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Rainwater Harvesting in Ethiopia

Capturing the Realities and Exploring Opportunities

Daniel Kassahun

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Contents

List of Tables, Figures, and Plates

Tables

Figures

Plates

Acknowledgements

The draft of this working paper was presented at the 4th International Conference of the Ethiopian Economy in June 2005 and at the 10th Symposium of Water Resources Development at Arba Mich University in September 2006. We would like to thank all those who contributed to the improvement of the paper. We particularly wish to thank field investigators, data enumerators, development agents, agricultural experts, and respondents of sample *weredas* in the Amhara and Oromia Regions. The National Meteorological Services Agency, the Ethiopian Rainwater Harvesting Association, and Ministry of Agriculture and Rural Development are duly appreciated for their cooperation.

1. INTRODUCTION

1.1 Background

Ethiopia is bestowed with rich water resources. A potential of 110 billion cubic meters of surface water with an irrigation potential of 3-5 million hectares is believed to exist. Such figures exclude the rainwater harvesting (RWH) potential in the country. The mean national rainfall is 1090mm, which exceeds the average level of the continent, which is only 686mm. However, the annual amount of rainfall in Ethiopia gives the wrong impression that "rainfall is adequate for crop production". This is by concealing problems related to uneven distribution of rainfall.

Due to global climatic changes there are emerging evidences that the amount of rainfall is increasing in East African highlands. However these increases are coupled with enhanced frequency and magnitude of extreme events of rainfall. The rainfall pattern also shows high level of variations. These processes have been manifested after mid 1980's, and posed formidable challenge to rainfed agriculture. As a result, water scarcity-triggered hazards, such as repeated crop failure, food insecurity, drought and famine, have increased their frequency. Currently, about 52% of the population or 214 districts of the country are food insecure. In 2006, for instance, about 15 million people were food insecure mainly because of rainfall variations.

To address the challenges of food insecurity and the associated poverty, improving agricultural productivity occupies a central place in the Agricultural Development Led Industrialization (ADLI) Strategy of the country. As 85% of the Ethiopian population depends on smallholder rainfed agriculture, effective utilization and management of rainwater plays a vital role. The fact that one ton of grain requires 1,000 tones of water highlights the basic role of water supply and its distribution. In Ethiopia, when there are adequate and well distributed rainfalls, most farmers produce surplus food grains. On the other hand, when the condition deteriorates, the reverse happens. For instance, the growth rate of the value added of the agricultural sector to the economy in 2002/03 and 2003/04 were -12.6 and 18.9, respectively. The only factor that varied between the periods in question, according to EEA (2006), was the availability of rainfall and its spread. Therefore, under the current crop farming system, an adequate (or even surplus) volume of food grain could be grown when the rainfall distribution is fairly even. The grim reality, however, is that the magnitude of rainfall variations in Ethiopia has been scaling up through time. As witnessed in several parts of the world, complications due to the amount and distribution of rainfall could be averted through the expansion of RWH practices.

RWH is a broad term which covers different methods of collecting and improving the productive use of rainwater. In Ethiopia, this practice dates back to the Pre-Axumite (560 BC) period (Fattovich 1990). However, compared to its long history, the technical improvement the practice enjoyed has been insignificant if not none. It was after the drought and famine of the 70s that it regained importance in some parts of the country.

According to UN officials, Ethiopia is among the nine countries of Africa which possesses great potential for RWH. It is estimated that the country could meet the needs of six to seven times its current population, i.e., equivalent to 520 million people.

Since 2003, the government of Ethiopia has been engaging in a massive expansion of on-farm RWH structures. In the national food security strategy of Ethiopia, RWH is considered the main pillar (Rami 2003). In four major regional states of the country (Amhara, Tigray, Oromia and the SNNP), about 952,120 ponds of various RWH types were constructed. Between 2003 and 2005, about 20,000 ha of land was cultivated. Moreover, in 25 of the newly established Agricultural Colleges, where development agents (DA) of rural areas are training, a new course, called Rainwater Harvesting, has been incorporated into the curriculum.

1.2 Statement of the Problem

Fighting poverty and reducing food deficiency are at the heart of ADLI. Government has committed itself to the reduction of the poverty level by half, through the endorsement of the Millennium Development Goals (MDG). In this regard, RWH is one of the pursued strategic interventions. The country has promoted RWH through huge financial and labor investments. This massive intervention, however, has been undergoing without the benefit of information derived from research and informed debate.

RWH is a cross-cutting issue. It has complex interfaces with the environment, economy, gender, health and policy. However, hitherto studies in that line were not only scanty but also narrowly focused. In Ethiopia, there has been very few research on the issue. As Alemneh (2003) indicates, most of the RWH assessments in Ethiopia have narrowly focused on the design, cost, benefit and risk aspects.

The merit and compatibility of RWH ponds with the rural livelihoods have been debated, though not widely, among various scholars and politicians. While government promote RWH as a "magic bullet" to fight food insecurity problems, some critics have minimized its role in the context of acute land scarcity, absolute poverty, vulnerability to malaria and abundance of rivers in the country. Those debates, however, have not been informed by adequate research-generated data.

It is undeniable fact that the interface between RWH, food security, and poverty reduction efforts are not meshed perfectly. As policy plays a crucial role in leveraging the function and performance of RWH, it needs to be informed by policy-oriented research to realize the food security and poverty reduction goals. RWH has been operating without the benefit of such research.

1.3 Specific Objectives

This study aims to:

i. Assess the interface of the ongoing RWH practices with the biophysical, socio-economic, and health attributes of the country;
ii. Analyze the policy framework within which the RWH strategy is currently operating; and
iii. Generate policy recommendations to enhance the effective management of RWH practices in Ethiopia.

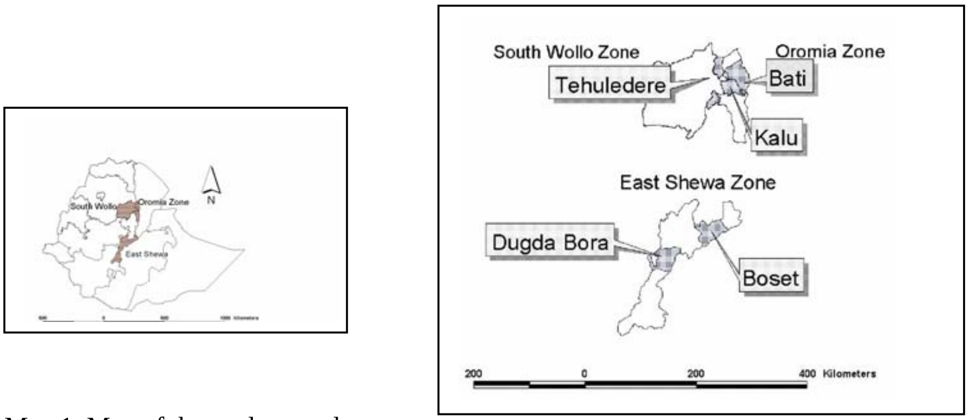
1.4 Significance of the Study

A crop production system based on sustained water supply is a *sine qua non* for agricultural development. Such development could be achieved through effective planning, implementation and evaluation of rainwater management in the Ethiopian context. Knowledge of the biophysical and socio-economic aspects of RWH could furnish vital data on the prevalent practices in the context of the underlying policy framework. As the practice of RWH is site-specific, it is essential to study representative regions that may show different outcomes.

Thus, by assessing RWH practices in different settings, and identifying the challenges and opportunities of the existing RWH practices, the research can provide insights for policy makers and RWH practitioners to review, and improve their current approaches.

1.5 Description of the Sample Sites

Of all the regional states, RWH has been widely promoted in Tigray, Amhara, Oromia and Southern Nations, Nationalities and Peoples (SNNP) Regions. This study was conducted in Oromia and Amhara regions. In consultation with other experts, East Showa zone of Oromia, South Wollo and Oromia Zones of the Amhara regional states were selected (Map 1).



Map 1. Map of the study weredas

These zones are generally characterized by low, erratic and variable rainfall distribution. Besides, they are typified by rapid depletion of land resources by the high population density. Due to the recurrent food shortages, drought, and famine problems, government has aggressively promoted RWH activities in those areas.

The biophysical characteristics of the study areas are presented in Table 1. Except *Dugda Bora*, which belongs to the Lakes region, all the *weredas* are found in the Awash drainage system.

Table 1. Physical characteristics of the study weredas

Wereda	General elevation (m)	Major soils	Annual rain (mm)	Coef. of variation (%)	Mean annual water deficit (mm)
Boset	1000-2000	Vertic Andosols	832.5 (at Welenchiti)	44.2	500 - 700
Dugda Bora	1000-2000	Luvic Phaeozems & Andsolos	713.7 (at Meki)	26.4	500 - 700
Tehuledere	2000-3000	Luvic Phaeozems	1126.7 (at Haik)	18.9	300 - 500
Kalu	1000-2000	Chromic and Eutric Cambisols	980.5 (at Kombolcha)	17.3	500 - 700
Bati	1000-2000	Chromic and Eutric Cambisols	835.1 (at *Bati*)	23.6	700 - 900

1.6 Data and Methodology

Data

Both qualitative and quantitative data were collected from the study sites through the following techniques:

a) Household survey: a structured survey questionnaire, with closed- and open-ended questions translated into Amharic language, was used to gather primary household data at the village level. As enumerators were assigned in areas where they come from, there was no problem of language barrier. Both Users and Non-Users of RWH were involved in the survey. The pre-tested questionnaire includes, *inter alia*, data on household and demographic profile, land holding, agricultural characteristics, rain water management, soil conservation practices, pond location attributes, household's participation in various phases of RWH, health aspects of RWH, peasant's perception and awareness about RWH, etc.

b) Focus group discussion (FGD) – The focus group is composed of six to eight elders and community leaders in each sample village. Wide ranging issues of RWH were raised to capture the insights, thoughts, attitudes, beliefs, perceptions and practices concerning several aspects of RWH. The in-depth discussions were led by the principal researcher, assisted by a research assistant.

c) Key informants: Opinion of agricultural experts and development agents (DAs) working in the respective sample villages were collected through pre-prepared unstructured interviews.

d) Meteorological data – this includes climate data of five meteorological stations (*Boset, Meki, Kombolcha, Haik, and Bati)* obtained from the National Meteorological Services Agency (NMSA). The data spans from the 1980's up to the present time. An attempt to get the pentad and daily rainfall data and potential evapotranspiration was not successful.

Selection of Survey Sites

Five *weredas* were purposively chosen (Table 2) from the Amhara and Oromia Regional States. The selection process was in consultation with zonal experts. Accordingly, a total of twelve peasant kebeles were chosen from the sample *weredas*. Both stratified and random sampling approaches were used to collect the primary data. In each sample wereda, 60 households consisting of 30 Users and 30 Non-Users of RWH were selected. The selection of RWH Users was undertaken through systematic sampling technique. Based on the location of houses[1] in each village,

[1] Rural households are not arrayed in a defined pattern. To avoid biases and keep the representativeness of sample households, the sample village would be roughly grouped into two to three rows. In each selected line, systematic household selection was made.

every other RWH user household was selected. In the case of Non-Users of RWH, every fifth household in a village was sampled.

Table 2. Sampling frame of households

Region	Zone	*Wereda*	*Kebeles*	No. of households	
				Users	Non-Users
Oromia	E. Showa	*Boset*	*Buta Dalecha* *Geda* *Hate-2*	30	30
		Dugda Bora	*Wolde Hafa* *Bertha Semi*	30	30
Amhara	S. Wollo	*Tehuledere*	*Kete* *Gobeya* *Degan*	30	30
		Kalu	*Abecho* *Gerba*	30	30
	Oromia	*Bati*	*Birra* *Mammed*	30	30
Total	3	5	11	300	

The rational for including Non-Users in the survey was to use their opinion and agricultural performance as a benchmark for the appraisal of the information obtained from RWH Users. Besides, Non-Users of RWH are potential users of RWH. Their knowledge, attitude and perception of the ongoing RWH are vital inputs to the design of strategies for expanding RWH in the future.

To undertake the household survey, enumerators were recruited from respective *weredas*. Preference was given to DAs, who were either stationed in the respective localities or those who were in their apprenticeship phase. Only less than 25% of enumerators were graduates of secondary schools.

The Fieldwork

A preliminary field visit was made in October 2005. The purpose was to assess conditions of RWH in the selected *weredas*. Simple observation, discussions with MoA staff and community leaders were used to set the criteria for survey site selection and to get the views of the communities about which investigation is sought. The actual field survey lasted from December 2005 to February 2005[2].

Methods of Analysis

The research is exploratory and descriptive. Consequently, the method of data analysis and presentation of findings follows standard approaches of describing qualitative and quantitative data. Statistical software, called SPSS, was used to compute ANOVA, correlation analyses and descriptive statistics.

1.7 Limitations of the Study

Ethiopia is a country of diverse agro-ecological and socio-economic conditions. This necessitates a very large sample size to capture the general reality. However, attempts were made to identify representative RWH intervention areas of the country, which are characterized by crop production in an erratic rainfall pattern.

Rainfall data with a shorter time scale (either at a daily or pentad intervals) could have been a very useful input for the quantified analysis of dry spells and the RWH water management. However, those data were not available at the disposal of NEMSA. Therefore, the analysis is based on decadal and monthly data, which is crude in temporal terms.

As modern on-farm RWH is a new practice, its users at a village level are fewer in number. Therefore, the majority of users have been involved in the survey. As most of those users are the privileged ones, who either have the wealth, proximity to the government officials, or are elected officials of PAs, there is an inevitable tendency by these respondents to magnify the success of the RWH technology. However, the inclusion of Non-Users of RWH is assumed to moderate such biases.

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[2] The actual field survey was not done without interruption. There were frequent interruptions due to the extensive meetings of development agents and peasants in the period.

At last, because of time and budget constraint, the sample survey was administered based on the results of farmers' response to inquiries, rather than on-site measurements. Therefore, there are no records of inputs and outputs related to the RWH irrigated plots.

2. THE CONCEPTUAL FRAMEWORK

2.1 The Conceptual Framework

Of the several factors which necessitate sustained water supply for crop production, factors such as soil degradation, climatic degradation and the growing population pressure are the principal ones (Figure 1). Those factors significantly affect the carrying capacity of agricultural lands. Various research findings show that the water holding capacity, fertility, and depth of most soils have been declining. The prime causes of reduced water holding capacity of soils are declining level of soil organic matter (OM), coarsening of soil texture due to erosion, and depletion of the top most agricultural soil. Such processes have contributed to the dwindling of the rural land productivity.

The quality of climate, too, has been deteriorating, both at the global and national levels. Climate variability is intensifying mainly due to the impact of global warming. The impact is most pronounced in poor countries such as Ethiopia, where agriculture is the mainstay of the economy. Climatic degradation is commonly manifested through its declining amount and distribution of rainfall and temperature. For instance, between 1970 and 1995, Africa has experienced a decrease of 2.8 times in water availability (Shiklomanov 1996, 127). In particular, rainfall has become erratic in its onset; frequency and duration of dry spells; and withdrawal. Such changing characteristics make the rainfall an unpredictable resource. On the contrary, secured water supply reduces risks of crop failure, thereby increasing farmers' incentives to invest in farm inputs such as fertilizers, hybrid seed and pest management.

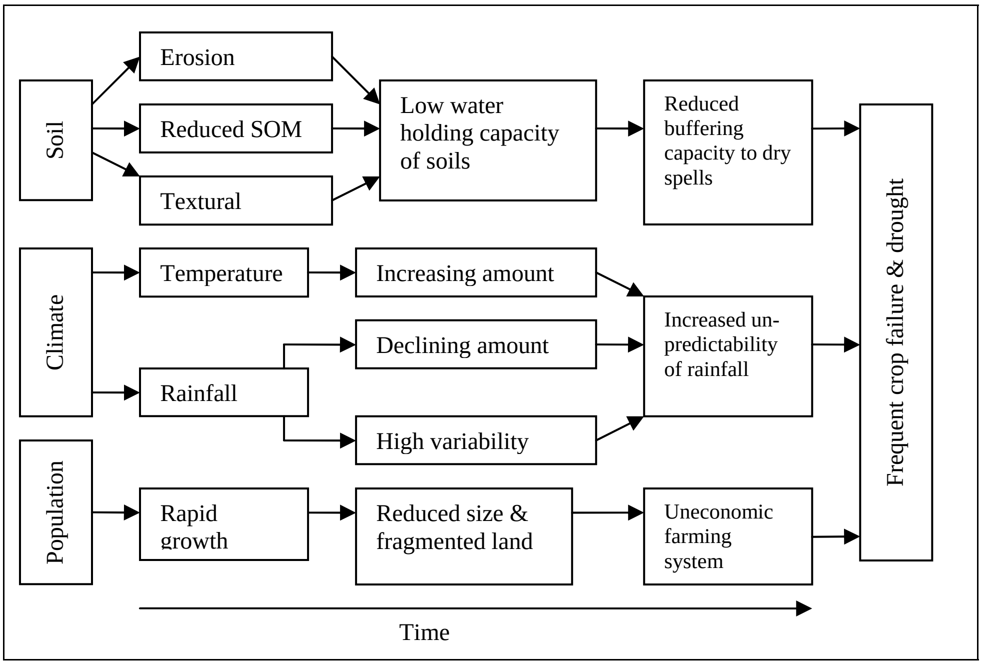

Figure 1. Changing qualities of land productivity factors and implication for RWH intervention.

Population pressure has been mounting from time to time. Currently it has become a critical challenge. At the beginning of 2006, the number of population in Ethiopia was 74.8 million, which is projected to reach 107.8 million in the year 2025. Such rapid growth leads to continued land fragmentation and poses intense stress on the available farmlands. Consequently, the yield per capita plummets and the land size falls below the economic scale. This makes any technological intervention to be uneconomical. In Ethiopia, almost 40% of rural households own a land size which does not exceed half a hectare and more than 60% have less than one hectare. Consequently, most soils in Ethiopia are getting inferior, which resulted in frequent crop failure, drought and famine. This leads to the “poverty, food insecurity, and natural resources degradation trap”.

Of the many alternative solutions to curb the downward spiral, RWH is one of the viable intervention strategies. It is indispensable as it significantly increases the unit productivity of land. However, like any intervention strategy, RWH needs to be fine-tuned to the underlying biophysical, socioeconomic and policy environment. The biophysical factor is like a hardware which defines the physical framework to which RWH is fitted. The level of biophysical conformity, in turn, is dependent on the government's economic and social policies.

2.2 Literature Review

RWH is centrally enshrined in the culture of Asia. It is believed to have originated in Iraq over 5000 years ago in the so-called Fertile Crescent. In India and China, the technique dates back to 4000 years. For instance when a girl is to be married to a boy in northwest China, her parents ask the boy: *How many 'Jiaos' (underground tanks) do you have?*

In China there are over five million rainwater catchment systems. The system supports the domestic water supply for 21 million people and irrigation water for over one million hectares of land. As a result, farmers have changed their traditional cultivation of only one harvest of corn in a year into one or two harvests of rice and one of corn (Zhu and Li 2004). Despite all those contributions, RWH is not taken as the only way out of the complex problem in China. A development strategy, which comprises "terracing + plastic sheeting + rainwater harvesting + agriculture structure modification," is a prominent approach in Northwest China. RWH still occupies a central place in China (Zhu and Li 2004) and therefore land productivity is enhanced. RWH has also helped farmers to abandon cultivation on slope lands while using the sloppy land for planting grass and trees. Such processes have played a beneficial role in recovering the ecological conditions of the degraded areas.

According to Falkenmark, Rockström, and Rain (2005), 70% of the world's poor live in rural areas and are often at the mercy of rainfall-based sources of income (rainfed agriculture). In developing countries there is an increasing competition for limited water resources. As a result, food production is water-constrained and the degree of freedom is constantly shrinking. Therefore, water is increasingly understood as a key factor in socio-economic development. The same source predicted that the future conflicts of interest will be over land-water use, water quantity-quality, upstream-down stream availability, and humans-ecosystems.

According to the opinion of water sector professionals, RWH in the future will become increasingly important because: ground water levels in many places are falling; surface water in many places is polluted; population pressure is forcing people to move into water-scarce areas. Those people tend to be in areas that cannot be served by more conventional means.

Food shortages and livelihood losses due to shortage and variability of rainfall are typical characteristics of smallholder producers of semi-arid Africa. According to SIWI (2001), hunger and poverty are predicted to remain a major problem especially in arid and semi-arid regions, both subject to an "under-nutrition climatology". Although shortage of rainfall is an important factor, the most critical problem, according to Barron *et. al* (2003), is the inter- and intra-seasonal variability. The problem is aggravated as close to 80% of the rainfall is subject to loss due to evaporation or runoff that causes erosion and downstream flooding (Hatibu 1998).

Nowadays, due to threats from the quality, quantity and variability of rain resource to the rapidly growing population, RWH has been recognized as one of the key solutions for achieving food security. Even in areas where the average annual rainfall is adequate enough (i.e., greater than 1000mm in a year), the amount might fall in short spells of high intensity. According to Zhu and Li (2004), RWH can well mitigate the drought caused by the climate variability.

RWH is one of the technologies that are reported to help the rural poor break away from the poverty trap (Kariuki 2005). This is because secured crop water supply reduces risks for crop failure, thereby increasing farmers' incentives to invest in farm inputs. Research conducted in Tanzania (Hatibu *et. al* 2004) show that RWH technology enable to produce maize, paddy and vegetables in semi-arid areas where it would otherwise be impossible or very difficult. Similarly, Prinz and Singh (2000) reported that wheat grown under RWH in Pakistan was more viable and profitable than any of the traditional methods. Even in countries like Tunisia, considerable investments are being made to capture the scarce amount of rainwater (100mm to 230mm annually) for agricultural and domestic purposes through RWH (Ouessar *et. al* 2004).

The appropriate choice of RWH technique depends on the amount and distribution of rainfall, land use/vegetation cover, land topography, soil type and soil depth, and local socio-economic factors (Prinz and Singh 2000). According to Hatubu and Rockstrom (2005), the productivity of labor, water, and land under rainfed farming can be doubled or even tripled through the management of dry spells. However, these achievements are only small 'islands of success' in the semi-arid areas and therefore there need to be policies, strategies and programmatic frameworks which facilitate integrated management of land, water, and markets.

Water scarcity caused by rainfall fluctuations is common, causing meteorological droughts and dry spells. According to (Rockstrom 2004) water scarcity causing food deficits is more often caused by management induced droughts and dry spells. Bridging dry spells combined with soil fertility management can double and even triple on-farm yield levels.

In Ethiopia rain water harvesting dates back to the pre-Axumit period (560 BC) (Fattovich 1990). However, it has not been filtered through modernization. While direct diversion of overland surface water onto the field has been commonly practiced in many parts of Ethiopia, digging holes to collect water is rather a new practice in the highland parts (Getachew 1999). Hune (2004) reported that, in the Food Security Strategy of Ethiopia, RWH is envisaged to meet two goals: to cultivate horticulture during dry period, and to provide water as supplementary irrigation in wet seasons.

However, the definition of RWH in Ethiopia, according to Alemneh (2003), has confusion. This is because small river diversion is also included in the definition of RWH. While RWH is seen as the only solution for securing food security, Alemneh (2003) cautioned that RWH should be seen as an integral part of the natural resource management, which requires collective action for its success and sustainability.

Mills (2004) has witnessed that RWH fits well into the overall consumption culture of Tigray. Likewise, research conducted by Mintesinot and Mitiku (2002) in Tigray revealed that irrigation from micro-dams water could obtain a three-fold increase in income compared to Non-Users. On the contrary, limitations of RWH are identified in various parts of Ethiopia. For instance, Tedros *et al* (1999) have revealed that in areas where altitudes are lower than 2000 masl, households living near to the stored water are faced with increased risk of malaria incidence, which is close to a seven fold increase of risks in children.

In Ethiopia, most of the RWH related studies were conducted through rapid survey techniques undertaken by expatriate bodies, such as ICARDA (Oweis, Hachum and Kijne 1999), World Bank (Anderson 2002), OCHA (Rami 2003). Those studies have neither the breadth nor the depth to capture the complex issues of RWH in Ethiopia. The existing literature has attempted to demonstrate the great potential of RWH for enhanced crop production, with little or no emphasis on the integrated impact of the biophysical, socioeconomic and policy attributes. Therefore, studies undertaken in Ethiopia could be generalized as: narrowly localized in a few geographical locations, biased towards the technical/engineering aspects, and hardly addressed the complex realities of RWH practices in the country.

3. Major Findings and Discussion

3.1 General Features of RWH in the Study Area

Biophysical, Demographic and Socio-economic Characteristics

The average family size of households in the surveyed area ranges from 5.63 to 6.53 (Table 3). This size is a typical size of the national average. Partly indicative of the underlying population pressure, land fragmentation is common in the study area. At zonal level, the average number of plots ranges from 2.07 in South Wollo to 3.57 in East Showa. Such variations could be explained by the differences in the crude population density in sample *weredas*. Based on the CSA (2004) data, crude population density for *Boset*, *Dugda Bora*, *Tehuledere*, *Kalu* and *Bati weredas* is calculated as 102, 127, 324, 193, and 142, respectively. If these figures are computed at the regional level, it is possible to note that population density is exceedingly higher in *weredas* of the Amhara than the Oromia Region. However, the number of farm plots in Oromia exceeds those in the Amhara *weredas*. This could be partly explained by the effect of recent land redistribution practices in the Amhara region.

Table 3. Description of sample households in the study area

Characteristics	Amhara			Oromia	
	South Wollo		Oromia	East Showa	
	Tehuledere	*Kalu*	*Bati*	*Boset*	*Dugda Bora*
Household size	6.53	5.78	5.91	6.30	5.63
Maximum educational level attained	4.43	3.98	4.53	7.23	7.19
No. of farm plots in HH	2.07	2.30	2.93	3.60	3.57
No. of fruits & vegetables by HH	5.79	3.13	3.43	3.67	3.70

Here, an interesting issue is observed in *Tehulederie wereda.* Apart from its better rainfall amount, the *wereda* is endowed with rich water sources (streams and lake water). However, *Tehulederie* is "food-insecure." The prime reason for such a paradox is the extreme land shortage problem manifested in the locality.

Women could benefit enormously from the RWH-based farming systems. In the survey area, about 20% of households are female-headed. Such figure is also true for the national average. In practice, however, female-headed households hardly have the privilege to own RWH ponds. It is the strong male-headed households that own RWH ponds. Digging ponds demands a collective labor locally called "*debbo*". This system is implemented through a "give and take" mechanism. As women are not as muscular as their men counterparts, almost all women-headed households were unwittingly barred from the benefits of RWH.

The diversification of crop types has varied between Users and Non-Users of RWH. While Non-Users have cropped 1.87 types, RWH Users had 3.53. Such significant variations could be attributed to the availability of water from ponds. When it comes to *wereda* level, *Tehuledere* has higher diversification. This could be due to the long tradition of water use from Lake Haik coupled with the influence of high population pressure in the *wereda*. Generally, it is believed that commodity market necessitates crop specialization. However, in developing countries, such as Ethiopia, mono-cropping is not the right option. It is rather a diversified farming system, which protects rural households from periodic food shortages and malnutrition.

Unlike the traditional communal pond types observed in the lowlands, the modern RWH is mainly installed in the farmlands. There are debates in this regard. Some literature (e.g., Oweis Hachum and Kijne 1999) advocates the effectiveness of large-scale communal RWH pond than the ones in the individual farms where land holdings are small. On the other hand, *weredas* in the survey area are densely populated and one can hardly get a suitable place for communal pond construction. In most cases, vacant communal lands are found in a severely degraded and abandoned land, which is usually located on steeper slopes. The other problem is that if ponds to be dugin those places, they are usually at higher distances from existing farm plots.

Figure 2 demonstrates the pattern of RWH pond expansion in the study area. It was in the last four years that rapid expansion was undertaken. Such rapid expansion, according to Rami (2003), has “flaws in the design of structures”. In effect, most RWH ponds of the country were expanded without the corresponding appraisal of the technology. One of the cardinal issues of expansion, raised by key informants of the study area and by some experts (Hune 2004), was the implementation of the “quota system”.

The quota system is held responsible for the poor quality of pond structures (Rami 2003). It was after a couple of years that this system was abandoned by the Amhara Regional State. Instead, the region has mandated local planners to plan and execute the expansion process. In Oromia, for instance in *Boset wereda,* the government has a plan to build

100 tankers annually, with 25% annual increment. In *Dugda Bora wereda*, the plan is to enable all households to possess at least one pond, to expand communal ponds for livestock areas, and to diversify the utility of RWH through introduction of brick production.

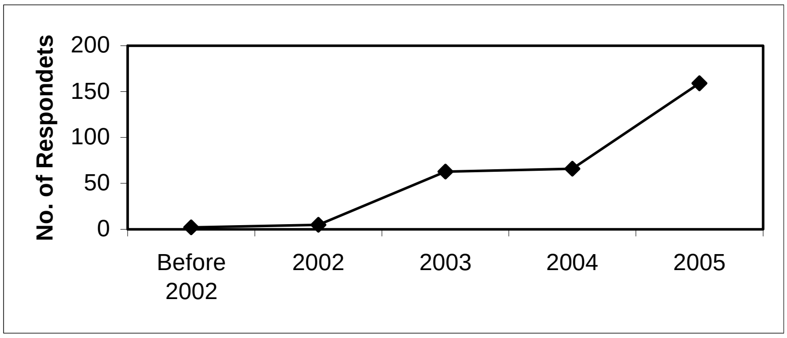

Figure 2: Patterns of RWH pond expansion in the survey area

Almost all RWH Users have extracted water for the cultivation of horticultural crops. Nowadays, RWH has become synonymous with horticulture production. However, there are some variations with respect to the functions of RWH across the study areas. The following multiple services of ponds were noted in the study areas:

- For domestic purposes- in *Dugda Bora* (Oromia)
- For beef fattening - in *Boset* (Oromia)
- For tree nursery– in *Boset* (Oromia)
- For selling domestic water - in *Boset* (Oromia)
- For chat cultivation - in *Tehuledere* & *Kalu* (South Wollo)
- For bee hiving - in *Bati*, *Tehuledere*, *Boset* (Oromia and Amhara)

Such multiple functions of RWH could also furnish valuable services to the ecosystem. Nutrient cycling and flood and erosion controls are the prominent ones. However, those ecological services of RWH are hardly recognized by the government and local experts.

3.2 Biophysical Aspects

Under this topic factors of the biophysical aspects, such as climate (rainfall and temperature), topography, soil, agronomy, etc., would be assessed.

Climate

Farmers say that rainfall variability, which is expressed through irregular distribution in space and time, can occur at any moment of the cropping season. It could happen either at the onset, middle or end of the cropping season. For instance, in *Boset wereda*, farmers reported that nowadays, drought happens almost every year. According to them, “the good years are gone”. In response to this problem, farmers in the surveyed areas have adopted various coping mechanisms. If the onset of the rainy season delays, about 85% of respondents patiently wait for it. When it comes, they sow the same seed. If a dry spell happens in the middle of a cropping season, the majority of respondents (about 75%) decide to re-cultivate their farmlands using short maturing varieties of crops. If the rain withdraws at an early stage of the season, about 66% of respondents would feed their wilting straws to the livestock.

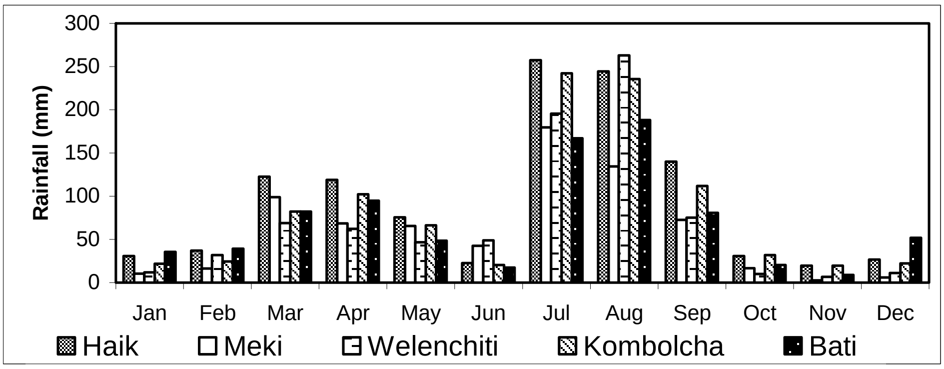

Figure 3: Patterns of average monthly rainfall in the study area

At the outset, Figure 3 might lead planners to that wrong conclusion, where the distribution might support agriculture for two seasons (July to September, the big rainy season, and February to May, the short rain season). However, the data were computed on a monthly basis and capable of masking dry spells within those months. In this regard, the gap between the big and small rainy seasons usually ranges from one to two months. Through effective utilization of RWH, the gap could be mitigated effectively. Such RWH potential enables the cultivation of not only vegetables but also cereal crops, which require longer growing seasons. It is well known that there is a positive correlation between the length of the growing season and the amount of obtainable yield.

Information obtained through FGD showed that water scarcity due to the changing rainfall characteristics has been intensifying. This is because the rain is becoming not only decreasing in amount, but also irregular in its distribution. Especially in *Dugda Bora*, *Boset* and *Bati weredas*, rainfall anomalies have become very common. On the contrary, in all the surveyed areas, there is an increasing demand for water, which is due to the increased human and livestock population.

Though not severe like that of the rainfall anomaly, farmers in the study area have also experienced the rising trend of temperature and its impact on crop production. About 72.6% of the respondents put temperature as one major factor affecting the production of crops. Of course the rising temperature of Ethiopia could be associated with the global climate change.

Simple rainfall trend analysis shows that the amount of rainfall has been declining (Figure 4) and its distribution getting erratic. Such results conform with the views of peasants expressed during the FGD and interviews. As shown in Table 2, in places where the mean annual rainfall is less, the coefficient of variation is higher, which makes the rainfall of drier environment to be less predictable. This therefore justifies the need to pursue RWH.

The trend of annual rainfall (1993-2005) has two major patterns (Figure 4). While stations of Amhara Region (located in the north central Ethiopia) showed a declining trend of rainfall, stations of the Oromia Region have demonstrated a slight increase of rainfall. Such variations could be linked to the variable effects of climate change in Africa.

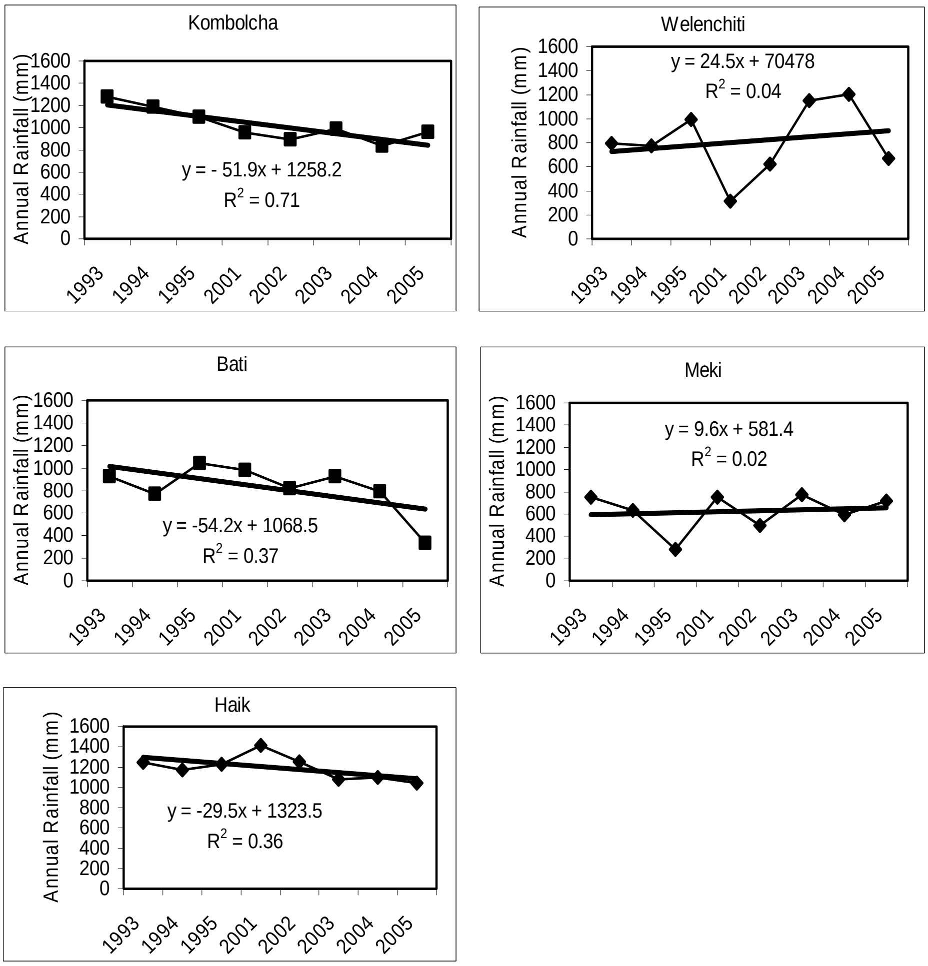

Figure 4: Linear trends of rainfall amount across the study areas (from 1993 -2005)

Topography/Soil

With respect to the suitability of topographic elements of RWH ponds, a sharp dichotomy was noted: between plots of land with low gradient (< 18^0) and high gradient (>18^0). According to the idea obtained from FGDs, constructing ponds on high gradient land is labor-intensive. The digging has to penetrate not only soil solum, but also bedrocks. Such activity is challenging especially for households headed by women, physically weak persons, and in a community where collective work is not practical. However, once the ponds are dug in place and the structures planted, the probability for collapse is minimal if not none. This is because, according to farmers, the land at a high gradient has a hard and compact physical structure.

Conversely, installing RWH ponds on low gradient land has both advantages and disadvantages. The advantage is that there is little chance of digging through bedrock. The problem, on the other hand, is that the topography of most of the low-lying land is dominated by fine textured soil which contains vertic properties. Soil with vertic property poses series a physical (engineering) limitation as it alternatively swells and shrinks. This is due to the presence of montimorilinitic minerals in the soil. Such properties often result in the fast collapse of pond structures, especially the ones constructed with concrete.

At the onset of RWH expansion, there was acute paucity of information on the topographic/soil conditions. As a result, the choice of pond types becomes arbitrary. Through time, farmers have learned that the type of ponds should conform well with the various topographic features and the associated soils. While concrete-based structures are recommended for high gradient lands, ponds constructed from plastic lining (geo-membrane) are found suitable for low-lying land. At *Bira* kebele *(Bati)*, the FGD revealed that those low-lying lands are the most preferred type of topographic feature for RWH ponds. Those lands, according to the valuation by farmers, are more fertile than the hilly counterparts. This type of land evaluation also conforms well with the modern Land Capability and Suitability Classification System. Farmers cautioned that ponds constructed on high gradient lands are susceptible to immediate deposition and damming by the transported sediments. In the study areas, cost-benefit evaluation of RWH locations across topographic gradients was not undertaken. This is partly justified by the fact that, according to Rami (2003), structural engineers were not consulted by the Amhara Agricultural bureau when it prepared the RWH manuals.

In principle, shaping or treatment of the catchment surface is a prerequisite to boost the harvestable runoff yield in the ponds. According to Hudson (1988), significant increase in the runoff yield can be achieved through treatment of the surface, either through removal of vegetation or moving stones on the surface. However, reshaping was hardly undertaken in the surveyed areas (Plate 1).

Plate 1: Ponds surrounded by vegetative cover. Volume of harvestable water is limited by the percentages of vegetative cover (*Tehulederie*, Amhara).

In the study area, more than 75% of the pond catchments are covered by various vegetation (crops and grasses), which results in enhanced percolation of rainwater and reduced run-on to the ponds. According to MoA estimates (Anderson 2002), the runoff coefficients of agricultural field ranges from 0.25 to 0.40. Of course, in the context of chronic land scarcity faced by the farming community, sparing bare lands for the benefit of ponds is not justifiable.

As assessed through 'silt marks' of uncovered ponds, some of them had never been filled at all (Table 4). Close to 30% of ponds were found empty in *Dugda Bora* and *Bati* study sites (Plate 2). On the other extreme, where rills and gullies are channeled to the ponds, volume of water supply might exceed the carrying capacity of ponds. As has been witnessed in *Buta Dalecha Geda (Boset,* Oromia*)*, there were several instances of damages inflicted by pond overflow. Currently, spillways have become essential components of ponds.

Unpublished reports of Oromia[3] shows that in *Boset* and *Dugda Bora weredas*, 250 and 1000 ponds, respectively, were planned for the year 1994/95. However, only 51 and 142, respectively, were reported to hold water.

Plate 2: Ponds without water. In some places, ponds were dug without the provision of the necessary materials (*Dugda Bora*, Oromia)

Table 4. Pond characteristics in the survey area

Parameters	Region					
	Amhara Region				Oromia Region	
	Oromia Z.		S. Wollo Z.		E. Showa Z.	
	Yes	No	Yes	No	Yes	No
Do you encounter siltation problems?	13 (43.3)	17 (46.7)	17 (28.3)	43 (71.7)	24 (40.7)	35 (59.3)
Does your pond get filled with rain?	30 (100)	0 (0.0)	55 (91.0)	5 (8.3)	47 (78.3)	13 (21.7)
Is your pond covered?	9 (30.0)	21 (70.0)	17 (28.3)	42 (71.2)	22 (38.6)	35 (61.4)

N.B.: Numbers in parenthesis are percentages.

One of the major challenges of the Ethiopian environment in general and of agriculture in particular is the ever-growing magnitude of soil erosion. Erosion in the form of sheet erosion, which is taking place massively on

[3] An evaluation report prepared by the Central Oromia Irrigation bureau, Nazareth.

croplands, is the prime one. In this study, an attempt was made to assess the link between RWH-based cultivation practices and the magnitude of soil erosion. Direct observation by the researcher as well as the information obtained from farmers and key informants confirmed that the magnitude of soil loss could be reduced considerably by various water conservation structures, which are installed on the RWH areas. Other advantages of RWH include the replenishment potential of the ground water, which in effect enriches springs and wetlands.

Agronomy

RWH is closely linked to agronomic practices, farming systems and livelihood activities of households. Some studies (e.g., Mills 2004) noted that investment in ponds reduces risks from the agronomic point of view. It is obvious that almost all Ethiopian arable farmers cultivate rainfed cereals. Irrigated cultivation of fruits and vegetables is a new experience not only to the farmers, but also to the DA's working in the study areas. Due to the availability of pond waters, significant changes are taking place towards new and high value crops. These changes are accompanied by the diversification of crop types. The probable bottleneck in this regard is the perceptible knowledge gap in agronomy, protection, irrigation schedule, etc., of the newly introduced crops.

The suitability of pond water temperature for irrigation is a grey area where scientific knowledge is lacking. There are diverse views regarding the nexus between water temperature and irrigation scheduling. While some farmers prefer to apply water when the pond water is hot, others recommend the opposite. There is no clear guidance given by agricultural experts in the surveyed areas. Similarly, the amount of water required to irrigate crops tuned to the species, variety and growth stage of a crop are still unknown.

An interesting phenomenon in the RWH-based cultivation system is the declining use of fertilizer and its increasing replacement by compost. It could be due to the dominance of horticulture in pond areas, which grow using compost in the backyards. Of course, the unlimited supply of water at first could conceal the necessity of commercial fertilizers needed for the crops. This might be due to the residual fertility levels in the soil. Through time, however, the residual nutrient depletes and the yield of RWH-irrigated crops would be reduced significantly. Therefore, agronomic factors need to be adequately considered in accordance with the crop's response to water supply, soil factors, land husbandry, crop variety and choice, etc.

Currently, most of the harvested waters are allocated for horticultural production. In some PAs of *Tehuledere*, *Kalu* and *Bati weredas* chat (*catha edulis*) cultivation has taken advantage from the pond water (Plate 3). In a way, there is a landuse shift from cereals to horticulture. According to Ngigi et al (2005), such land use changes are driven by the need to improve agricultural production and livelihoods. In the survey areas, more than 75% of responding farmers (both Users and Non Users) believe it is difficult to cultivate cereals using pond water. Various explanations could be given for such a belief. The location of ponds very close to households could be. A visit to an agricultural field shows that cereal farms are located far away from residential units. The other factor could be due to the intensive labor requirement for watering the cereal crops. There is also shared a perception among farmers that "cereals require voluminous water than horticultural crops".

Plate 3: In some localities water from ponds are utilized for *chat* (catha edulis) cultivation (*Tehulederie*, Amhara)

It is important to see the patterns of water shortage in cereal production. The duration of dry spells (within the cropping period) lasts for a maximum period of three weeks. If pond water is applied once between the seventh and tenth day from the onset of the dry spell, the crop could escape wilting or drying. Experiences in Asia (especially in China) show that maize could best be cultivated through harvested water. Of course, there are variations in the response of farmers. While the majority of respondents in East Showa and Oromia zones believe that cereals do not fit with RWH waters, about 33% of respondents in South Wollo think the RWH could be effectively applied for cereals.

However, there is no information available to farmers regarding the optimum spacing among vegetables, irrigation timing, and seeding rate. There are no prior studies on the alternative land utilization type and its implication for the environment, existing crops, labor, the market, etc.

3.3 Technical Aspects

Technical aspects of RWH include issues such as pond coverage (Plate 4), water lifting from ponds, and irrigation techniques. On average, more than 50% of the ponds are not covered, and the case in *Dugda Bora* area is exceptionally unique (Table 4). Coverage of ponds at the top is important as there are several implications. The uncovered ponds loose a significant portion of their water due to evapotranspiration. It is also responsible for the breeding of mosquitoes. It also becomes a 'death trap' as children and livestock are liable to fall in them. Another problem of uncovered ponds is related to the geo-membrane structures. This is because in dry seasons, wild animals (e.g., hyena) are getting thirsty and coming to ponds for a drink. Those animals tear the plastic lining through their nails while they are attempting to get off from the ponds.

Another challenge surrounding RWH is the water lifting system. Irrigating crop fields through pumping, using pedals, could ease the burden of water lift up through buckets. However, it could be inefficiently drawn through pedal pump. In some areas, such as South Wollo and *Bati*, there are attempts to irrigate crops, not the land, through drip irrigation (Plate 5). Water application using buckets allow pouring water directly on the plant's root. This system enabled an increment of harvest by 40% in China.

Plate 4: Diversity of pond coverage in the study sites

Plate 5: Application of low-tech drip irrigation. The left picture (*Bati*, Amhara) shows a manual and low cost system of drip irrigation. The right picture (*Dugda Bora*, Oromia) shows how the pond water is pumped to a high positioned barrel so that the water could be channelled through conduits to the plants using drip irrigation technique.

Siltation of sediments due to transportation of sediments generated from the runoff area is identified as a major problem in the study areas. The magnitude is of the problem is high in ponds installed with no silt traps. Siltation could substantially shrink the capacity of ponds to accumulate water. The majority of farmers install silt traps (Plate 6) in the form of ditches dugs few meters away from ponds. Usually those ditches are filled with sediments during rainy seasons. Unless farmers excavate the silt on time, there is a higher chance of depositing voluminous silts in the pond.

Plate 6: Silt traps of such kind are considered ideal places for malaria breeding (*Bati*, Amhara)

The intensity of rainfall in the study area is high. Most of the respondents noticed that the installed ditches are not adequate enough to trap the silt-laden floods. In effect, there are several chances of overflowing of water. Interestingly, there are few farmers who put in double silt traps (Plate 6). In most cases, the harvested sediments are utilized as fertile soil and are added on the farm plots.

Ponds which are lined with geo-membrane are commonly susceptible to tearing along fold lines developed during storage. This is because the geo-membrane materials are deposited for a very long period, even years, at various stores of agricultural offices (Plate 7).

Lineaments of fold-marks would be created and this would be the area where tearing would easily result. The plastic lining also easily tears due to friction with rough pond surfaces and contact with buckets during water lifting. In general, about 40% of RWH Users have faced either one or a combination of seepage, crack, tear or collapse problems. Especially in South Wollo and *Bati* zones it is very common to observe the conversion of damaged geo-membranes into various functions.

Plate 7: Plastic materials are usually stored for long time in zonal and *wereda* agricultural bureaus (*Bati*, Amhara).

3.4 Socio-Economic Analysis

A. Involvement in RWH

At the initial stage of RWH implementation, almost all major regions adopted a “quota system” to diffuse the technology. In order to meet the quota, the authorities were pushing local experts to dig as many ponds as possible. Such activities were undertaken irrespective of the necessity, locational condition, geological structure, soil type, pond type and the like. It was after the installation of those ponds that many problems cropped up. During the performance evaluation, conducted by experts, some of the identified problems were given due attention.

According to Rami (2003), the criteria that were used for selecting the RWH beneficiaries in the Amhara region include a household known to be food insecure, industrious, good farmer, willing to adopt new technology, etc. In this study, it was discovered that those who actually owned RWH were not the poor section of the communities. Rather it was households who were known to be food secure, own large land, an official in PAs, etc.

About 77% of RWH Users were initiated by government agents to employ RWH. Overall, about 65% of sample households declared themselves as ‘food insecure’. RWH Users showed a significant correlation with involvements in PA leadership ($p > 0.05$); ownership of larger lands ($p > 0.01$) and the maximum educational attainment of households ($p > 0.05$). On the contrary, insignificant correlations were attained between Non-RWH Users and family size, number of children, the amount of fruits grown by households.

The participation of RWH beneficiaries in the various phases of the implementation of the RWH activity is very crucial. The chances for success are much greater if they are involved from the early planning stage onwards (Oweis *et al.* 1999). However, such important involvement was not demonstrated in the studied areas (Table 5). The involvement of beneficiaries especially in training of pond maintenance is found very minimal.

Table 5. Participation of households in various phases and activities of RWH management

Were you ….	Amhara Region				Oromia Region	
	Oromia Z.		S. Wollo Z.		E. Showa Z.	
	Yes	No	Yes	No	Yes	No
participating in pond site selection?	24 (80)	5 (16)	56 (93)	4 (6.7)	53 (71)	7 (11)
trained in pond digging?	6 (20)	24 (80)	15 (25)	43 (74)	25 (43)	33 (56)
trained in pond management?	13 (43)	17 (56)	13 (21)	47 (78)	19 (32)	39 (67)
trained in pond maintenance?	4 (13)	26 (86)	6 (10)	54 (90)	11 (19)	45 (80)
participating in crop type selection?	24 (80)	6 (20)	52 (88)	7 (12)	40 (66)	20 (33)

NB: Numbers in parenthesis are percentages

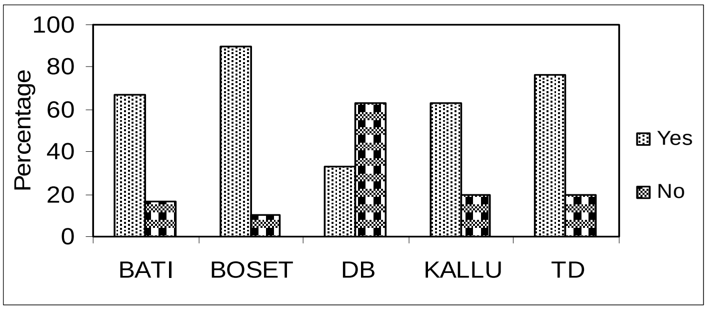

Figure 5: Farmers preference to dig supplementary ponds

Of the total of 150 RWH Non-Users, about 90% showed their interest in acquiring additional ponds (Figure 5). However, as most of them are very poor, they look for financial and labor support either from donors or the government. Similarly, 88% of the RWH beneficiaries are interested in adding ponds in the future. However, both categories prefer to locate additional ponds far away from their homesteads. The reason could be: to be further away from uncovered ponds ('death traps'), to keep mosquito areas at bay, or to supply cereal crops with pond water.

B. Site and Situation

In planting RWH ponds at a particular place, local variability needs to be assessed carefully. This is because locations of ponds have important implications for management, health, efficiency and crop productivity. According to Rami (2003), mistakes in site selection are responsible for most of the failures. Survey results show that locations of RWH ponds were not set at optimum positions. In this regard, the information given to the beneficiaries was minimal.

It was found out that about 80% of respondents had their ponds dug within a 10 meter radius from residential units. The question is where should the best location of RWH be? Most RWH Users in the past preferred ponds to be located very close to their homesteads. Such preference could be linked to the problem of land tenure insecurity. As rural land re-distribution had been repeatedly practiced in most highland parts of the country, farmers were hesitant to dig ponds at outlying plots where there was the chance of losing it in the re-distribution process. Such risk aversion strategy has also been encountered in the case of inadequate investment of households in the SWC structures.

A contrasting argument from sample farmers is that locating ponds at backyards enables to harness labor and time of housewives. Women can simultaneously cultivate pond-water irrigated crops while caring for children and cooking food. Still there are other farmers who argue the importance of locating ponds at backyards for safety reasons. As RWH practice enables to grow "high value" crops, protection from thieves and animals requires manpower. If ponds are located at nearby distances, protection of crops from damage and loss would be minimal.

Despite the stated advantages of locating ponds nearer, the majority of farmers (Figure 6) expressed the opposite opinion. Such preferences could be from different perspectives. The first is the easing of government's land policy, which gives, short of selling, wider land rights. Such move might have prompted farmers to feel more secure and decide to dig ponds at far away plots. The other factor could be the health impact. Ponds at closer proximity are prone to malaria attack, and farmers might have decided to avoid mosquito breeding ponds.

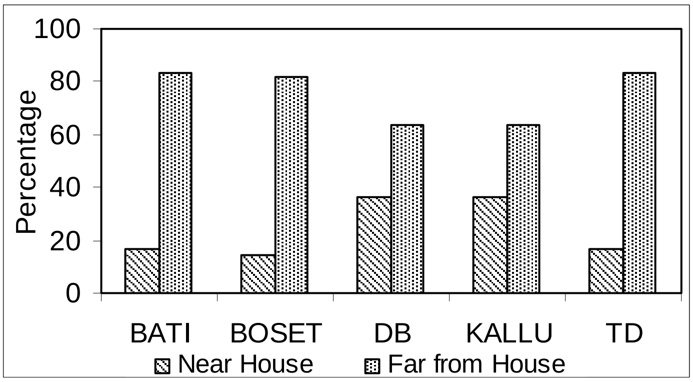

Figure 6: Preferences of farmers to locate their ponds in the future

C. Food Security, Income and Market

RWH has facilitated diversification of livelihoods among its users. Diversified livelihood not only mitigates risks but also stabilizes income. It was found out that, in terms of agricultural produce and general socioeconomic well-being, there were stark contrasts between Users and Non-Users.

In most households of the study areas, the agricultural produce of a household suffices for a maximum of nine-month consumption. The remaining period would be short of quality and quantity nutrition. This is the period in which most Ethiopian farmers employ different types of coping mechanism, such as cutting trees for charcoal making, selling livestock, out-migration in search of off farm activity, etc. About 65% of respondents described themselves as “food insecure”. One of the great advantages of vegetable grown through RWH is its strategic importance to fill the deficits in such critical periods (Figure 7).

Research reports (Hussien and Hanjra 2003) have confirmed that irrigation reduces poverty. It directly boosts yields and gives farmers the ‘water security’ they need to risk investing in other productivity enhancing inputs such as fertilizers and improved seed. Respondents at all sites have reported that RWH ponds are useful not only to the rich but also to the poor households.

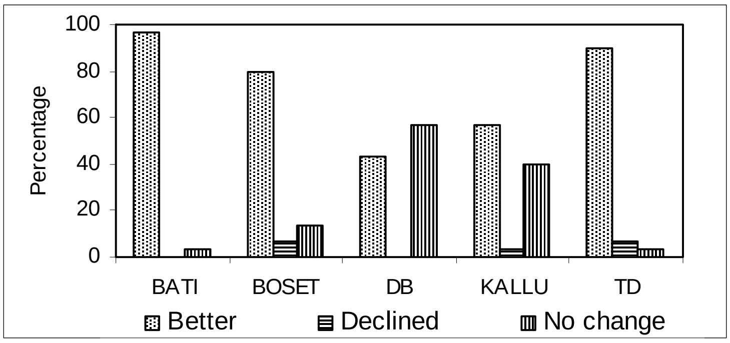

Figure 7: Patterns of household economy after using RWH activities

In the study area, the lion’s share of RWH-based producers is meant for the market. So far there is no problem of market in all the surveyed areas. As they are sold locally, the problem of storage and transportation is not yet experienced. However, given the growing interest of farmers in dependable production through RWH, there would undoubtedly be production which would exceed local demands, and there might be problems emanating from competition, market information system, etc.

D. Input (labor, capital)

RWH is a labor intensive venture. It demands a great deal of physical work. In a rainfed agricultural system, households used to work in an active and slack pattern. As pond waters are capable of stretching the growing period, there would be extra tasks which are expected to fill up the majority of the year. The majority of RWH Users have complained the higher allocation of time to cultivation work (Figure 8). They found water lifting and irrigation activities to be annoyingly tedious. A farmer at *Degan* kebele of *Kalu wereda* stated “**እንኳንስ ለባል ብቻ ይቅርና፤**

ከነሚስትም አይቻልም" (meaning, let alone for the husband, it is difficult even with the support of the wife).

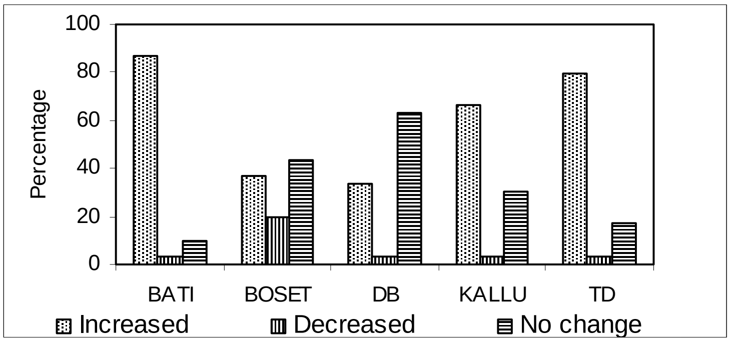

Figure 8: Labor requirement of RWH-based farming practice

With respect to the capital needed to install RWH ponds, there have been two categories of RWH Users. The first group involves the few chosen farmers who were handpicked by local officials. The type of RWH they installed was mainly concrete-based dome. These beneficiaries have provided nothing but a piece of land for setting up RWH. The purpose of such help was to serve as a RWH demonstration. They were freely provided with everything necessary for RWH construction, i.e., cement, labor, and other materials. Support in the form of food-for-work was employed to excavate and construct ponds. The second group of RWH beneficiaries includes some prominent and motivated individuals, who partially contributed to cover the financial expenditure. This time, the dominant type of RWH was geo-membrane.

The estimated cost of bottle-shaped, half-ball shaped, and dome-shaped pond construction is birr 1,700.00[4], 3,500.00; and 6,000.00, respectively. The plastic material needed to cover the ponds (geo-membrane), which is adequate enough for the trapezoid-shaped (with the top side size of 8m * 8m; bottom side size of 2m * 2m; and a depth of 3.1m) pond was initially estimated to cost birr 1,000.00. This amount was unaffordable to almost all farmers and the government decided to significantly subsidize the cost

[4] Costs for concrete based ponds were estimated before the time where unprecedented price hike were observed on the cement market in Ethiopia.

by 85%. Farmers now pay only birr 159.58 (which is 15% of the estimated total).

3.4 Health Aspects

All sample villages are malarious. However, respondents have the opinion that malaria in the past was not only harmless but also localized in a few pocket areas. Currently, malaria illness has become severe and covers almost all parts of the studied areas. Most notably, there are variations in the surveyed areas. Higher malaria incidence was observed in two sample *weredas* of South Wollo, which are found at relatively higher elevations than the three low-lying *weredas*. The fact that people residing in the higher elevation have no adaptation mechanism to malaria might have made them defenseless to malaria than the low lying areas where malaria is endemic.

In some of the study areas, the introduction of RWH has brought a new dimension to the disease. Elsewhere in the RWH promoting countries, waterborne and malaria diseases are the commonest threats that are induced by RWH practices (Tedros *et al.* 1999). In the surveyed areas, the magnitudes of households who drink pond water are negligible, with the exception of *Dugda Bora* and *Boset wereda*. In these *weredas*, close to 66% of RWH Users utilize the ponds for drinking purpose during dry seasons. Such utilization pattern significantly narrows the opportunity for waterborne diseases. Therefore, the leading health hazard induced by RWH is malaria.

There have been plenty of evidences that stored waters, such as micro-dams and irrigation areas, are responsible for the proliferation of malaria disease. In the conception of RWH strategy in Ethiopia, planners should have considered such problems and taken the necessary precautionary measures. However, it was after observing some tragic epidemics that some mitigating measures, such as dispersing the pond water through wooden shaft, came to be taken. Farmers noted that the probability for the mosquito eggs to be hatched would be significantly reduced by the dispersion of water through sticks. Regrettably, it was very lately that people realized that mosquito breeding also takes place in the ditches which were constructed for trapping silts. Many farmers in South Wollo

Zone and *Bati wereda* label such siltation traps as “lethal spots”. In general, there was learning through “trial and error” at a bigger cost of human lives.

The majority of respondents in the surveyed areas (Figure 9) have witnessed that on average malaria transmission lasts for about two months each year. In those times, at least one member of a household is fall ill. Children and pregnant women are the most vulnerable section of the community. Farmers often fail to discharge their farming business not only because of their sickness, but also to attend to sick family members. Increased health risks due to RWH ponds could also diminish the labor productivity.

A good correlation exists between malaria and pond ownership. This connection is known by all respondents. About 60% of Non-Users correlate the rapid expansion of ponds to the growing malaria incidence. On the other hand, close to 35% of RWH-Users state “malaria has nothing to do with the expansion of RWH in the locality”. Given the information that most of the prior RWH beneficiaries were PA officials, some RWH Users might try to conceal the health related problems of RWH intervention.

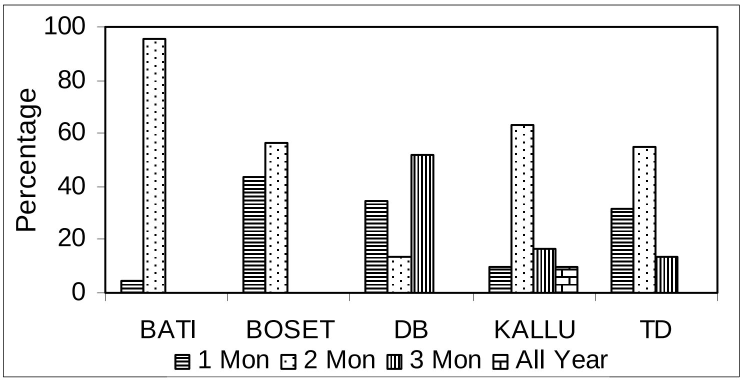

Figure 9: Average duration (in months) of malaria incidence in a household in a year

Households in *Tehuledere wereda* reported that DDT sprays are still used in a few pocket areas of their localities. This service follows the malaria map which was prepared some three decades ago, during the Imperial Period. While areas of malaria disease have gradually expanded to higher elevation areas since then, Ministry of Health personnel still rely on the obsolete malaria maps and as a result the eradication efforts have not been successful.

Of the five sample *weredas*, the majority of respondents in *Dugda Bora* and *Kalu* have stated that the health condition in the locality have worsened after the promotion of malaria in their respective areas. On the contrary, the majority of respondents in *Boset* and *Bati* have noted the improving status of health condition despite the expansion of RWH activities in their respective localities.

However, it would be very controversial to attribute the resurgence of malaria to the expansion of RWH in the country. As witnessed in east African highlands, malaria has shown rapid expansion in highland areas which used to be non-malarious. Therefore, it is worth noting that the recent malaria resurgence, especially in RWH expansion areas, is compounded with the changes in the climatic and eco-epidemiology.

4. POLICY ANALYSIS

There are several policies and proclamations in Ethiopia with which rainwater harvesting practices are directly or indirectly connected. The most important ones include, Water Resources Management Policy (1999), Water Resources Management Proclamation (No.197/2000), National Agricultural Research Policy and Strategy (1993), Food Security Strategy (1996), National Policy on Ethiopian Women (1993), Rural Land Administration and Use Proclamation (No. 456/2004), Environmental Policy of Ethiopia (1997), National Fertilizer Policy (1999), the Health Policy (1993), and Public Health Proclamation (No. 200/2000).

The following policy issues were drawn from the findings of the research:

4.1 Targeting: RWH is a labor intensive activity which requires profound expenditure of household's physical labor. The digging activity, even under the incentive packages, was the responsibility of the beneficent household. The beneficiaries undertake such arduous activity through collective labor called "*debbo*". People participate in *debbo* provided that there is mutual benefit. This implies that strong and able men would selectively team up for digging ponds. Such practice has resulted contrary to the envisaged goal, i.e., the exclusion of the poor. It implies that the poor section of the society, which includes women-headed and physically-weak households, would be marginalized eventually. In the survey, however, none of the sample households were female headed.

4.2 Biases in Approaches: knowingly or unknowingly, RWH practice in Ethiopia has suffered from various types of biases. For instance, the expansion is biased towards areas where the climatic conditions are semi-arid. As can be seen from the literature, RWH is associated with arid and semi-arid conditions. This is from the misconception of several individuals that RWH could turn arid and semi-arid environments into green areas. However, even areas of temperate climatic condition, which are supposedly receiving adequate annual rainfall, have been suffering from crop failure due to uneven distribution of rainfall. The role of RWH to buffer dry spells has not been given due consideration. The other RWH bias is the higher tendency to utilize RWH for the cultivation of horticultural crops. Experiences in China show that cereal productivity could be increased by 40% through the use of RWH. As the share of cereals in the Ethiopian agriculture is very significant, the diversification of RWH to support cereals is an important venture. The other bias is towards concrete and plastic membrane lining. An attempt to use local and low cost materials (for instance clays) has been ignored. In some places, ponds were dug while there were small rivers which could be diverted easily.

4.3 Subsidy: subsidies are important strategies to bring about useful outcomes. In Ethiopia, soil and water conservation activities have been heavily subsidised. Such assistance was made not because the economic return was anticipated in a short period of time. Rather, it was because the effort pays off in the long run. In the initial stage of RWH there had been subsidies to the RWH Users, and few households have benefited both for digging and construction materials. However, the government has decided to avoid such assistance, with the exception of reduced geo-membrane sell. However, several farmers are not in a position to afford the RWH maintenance, let alone the new making.

During the FGD, several farmers have objected to the decision of the government. The question would be “which comes first”: rehabilitation of degraded land or ensuring food production through expansion of ponds? Farmers argue that government should continue to support pond construction.

4.4 Linkages: RWH is a crosscutting issue, and various forms of linkages, i.e., institutional, professional, and the like are mandatory. It requires the involvement of professionals like civil engineers, agronomers, health practitioners, crop protectionists, economists, environmentalists, etc. Likewise, the strong linkage within sectors of the government (e.g., Ministry of Agriculture, Water Resources, Health, etc.) and cooperation with NGOs and research institutions is imperative.

Currently, the RWH practiced in Ethiopia is new to many farmers of the survey areas. However, there have been traditional RWH practices still operating in some parts of Ethiopia. Therefore, trying to modernize the cultural practices, or making the modern ones an outgrowth of the traditional ones is a noble exercise. The need to establish linkages between investment in RWH and rural micro-credit services is another important issue. In all the surveyed areas, however, the available micro-credit services have not been tuned to the expansion of RWH. Hune (2004), too, noted that the availability of credit facilities for RWH in Ethiopia is limited.

4.5 Knowledge Base: Before the launching of RWH, prior experiment was conducted in the areas around Nazareth, which is found in the rift valley, characterized by erratic rainfall, sandy soil, deep water table, etc. It was the technology generated from this area which was diffused to the rest of the country. The approach has been “one size fits all”. Knowledge obtained from such experiment has two practical limitations. First, the area selected for experimentation was not representative enough for the whole country. However, the climates of Ethiopia are varied and varying; varied because they range from ‘*Wurch’* (cold climate at more than 3,000 masl altitude) to ‘*Bereha’* (hot and dry semi-desert lowlands). They are *varying* because all these climates exhibit differing degrees of temporal variability, particularly with regard to variability. When such variabilities are overlaid on the diverse socio- economic conditions, the result would be a very intricate environmental condition. Therefore, adopting the rift valley-generated technology to the diverse and heterogeneous environment would be a futile exercise. The second limitation is that the available knowledge was mainly of the engineering (mainly structural) and cost analysis type. Information on water lifting mechanism, irrigation scheduling and the amount, crop protection, storage systems of vegetables, the maintenance of ponds, etc., were not addressed.

4.6 Policy Interface: available policies, which have direct and indirect relationship with the RWH activity, need to have been harmonious. However, it was found out that while the Ethiopian Water Resources Management Policy (1999) states that “any water which is collected in a neighborhood is considered dangerous as it proliferates malaria” (2006) but the food security strategy” of the country has put the collection of water in the form of ponds as a strategic intervention in rural areas.

***4.7 Tenure Security*:** Secure land tenure rights are essential to induce farmer investment in RWH technology and maintenance. Why did RWH beneficiaries prefer to locate ponds very close to their homesteads? Why are these beneficiaries interested in adding new ponds to be located at the farthest distance from homesteads? Such questions relate to the problem of land insecurity in the past, and one can see the nexus between proximity of ponds to homesteads and the new Land Use Proclamation. Security of tenure is one of the policy challenges that must be addressed if RWH expansion is to reach the scale. Having land security has a positive effect on the poor's willingness to invest in farming improvements.

Here, an important point to note is the land insecurity problem that used to discourage farmers from locating their RWH ponds at distances far away from their residence unit. However, the provision of Rural Land Administration and Use Proclamation (No. 456/2004) is found instrumental in encouraging farmers to locate ponds at far away distances from their households. The second Five Year Plan of Ethiopia states that about 13 million farmers would get land holding certificates, and this is a step forward. However, there are still various factors of land tenure insecurities, which play a disincentive role to invest in RWH and tree planting at distant farmlands.

Plate 8: Rainwater cooperatives could be ideal conduits for technology transfer and improvement (*Boset*, Oromia)

4.8 Local Institutions: Assisting local institutions through cooperatives (Plate 8) bears an important contribution to the efficiency of RWH technology. First of all, it facilitates the technological diffusion. Secondly it makes the technical support of the government and NGOs easier and faster. Finally, it could assist poor sectors of the society (i.e., female-headed, elders, physically-weak households, etc.) to be RWH beneficiaries.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In the face of rising rural population density, emerging climate change, and ever intensifying land degradation problems of Ethiopia, the importance of RWH is not only unquestionable, but also a survival strategy. Potentially, RWH is the right intervention for attaining food security in Ethiopia. However, only a fraction of the potential is realised so far. In this regard, RWH has hardly benefited from scientific research outputs, and monitoring systems. RWH was neither pro-poor nor women-centered. This has serious implication for not meeting the MDGs. To avert the potential limitations and maximize the benefits of RWH as a strategy for poverty reduction, new policies are needed. By resolving the biophysical, socioeconomic and policy constraints of RWH, it is possible to improve the situation of millions of poor farmers through reduction of vulnerability to crop failure, malnutrition and seasonal food deficits. The downside of RWH, however, is the proliferation of malaria sickness, which could be mitigated through efficient management practices. Therefore, weaknesses of RWH observed in some parts should not imply its abandonment, but rather should bring about a new role for institutions who are directly and indirectly involved in RWH.

There are three basic factors to consider with regard to RWH system: it should offer food security; it should contribute to improved land management practice; and it should contribute to intensive agriculture and reduced risk and it should capacitate the vulnerable section of the society. A broadened approach to RWH is therefore critical for improving the livelihoods of communities, particularly for those in areas where rainfall distribution is unreliable.

6.2 Recommendations

With the major findings of the research and the conclusion drawn, the following policy issues and processes are suggested for critical consideration:

i) There should be enhanced space for dialogue and information exchange among various stakeholders and sectors. Farmers should be involved at all stages of the planning, designing, implementation, and monitoring of the RWH system.

ii) Integrated institutional arrangements should be promoted to co-ordinate and streamline the design, implementation and evaluation of RWH technologies. There is an urgent need for a systematic approach.

iii) The close links between RWH, biophysical and socioeconomic factors have to be more widely recognized and translated into adequate governance activities. To do so, there should be on-farm trials for various RWH types at different locations, land use, soil, and slope types. A database which is specific to the agro-climatic zones, on soil, land use, cropping pattern, rainfall amount and distribution, and water resources should be developed as a national inventory of the potential of RWH. Defining the appropriate role of MoA vis-à-vis other sectors would be critical to put the RWH strategy right.

iv) Water management should be seen as one strategy of maintaining food security, and RWH should be synergized with other strategies to foster sustainable development.

v) Opportunities for equal access of women and other marginalized farmers to the benefits of the RWH should be provided; and the relation between land tenure, RWH rights and the introduced water harvesting technologies should be carefully considered.

vi) Policies relevant to RWH should be reoriented in the right direction. Sectoral policies affecting RWH should be harmonized.

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