting scheme includes three parts: the catchments area, the pond/reservoir, and the irrigated land. The catchment area channels runoff to the reservoir/ pond. The size and capacity of ponds could vary: the most common pond size is 12m x 12m area with a depth of 2.5m (182m^3). Most of the constructed ponds have a storage capacity ranging from 57 to 183m^3. The water harvested within one season was expected to supplement irrigation from September to October on a 2000 square meters of cultivatable land. Ponds are excavated and constructed manually.

Interior walls of the pond have a slope in order to minimize seepage. To prevent seepage clay blanket or cement or plastic lining are used as well. The most common lining material of the observed ponds is a plastic sheet made of black polyethylene membrane. Cost for plastic lining were met from the government budget .The unit cost of the polyethylene membrane is 1500 Birr, but was sold to farmers on credit bases with a subsidized price of 650 Birr.

At the pond intake it has a silt trap structure to prevent erosion, capturing sediment that would otherwise fill in the pond. It has also spillways to discharge excess water to preserve the integrity of pond. Very few ponds are fenced by native thorny vegetation to prevent human being and livestock from trampling on pond banks or drowning. Ponds are mostly located around the farmers' houses on homestead farmlands so that there will be a close management by family members. The ponds have an average projected lifetime of 10 years with annual maintenance (Cowater International Inc, 2003).

For all sites, it was assumed that ponds would store water collected during the wet season to be used mainly for supplementary irrigation to meet gaps occurring during the rainy season or for use immediately after the rains were finished. Water stored in the pond was also considered for multipurpose use including small scale irrigation, domestic, water supply and livestock watering.

Discussions held with pond owners showed that ponds whose surface is covered or blanketed with compacted clay soil can keep the stored water on average for nearly a five weeks period after the cease of the rainfall while ponds that are lined with black polyethylene membrane can retain the harvested water in the pond in most case until the end of December, i.e. 3 months after the cease of the rainfall. On the other hand, ponds whose surface is not covered or blanketed with compacted clay or plastic were found to be ineffective with the water stored in ponds being lost within a few days.

With regard to the total cost of the construction, a pond covered with geo membrane plastic costs between 5100 to 5600 Birr while a pond without geo membrane plastic but compacted with clay soil and stone riprap costs between 3600 to 4000 Birr. Construction is usually completed in less than four weeks.

Payment for excavation work of a pond was made using Food For Work grain or both cash and grain, and totally were covered from the government (donors food or cash aid supported) budget. The payment excavation related work of a pond was made based on a lump-sum contractual agreement made with groups of farmers organized into a construction crew, but the amount of food for work payment varies between woredas,

The means of water lifting in the study area are mainly bucket and rope. Most households use this technology to lift water from the pond to irrigate their plots. Only very few households are observed using treadle pump as a means of lifting water from ponds. The land covered by different types of vegetation ranges from 0.001 to 0.25 ha depending whether the harvested water is used for supplementary or full irrigation. Those farmers who were planting crops like onion during the rainy season and brought them to harvest using the pond water for supplementary irrigation managed to have a large size of land and they are the ones who appreciated the water harvesting scheme. Those who solely depend on harvested water for raising vegetable crops had plots as small as 0.001 ha

<u>Summary of sample pond characteristics:</u>
Reservoir Volume

- Range (m3) 57- 183

Condition (%)

- Adequate; 10%

- Poor 33%
- Abandoned 53%

Water source (%)

- Runoff only from upper micro catchments 97%
- Gully only 2%
- Runoff and gully combination 1%

Figure 1: Pond with geo membrane lining sheet

Figure 2: Pond compacted with clay and stone riprap

Photos: Haile Tesfay

Unlike wells, ponds are meant mainly to be used for supplementary irrigation although, in addition, they can be used for home gardening to grow vegetables in the backyard, for human sanitation and drinking water for livestock.

<u>Principal use by sample pond users (%):</u>

- Supplemental irrigation only 12.75 %
- Horticultural growing/vegetable gardening only 10.11%
- Domestic and livestock watering 7.15%
- Not used 69.99%

Figure 3: Sample ponds used for horticultural growing

Photo: REST Public Relation Unit

ii) Hand dug well/shallow well

Shallow well is the other type of water harvesting structure widely promoted in Tigray and Amhara regions. Shallow hand dug wells have a circular shape. They are about 3-4 meters (m) in diameter with varying depths depending on the water level. In practice, however, the size varied with respect to land and labor availability. The source water is from shallow water table aquifers at depths between 3 and 16 meters and dug with human labor.

The depth at Kilte Awlaelo, Alamata and Kobo Woredas ranges from 3 to 7 m, 6 to 13m and 6 to 15 m, respectively. The variations in depth are accounted for: a) their locations in the valley, i.e. those wells located at a comparatively higher elevation in the valley are relatively deep than those located at a lower point; and b) farmers' perception of the water levels of wells (there are differences in perception about changes in water level height as the dry season goes by). Those who assumed the level remains constant throughout the year stopped digging early as soon as they reached the water table while others kept on digging deep, some up to 15 m depth, to make it a reliable source throughout the dry season.

The wells are dug with hoes, shovels, pickaxes and diggers. Water, soil and stones are removed from the hole using a human-powered bucket-rope-pulley arrangement. Water from the dug-wells is pumped through a treadle pump or human labour bucket-rope. To prevent collapse of the ponds some farmers built a masonry wall along all the sides of the pond.

Many hand-dug wells in the study areas provide water for horticultural growing as well as for drinking for humans and livestock. The construction cost of a well ranges from 3000 - 10,000 Birr. Construction cost for cement lining of a shallow well have been estimated at 10,000 Birr per unit while construction costs for a well having a depth of 6 meters and without cemented side wall are 3000 Birr. The major cost items in constructing a well include: labour for excavation, masonry work and stone collection and hand tools cost (tools depreciation cost).

Like ponds, labour cost for the excavation, masonry and stone collection work of a well was contracted out to a group of farmers organized into a construction crew; and payment was made using Food For Work or in some case a combination of cash and food payment; the cost was mainly covered from the government or NGO's budget. Basic hand tools were purchased by the regional government and distributed to each kebelles to be used in a pool system. However, there are many cases of households who dug a well by mobilizing their own family labour and tools without obtaining any financial assistance from the government or NGOs.

A treadle pump is widely used by most farmers to extract and direct the water to the channels. Though there are only a few, motor driven pumps are also in use. Only a few farmers especially are using bucket to extract water. The prevalence of more treadle pumps is an indication that the shallow well water harvesting program is paying off and has a widespread acceptance.

Principal use by sample well users (%):

- Livestock only: 12%
- Horticultural growing/vegetable gardening: 42.26%
- Livestock and domestic use: 29.7%
- Both for vegetable gardening, and livestock and domestic use: 15.04%

Figure 4: Sample shallow well from Abreha-Atsebeha kebelle

Photo: Haile Tesfay

iii) Household Underground Tankers

Underground household tanker reservoir is a circular or rectangular shaped dug out pond excavated into shallow, water-tight bed rook. Its side wall is lined with cement and roofed in two ways (i) roofed with a wooden framework covered with grass shade or corrugated or plastic shade (which is common in Tigray) (ii) dome like shaped tank which its roof is covered with angle iron cemented reinforcement bar (this type is mainly found in the Amhara region).

The underground tanker rainwater harvesting systems are generally designed to hold 60 to 100 m3 of water, and collect water from nearby micro catchments area runoff and have a feeder canal. During irrigation, water is lifted by foot-pumps, a treadle pump or hand left bucket. They are relatively expensive to build and require relatively skilled labor. The cost of one underground tanker ranges from 5000-10,000 Birr (10, 000 Birr is mainly for the underground tanker dome type). In all the study woredas about 391 underground tankers were constructed.

Those tankers have several benefits, the main one being that they protect the water stored within from outside pollution and from vector breeding such as mosquitoes. This makes them ideal as a domestic source of potable water and for backyard horticultural production. One of the major drawbacks is that they are difficult to clean out when they get silt inside.

Many farmers in the study areas use the water of underground tankers for producing high value crops (vegetable and fruits) during the dry season and also for supplementing rainfed/wet season-farming and sustaining a source of water for livestock.

Figure 5: Household underground tankers of different shape

Photo: Haile Tesfay

5.3 WATER HARVESTING IMPLEMENTATION MODALITY

5.3.1 Implementation approach

The overall implementation of the RWH program was guided by the Woreda steering committee consisting of representatives from the Woreda according to the pervious structure: Rural Development office-chair person, Water Resource Development office, health officer, Youth associations, Women association, Farmers Association, Food Security desk and Woreda propaganda offices. At Kebelle level also the program was coordinated by a committee composed of the kebelle chairperson, development agents, health officers and kebelle rural development affair representative. Similarly, this structure goes down to the village level.

Participants to community focused group discussions noted that during the first year of the implementation of the water harvesting program the whole planning exercise was not thoroughly discussed with all concerned stakeholders. In all the study areas, the most often cited failure of the implementation approach of the water harvesting program was that the planning started without full farmer participation; it appears that many farmers were forced to construct the water harvesting particularly the ponds. Due to this, many visited ponds were constructed even in cases where it was not the most ideal location in hydrological and topographical terms; also, many ponds are constructed far from farmers' residences.

Many respondents expressed that beneficiary participation during the design and planning process particularly in pond water harvesting was almost none; due to this, pond beneficiaries could not develop a sense of ownership, making them not willing to fully use the stored water in the pond. Furthermore, coordination among the various regional, woreda and Kebelle stakeholders was also weak.

Participants of the group discussion asserted that, initially most of the farmers were not willing to construct the water harvesting schemes on their plots. However, after witnessing that farmers adopting these technologies were benefiting economically from these schemes, most of them were motivated to construct the water harvesting schemes even without the assistance from the government.

5.3.2 Role of community and institutions involved in the water harvesting implementation

The role of each actor in the implementation of the water harvesting was as follows:

Bureau of Agriculture and Rural Development (BoARD)
The main role of the Woreda office of Agriculture and Rural Development was:
- Allocating quota on the number of ponds and wells (currently the wells are handled by the Water Resource Development Bureau) to be constructed in each Kebelles;
- Providing technical supervision and follow-up for the implementation of the construction of ponds;
- Training of model / contact farmers on pond construction technology;
- Provide quality of extension services to water harvesting scheme farmers to help them enhance their production and productivity;
- Supply of input materials and treadle pump to farmers;
- Cover full unskilled and skilled labor cost for construction of the pond or wells through food for work payment;
- Subsidize the cost of industrial materials usage (such as geo membrane, cement, angle iron use) for construction of the ponds.

Water Resources Development Bureau
The role of Water Resources Development Bureau is the provision of technical backup in the implementation of water harvesting schemes:
- Site identification for well construction;
- Training of pond foremen and shallow well technicians;
- Decision on construction material;
- Study and design of shallow wells and implementation of the construction;
- Assessment of environmental impacts of irrigation in collaboration with concerned bodies.

Private sector
The local small and micro enterprise private sectors were involved particularly as manufactures and as suppliers of various irrigation technologies such as treadle pump and family drip kit apparatus such as reservoir barrel, as well as a contractor to construct the underground tankers.

Community/beneficiaries
Provide labor for construction of individual well/pond, catchments treatment, labor for fence construction, operation and maintenance, and long term management of the constructed water harvesting scheme and the catchments area

5.4 RULES AND REGULATIONS IN PLACE TO USE WATER IN THE STUDY AREAS

The Ethiopian law provides for the "Supervising body" to issue permits for water abstractions and utilization. The legislation states that groundwater belongs to the state rather than to the owner above that resource. The country has adopted the Water Resources Management Policy and Strategy including water law to facilitate the implementation. Currently, however in all the study areas the water right system is poorly defined. The ability to extract and utilize groundwater depends on rights and access to the land above it. In the absence of a clear law defining and enforcing ownership and user rights, groundwater is appropriated by those who command the land over it and who have the means to lift it.

Due to this, in many of the visited sites, the researcher observed competition and conflict between farmers to dig wells, as well as conflict for getting a way of passage to harvest water from the upper catchments of ponds. This may lead, particularly for underground water utilization, to cataloguing existing abstractions and computing a water balance for the site under study. Water rights disputes are currently handled in an ad hoc manner by the village administration.

In all the study areas there was no clear regulation and policy regarding ground water extraction and utilization; there was no written guideline on how much the distance should be between two wells. As a result, there was high competition among farmers to dig wells without giving due regard to the distance between the wells. Due to absence of clear ground water regulation, in Alamata and Kilte Awlaelo study areas there were some instances of conflict between adjacent well owners.

In view of limited ground water resources in the area coupled with the absence of a functional regulatory body, the impact of the underground water harvesting for irrigation development could in the long run be a challenge for the sustainable management of the ground water. So the ground water level has to be frequently monitored to ensure necessary action timely.(for its mitigation). Therefore, an urgent embark on a regulatory function by the respective agency is a precondition for the sustainability of ground water use for irrigation purposes.

5.5 WATER USE EFFICIENCY OF HOUSEHOLD BASED PONDS AND SHALLOW WELLS

i) Shallow well /hand dug wells

The community of the surveyed areas are drought-prone and food insecure with severe water shortages. The water harvesting shallow well irrigation has been properly identified to address the most pressing needs of the community. In the past three years in the three study woredas about 2,541 ponds have been constructed.

All hand dug wells have got water of different levels based on the location in the valley bottom, their depth, and number of wells dug at the site. The level of water has diminished in all sites as the dry season has progressed.

A treadle pump is widely used by many users of shallow well water harvesting to lift and direct the water to there farm plot. Though it there are few, motor driven pumps are also in use. Only a few farmers, especially in Alamata and Kobo Woredas, are using a watering-can or bucket to extract water.

ii) Ponds

Until the end of 2006, in all study Woredas a total of 3,603 household ponds had been constructed; however, only about 77% of the constructed ponds were storing water adequately that can be used for supplementary irrigation while the remaining 23% ponds were either empty or had a very limited amount of water mainly due to a high seepage problem.

The clay line ponds were ineffective in preventive seepage as either incorrect material had been chosen, compaction had not been carried out at the right moisture content, or the thickness and layering of the clay layer was too small. The net result has been that farmers did not believe that clay lined ponds would hold water and that unless they are given plastic to line them, they will not have confidence in their potential to hold water. By contrast, ponds lined with plastic sheets were found to be effective in retaining the accumulated water. The main problems observed on such types of ponds were that the plastic gets damaged and get small holes which lead to water leakage. The researcher had a chance to visit more than 20 ponds; many of the ponds had no water when they were visited in September

In general, many respondents were lacking interest in using the ponds; this lack of enthusiasm was expressed in various ways: unwillingness to take plastic lining on a credit basis, which arose from the perception that the benefit that they could possibly collect from the scheme did not enable them to repay the loan. Others did not make the required effort to make their pond hold the maximum possible water by effectively utilizing the catchments and repairing the damaged ponds

iii) Treadle pumps

To increase the utilization of the household level water harvesting program, the government has been promoting a foot-operated low cost treadle pump capable of producing 1 litre of water per second from depths up to 6 meters. The pump is made of mild sheet steel and produced locally by small-scale manufacturers. The pump enables marginal farmers to produce vegetables and other cash crops. Until the end of 1998 EC, a total of 1235 treadle pumps had been distributed in the study Woredas alone. Furthermore, a few farmers also started to use motor pumps to lift the water for irrigation purposes. Therefore, the prevalence of more treadle pumps and motor driven pumps is an indication that the water harvesting program is paying off and has a widespread acceptance.

The cost of the treadle pump is Birr 400-600 – less than one tenth of the cost of a diesel pump (Birr13, 500-17,000). The lifespan of a treadle pump is around four to seven years, depending on many factors, including the salinity of the water, the quality of maintenance, type of aquifer etc. A case study with 5 households in the study areas estimated that farmers using the treadle pump typically earn a gross income of Birr 1200-3500 per season by using the pump for shallow wells. The treadle pump is considered as an entry level technology for poor farmers who cannot afford to rent or purchase diesel pumps.

Many beneficiaries expressed that treadle pumps helped them increase crop diversity and save labor to irrigate their plots This is particularly evident in the Abreha Atsbia Kebelle, Kilte Awlaelo woreda, of the Eastern zone of Tigray where many farmers have been able to increase their cropping intensity and efficiency and obtain higher incomes. It enabled farmers also to grow vegetables and fruits as well as cash crops, which helped them increase dry season vegetable and fruit production and make use of land previously left fallow during dry seasons. The treadle pump is considered a “gender friendly” technology in that it can provide increased economic opportunities for women.

Figure 6: The treadle pump used by farmers

Photo: Haile Tesfay

iv) Drip irrigation system

Low cost household drip irrigation system is also one of the irrigation technologies recently introduced in the study areas side by side with the promotion to increasing household level water harvesting ponds and wells. The cost of the household level drip (to cover 500 meters square) ranges from Birr 3500 – 4000. Farmers are expected to repay the cost over a 4 year period. Currently, few farmers have started to use this water harvesting technology. It is expected to offer many advantages like water saving, reducing labor required for irrigation, reducing soil erosion, and increasing crop productivity. This is a most promising water saving technology in the near future.

Figure 7: Drip irrigation users – Abreha Atsbeha

Photos: Haile Tesfay

5.6 MAJOR ISSUES AND CHALLENGES FACING WATER HARVESTING IRRIGATION DEVELOPMENT

In all the study areas there are a number of factors which hamper the success of the water harvesting micro-irrigation development. Some of the main issues that need to be addressed, according to the study findings, are the following.

The researcher observed high competition among farmers in digging wells (mainly in Abreha Atsbie study areas), and there was no written guideline on how much the distance had to be between the two wells. In areas where groundwater is extensively exploited like in the Abreha Atsbeha kebelle, there are indications of high reduction of the groundwater. This could pose a serious threat for the sustainability of the hand dug wells resulting from an unbalanced discharge and recharge rate unless measures are introduced to regulate the harvesting of groundwater.

(i) Constraints of shallow well water harvesting

While shallow-wells seem to work well, and are much preferred by farmers as compared to ponds, some of the major problems observed during the field assessment were the following:

- In all the study areas there was no clear regulation and policy regarding groundwater extraction and utilization; this being a considerable source of conflict among adjacent ground water users for irrigation.
- Partial or total collapse of the side walls is common in all the study areas. This has resulted in either frequent drying up of wells or drastic declines in the water level: this forced well owners to periodically maintain or deepen the well during the dry season. The other common problem was silting-up of wells.

Figure 8: Shallow well water harvesting
Photo: Haile Tesfay

(ii) Constraints of pond irrigated farms

- A considerable number of the visited ponds in Alamata and Kobo study areas were constructed in areas far away from the owners' homesteads. As a result of this, many pond owners were not encouraged to use the harvested water in the ponds. Moreover, the quality of the construction work was very poor. These two were the main reasons for the lesser success of the pond water harvesting scheme.
- The other most commonly mentioned weakness in the pond water harvesting was lack of experience in utilizing and managing stored water in the pond, which resulted in poor water utilization and management.
- Ponds have high seepage and evaporation and as a result of this, water does not stay more than one to two months after the rain.
- In all the study areas there were many known instances of animals, humans and other material falling into the ponds. This happens particularly when the ponds are constructed near to the owner's house and if the pond is left uncovered or unfenced.
- The catchments for some of the ponds are relatively small resulting in a small runoff and consequently to a smaller stored volume of water.
- Eighty three percent of the sample households responded that their involvement in the identification, planning, and designing of the water harvesting program was low.

5.7 LINKAGE OF WATER HARVESTING WITH MARKETING

Farmers in both study areas do not live far from major towns like Alamata, Kobo and Wukro Awlaelo. Most of the horticultural crop producers transport (usually by donkey) their harvest to the market and sell their vegetables to retailers/traders or directly to consumers.

Due to lack of market information farmers are not producing following a staggered cropping calendar; most of the time farmers produce similar agricultural products leading to flooding of the markets with the same type of agricultural produce, this causes a drop in price even to the extent of damping their perishable crops and it discourages many farmers from producing similar vegetables again.

Market information of the study areas shows that the price of vegetables lowers immediately after the post harvest period, as most farmers tend to sell to cover their immediate needs. However, those who are able to store portions of their harvest are more likely to receive a better price for their produce as its availability decreases.

Vegetables grown in a particular season are selected based on the price that they fetch and the shelf life of the crop. The market price of one kilogram of tomato ranges from 0.75 cents to 3.5 Birr in different seasons depending on supply and demand. In addition, crops of such kind cannot be left in the field or stored for a long period of time so that farmers are compelled to sell it at the price that the market offers and often the low market price discourages farmers from growing them. On the other hand, crops like garlic can be kept longer. This gives growers an opportunity to sell them when the market offers them better prices, provided that they are not cash constrained. Furthermore, poor transportation has also jeopardized current efforts of the government to increase horticultural production.

5.8 LINKAGE OF THE WATER HARVESTING HOUSEHOLD PACKAGE AND EXTENSION SERVICES

The most important on-going development interventions, which are directly or indirectly linked to the water harvesting activities in the study areas visited, include the expansion of the on-going household extension package program. The program focuses on improving food production and diversifying the source of household income by providing different agricultural inputs. However, the extension workers are more technically oriented and seriously lack market oriented training capabilities.

5.9 IMPACT OF WATER HARVESTING

5.9.1 Change in household months of food shortage

The annual average food self-sufficiency months was assessed for the randomly selected samples of households. The result showed that the mean number of food self-sufficiency months per household from their own production and purchase was adequate to cover 9.09, 8.49, 8.77 and 8.52 months for shallow well users, underground tanker users, pond users and non users of the water-harvesting respectively. About 27 percent of the "shallow well irrigators" have attained food self-sufficiency for the whole year. However, only 8% of the respondents from pond beneficiaries and 10% of the non-users of the household rain water harvesting (control group) used to have food self-sufficiency the whole year.

Furthermore, the water harvesting shallow well schemes have made a considerable contribution in improving household vegetable consumption. About 39 % of shallow well and 12 % of pond irrigation users mentioned that they *are* consuming varieties of vegetables at least once a week after the start of household level water harvesting irrigation scheme. However, only about 9 percent of the non-users of the water harvesting scheme consume vegetables at least once a week. The cash generated from selling vegetables and other produce is commonly used to buy food to cover the household demand during the food deficit months. The details of the results of the survey are shown in Table 7 below.

Table 7: Length of month's household can feed themselves

Irrigation Type	Summary of number of months a household was able to feed itself		
	Mean	**Std. Dev.**	**Freq**
Shallow well	9.09	2.03	110
Pond	8.49	2.44	63
Dome shape pond	8.77	2.20	22
Non users of pond or well	8.52	2.42	308

Source: Household survey

Generally, one can conclude that the use of the water harvesting shallow well schemes has improved the livelihood of the beneficiaries. As a result of these achievements, a majority of the surveyed shallow well users unanimously responded that they are very happy and satisfied with the water harvesting shallow well schemes.

5.9.2 Impact on household income

Group discussion participants of the shallow well reported that as a result of the dry season irrigation they registered an increase in income between 950-8000 Birr from grown vegetables. In Kilte Awlaelo Woreda, Abreha Atsbeha kebelle (peasant association) study area, for instance, an assessment by the extension agent indicated that shallow well user households received an income increase of between 2,000 and 8,000 Birr from producing vegetables. In Alamata study areas, participants of the group discussions conducted noted that there was a significant improvement in household income of shallow well users by 3000 to 5000 Birr. The major types of vegetables/fruits grown on plots with wells include pepper, onion, tomato, lettuce, papaya, guava etc.

These high incomes are mainly due to the cropping patterns being practiced which incorporate high value horticultural crops. On the other hand, the participants of the group discussion noted that most pond water harvesting irrigation users have been generating very little income from vegetable growing.

5.9.3 Diversifying cropping pattern

Prior to the introduction of the household water harvesting a majority of the households in the study areas cultivated main staple crops like maize, sorghum, wheat and barley. Moreover, dry season vegetable and fruit cultivation was only limited to households who have access to irrigation from river diversion and micro dams. But after the introduction of the household level water harvesting program many farmers are producing high value horticultural crops such as potato, tomato, pepper, onion, cabbage, green maize, garlic, and also fruits like papaya, mango, lemon and also cereal. Therefore, we can say that cultivation of additional dry season vegetables and planting of fruit trees are the main direct benefits of shallow well water harvesting irrigation.

Nearly 27 percent of households owning ponds have two or more crops on their plots while about 69 percent of households owning wells reported that they have more than two crops on their plots. A more diversified cropping pattern is observed mainly at Kilte Awlaelo study areas, which includes a much greater proportion of high value vegetable and fruit crops.

Many users of shallow wells noted that though there is a high demand; they are not interested in growing perennial horticultural crops in large quantity for the purpose of the market, as it requires a long time for maturity and harvest. From Table 8, we can understand that following the introduction of water harvesting schemes production of vegetables and fruits has increased.

Table 8: Proportion of sample households' grown vegetable and fruits by irrigation type

Crop type	Proportion of sample households' produced vegetables and fruits		
	Shallow well	**Pond**	**Underground Tankers**
1. Vegetables			
Tomato	39%	14%	5%
Onion	41%	21%	18%
Carrot	1%	3%	0
Pepper	29%	0	0
Cabbage	7%	0	0
Lettuce	6%	3%	0
2. Fruits			
Papaya	25%	11%	0
Mango	6%	35	0
Guava	7%	0	0
3. Oil crops			
Groundnut	4%	0	5%
Cotton	28%	35%	18%

Source: household survey

Table 9: Percentage of area covered by different crops planted during 2006 by sample households

Crops	Users of RWH-shallow well	Users of RWH-Pond/underground tankers	Non Users of RWH
Onion	6%	5.3%	1.32
Tomato	5.17%	2.83%	1.47%
Pepper	4%	0%	0.85%
Cotton, chat, & groundnut	9.89%	6%	2.17%
Different fruit	6.44%	3.83%	0%
Maize	7%	3.53%	5.03%
Sorghum	22.8%	36.75%	38.54%
Teff	26.57%	32.51%	39.63%
Barley	2.24%	1%	2.4%
Wheat	1.54%	-	1.24%
Other crops	12.24%	4.36%	7.35%
Total	100%	100%	100%

Source: Households survey

With regard to the proportion of vegetable production, onion holds the lion's share in all studied Woredas. Over 41% of the shallow well beneficiaries planted onion in year 2006 (Table 9). However, farmers noted that concentrating on one crop (onion) has had a negative implication in that it causes competition for market among producers, especially when they bring their produce to the market in the same period. Farmers reported the following reasons for why they produce onions in large quantities:

- The local seed of onion is easily obtained;
- Irrigation water application and its field management is relatively easy;
- It is less perishable, easy to harvest and transport compared to other crops; and
- It withstands disease when compared to other crops.

There is a significant change in the cropping pattern after the introduction of the RWH (Table 10). So we can conclude that the water harvesting scheme particularly the shallow well irrigation has permitted the growing of crops that would not be grown under dryland conditions. And this has been encouraging beneficiaries of the water harvesting program to diversify their production into higher risk but potentially higher income activities.

Table 10: Crops grown in the study areas using the different irrigation system

Irrigation Typology	Major crops grown
Pond	Tomato, onion, papaya, mango, cotton, maize, barley, teff
Shallow well	Tomato, onion, pepper, cabbage, papaya, guava, mango, cotton, and maize
Underground tank	Onion, tomato, cotton

Source: Household survey

5.9.4 Changes in input use

One of the expected changes as a result of improved access to water is increase in use of yield-enhancing technologies (mainly fertilizer and improved vegetable seeds). The household survey data for study areas indicated that the proportion of farmers who used urea fertilizer was about 9%, 0% and 6% for shallow well, pond, and non water harvesting scheme beneficiaries respectively, while for DAP fertilizer it was about 7%, 0% and 3% for shallow well, pond, and non water harvesting scheme beneficiaries, respectively. With regard to the use of improved seed 20% of shallow well users, 21% of pond users and 3% of non-owners of ponds and wells used them. Regarding the usage of improved seed, only vegetable seeds are commonly used by the water harvesting users (Table 11).

Table 11: Percentage of sample households using inputs by Woreda

Input	Kobo			Alamata			Kilte Awlaelo		
	Well user	Pond user	Non-user	Well User	Pond user	Non - user	Well user	Pond user	Non - user
Improved seed	13	20.54	1	20	16	4.6	19	71	20.7
Pesticide /Fungicide	0	0	0	1.27	0.48	0	0	0	0
Fertilizer-Urea	0	0	0	2.22	0	1.17	23.19	26.72	22.09
Fertilizer-DAP	0	0	0	1.01	0	0	12.6	17.75	13.11
Manure	4.84	5.48	1.56	21.43	6.03	8.04	25.72	30.77	27.03

Source: Household survey

As to the application of agricultural input usage per hectare is concerned, the researcher did not find any significant difference (at P-value < 0.01 level) between households having ponds and wells and those without them (Table 12). From this we can conclude that the development and use of water harvesting irrigation has no impact on increased and more intensive use of agricultural inputs.

Table 12: Comparison of Average amount of input use (kg) per hect

Input	Average input usage per hectare					
	Shallow well users		Pond users		Non users of pond and wells	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Improved seed	16.90	63.55	8.74	14.65	5.17	8.72
Pesticide /Fungicide	0.02	.30	0.11	1.90	0.53	12.6
Fertilizer- Urea	11.25	66.99	0	0	4.70	22.63
Fertilizer- DAP	4.21	22.54	0	0	2.04	13.55
Manure	232.81	935.24	238.29	805.53	211.01	1054.25

Source: Household survey

5.9.5 Impact on employment

Dry season was a slack season for a majority of the farmers in the study areas. As a result of introduction of shallow well and pond water harvesting schemes, dry season cropping begun, which requires considerably high labour for land preparation, planting, weeding, watering, hoeing, and harvesting of irrigated crops.

Over 74% of the respondents from the "shallow well scheme" beneficiaries reported that the farm labour requirement increased considerably after the starting of shallow well irrigation while only about 5% of the respondents from the "pond" beneficiaries reported that farm labour requirement increased after the start of pond water harvesting (Table 13).

Table 13: Percentage of sample households reporting change in use of farm labor after introduction of water harvesting scheme

Change in labor use as compared to non users of water harvesting	Kilte Awlaelo		Alamata		Kobo	
	Shallow	Pond	Pond	Shallow	Pond	shallow
Increase	95	12.3	7.2	63.6	2.9	43
Decreased	0	0	2	0	0	0
No change	5	83.7	90.8	36.4	97.1	57

Source: Household survey

Most farm households had surplus labour prior to the use of water harvesting agriculture. Nearly a quarter of the respondents from shallow well users mentioned that they are engaged in their own farming activities during the dry season months, which is not experienced by the "rainfed" respondents. This clearly shows that the shallow well water harvesting contributed employment opportunities for a considerable number of household's family members.

At Kilte Awlaelo study area, farmers did report a steady rise in the opportunity for family labour use for the shallow well water harvesting irrigation. Focus group interviews also confirmed that farmers used to have about six months free time, which has been reduced to almost nothing since shallow well irrigation due to the higher labour requirement.

With regard to pond water harvesting, the household survey revealed that only 5% of the respondents mentioned that the pond water harvesting scheme has increased family labour requirements. Table 14 indicates that the employment linkages are relatively strong for shallow well irrigation.

Table 14: Summary of average family labor (person days) used for crop production during 2006 production years

Type of water harvesting	Mean	Std. Dev
Shallow well users	103	61
Pond users	71	41
Underground tanker users	78	32
Non users of household water harvesting	75	71

Source: Household survey

With regard to the effect of water harvesting on hired labour usage for farming activities, the result revealed that on average in a year a household uses 19, 9 and 12 person days by well owners, pond owners and non water harvesting users, respectively (Table 15). However, the mean separation test indicated that the number of hired labourers employed by water harvesting scheme owners was not significantly different (at 10% probability level) as compared to the non water harvesting users. This indicates that the introduction of household water harvesting has not brought a significant effect on hired labour use

Table 15: Summary of Average Hired Labor (person days) used by sample households for dry season cultivation

Type of water harvesting	Mean	Std. Dev
Shallow well users	19	4.86
Pond users	9	1.72
Non users of pond or well	12	2.02

Source: Household survey

Figure 9: Shallow well user from Abreha Atsebe tabia and kelte Aelelo woreda. Farmer working with his family members

Photo: by Haile Tesfay

5.9.6 Household annual consumption expenditure

It has been documented in several studies that technological change and commercialization of smallholder agricultural production improve the level of consumption expenditure of participating households (von Braun and Kennedy, 1994). Changes in consumption expenditure are generally associated with more readily available cash income, but increased access to water security for irrigation purposes can lead to increase in self food sufficiency through increased land and labour inputs into higher food production and changes in cropping patterns (von Braun et al 1989). With higher incomes, a substitution of cheap calories by more expensive calories often takes place and diets gain in quality and diversity.

The introduction of low cost household level water harvesting is expected to improve household consumption expenditure. This is evident by looking at differences in average annual consumption expenditure between the three groups of household categories (Table 16). *The per* capita food consumption with ponds amounted to Birr 841.15 compared to Birr 783.22 for those who do not have ponds or wells. Likewise, the average per household food consumption expenditure for users of wells was found to be Birr 884.54 compared to Birr 783.22 for non users of pond or well water harvesting.

The total consumption expenditure also indicates that the average annual consumption expenditure per capita per year for users of well, pond and non users of water harvesting was Birr, 1377.28, Birr 1218.44 and Birr 1116.47 respectively. The annual household consumption expenditure of shallow well users is higher than the pond and non-users with an estimated difference of Birr 547 and 1002 respectively.

Table 16: Summary of the average annual food and consumption expenditure per capita

Household Categories	**Mean per capita food expenditure**		**Mean per capita total consumption expenditure (include food and non food expenditure)**		**Number of households**
	Mean	Std. Dev	Mean	Std. Dev	
Shallow well	884.54	313.52	1377.28	481.99	110
Pond	841.15	329.71	1218.44	440.37	63
Non users of pond or well	783.22	293.98	1116.47	412.00	195

Source: Household survey

Households were also asked whether the household water harvesting would have an effect in changing their livelihood in the near future, to this question, 81.2 percent of those owning wells responded that they believe wells will in near the future play a major role in changing their livelihood, while only about 11 percent of pond owners believed that ponds will change their livelihood in the near future.

The degree of the households' annual expenditure shows that there is a slight difference in the patterns of cash expenditures between users of water harvesting and non-water harvesting owners. These differences mainly occur within the non-food categories of commodities. Households with water-wells do purchase more farm input, as reflected in Table 18. These households exclusively purchase seeds, and water lifting and conveying devices for vegetable production. Moreover, households who have well irrigated plots were to some extent also in a better position to spend more on cloths, education, loan repayment and health in comparison to the pond and non-users of water harvesting schemes. They receive more annual income from backyard horticultural farm activities and thus become better off compared to farmers who do not have well irrigated plots.

Expenditure on food and miscellaneous expenses for food accounts for about 66 and 67 percent of the total annual household expenditure for owners of shallow wells and ponds, respectively. On the other hand, expenditure on food and miscellaneous expenses accounts for about 65 percent of the total annual expenditure for the "non owners of pond and shallow well" households.

Many users of the shallow well irrigation indicated that as a result of the shallow well water harvesting they have increased their consumption of fresh green vegetable supplements in their diet, as compared to the corresponding consumption before the introduction of these water harvesting and management technologies. Likewise, vegetable consumption from own production reduces their cash expenditures to purchase Onion and Tomato from local markets; this enabled them to save their income. Portion of their produce was also sold and the cash proceeds were also used to buy other food stuff and to satisfy other pressing basic needs of the household.

Table 17: Share (%) of household annual expenditure by type

Types of Expenditure	Water harvesting users		Non owners of well or pond (%)
	Shallow well owners (%)	Pond owners (%)	
Food	63	64.8	63.1
Miscellaneous for food	3	2.4	2
Farm inputs (fertilizer, seeds, tools)	11.3	8.17	8.04
Payment for farm labourers	2.8	2	2.2
Medical expenses	3.2	2.7	2.56
Loan repayment	3.1	1.7	1.01
Clothes	4.1	3.3	3.17
Education	1	0.8	1
Social Expenses	5	6.02	5.97
Other expenses	3.5	8.11	10.95
Total	100	100	100

Source: Household survey

5.9.7 Impact on reducing seasonal out migration

The household survey revealed that the proportion of people who migrated during the year 2006 was estimated to be about 10%, 11% and 12% for the shallow well users, pond users and non owners of ponds and wells households respectively. This shows that there is no significant difference between the owner and non-owners of the water harvesting scheme. From this it can be concluded that the impact of water harvesting irrigation development in minimizing migration in search of temporary job is insignificant.

5.9.8 Water harvesting impact on farmers' livestock holding

Livestock and livestock products are obviously very important sources of livelihood since a mixed crop-livestock system is the economic base in all study areas. Livestock are closely integrated with the range of purposes such as direct production, draft power, transport, and manure production to sustain soil fertility and as a store of wealth. The relationship between water harvesting micro irrigation and livestock production is investigated only at a very superficial level. To assess this the researcher hypothesized that the average livestock holding per household in the study areas would increase in conjunction with increased access to household level water harvesting schemes. This is due to the fact that access to livestock feed and watering affects the production and productivity of the livestock sector. The increase in household revenue from increased crop production as a result of the introduction of the water harvesting would help beneficiaries to invest their income in livestock to protect their livelihoods and as a buffer against risk from external shocks.

Considering the above expectation, the household survey data revealed that about 9 percent of the "shallow well users" respondents said that they had purchased livestock such as ox, donkey, goat/sheep, or cow after using irrigation while only 5.76 and 5.86 percent of the pond beneficiaries and "rain fed users or control group" respondents respectively said they bought livestock in the last one year (Table 18).

Table 18: Percentage of sample households purchased livestock during 2006

Type of respondents	Percentage of respondents who purchased livestock			
	Oxen	Cow	Sheep	Goat
Shallow well	9.01	2.73	7.27	1.82
Pond	5.76	4.76	4.77	9.52
Non users of SW or pond	5.86	1.63	3.58	4.23

Source: Household survey

In line with the above assumption, the assessments showed that the current percentage of households livestock holding indicates that users of the water harvesting have a slight improvement in ownership of livestock number over non users of water harvesting, and those reporting an increase in livestock numbers attributed this to increased household cash income, availability of fodder crops and crop residues used as animal feed.

Table 19: Trends in proportion of sample household livestock holding

Type Animal	Percentage of respondents keeping livestock since irrigation change		
	Shallow well	Pond	Rain fed
Oxen	21.0	31.7	19.0
Cow	47.6	47.6	33.6
Bull	76.5	78.0	72.5
Goat	87.0	84.0	85.3
Sheep	80.1	76.0	79.0
Donkey	68.0	89.0	79.8

Source: Household survey

The insignificant difference on the livestock holding among users and non users of the irrigation with regard to livestock holding suggests two related facts: the first is that livestock production is little integrated into the design and implementation of household level water harvesting. As a result, the livestock sub-sector may benefit little from current water harvesting micro irrigation typology. The second implies that the overall increase in household revenue from increased crop production as a result of the introduction of the water harvesting, did not help the beneficiaries of the water harvesting program to invest in livestock production. With regard to the impact on increase of income from animal production, it was not reported in both categories.

5.9.9 Effects on drinking water for animals

An attempt was made to investigate whether pond, underground tankers and shallow well water harvesting have affected sources of drinking water for livestock. In all study areas participants of the group discussion reported that, as a result of the developed shallow well ponds and underground tankers, time required for livestock watering is apparently reduced. Prior to the water harvesting construction, herders used to travel quite long distances to fetch water. Today, they get drinking water for livestock in their backyard. In Alamata and Kobo, beneficiaries reported that their livestock are drinking water from their shallow wells and underground tanker instead of going to far rivers. In this sense it can be argued that, today, livestock are likely to drink more water per day of better quality than in the past. In this light, animals get drinking water at no additional cost to society or the households.

However, there has been no special provision made for animals in the design of water harvesting structure. According to the results of the focus group discussions, in Alamata and Kobo study areas where water is relatively in short supply, farmers argue that milk yields could increase if cows get more drinking water on a regular basis. In Alamata and Kobo study areas, water shortage is reported as one of the main constraints to milk production. However, participants of the group discussion indicated that milk production is apparently high for users of well irrigation. Perhaps, access to water from the well has contributed to increased milk yields.

5.9.10 Effects on animal feed

In all the study Woredas there is a severe feed shortage especially during the dry season. According to results of focus group discussions, although there is few observable evidence the introduced micro water harvesting have no significant effects on animal feed.

In some of the study areas some available evidence shows that although the increment animal feed is not significant, the production of crop residues from vegetables has nevertheless increased since the introduction of the water harvesting. For instance, in the Kobo study area, in particular the leftovers of onion (i.e. the stalks and leaves) are extensively used as animal feeds. Members of focus group discussions reported that milk yield has increased as a result of increased use of residues from onions. However, they noted that cows feeding on such residues produce milk having an unpleasant odour. Some farmers reported that they were reluctant to use onion residue for feeding cows.

Generally, it appears that household water harvesting development has not led to the intensification of livestock production, since the crops produced under this micro irrigation are mainly vegetables which do not have more left over or residue like other cereal crops for livestock feed.

5.9.11 Impact on household assets holding

In order to get more insight into the effect of irrigation on the actual living conditions of households, respondents were asked to estimate changes in household assets. From table 20, we can see that the household physical assets ownership such as radio, wood or iron framed bed and fuel efficient stoves among the users of the shallow well were found to be about 28%, 25% and 6.5%, respectively. While for pond users the proportion was 24% for radio, 22% for bed and 7.2% for stove. Compared to the pond users and non users water harvesting, a physical assets holding of the shallow well owners is slightly improved. However, this difference was found to be statistically insignificant at a 5 percent probability level.

Table 20: Proportion of households owning fixed assets

Type of asset	Proportion of households who own the asset		
	Shallow well owners	Pond owners	Non users of pond and well
Radio	28.18	23.81	23.38
Bed	25.45	22.22	18.83
Stove	6.55	7.22	7.94

Source: Household survey

The conclusion that can be drawn from the table above is that shallow wells have a promising impact on the accumulation of wealth by the participants. However, there is no significant difference between pond and non pond users.

5.9.12 Impact on average household diet diversity

To compare average household diet diversity among water harvesting users and non users, the number of different food components consumed was asked to the sampled households using a 24 hours recall period and non-time bound equations about the food they consumed. A household dietary diversity score was estimated by summing the food groups consumed by all households in each category divided by the number of interviewed households from each category (i.e. pond users, well users and non users of water harvesting).

Accordingly, the survey revealed that the overall average dietary diversity score was found to be 7 for shallow well users, 4.08 for pond users and 3.98 for non users of ponds or wells. This means that, on average a household using shallow water had consumed about four to six different food components compared to non users. This revelled that more farmers of the study areas who own hand dug wells have reported that they are eating more vegetables and fruit (papaya) from their production than in the period before they own well. On the other hand, the study showed that there is no difference in diet diversity among pond users and non users of water harvesting ponds/wells

Over 70 percent of the farmers interviewed using shallow well irrigation reported that they have the opportunity to consume vegetables every two weeks. Clearly, these changes must be closely associated with the direct benefits of water harvesting irrigation for farming households.

5.9.13 Gender dimension of the water harvesting

To assess the effect of water harvesting irrigation on gender, focused group discussions with women were conducted at each study areas. The summarized results of the discussion are briefly presented below.

In the field survey it became clear that it is often women and children who participate in the production of vegetables and other crops using water harvesting shallow wells and ponds. In all the study areas the researcher also observed that household water harvesting, mainly shallow wells, offers an opportunity for women to make a living and feed their family with only a small area of land and with more security and less labour than rainfed agriculture. The introduction of household level micro irrigation also appears to have changed labour relationships within households; female family labour is increasingly used in the well and pond water harvesting farming, especially among the shallow well users. This to some extent increases their workload. For many women the water harvesting development has created good opportunities for income generation such as vegetable production close to their backyards.

The findings of this study show that the water harvesting has a remarkable impact on women through the promotion of women's vegetable gardens. This is an area of real and demonstrable importance to family life, nutrition, and women's empowerment. It also creates opportunities for women to learn new skills. In all study areas women participants of the group discussions expressed unanimously the advantage of well irrigation by saying that it helped them for backyard horticultural production as well as a source of feed and drinking water for their livestock. They further explained that well micro irrigation provides additional fresh grass and weeds that grow around the fields and that these have become a feed source for livestock. Women have expressed their appreciation of the shallow well irrigation by saying that they managed to send their children to school, and can easily get health services with the income from the backyard grown vegetables.

Figure 10: A typical pond and a pond user from kelte Aelelo woreda harvesting pepper from her plot

Photo: REST Public Relation Unit

In all the study areas caring for livestock is the task of both women and men. The focused group participants reported that caring for livestock by women has become easier, as water harvesting ponds and wells increase water availability for drinking for the livestock in the dry season near the backyard of the household.

The focused group participants also reported that as a result of the water harvesting wells and ponds an overall increase in quantity and availability of water for domestic purposes such as bathing, washing clothes, cleaning utensils (pots and pans, etc.) has been observed.

5.9.14 Strengths, weaknesses, opportunities and threats (SWOT) analysis of water harvesting irrigation

Strengths	Opportunities
• Being owned and managed at household level would be good for sustainability and replicability. • Water harvesting is a base for all development sectors (agriculture, health & hygiene, gender, etc.), the "cement" of development. • Provide some evidence that there is a possibility for cash crop production in the dry season, income diversification, and asset building • Women's backyard gardens have been developed, this has had a very significant impact on the women and families who have directly benefited from it • Provide water at household level • There is a strong willingness to learn, and modify the approach of implementation particularly to find ways to solve these problems • Skill improvement and know-how among the beneficiaries • Increased source of household food and income diversification • Increased access for women to cash income • Low cost and less capital intensive intervention approach • Knowledge is transmitted to the communities (transfer of knowledge – local capacity building); • Construction of ponds is considered as a good opportunity for underground water recharge, • Farmers start producing perennial crops	• Intensify government replicability of household level water harvesting in order to reach out to more people and to expand experiences in all regions • Diversification into more paying livestock husbandry • Make use of local materials and technology • Existence of marketing cooperatives • Use the community for social transformation, fighting crop failure • Make household shallow wells more attractive to the community; provide them with more benefits • Explore and exploit better the collaboration with other stakeholders particularly with cooperatives and NGOs who are involved in water harvesting and marketing activities • Set explicit rules with the communities (by-laws) and policy on constructing hand dug wells • Establish a community institution who can monitor underground water harvesting and utilization so that it is done in a sustainable way
Weaknesses	**Threats**
• Weakness in the implementation approach, follow uniform approach • Beneficiary participation in the study and design process is inadequate to develop a sense of ownership in the process and influence design • Weak coordination between the different government stakeholders is openly	• Micro catchment conflicts can occur due to competition for runoff produced from the limited nearby catchment areas • Competition could increase for use of limited

recognized at all levels as a major weakness in the implementation • There has been too little sharing of institutional knowledge. This applies at three levels, (1) between regions, (2) between Woredas, and (3) between users. This limits the spread of good practices from the best performing regions, Woredas, persons to others • Provision of post construction technical support and follow up is low • Lack of fence/limited safety measures lead to the death of human beings and livestock • Weakness in the design and site selection leads to high water loss • Since ponds and wells are built close to the household residential quarters, many beneficiaries reported it as becoming breeding areas for malaria causing mosquitoes • Many ponds are not fenced and as a result, human and animal deaths have occurred • Weak linkages with formal extension, and marketing services; • Shortage of supply of implements and input packaging • High price of inputs (e.g. fertilizer) • Farmer's experience of markets was found to vary considerably with some farmers selling to traders from Mekelle, and others throwing away their produce due to oversupply	underground and runoff, which could lead to ground water depletion • The issues of competition, and in some cases conflict among users of hand dug wells is a major concern in the future • Lack of legal framework for water extraction and utilization • High water loss due to evaporation, seepage, and misuse of water are also serious challenges • Physical access to the market is challenging • Purchasing capacity of the rural population in the study area is extremely limited • High transaction costs limit the possibilities for sending products to major market areas • Lack of resources and budget constraints • The issue of sustainability is not addressed • Loss of agricultural land due to poor pond structural design

6. CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The following conclusion can be drawn from the site visits, household interviews and discussions held with user communities and key stakeholders.

Currently, the government of Ethiopia has adopted the household level water harvesting ponds, shallow and deep well development as one strategy of the country's irrigation development in order to alleviate the problem of food security and enhance the overall growth of the rural economy. This is clearly stated in the policy document of Agricultural Development Led Industrialization (ADLI), by saying that in drought-prone areas, agricultural production, among others, can be increased through the development of water harvesting irrigation by providing the necessary farm inputs, credit facilities and extension services.

From this study the researcher found in many visited study areas that shallow well water harvesting has been used for many purposes as backyard horticultural gardening, water for drinking for humans and livestock, as well as for household domestic use.

One of the important benefits brought as a result of improved access to water is increased diversity of the crop types grown by the households. The assessment results indicate that as compared to pond users the diversity of crops grown by households having wells was improved to some extent. In nearly 27 percent of the cases, households owning ponds have two or more crops on their plots while about 69 percent of all households owning wells have more than two crops on their plots. Furthermore, 31 percent of the respondents using shallow wells responded that they are using all their labour efficiently all throughout the irrigation season, which otherwise the labour could have been wasted during the lack season. With regards to the average fertilizer use the study showed that there is no significant difference among households having water harvesting ponds or wells and those having none.

The study revealed that most of the constructed shallow wells have the potential to improve and diversify household food security and income in the future if some of the gaps are addressed. This is likely to have a significant impact on the lives of women in terms of access to income and better nutrition opportunities for the families. Being owned and managed at household level gives an opportunity for higher replicability, more efficient water use and prolonged lifespan of the system.

The study shows that households with wells have a relatively better position than households with ponds and without ponds and wells in terms of per capita annual food expenditure, per capita total consumption expenditure and number of food self sufficiency months,

On the other hand, the study indicated that only a few have used the pond water harvesting successfully, otherwise the majority of pond irrigation users were relatively unsuccessful. The study revealed that there is no significant difference between pond users and non users of water harvesting in terms of indicators like household number of months food self sufficiency, productive assets holding, consumption expenditure per capita, effect on family and hired labour employment generation. Many constructed ponds are in poor working conditions for the reason that it is not properly designed and constructed. According to key informants, the main contributing factor for this was that at the beginning of the program implementation there was low technical capacity, particularly in design and construction capacity at site levels. Seepage is the main problem in pond water harvesting.

Many farmers were lacking enthusiasm for the use of ponds to alleviate the moisture stress problem that the main crops are facing soon after the cease of the rainfall. The lack of enthusiasm was expressed in various ways: unwillingness to take plastic lining on a credit basis, which came from the perception that the benefit that they would possibly collect from the scheme does not enable them to repay the loan; many did not believe that the harvested water would be used for supplementary irrigation of their cereal crop; and lack of effort to made their pond holding the maximum possible water by effectively utilizing the catchments and repairing the damaged ponds. Such scepticism and poor performance was observed in all study areas. This does not mean that the pond water harvesting is not technically sound for supplementary or dry season irrigation, since there are instances of a few farmers who are effectively using the pond water harvesting both for supplementary and horticultural production. This success has mainly been achieved where the ponds were constructed in a proper way, had a sufficient micro catchment area to feed water to the pond, and the construction location was close to backyards of the farmers' houses.

One of the key elements of the water harvesting program is that it has enabled the farmers to develop commercial mentality; however, linking farmers in remote areas to markets which can absorb their production is very challenging. Difficulties of physical access, lack of market information and the overall small absorption capacity/size of the market are major hindrances to the achievement of the goal of beneficiaries from the water harvesting.

The researcher also observed high competition among farmers in digging wells (mainly in Abreha Atsbie study areas), and there was no written guideline on how much the distance had to be between the two wells. In areas where ground water is extensively exploited like Abreha Atsbeha kebelle, there are indications of high exploitation of the ground water. This could pose a serious threat for the sustainability of the hand dug wells resulting from unbalanced discharge and recharge rate unless measures are introduced to regulate harvesting of ground water. This highlights the importance of performing an extensive assessment on the water potential of the perched aquifer so that it is possible to quantify the amount that should be exploited every year. This helps for proper planning and management of the program so as to ensure its sustainability. The rate of infiltration is the source that replenishes the ground water and can be increased by treating the catchments area with natural and physical means and by constructing simple water retention structures like ditches. Treating the catchments area or repairing the physical structures already built requires the mobilization of not only the beneficiaries of the water harvesting scheme, but of the whole community, which may require significant resources. Integrated watershed management may offer a sustainable solution to the problem.

Although the country has adopted a Water Resources Management Policy and Strategy including water law to facilitate implementation, there is currently no effective agency that is undertaking the monitoring of expanding underground irrigation water use in all study areas. In view of limited water resources and fragile environmental conditions in the area which has ground water, coupled with the absence of an effective regulatory body, the impact of the underground water irrigation development in the study areas could in the long run be far reaching and a challenge for the sustainable management of the ground water.

Markets also pose a serious problem and may undermine the opportunities offered by water harvesting. This calls also for investments to improve market access and minimize post harvest loss through improved access to storage facilities and value-adding small scale processing plants. Identifying other market outlets is also another intervention area worth exploring.

Coordination among offices of Water Resources, Mines and Energy, office of Agriculture and Rural Development, and Office of Health at field level with regards to the water harvesting planning, implementation and monitoring was weak.

6.2 RECOMMENDATIONS

The following is a summary of the recommendations that have come out of the study.

- A bottom-up approach is ideal for household level water harvesting irrigation development that is treating farmers as "owners" and not as "beneficiaries". Consequently, farmers should participate in all processes i.e. in site selection, implementation and monitoring phases. Furthermore, the existence of strong coordination of all relevant institutions involved in household level water harvesting irrigation development is important during the planning and implementation phases. These development actors should coordinate their efforts to serve the community better and on a sustainable basis.

- Different water harvesting solutions should be available to the community that can be applied under different agro ecological, geological and social conduction.

- The study revealed that in areas which have sufficient groundwater, shallow well water harvesting is found to be an effective way of spreading benefits among wider target groups and have the potential to improve and diversify household food security and income in the future if some of the gaps are addressed.

- Pond water harvesting is appropriate in areas which have sufficient micro catchments rainfall runoff and construction materials although the experience in the region was a blanket approach that demands many farmers to construct a pond even without having any interest to do so. This has led many community members of the study area to have a wrong outlook towards pond water harvesting indicating the need for alternative water harvesting schemes in areas where ponds are not technically feasible.

- Given that water is the most limiting factor in smallholder irrigation development in Ethiopia, pond and well users need considerable energy to lift water from the water scheme. The high labour required for lifting water is one challenging issue for effective utilization of the water from ponds and wells. The current level of water utilization efficiency should thus also be promoted through the expanding usage of low cost water saving and lifting irrigation technology. In this regard, farmers should be encouraged to make the change by sharing the cost of the water saving and lifting technologies. Furthermore, strengthening of the local manufacturers to produce more efficient and affordable water lifting and saving technologies is also of paramount importance for future success of the household level water harvesting program.

- Many ponds are in poor working conditions since they are not properly designed and constructed. The implementation of pond water harvesting schemes needs to be revisited.

- Training in water management, general crop production and marketing are important for all the water harvesting beneficiaries.

- In all study areas there is competition over limited underground water resources. If it is to continue like this there is anticipated fear of exceeding the carrying capacity of the ground water potential due to over-use of wells. In order to regularize sustainable ground water use, a mixture of measures is required. The main measures are described below:

    - At village level there is an urgent need to formalize the importance of regularizing water extraction/ use permits (both from underground water and micro catchments water harvesting). Therefore, a directive should be issued to all woredas to

institutionalize the water permit prior to the start of construction of shallow wells or ponds. So it is necessary to establish the relevant institutions and operational mechanisms, such as building functional water permit system for ground water exploitation by farmers.
- To control excess groundwater withdrawal it is important to set up a groundwater monitoring system at woreda or village level.

- While the availability of irrigation water through wells enables farmers to increase their productivity, grow high value crops and use improved technologies, the market situation plays a critical role in enabling farmers to exploit those market-led opportunities. Hence, to realize the full potential of these interventions the following intervention areas need to be given priority:
  - Improve market information channels and coverage to improve market access for farmers;
  - Improve supply of seeds and seedlings at right prices and affordable packages;
  - Provide training to extension agents on marketing.

- Continuous monitoring of the constructed irrigation structure is necessary to provide feedback information that helps in the planning, implementation and management of future schemes.

7. REFERENCES

BOFED, 2007. Tigray Regional Government Five Year Plan(2007-2011), Meklle, Ethiopia

BoWaRD. 2003. Annual Operational plan of BoWaRD 2003, Mekelle, Ethiopia

Cohen, J. and Isaksson. N. 1988. Food production strategy debates in. revolutionary Ethiopia. World Development, 16 3 323–348.

Commission of Sustainable Agriculture and Environmental Rehabilitation in Tigray-CoSAERT (2002). Annual Report of 2001, Mekelle, Ethiopia.

Cowater International Inc. 2003. Water Harvesting Techniques and their Application in the Regional State of Tigray, Ethiopia.

MoFaED. 2000. Food Production and Availability in Ethiopia, MoFaED, Addis Abeba, Ethiopia.

FDRE. 2002a. Ethiopia Food Security Strategy. Addis Ababa, Ethiopia.

FDRE. 2002b. Ethiopia: Sustainable Development and Poverty Reduction Program (SDPRP). Ministry of Finance and Economic Development. Addis Ababa. Ethiopia.

Federal Food Security Bureau. 2004. Productive Safety net Program Implementation Manual, Addis Ababa, Ethiopia.

Gebremedhin, B., Pender, J., Simeon, E. and Mitiku, H. 2003. Policies for Sustainable Land Management in the Highlands of Tigray, Northern Ethiopia. Summary of papers and proceedings of a workshop held at the Axum Hotel, Mekelle, Ethiopia.

Helmut, K. 1990. Peasant irrigation development and food production in Ethiopia. Department of Geography, Addis Ababa University.

J. M. Cohen, N. I. Isaksson.1998. Food Production Strategy Debates in Revolutionary Ethiopia. *Journal of the International African Institute*, Vol. 58, No. 3 (1988), pp. 364-369.

MoFaED. 1999. Poverty Situation in Ethiopia. Welfare Monitoring Unit. Addis Ababa

MoFaED.2000. Ethiopia: Sustainable Development and Poverty Reduction Program, Addis-Ababa.

Pender, J., P. Jagger, Gebremedhin, B. and Mitiku, H.2002. Agricultural Change and Land Management in the Highlands of Tigray: Causes and Implications, A paper presented at the seminar on 'Policies for Sustainable Land Management in the Highlands of Tigray', March 28-29, 2002, Mekelle University, Tigray, Ethiopia.

SAERA and Consulting Enterprise P.L.C.2003. Amhare National Regional State, Feasibility study Report for the kobo-Girna Valley Development Program, volume ii, Main Report. Ethiopia

UNDP Human Development Index Report, 2005.hhttp://hdr.undp.org/reports/global/2005/pdf/HDR05-HDI.pdf

World Bank, Voices of the Poor, a Study in three volumes commissioned by the World Bank, OUP, 2000.

8. ANNEX

ANNEX 1: KEY INFORMANTS

G/medhin Gebre	Kilte Awlaelo Kebelle administration Chairperson, Kebelle
Muruts W/brihan	Kilte Awlaelo, Kebelle administration Member
Kidan Girmay	Kilte Awlaelo, Kebelle administration Member
Husian Mehamed	Kobo Woreda Extension officer
Tesfay Hailu	Kobo Girna Vally development
Aylanuw	KOBO Woreda, 08 Kebelle Extension Agent
Tesfu	KOBO Woreda, 08 Kebelle Extension Agent
Nugus	KOBO Woreda, 03 Kebelle Extension Agent
Fantu	KOBO Woreda, 08 Kebelle Extension Agent
Tesfay Mesele	Extension Team leader of Alamata Woreda
Shumay Haile	Extension agent Atakilit Kebelle
Negistic Yetabrek	Extension agent Atakilit Kebelle
Kashum	Extension agent of Selam Bekalse Kebelle

List of Publications

Reports:

1 A. Synnevåg, G., Halassy, S. 1998: "Etude des indicateurs de la sécurité alimentaire dans deux sites de la zone d'intervention de l'AEN-Mali: Bambara Maodé et Ndaki (Gourma Malien)", Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

1 B. Synnevåg, G. and Halassy, S. 1998: "Food Security Indicators in Two Sites of Norwegian Church Aid's Intervention Zone in Mali: Bambara Maoudé and N'Daki (Malian Gourma)", Drylands Coordination Group and Noragric, Agricultural University of Norway.

2 A. Aune, J.B. and Doumbia, M.D. 1998: "Integrated Plant Nutrient Management (IPNM), Case studies of two projects in Mali: CARE Macina programme and PIDEB", Drylands Coordination Group and Noragric, Agricultural University of Norway.

2 B. Aune, J.B. et Doumbia, M.D. 1998: "Gestion Intégrée de Nutriments Végétaux (GINV), Etude de Cas de deux projets au Mali: Programme de CARE Macina et PIDEB", Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

3 A. Berge, G., Larsen, K., Rye, S., Dembele, S.M. and Hassan, M. 1999: "Synthesis report and Four Case Studies on Gender Issues and Development of an Improved Focus on Women in Natural Resource Management and Agricultural Projects", Drylands Coordination Group and Noragric, Agricultural University of Norway.

3 B. Berge, G., Larsen, K., Rye, S., Dembele, S.M. et Hassan, M. 1999. "Rapport de synthèse et quatre études de cas sur Les Questions de Genre et Développement d'une Approche Améliorée concernant les Femmes et les Projets d'Agriculture et de Gestion des Ressources Naturelles", Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

4 A. Sydness, M., Ba, B. 1999: "Processus de décentralisation, développement institutionnel et réorganisation des ONG financées par la Norvège au Mali", Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

4 B. Sydness, M. and Ba, B. 1999: "Decentralization Process, Institution Development and Phasing out of the Norwegian Involvement in Mali", Drylands Coordination Group and Noragric, Agricultural University of Norway.

5. Waktola, A. and Michael, D.G. 1999: "Institutional Development and Phasing Out of the Norwegian Involvement, the Case of Awash Conservation and Development Project, Ethiopia", Drylands Coordination Group and Noragric, Agricultural University of Norway.

6. Waktola, A. 1999: "Exploratory Study of Two Regions in Ethiopia: Identification of Target Areas and partners for Intervention", Drylands Coordination Group and Noragric, Agricultural University of Norway.

7. Mossige, A. 2000: "Workshop on Gender and Rural Development – Training Manual", Drylands Coordination Group and Noragric, Agricultural University of Norway.

8. Synnevåg, G. et Halassy, S. 2000: "Sécurité Semencière: Etude de la gestion et de l'approvisionnement en semences dans deux villages du cercle de Ké-Macina au Mali: Kélle et Tangana", Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

9. Abesha, D., Waktola, A, Aune, J.B. 2000: ”Agricutural Extension in the Drylands of Ethiopia”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

10. Sydness, M., Doumbia, S. et Diakité K. 2000: ”Atelier sur la décentralisation au Mali”, Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

11. N'Dior, P. A. et Traoré, N. 2000: ”Etude sur les programmes d'épargne et de crédit au Mali”, Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

12. Lode, K. and G. Kassa. 2001: ”Proceedings from a Workshop on Conflict Resolution Organised by the Drylands Coordination Group (DCG), November 8-10, 2000 Nazareth, Ethiopia”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

13. Shiferaw, B. and A. Wolday, 2001: “Revisiting the Regulatory and Supervision Framework of the Micro-Finance Industry in Ethiopia”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

14 A. Doumbia, M. D., A. Berthé and J. B. Aune, 2001: “Integrated Plant Nutrition Management (IPNM): Practical Testing of Technologies with Farmers Groups”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

14 B. Doumbia, M. D., A. Berthé and J. B. Aune, 2001: “Gestion Intégrée de Nutriments Végétaux (GINV): Tests Pratiques de Technologies avec des Groupes de Paysans”, Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

15. Larsen, K. and M. Hassan, 2001: “Perceptions of Knowledge and Coping Strategies in Nomadic Communities – The case of the Hawawir in Northern Sudan”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

16 A. Mossige, A., Berkele, Y. & Maiga, S., 2001: “Participation of Civil Society in the national Action Programs of the United Nation's Convention to Combat Desertification: Synthesis of an Assessment in Ethiopia and Mali”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

16 B. Mossige, A., Berkele, Y. & Maiga, S., 2001: “La Participation de la Société Civile aux Programme d'Actions Nationaux de la Convention des Nations Unies sur la lutte contre la Désertification”, Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

17. Kebebew, F., D. Tsegaye and G. Synnevåg., 2001: “Traditional Coping Strategies of the Afar and Borana Pastoralists in Response to Drought”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

18. Shanmugaratnam, N., D. Mamer and M. R. Kenyi, 2002: “From Emergency Relief to Local Development and Civil Society Building: Experiences from the Norwegian Peoples' Aid's Interventions in Southern Sudan”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

19. Mitiku, H. and S. N. Merga, 2002. “Workshop on the Experience of Water Harvesting in the Drylands of Ethiopia: Principles and practices”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

20. Tesfai, M., V. Dawod and K. Abreha, 2002. “Management of Salt-affected Soils in the NCEW 'Shemshemia' Irrigation Scheme in the Upper Gash Valley of Eritrea”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

21. Doumbia, M. D., A. Berthé and J. B. Aune, 2002: “Gestion Intégrée de Nutriments Végétaux (GINV): Tests Pratiques de Technologies avec des Groupes de Paysans- Rapport de la Campagne 2001”, Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

22. Haidara, Y., Dembele, M. et Bacha, A. “Formation sur la lutte contre la désertification atelier organisé par groupe de coordination des zones arides (GCoZA) du 07 au 10 octobre 2002 à Gossi (Mali)”, Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

23. Aune, J. B. 2003. “Desertification control, rural development and reduced CO_2 emissions through the Clean Development Mechanism of the Kyoto Protocol - an impasse or a way forward?” Drylands Coordination Group and Noragric, Agricultural University of Norway.

24. Larsen, K. and Hassan, M. 2003. “Sedentarisation of Nomadic People: The Case of the Hawawir in Um Jawasir, Northern Sudan”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

25. Cissé, I. et Keita, M.S. 2003. “Etude d’impacts socio-économique et environnemental des plaines aménagées pour riziculture au Mali.” Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

26. Berkele, Y. and Mossige, A. 2003. “Indicators to Promote Civil Society’s (NGOs and CBOs) Participation in the implementation of Ethiopia’s National and Regional Action Programs of the United Nations Convention to Combat Desertification. A guideline Document”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

26B. Berkele, Y. and Mossige, A. 2003. “Indicateurs visant à promouvoir la participation de la société civile (ONG et OCB) à la mise en oeuvre en Ethiopie des Programmes d’action national et régionaux de la Convention des Nations Unies sur la lutte contre la désertification”. Drylands Coordination Group and Noragric, Agricultural University of Norway.

27. Assefa, F., Dawd, M. and Abesha, A. D. 2003. “Implementation Aspects of Integrated Pest Management (IPM): Policy and Extension Gap in Ethiopia”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

28. Haile, A., Selassie, D.G., Zereyacob, B. and Abraham, B. 2003, “On-Farm Storage Studies in Eritrea”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

29. Doumbia, M.D., Berthé, A., Aune, J.B. 2003, “Gestion Intégrée de Nutriments Végétaux (GINV): Tests Pratiques et Vulgarisation de Technologies”, Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

30. Mossige, A. and M. Macina 2004, “Indicateurs visant à promouvoir et suivre la participation de la Société Civile (ONG et OCB) dans la mise en œuvre des Programmes d’Action National, Régional et Communal de la Convention des Nations Unies sur la lutte contre la désertification”, Groupe de Coordination des Zones Arides et Noragric, Agricultural University of Norway.

31. Tesfay, Y. and Tafere, K. 2004. “Indigenous Rangeland resources and Conflict Management by the North Afar Pastoral Groups in Ethiopia. A Pastoral Forum Organized by the Drylands Coordination Group (DCG) in Ethiopia, June 27-28, 2003, Mekelle, Ethiopia”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

32. Kebede, D. and Retta, S. 2004. “Gender, HIV/AIDS and Food Security, Linkage and Integration into Development Interventions”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

33. Kidane, A., Araia, W., Ghebremichael, Z, and Gobezay, G. 2004. “Survey on striga and crop husbandry practices in relation to striga management and control of sorghum (Sorghum bicholor) in the Goluge sub zone: Lessons to be learned and creating awareness”, Drylands Coordination Group and Noragric, Agricultural University of Norway.

34. Kibreab, G., Berhane, T., and Ghezae, E. 2004. "A Study to Determine the Extent and Use of Environmental Impact Assessment of Agricultural Development Projects – A Case Study from Eritrea", Drylands Coordination Group and Noragric, Agricultural University of Norway.

35. Meehan, F. 2004. "Female Headed Household in Tigray, Ethiopia. A Study Review". Drylands Coordination Group and Noragric, Agricultural University of Norway.

36. Doumbia, M. Berthe, A., Aune, J. B. 2005. "Integrated Plant Nutrient Management in Mali. Summary Report 1998-2004". Drylands Coordination Group, Miljøhuset G9, Norway.

37. Kaya, B., Traoré, C. O., Aune, J.B. 2005. "Etude d'identification des prototypes d'EcoFermes au Mali. Rapport diagnostic et plan d'action pour 2005". Groupe de Coordination des Zones Arides, Maison de l'Environnement G9, Norvège.

38. Nedessa, B., Ali, J., Nyborg, I. 2005. "Exploring Ecological and Socio-Economic Issues for the Improvement of Area Enclosure Management. A Case Study from Ethiopia". Drylands Coordination Group, Miljøhuset G9, Norway.

39. Makenzi, P. 2005. "Natural Resource Management in the Didinga Hills. A Baseline Study from Budy County, South Sudan". Drylands Coordination Group, Miljøhuset G9, Norway.

40. Ogbazghi, W., Bein, E. 2006. "Assessment of Non-Wood Forest Products and their Role in the Livelihoods of Rural Communities in the Gash-Barka Region, Eritrea". Drylands Coordination Group, Miljøhuset G9, Norway.

41. Kouyaté, S., Haidara, C. M. 2006. "Etude sur la Problématique des Périmètres Irrigués Villageois au Nord du Mali". Groupe de Coordination des Zones Arides, Miljøhuset G9, Norvège.

42. Haile, A. 2006. "On-Farm Storage of Chickpea, Sorghum, and Wheat in Eritrea". Drylands Coordination Group, Miljøhuset G9, Norway.

43. Ask, V. 2006. "UNCCD and Food Security for Pastoralists within a Human Rights Context". Drylands Coordination Group, Miljøhuset G9, Norway.

43B. Ask, V. 2006. « La CCD et la Sécurité Alimentaire des Pasteurs Dans le Contexte des Droits de l'Homme ». Drylands Coordination Group, Miljøhuset G9, Norway

44. Desta, M., Haddis, G., Ataklt, S. 2006. "Female-Headed Households and Livelihood Intervention in Four Selected Weredas in Tigray, Ethiopia.". Drylands Coordination Group, Miljøhuset G9, Norway.

45. Araia, W, Haile, A. 2006. "Baseline study on crop husbandry, *in-situ* conservation and informal seed supply system in Eritrea". Drylands Coordination Group, Miljøhuset G9, Norway.

46. Emana, B., Gebremedhin, H. 2007. "Constraints and Opportunities of Horticulture Production and Marketing in Eastern Ethiopia". Drylands Coordination Group, Miljøhuset G9, Norway.

47. Malifu, E., Tefera, H., and Mekiso, M. 2007. "Evaluation Report on Training of Trainers on UNCCD/NAP". Drylands Coordination Group, Miljøhuset G9, Norway.

48. Assefa, D., Belay, M., Tsegay, D., and Haile, M. 2007. "Transplanting Sorghum as a Means of Ensuring Food Security in Low Rainfall Sorghum Growing Areas of Northern Ethiopia". Drylands Coordination Group, Miljøhuset G9, Norway.

49. Tsegaye, D., Balehegn, M, Gebrehiwot, K.,.Haile, M., Samuel, G.,Tilahun, M., and Aynekulu, E. 2007. "The Role of Dobera glabra for Household Food Security at Times of Food Shortage in Aba`ala Wereda, North Afar: Ecological Adaptation and Socio-economic Value. A Study from Ethiopia". Drylands Coordination Group, Miljøhuset G9, Norway.

50. Teklehaimanot, G. and Haile, M. 2007. "Women in Backyards: Root Crop Production and Biodiversity Management in Backyards". Drylands Coordination Group, Miljøhuset G9, Norway.

51. Bengtsson, Frida. 2007. "Review of Information Available on Seed Security and Seed Aid Interventions in Ethiopia, Eritrea, Mali and Sudan". Drylands Coordination Group, Miljøhuset G9, Norway.

52. Tesfay, Haile. 2007. "Assessment of Institutional Setup and Effect of Household Level Water Harvesting in Ensuring Sustainable Livelihood. A Case study of Kobo, Almata and Kilte Awlaelo Woredas in Amhara and Tigray Regions of Ethiopia". Drylands Coordination Group, Miljøhuset G9, Norway.

Proceedings:

1. Drylands Coordination Group. 2000. Seminar on the Formation of DCG Ethiopia-Sudan. Proceedings from a Seminar organised by the Drylands Coordination Group in Nazareth, Ethiopia, April 10-12, 2000. DCG/Noragric, Agricultural University of Norway, Ås.

2. Drylands Coordination Group. 2001. Seminar on the Formation of DCG Eritrea. Proceedings from a Seminar Hosted by the National Confederation of Eritrean Workers (NCEW) in Asmara, Eritrea, March 26th-28th, 2001. DCG/Noragric, Agricultural University of Norway, Ås.

3. Amha, W. 2001. Revisiting the Regulatory and Supervision Framework of the Microfinance Industry in Ethiopia. Proceedings from a Seminar Organised by the Relief Society of Tigray (REST), on behalf of the Drylands Coordination Group in Ethiopia and Sudan, In Mekelle, August 25, 2001. DCG/Noragric, Agricultural University of Norway, Ås.

4. Mossige, A. and Berkele, Y. 2001. Civil Society's Participation in the National Action Program to Combat Desertification and Mitigate the Effects of Drought in Ethiopia. Proceedings from a Workshop organised by the Drylands Coordination Group (DCG) in Ethiopia, Debre Zeit, September 13-14, 2001. DCG/Noragric, Agricultural University of Norway, Ås.

5. Maiga, S. et Mossige, A. 2001. Participation de la Société Civile dans la Mise en Oeuvre Programme d'action pour la Convention Sur la Désertification (CCD) au Mali. L'atelier Organise par le Groupe Coordination sur les Zones Arides (GCOZA) Au Centre Aoua Keita, Bamako, Les 5 et 6 novembre 2001. GCOZA/Noragric, Agricultural University of Norway, Ås.

6. Drylands Coordination Group. 2002. Do conventions need civil society? A critical review of the role of civil society in the implementation of international conventions. Proceeding from a Seminar Arranged by the Drylands Coordination Group and Forum for Development and Environment (ForUM) in Oslo, January 15th, 2002. DCG/Noragric, Agricultural University of Norway, Ås.

7. Berkele, Y. 2002. Workshop on training of trainers in UNCCD/NAP implementation in Ethiopia. Proceedings from a workshop arranged by the Drylands Coordination Group in Ethiopia, Nazareth, June 10-15, 2002, DCG/Noragric, Agricultural University of Norway, Ås.

8. Drylands Coordination Group. 2002. Sustainable livelihoods of farmers and pastoralists in Eritrea. Proceedings from a workshop organised by DCG Eritrea in National Confederation of Eritrean Workers Conference Hall, Asmara, November 28 –29, 2002. DCG/Noragric, Agricultural University Of Norway, Ås.

9. Drylands Coordination Group. 2003. DCG networking seminar 2002, 15th-22nd November 2002, Khartoum, Sudan. DCG/Noragric, Agricultural University of Norway, Ås.

10. Soumana, D. 2003. Atelier d'information, d'échange et de réflexion sur l'élargissement du Groupe de Coordination des Zones Arides (GCoZA) au Mali, Au Centre Aoua Keita, Bamako, Les 18 et 19 février 2003. DCG/Noragric, Agricultural University of Norway, Ås.

11. Ati, H. A.and Nimir A. A. H. 2004. Training Course On The Role Of Local Institutions In Regulating Resource Use and Conflict Management, Um Jawaseer, June 2003. DCG/Noragric, Agricultural University of Norway, Ås.

12. Berkele, Y. and Ayalew, B. 2004. Training of Trainers in Implementation of UNCCD/NAP in Ethiopia. Third Round, 10-14 Nov. 2003. DCG/Noragric, Agricultural University of Norway, Ås.

13. Macina, M. 2004. Atelier National et Campagne d'Information et de Sensibilisation sur la CCD. Un Atelier organisé par la Coordination des Associations et ONG Féminines au Mali (CAFO) en partenariat avec le Groupe de Coordination des Zones Arides (GCoZA). Les 29-30 novembre 2004 à Bamako, Mali. DCG/Noragric, Agricultural University of Norway, Ås.

14. Musnad, H.A. and Nasr N. K. 2004. Experience Sharing Tour and Workshop on Shelterbelts and Fuel Wood Substitutes in Sudan. DCG/Noragric, Agricultural University of Norway, Ås.

15. Gakou, M. 2005. Atelier d'information et de formation des ONG membres de GCoZA sur le montage des projets/ synergie entre les conventions de la génération de Rio et de la convention de Ramsar. Le 28 décembre 2004, à Bamako, Mali. GCoZA, Oslo.

16. Berkele, Y., Mossige, Anne. 2005. Awareness Promotion and Experience Sharing on the Implementation of UNCCD-NAP to Enhance Pastoralist Areas Development. Workshop organized by the Drylands Coordination Group Ethiopia for the Pastoral Affairs Standing Committee and the Natural Resource Development and Environmental Protection Standing Committee, Members of Parliament - Ethiopia. December 17-19, 2004 in Nazareth, Ethiopia. DCG, Miljøhuset, Oslo.

17. Esheteu Bekele, E., Azerefegne, F., and Abate, T. 2006. Facilitating the Implementation and Adoption of Integrated Pest Management (IPM) in Ethiopia. Planning Workshop, 13-15 October 2003, Melkassa Agricultural Research Center, EARO. Jointly organized by the Association for Advancement of IPM (ASAI) and the Ethiopian Agricultural Research Organization (EARO). DCG, Miljøhuset, Oslo.

18. Kodio, A. 2006. Atelier de Formation des Membres du GCoZA Mali à l'Approche Epargne Crédit Musow ka Jigiya Ton (MJT) au Mali. Atelier organisé par CARE Mali et le GCoZA Mali du 1er au 5 août 2005 au Centre Gabriel Cissé de Ségou au Mali. DCG, Miljøhuset, Oslo.

19. Belal, A. A. and Hussein, F. S. 2006. Awareness Raising Workshop on the Implementation of the United Nations Convention to Combat Desertification. Workshop organized by DCG Sudan for the Parliamentarians and other Stakeholders. December 28th and 29th 2005 in the Green Hall of Sudan's Parliament, Omdurman, Sudan. DCG, Miljøhuset, Oslo.

20. Dembelé, T., Berthé, A. et Yattara, M. 2006. Atelier de formation en matière du Guide Programme Communal d'Action Environnementale (PCAE) et des techniques Gestion Intégrée de Nutriments Végétaux (GINV). Atelier Organisé par GCOZA Mali et le Consortium Synergie –AMAPROS ACD pour les membres de GCOZA et des trois communes (Saloba, Souley et Sana). Du 20 au 22 juin 2005 à la Maison du Partenariat à Bamako, Mali. DCG, Miljøhuset, Oslo.

20B. Yattara, M. 2006. PCAE ani GINV baarakqfqqrqw dùnniyaw dqmqnan lajqkalan kùnùkow sqnsqnnen. Lajqkalan sigilen sen kan GCOZA Mali ani xùgùndqmqjqkulu AMAPROS ACD fq, ka xqsin GCOZA tùndenw ni Saloba, Suleyi ani Sana komini saba kùnùmùgùw ma. K'a ta san 2005 zuwqnkalo tile 20 ma, ka se a tile 22 ma Mali la, xùgùndqmqjqkuluw ka soba la Bamakù. DCG, Miljøhuset, Oslo.

21. Touré, B. 2007. Atelier de Renforcement des Capacités des Organisations de GCoZA Mali sur les Mécanismes de Financement des Projets et Programmes pour la Mise en Oeuvre de la Convention des Nations Unies sur la Lutte contre la Désertification (CCD). Atelier Organisé par la Coordination des Associations et ONG Féminines du Mali (CAFO) et GCoZA Mali pour les membres de GCoZA Mali. Du 11 au 13 septembre 2006 au Mémorial Modibo Keita à Bamako, Mali. DCG, Miljøhuset, Oslo.

22. Negassi, A. and Beyene, Y. 2007. Bridging the Gap Between Research, Extension and the Farmer in Eritrea. DCG, Miljøhuset, Oslo.

23. Anage, A. and Lulu, M. 2007. Awareness Raising Workshop on UNCCD/NAP and Experience Sharing Sessions on Drylands Development Issues in Ethiopia. Workshop organized for the Pastoral and Natural Resources and Environment Affairs Standing Committees of the Parliament of the Federal Democratic Republic of Ethiopia. December 8th -10th 2006, Adama Mekonen Hotel, Nazareth, Ethiopia. DCG, Miljøhuset, Oslo.

Drylands Coordination Group
TØRRLANDS-KOORDINERINGSGRUPPEN
GROUPE DE COORDINATION DES ZONES ARIDES

Drylands Coordination Group Addresses in Norway:

Secretariat of the Drylands Coordination Group
Grensen 9b, 0159 Oslo, Norway
Tel: +47 23 10 94 90, Fax: + 47 23 10 94 94
E-mail: dcg@drylands-group.org

ADRA Norge
Postboks 124, 3529 Røyse, Norway
Tel.: +47 32 16 16 90, Fax: +47 32 16 16 71
E-mail: 102555.2157@compuserve.com

CARE Norge
Universitetsgt. 12, 0164 Oslo, Norway
Tel: +47 22 20 39 30, Fax: +47 22 20 39 36
E-mail: care.norge@online.no

Development Fund
Grensen 9b, 0159 Oslo, Norway
Tel: +47 23 10 96 00, Fax: +47 23 10 96 01
E-mail: u-fondet@u-fondet.no

Norwegian Church Aid
Postboks 7100, St. Olavs plass, 0130 Oslo, Norway
Tel: + 47 22 09 27 00, Fax: + 47 22 09 27 20
E-mail: nca-oslo@sn.no

Norwegian People's Aid
P.O. Box 8844 Youngstorget, 0028 Oslo, Norway
Tel: + 47 22 03 77 00, Fax: + 47 22 17 70 82
E-mail: norsk.folkehjelp@npaid.no

Noragric, Department for International Environment and Development Studies
University of Life Sciences, P.O. Box 5003, 1432 Ås, Norway
Tel: +47 64 94 99 50, Fax: +47 64 94 07 60
E-mail: noragric@noragric.umb.no