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SCHOOL OF GRADUATE STUDIES
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**Determinants of Household Food Security with a particular
focus on Rainwater Harvesting: the case of Bulbula in Adami-Tulu
Jido Kombolcha *Woreda*, Oromia Region**

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in
Partial fulfillment of the Requirements for the Degree of Master of Arts in Development
Studies (Environment and Development)

By

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Title

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Acknowledgements	i
List of tables	iv
List of figures.....	v
List of tables in the annex	vi
Abbreviations	vii
Abstract	viii
Chapter One.....	1
Introduction.....	1
1.1 Background of the study	1
1.2 Statement of the problem	2
1.3 Objectives of the study.....	3
1.4 Research questions.....	3
1.5. Scope and limitation of the study.....	4
1.6. Significance of the study.....	4
1.7. Organization of the thesis	5
Chapter Two.....	7
Literature Review	7
2.1. Definition and concepts	7
2.1.1. Food security	7
2.1.2 Household food security.....	9
2.1.3 Measurements of food security and its indicators	10
2.1.4 Food security situation in Ethiopia.....	16
2.2. Meaning of rainwater harvesting	17
2.2.1 Classification of rainwater harvesting.....	19
2.2.2 Rainwater harvesting in Ethiopia	20
2.3 Challenges of RWH implementation	22
2.4. Empirical evidences on determinants of household food security	23
2.5. Conceptual framework.....	26
Chapter Three.....	29
Description of the study area.....	29
3.1. Location.....	29
3.2. Major economic sector, land use, crop and cash crop type	29
3.3. Vegetation and wild life	30
3.4. Geology and Soil	31
3.5. Climate	31
3.6. Population.....	32
3.7. Food security situation of the study area.....	32
Chapter Four.....	33
Research Methodology	33
4.1 Sampling design, the study population and sampling method.....	33
4.2 Data collection	34
4.2.1 Primary data.....	35
4.2.2. Secondary data.....	35
4. 3. Method of data analysis	35
4.4. Definition of variables and hypothesis	36

4.5. Model specification.....	40
Chapter Five.....	43
Over view of practice and challenges of RWH in Bulbula	43
5.1. Over view of RWH implementation and trends in the study area	43
5.2. Types of RWH method in Bulbula	46
5.3. Challenges of RWH implementation in Bulbula	47
Chapter Six.....	50
Background of sample households.....	50
6.1. Description of household, demographic and socio-economic characteristics of the sample households.....	50
6.2. Bivariate association of some households characteristics, socio-economic, resources endowment, inputs supply and institutional issue factors with food security status of the households	53
6.2.1. Households characteristics	53
6.2.1.1. Age and food security.....	53
6.2.1.2 Dependency ratio and food Security	54
6.2.1.3. Educational status of the HH and food Security	54
6.2.2. Resource endowment.....	55
6.2.2.1. Labor availability and food security	55
6.2.2.2. Oxen availability, livestock availability and food security	56
6.2.2.3. Farm land size and food security	58
6.2.3. Inputs Supply	59
6.2.3.1. Use of fertilizer and food security	59
6.2.3.2. Credit service and food security	60
6.2.4. Institutional issue.....	61
6.2.4.1. Land tenure issue and food security	61
6.2.4.2. Market accessibility and food security	63
6.2.5. Role and association of RWH to Income and food security of the household.....	64
6.2.5.1. Rain fed income in the participants and the non-participants in RWH.....	65
6.2.5.2. Income from Asset (livestock) in the Participants and Non-participants in RWH.....	67
6.2.5.3. Aggregate income and food security	67
6.2.5.4. Engagement in RWH and food Security Status	68
Chapter Seven	71
Econometric model estimation	71
7.1. Food security determinants.....	71
Chapter Eight.....	80
Conclusion and Recommendation.....	80
8.1. Conclusion	80
8.2. Recommendation	83
Reference	86
Annex	92

List of tables

Table 1. Sample size determination from Homogenous population.	34
Table 2. Variable codes, Definitions and Measurement of Independent variables	39
Table 3. Sex and Age composition of the sample Households (N=140).....	51
Table 4. Education status and age in sample households.....	52
Table 5. Oxen, livestock (excluding oxen), labor and farm land size per sample households....	52
Table 6. Age in the sample Households by status of food security.....	53
Table 7. Dependency ratio in the sample households by status of food security	54
Table 8. Education Status of the HH by status of food security.....	55
Table 9. Labor availability in sample HH by status of food security.....	56
Table 10. Oxen availability in the sample HH by status of food security.....	57
Table 11. Livestock's availability in the sample HH by status of food security.....	58
Table 12. Farmland size in the sample HH by status of food security.....	59
Table 13. Fertilizer users in the sample HH by status of food security.....	60
Table 14. Credit service utilization in the sample HH	60
Table 15. Purpose of credit used and reason for not using credit service in the sample HH	61
Table 16. Land Tenure security in the sample HH by status of food security	63
Table 17. Land insecure/secured HH felling of threat /expectation in the sample study HH ...	63
Table 18. Market accessibility in the sample households by status of food security	64
Table 19. Annual income generated by sample households from the RWH participants.....	65
Table 20. Annual income generated from rain fed in the sample Households survey	66
Table 21. Annual income from Livestock sale in the sample households	67
Table 22. Aggregate income of the sample households by status of food security.....	68
Table 23. Food security status in the sample household by the engagement in RWH.....	69
Table 24. Households Calorie Consumption per AE per day by engagement in RWH.....	70
Table 25. The maximum likelihood estimates of Binary Logit Model (BLM).....	73

List of figures

Figure 1 Classification of RWH	20
Figure 2 RWH, Household characteristics, External factors and Food Security Linkages.....	28
Figure 3. Map of Adami Tulu-Jido Kombolcha <i>Woreda</i>	30

List of tables in the annex

Table A-1. Conversion factor used to estimate Tropical Livestock Unit (TLU).....	92
Table. A-2. Conversion factor used to calculate Adult Equivalence (AE).....	92
Table A-3. Conversion factor used to estimate Person-days Equivalent (PE).....	93
Table A-4. Caloric content of the food consumed in the study area.....	93
TableA-5. Engagement in the new Cash crop producers in RWH participants	94
Table A-6. Comparison of oxen and Livestock (excluding oxen) before and after engagement in RWH.....	94
Table A-7. Marriage status per age of the household head.....	94
Table A-8. Variance Infiltration Factor for the test of co-linearity among Continuous Variables.....	95
Table A-9. Contingency coefficient test for co-linearity between categorical variable.....	95
Table A-10. Bivariate Association of some Continuous Households characteristics, Socio-economic, Demographic and Institutional issue factors with Food Security Status of the Households.....	96
Table A-11. Bivariate Association of Categorical variables: household characteristics, socio- economic, Demographic and Institutional issue Factors with Food Security Status of the Households	96

Abbreviations

AE: Adult Equivalence

C: contingency Coefficient

DD: Dietary Diversity

DPPC: Disaster Prevention and Preparedness Commission.

FAO: Food and Agriculture Organization

GHA: Greater horn of Africa

HH: Household

HCA: Household Caloric Acquisition

IFI: Individual Food Intake

IHCS: Indices of Household coping Strategy

Mo A: Ministry of Agriculture

NCFSE: New Coalition on Food Security in Ethiopia

PA: Peasant Association

RWH: Rain water Harvesting

SSA: Sub- Saharan Africa

SASE: Semi-arid and Savannah Environment

SPSS: Statistical Package for social science

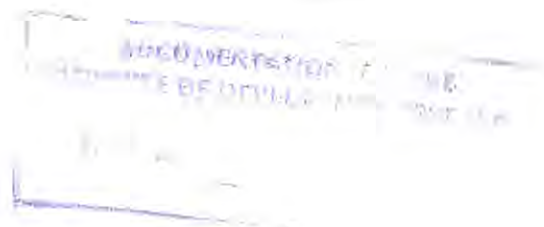
TLU: Tropical Livestock Unit

VIF: Variance Inflation Factor

WP: Water Productivity

Abstract

This study was conducted with the objectives of assessing the status and determinants of food security, to examine the contribution of RWH for food security and to explore practices and challenges of RWH in the study area. To that effect, primary data of the household survey and secondary data was used. The study area was selected through a multi-stage purposive sampling technique. In addition, simple random and purposive sampling techniques were used to select respondents and key informants and focus group discussion respectively. For analysis purpose the study employed both qualitative and quantitative. Basically, for the qualitative data analysis triangulation method was used whereas for the quantitative data descriptive statistics (percentage, mean, SD), bivariate and multivariate analyses were used. To decide the food secured and insecure households 2100Kcal was taken as a cut off point on the bases of 14-days food consumption of the households. Accordingly, 65% of the households were found to be food secured whereas 35% food insecure. The result from multivariate logistic regression analysis indicated that age, labor and market accessibility have shown significant and negative effect to food security whereas cultivable land size, fertilizer utilization, engagement to RWH and the interaction effect between education status and income category have shown significant and positive role for food security. Furthermore, the result from the qualitative data indicated that the overall trend of RWH adoption in the Woreda was found to be declined from time to time. However, a recent development around Bulbula shows an increase in the self-initiated adopters' in RWH. The finding of the study further revealed the challenges for the adoption of RWH to be institutional, technological and adopter's financial limitation. Thus, policy programming should be based on the rudimentary of the precise determinants of food security status and alleviation of challenges for the adoption of RWH. Further consecutive, rigorous and intensive research in this area clearly called for by the finding of the study.



Chapter One

Introduction

1.1 Background of the study

In Ethiopia the blend of man made and natural factors results serious and growing food insecurity problem, which expose five to six million people to chronic and transitory food insecurity problem each year. In addition, ten million people are exposed to vulnerable, with weak resilience (FAO, 2006). Thus, in order to withstand this problem there is a need to improve technologies of agriculture production to ameliorate the economic, social and institutional conditions necessary of the people (Mekuria, 2003).

Paradoxically, Ethiopia is considered as the 'water tower' of Eastern Africa even though only about 32% of the total population has access to clean and safe water. The potential irrigable land area of the country is estimated to be about 3.5 millions hectares. Despite its abundant water resources and irrigable land potential, so far 5.7% of the potentially irrigable land is believed to have been developed. Most of the farmers are unable to utilize the abundant water resources (Tesfaye, 2005).

At the same time, the potential for rainwater harvesting(RWH) per person is estimated to be 11,800 cubic meters as compared with annual renewable water resources-rivers and ground water, which is 1,600 cubic meters (UNEP, 2006). In quite similar way, Getachew (1999) described that Ethiopia is still endowed with enormous land and water resource potential that can be transformed into a dependable source of energy and food supply. Ironically, it is still one of the most drought prone countries in the world. Yet, much of Ethiopia's economy requires adequate and reliable rainfall for agricultural production. Over the years, scanty and erratic rainfall has led to significant crop losses and in some cases total crop failure. This means millions of people have been affected (Eyasu et al., 2007).

In technical terms of agronomic view, Ethiopia presently requires 57 Billion meter cube of water per year, which is nearly 50% of the existing potential to produce enough food sufficient to feed its 75 million people with adequate calorie requirement (2100 kilo Cal). However, the means and know how to harness available water resources into productive

use remains a difficult task. In addition, with the present practice and trend, water resource management remains challenging (Getachew, 1999).

Getachew (1999) further indicated that, the strategy pursued by the government to cope with the challenges of drought and food insecurity is broad based and RWH at present received a wider acceptance by policy makers. Nevertheless, the technological and investment options are limited, and the holistic approach to water security to meet the growing food need on a sustainable basis is still challenging and remains difficult task. Thus, would it be successful to combat food insecurity using RWH strategy in the study area?

1.2 Statement of the problem

Ethiopia is one of the most drought prone countries in the world. Much of Ethiopia's economy depends on agriculture, which is conditioned by adequate and reliable rainfall. Over the year, scanty and erratic rainfall has led to significant drought and subsequent famine (Eyasu et al, 2007). Every year five million people exposed to chronic and transitory (seasonal) food insecurity in particular to rural area (Workenh, 2006). The same study indicated that there is deep impoverishment and food insecurity in the country.

The study area-Bulbula has been subjected to repetitive chronic and transitory food insecurity problem in different years (DPPC, 2000; DPPC, 2002; DPPC, 2003; DPPC, 2004; DPPC, 2005).

In order to fight poverty and famine by insuring food security at household level, effective use of water resource is vital. RWH is one strategy used to increase agricultural productivity and improve the households' income (Getachew, 1999).

Adami-Tulu Jido Kombolcha *Woreda* particularly the study site Bulbula is characterized by drought and lack of moisture, which subject the people into chronic and transitory food insecurity problem. Moisture conservation and RWH to enhance agricultural production in the *Woreda* happen to be the most prominent activity implemented by the government since 2002. There has been limited or no effort to systematically and to analytically study the contribution of RWH on households' food security in the study area. There are some

researches made on the performance of RWH structure for food security such as by Eyasu et al (2007) dwell on the idea of profitability of pond to well system for production, and Danile (2007) dwelled much on policy issue and implementation of RWH. However, this study is different from the above studies in two ways. First, in the area context since food security differs from place to place. Second, this research will examine the determinants of household food security and explore local based challenges and practice of RWH, which were not considered in the studies mentioned above.

Furthermore, the implementation of the package was based on a single trail in Adama throughout the country, the practicability of the package to meet the objectives it was designed for need to be studied under a different context. Furthermore, a food security situation differs from place to place with respect to different agro-ecological context, local socio-economic situations and demographic factors that need to be studied in detail with in the selected study area.

1.3 Objectives of the study

The General objective: is to systematically examine the determinants of household food security and role of RWH for households food security in Bulbula and hence to recommend possible solutions to ameliorate the implementation of the package (RWH).

The specific objectives:-

- a. To identify determinants of household food security in the study area.
- b. To study the role of RWH for food security in the study area.
- c. To explore the practices and challenges of RWH in the selected study area.

1.4 Research questions

With the aims of addressing general and specific objectives of the study, the research work will be guided by the following specific questions:

- a. What are the determinants of household food security in the study area?
- b. What is the role of RWH to household food security?
- c. What are the practices and challenges of RWH in the study area?

1.5. Scope and limitation of the study

Scope: the research study is limited to address the mentioned objectives. Furthermore, the study is limited to Adami-Tulu Jido Kombolcha *Woreda* by purposively sampling Bulbula and its surrounding rural *kebeles*'

Limitation: During the data collection process, the researcher faced a number of problems. These problems were associated with farmers' recalling capacity, attitude of being suspicious and food aid expectation. Since farmers do not keep records their income and the information needed the collected data is very much dependent on his/her ability to remember what they did a year before. Hence, it is difficult to believe that all information given by respondent farmers is correct. Therefore, in order to minimize the problem the interview was conducted in the presence of the most knowledgeable members of the family.

Another problem, which was noted, was farmers suspicious to tell the right information especially with regard to their annual production, marketable surplus, and land size because of fear of taxation. In order to minimize this problem, DAs (Development agents) who are familiar with them were used to collect the data and they were taking some time to explain the purpose of the survey before embarking on the interview. The other problem could be lack of the consideration of women headed households could possibly magnify the percentage of the food secured households.

1.6. Significance of the study

The findings of this study will be useful in many ways. To begin with, it provides base line data on the determinants of household food security and role of RWH for household food security. It will serve in the future as the spring board for further studies and show how local government bodies in particular, development practitioners and policy maker in general should intervene to facilitate development intervention. It can also serve as a source in identifying the challenges and the practices of RWH in the area. Lastly, the result of the study can also contribute in building knowledge base for the academic, research, and envisages empirical evidences.

1.7. Organization of the thesis

The rest of the thesis is organized into seven chapters. Chapter two reviews the literature, chapter three describes the study area, chapter four explains the methodology of the study used, through chapter five to seven result and discussion, and last chapter(eight) give concluding remark about the over all study.

Chapter Two

Literature Review

2.1. Definition and concepts

2.1.1. Food security

The dynamic nature of food security makes it to have different definition that evolved over time (Hoddinnott, 1999; FAO, 2003). The comparison of these definitions shows the considerable rethinking and reconstruction of officials thinking on food security over the past 25 years (FAO, 2003). Food security as a concept emerged in the mid 1970s, in the discussions of global food crisis (Maxwell and Wiebe, 1999). The initial focus of food security was the one given by UN in 1974, which focused on food supply and price stability of basic consumable foodstuffs (FAO, 2003). This definition stated food security as “availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices” (UN, 1975, cited in Clay, 2002:2). This definition only indicates availability of sufficient food at a global level, yet it does not guarantee that every one has access to enough food at an individual or household level. Furthermore, it proposes a stable price as a means to ensure entitlement of food.

As a result, in 1983, FAO took up the center stage into further re-shaping the definition of food security to accommodate a new insight into securing access to vulnerable people to available supply of food. In other words, it was defined to maintain the balance between demand and supply sides of food security equation. It is stated as: “ensuring that all people at all times have both physical and economic access to the basic food that they need.” (FAO, 1983, as cited in FAO, 2003:27). However, this definition does not tell us whether what individuals consumed is enough or not. Apart from this, it fails to show to what extent the consumed food has nutritional value for active work.

Realizing the aforementioned gap, in 1986 the most influential definition of food security concept was introduced by World Bank. This definition happens to encompass broader sense of food security and the clear distinction between chronic food insecurity and

transitory food insecurity, which are caused by the natural disaster, economic crisis and conflict (Maxwell and Wiebe, 1999). This definition entitles mankind to have unlimited “access of all people at all times to enough food for an active, healthy life.” (World Bank, 1986:1) and takes the availability of food and the ability to acquire as its integral essential elements.

There are four core concepts, implicit in the notion of “secure access to enough food at all times”. These are: (a) access to enough food, defined by entitlement to produce, purchase or exchange food or receive it as a gift. Debebe (1995) explains lack of physical, human or social resources causes people’s access to fall below their subsistent need; (b) sufficiency of food, defined mainly as the calories needed for an active, healthy life; (c) security, defined by the balance between vulnerability, risk and insurance and (d) time, where food insecurity can be chronic, transitory or cyclical.

In the mid 1990s the new definition of food security, which ranges from individual to global level was inculcated. It happens to incorporate food safety and nutritionally balanced diet, which reflects the composition of the food. It also shows the food preference of the society needs to be considered as the component of human right makes the definition very complex (FAO, 2003). This definition was given by FAO in 1996, as “food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.”(FAO, 1996, as cited in FAO, 2003:28).

According to FAO (2003), food security is a situation related to an individual, nutritional status of the individual household that needs to be pivotal for food security where the essential element in this case is the introduction of social dimension of food security. Thus, the working definition of this study is the one given by FAO (2003:28), which is in line with the objectives of the study. Hence, food security exists “when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.”

Household food security is the application of this concept to the family level, and includes individuals within households as the focus of concern.

2.1.2 Household food security

The concept of household food security is a more recent development and the bulk of literature dated from 1980s equating national food security with food self-sufficiency is a problem that needs to be clearly understood. This indicates that attaining a macro-level food sufficiency does not ensure the achievement of household level food production and investment in food production and storage. It is necessary but not sufficient to solve household level malnutrition and food insecurity problems (Rukuni, 2002, as quoted in Workicho, 2007).

Debebe (1995:8) indicates that household food security is mainly conditioned by factors, which are related to the process of "...acquisition, household procurement strategies and socio-economic condition of the society." Access to different resources and the pattern of social support have greater impact on the procurement strategies of food supplies. The basic resources like cash, labor, land, market and public services determine the possibilities of increasing entitlement to food, which are the key components for either promoting food security or aggravating vulnerability to food insecurity. However, none of them by their own right are sufficient to affect the food supplies. The key elements that are critical to household food security are availability and stable access. The former is further influenced by the different source of food and handling patterns, which facilitate the time dimension of food availability in the household.

Besides, household is identified as food secured if entitlements of demand for food security is greater than food needs, which is defined as the aggregation of individual requirement. At individual level, the definition is much straightforward. An individual is food secured if his or her food consumption is determined by the claim the individual has on household food source. This may be affected by individual earning or asset or by individual position in the household (Thomson and Metz, 1997).

Above all Maxwell and Smith (1992) strongly argue that household food security is a complex issue that needs to see the food security status of different household members (intra-household bargaining), nutritional content of the food consumed, livelihood security, ecologically resilience and cultural acceptability of the consumed food item.

2.1.3 Measurements of food security and its indicators

Food security indicators are defined as the summary measures of one or more of the dimensions of food security used to show change or the results of a certain program intervention (Riely et al. 1999).

There is no single indicator to measure food security at all times as it is not self-sufficient (Workneh, 2006). The need for different types of indicators is inevitable to capture the various dimensions of food security at a country, household and individual levels (Hoddinnott, 1999). In the study of food security status in developing countries different types of indicators should be used in order to handle the multiple dimensions of the problems. These multiple methods are: food production, income, and total expenditure, share of expenditure on food, calorie consumption and nutritional status (Riely et al., 1999).

Food security is influenced by different interrelated socio-economic, environmental and political factors that require multidimensional considerations. As a result, assessing, analyzing and monitoring food security necessitates approaches ranging from a mere quantitative to a combination of both quantitative and qualitative measurements (Ayalew, 2003).

Frankenberge (1992) classifies food security indicators into two broad categories: process and outcome indicators. The former provide information on food supply and access. The availability of food is a critical dimension for household food security. Therefore, supply indicators give information on the likelihood of a shock or a disaster event that will adversely affect households' food security. This includes inputs and measures of agricultural production (agro-meteorological data), access to natural resources, institutional

development, market infrastructure and exposure to regional conflict or its consequences such as migration. Despite the limitation that they cannot detect asset availability of the vulnerable groups of the society, they have paramount significance in obtaining useful information regarding regional trends of food availability.

Food access indicators are used to show household food insecurity and the occurrence of famine situations were occurring despite the availability of food. In most cases they are called as coping strategy followed by the households in order to manage food insecurity problems. These include asset, risk-minimizing strategies, community inequalities and coping strategy pattern (Frankenberge, 1992). Frequently access indicators are used for food monitoring or in early warning systems at household level (RRC, 1990, as quoted in Debebe, 1995).

Some of the limitations of these indicators are: the raw data gathered for food monitoring or early warning systems may be misleading, unless baseline information about the 'normal' behavior of the population under study is not known. Owing to the area specificity of access indicators, it is very difficult to compare the outcome of different regions (Frankenberge, 1992). Unlike supply indicators their use vary from regions to regions, seasons to seasons and from one social stratum to other showing various strategies in the process of managing the diversified sources of food, income sources, and livestock sales (Debebe, 1995).

The other category of indicator given by Frankenberge (1992) is outcome indicators. Owing to the constraints of time and cost in collecting individual intake data for households, outcome indicators are usually used as a surrogate for adequate food consumption. The selection of surrogates indicators need to be considered as they show more than food consumption does. These indicators are further classified into two as direct and indirect indicators (Frankenberge, 1992).

Direct indicators are those indicators which approximately show the actual food consumption than the market channel or health status do. These include household budget

and consumption survey, which show the amount of money spent on food by individual or household. The other one is household perception of food security, which is described as the cultural acceptability of food items in times of food insecurity. The last one is food security frequency assessments that involve the collection of minimum amount of food consumption data, which is limited to the food items that constitute 90% of their diet (Frankenberge, 1992). It is simple and cost effective tool to detect the difference in food consumption among different households level (O'Brien-Place and Frankenberge, 1988, as quoted in Frankenberge, 1992).

Indirect indicators are used whenever direct indicators are unavailable or costly to utilize them. These categories of indicators comprise storage estimates, subsistence potential ratio and nutritional status assessments. Storage estimates indicate the amount of food stored to be used during food shortage times of the year. It is a very good indicator for household who can produce their own food. Subsistence potential ratio is used to compare the food produced with the sufficient caloric need by the households for the entire year. Nutritional status assessments are used to describe the prevalence of malnutrition in a population by measuring the nutritional status of an arbitrary sample of children less than five ages (Frankenberge, 1992).

Indirect indicators have a number of limitations. To begin with nutrition status assessments are usually used as late indicators of food security. Thus, it makes difficult to know the actual food security situation at the time of data collection. Furthermore, the use of age assessment as an indicator by comparing age with weight and height makes measuring food security problematic in nutritional status assessments method. Besides, storage estimates fails to show entitlement of food (Frankenberge, 1992). Von Braun et al (1992) further argued that food security at household level is best measured by direct surveys of dietary intake. Hence, the use of indirect indicators as measure of food security at household level is problematic.

The choice of indicators depends on its relevance, credibility, cost that is described in terms of time, personnel, and logistic, cost associated with data collection, processing and

analysis, comparability that is explained by its importance to show the impacts of one program on another, and resource allocation decisions between programs, time sensitivity and information use (to what purpose the information will be used determines the choices of an indicator) (Riely et al 1999).

Carletto and Morries (1999, as quoted in Tesfaye, 2003) argue that some indicators may be appropriate for monitoring purpose while others may be appropriate for outcome, supply or access indicators. It is up to the researcher to select a combination of indicators that suit the objectives of the investigation, the level of aggregation and specific circumstance of the study and study area. In a similar manner, Debebe (1995) argue that the objective and data availability matter most in the selection of food security indicators. Nevertheless, Riely et al (1999) emphasized that the choice of a particular indicator should lie in how to maximize the quality of the information and its benefit to decision-making against the costs of collecting, processing, and analyzing the information. Hoddinnott (1999) argue that process indicators are insufficient to characterize food security outcomes. A similar argument given by Chung et al. (1997, as cited in Hoddinnott, 1999) concluded that there is negligible relation between area level production and household food security.

Because of the above mentioned reasons as well as the objectives of the study, outcome indicators are preferred to process indicators. Of the outcome indicators, direct indicator is the one that shows food consumption or adequate calorie intake, which can give the desired objectives. In addition, they are cost effective and time saving. As a result, food consumption indicators from direct indicators will be utilized.

Hoddinnott (1999) lists four ways of measuring household food security outcome: individual food intake (dietary intake), household calorie acquisition, dietary diversity and indices of household coping strategies.

Individual Food Intake (IFI) is described as the measure of the amount of calorie or nutrient intake in an interval of time often within 24 hours. As to the data collection, there are two ways: the first one is an enumerator resides in the household throughout the entire day and

measure the amount of food each person served and prepared but not served food; the second approach is asking the responsible household member about the amount of food consumed within 24 hours and the food consumed outside the household. Then the data obtained will be converted into caloric content, using factor of convert quantities of edible portion. Later this intake will be compared with the minimum food needs. If it is done carefully it can give accurate amount of calories consumed by the individual and helps to measure the different level of intake among the household members. However, the data collection method is time consuming and demand experienced enumerator. In addition, it only gives the quantity of food consumed in calories (Hoddinnott, 1999).

Household Caloric Acquisition (HCA) is useful to measure the number of calories or nutrients available for consumption by household members over a defined period of time. The data will be collected for 7 to 14 days. Then the knowledgeable household member will be asked using a detailed questionnaire that consists of a list of food in an exhaustive manner (Hoddinnott, 1999). Then the total calorie content of those consumed foods will be calculated to derive a daily calorie intake per capita for each household (Iram and Butt, 2006). It is a crude estimate of the number of calories available for consumption in the household. Since the data collection is based on the memory of the respondent there may be edible portion, which can be forgotten and hence the data will be distorted. It lacks to capture food consumed outside the house. It does not incorporate considerations of wastage, nor is it possible to uncover differential allocations of food among household members. Yet, it is less time demanding than IFI and possible to see the quality of food consumed (Hoddinnott, 1999).

Dietary Diversity (DD) is described as the arithmetic sum of the number of different food group consumed by an individual in a given interval of time. The data collection will be done by asking the member of the household about the different food items consumed in a specified period. There are two possible methods of calculating it. The first one is by simple summing of the different food items consumed over the specified period. The second one is calculated by weighted sum, where the weights reflect the frequency of consumption. It is the most common type of measurement used in developing countries and

it is time effective and unlike any of outcomes indicators measurement it measure quality of food consumed. Thus, it is very problematic to calculate the caloric content of the consumed food items. Hence, it has a limitation of not recording quantity consumed by the household. (Hoddinnott, 1999).

The last type of measuring food security is by using Indices of Household Coping Strategies (IHCS). It is explained as the mechanism by which the household follows in order to cope up the threat posed by the food shortage. The data collection will be done by interviewing a member of the household, who is in charge of preparing and serving food for the household members. There are many ways to summarizing the information gathered. The first is by counting the number of different ways that the household uses as the strategy to cope the challenge. In this case the higher the different coping strategies the higher the rate of food insecurity. The second is by calculating the weighted sum of the different coping strategies, where the weight shows the frequency of use by the household. The decision will be the higher the weight, the high the rate of food insecurity. Despite simplicity and time effectiveness, it has several disadvantages to mention: it is subjective measurement, comparison among household member and locality is difficult and its simplicity makes it relatively straightforward to misreport a household situation (Hoddinnott, 1999).

All of the measurements described above are valid indicators for measuring household food security in different dimensions. Dietary diversity and indices of coping strategy are easier and less expensive to collect and analyses than measure of caloric acquisition and dietary intake (Hoddinnott, 1999). However, both cannot give as the actual food consumption or calorie intake, which makes measuring food security problematic. One of the common indicators used to measure household food security is caloric adequacy (Maxwell and Smith, 1992; Iram, and Butt, 2004). Therefore, the use of household caloric acquisition for food security measure is advantageous for the reason that it will help to measure the quantity consumed and the calorie content. Hence, the research will make use of household caloric acquisition for measuring food security status in the selected study area.

2.1.4 Food security situation in Ethiopia

Ethiopian agriculture is dependent mainly on traditional farming and rain fed methods with a very limited use of improved technologies. Over the past many years, the pattern, amount and distribution of rainfall have been deteriorating with several bad years in terms of food production in (1985 and 1994) during drought years, which indicated that the production trend is very much correlated with the rainfall trend (Kifle and Yoseph, 1999). As a result of this and other factors, Ethiopia has been suffering from both chronic and transitory food shortages. Three major famines have occurred in the country during the last successive decades (1974, 1984/85, and 1994) claiming the lives of many Ethiopians (Kifle and Yoseph, 1999).

For more than three decades only in 1960s, that Ethiopia was able to meet the need for food to its growing population. However, since the late 1960s up to present time the population numbers out stripes the production. Hence, the people are unable to meet their dietary needs (Markos, 1997, as quoted in Feleke et al., 2005).

A food security situation studied by Kifle and Yoseph (1999) in Ethiopia shows that over the past many years the agricultural sector has brought insignificant change. Total food production ranged between 5.05 million metric tones in 1985 and 10 million metric tons in 1994, and food grains accounted for an average of 85% during 1985-1991, and the overall food production showed steady increasing followed by a decreasing trend between 1991 and 1994.

The population of Ethiopia is among the most food-insecure in Africa. This is due to its deep-rooted poverty. Ethiopia's GNP per capita in 1995 was USD 100 against an average of USD 507 for the entire Sub-Saharan Africa for the same year (Thrupp, 1999, as quoted in Abeje, 2004). There is also a big contrast with respect to the level of daily calorie supply. According to a UNICEF (1992, as quoted in Feleke et al., 2005) during the period 1988-1990 the daily calorie supply, as a percent of requirement was only 73 percent, while Sub-Saharan Africa as a whole met 93 percent of its requirement for the same period.

Increasing unemployment in both the rural and urban areas, severe shortage of farmland holdings exacerbated by rapid population growth, declining soil fertility through centuries of soil erosion, low growth due to inappropriate development policies, and recurrent drought in parts of the country are among the most important contributory factors for the increasing food insecurity in the country that is why in most instances food insecurity turns out to be famine and catastrophic food hunger when there is shortfall (Seleshi, 2005, as quoted in Workicho, 2007).

According to Debebe and Maxwell (1992, as quoted in Workicho, 2007), the number of people that annually suffers from transitory food insecurity is found in the range of 2-5 million. The figure was 10 million in the year 2000 which accounts 15% of the population and in 2002/03 the magnitude so big to reach up to 22% of the total population (Abeje, 2004).

Ramakrishna and Demeke (2002:128) indicated that "...Famine and food insecurity have been geographically concentrated in two broad zones of the country. The first one is consisting of central and northern high land through Wollo and Tigraye and the second is stretching from Wollo through Hararge and Bale to Sidamo and Gamogofa."

Looking into the total food imports during 1980-1994, on average food imports accounted for about 19% of the domestic supply. In 1992, for example, nearly one million metric tone of aid was imported for an estimated 7.85 million disaster/drought-affected population (DPPC 1994, as quoted by Kifle and Yoseph 1999). Thus, all the above facts will put the country in food deficit for the last two decades. Hence, ensuring food security to the broadest segments of the society is a crucial question that needs to be addressed. That is why the government of Ethiopia included RWH as the mechanism to enhance the food security and to combat poverty situation in semi-arid areas.

2.2. Meaning of rainwater harvesting

The term Rainwater Harvesting (RWH) is used in different ways and there is no universally agreed definition (Ngigi, 2003). Many authors have defined RWH in a different ways. RWH broadly defined as "... roof water harvesting, run-off harvesting, flood water

harvesting and subsurface water harvesting.” (Finkel and Segerros 1995, cited in Getachew, 1999:1). It is a very general definition that includes every form of RWH. However, it fails to show that to what purpose the collected water is used for. In specific manner, for Gould (1999:5) RWH is “...a general term which describes the small scale concentration, collection, storage and use of rainwater run-off for both domestic and agricultural purpose.” It tells the scale of the collected water and unlike the above definition it has mentioned to what purpose the water collected is used for. While there are other possible ways of obtaining RWH, it mentioned run-off collection as the sole means of obtaining rainwater. Furthermore, the use of collected water for domestic purpose is out of the scope of this research. Thus, this definition cannot be taken as adequate for this research work. Similarly, Bores et al. (1982:145) define RWH as “... a method for collecting, storing and conserving local surface run-off or stream flows for different use.” This definition is quite similar with the definition given by Gould (1995:5). Yet, it contains other means of water harvesting method, which is stream. However, water harvesting from stream is not the concern of this research. As a result it cannot be used as adequate definition for RWH in the context of this research.

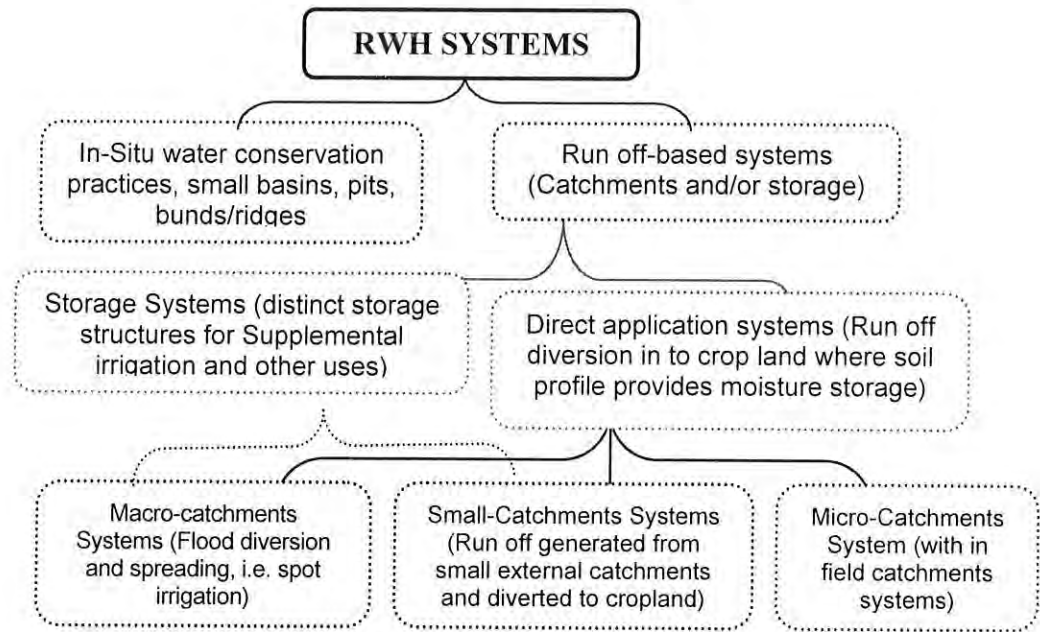
Nigigi (2003:5), defined RWH as “...the collection of run off for productive purpose- it includes all methods of concentrating, diverting, collecting, storing and utilizing and managing runoff for productive use.” This definition rather seems more meaning full as it includes all components of storing and collecting rainwater. Furthermore, it is specific to rainwater collection and include water management concept as integral part water utilization for sustainable manner. However, this definition fails to show different ways of obtaining rainwater except run-off collection. This limitation makes the definition incomplete. Thus, taking the blend of the all definitions mentioned above with a slight modification makes the definition of RWH complete, and it will be in line with the objective of this research. Therefore, for this research RWH is defined as: small scale collecting, storing, and concentrating, diverting, utilizing and managing of roof water, run-off, and flood water harvested for irrigation purpose.

2.2.1 Classification of rainwater harvesting

Different terminology has been used to describe the type and function of RWH system. These classifications are either based on the catchments, storage systems or their usage. The catchments based system mean either into roof or ground, while storage system includes cistern or pond systems. Based on the usage system it is classified as for agricultural, livestock, domestic, environmental, eco- tourism or industrial purpose (Maimbo et al, 2006). Therefore, different authors have used their own ways of classifying RWH system. Awulachew et al (2005) classifies rainwater harvesting in two: *in-situ* water conservation practices (small basins, pits, bunds/ridges), and runoff-based systems (catchments and/or storage). The storage system is usually used in supplemental irrigation. *In-situ* is a type of RWH systems that helps to enhance soil infiltration and water holding capacity. It has dominated over storage schemes in Ethiopia until recently (Awulachew et al., 2005). It is sometimes named as conservation methods, because it is basically used to hold the rainwater in the cropped area for prolonged time so that the infiltration capacity of the soil can increase (Maimbo et al, 2006). Despite the additional costs involved in storage schemes, the recent trend shows there is a relatively high degree of adoption.

Surface runoff from small catchments and roadside ditches is collected and stored in farm ponds holding an average of about 60m³ of water. This storage is not significant in volume but sufficient for supplementary irrigation of vegetables (Awulachew et al., 2005). The same source indicates that the use of storage systems can be extended to crop fields and larger plot sizes can be warranted through larger sizes of storage combined with efficient water application methods, such as low-pressure drip irrigation methods and conservation tillage. On the other hand, Ngigi (2003) classified RWH system based on run off generation process, types of storage system and size of catchments. More explicitly, he has illustrated the classification in the following diagram.

Figure 1 Classification of RWH



Adopted from Ngigi (2003)

2.2.2 Rainwater harvesting in Ethiopia

There are a number of examples that show the rich experience behind the traditional Ethiopian agriculture. Farming communities in the semi-arid areas have managed to deal with their environmental challenges and constraints through different locally innovated technologies and adaptive socio-cultural set ups. These include the traditional soil fertility management practices, flood harvesting and in-situ moisture conservation (Birhanu et al., 2000).

Moreover, rainwater was harvested and stored in ponds for agricultural and domestic water supply purpose, since 560 B.C in the pre-Axumit period (Fattovich, 1990, as quoted in Getachew 1999). It was a time when ancient monasteries, churches, and castles were engaged in harvesting rainwater for irrigation purposes and water supply. Still the evidence of the remains of ponds that once used for irrigation and a roof water harvesting set up are visible in the remains of one of the oldest palaces in Axum; in the palace of the legendary Queen of Sheba (Fattovich, 1990, as quoted in Getachew 1999). The same source indicates

other evidences are found in the remains of the old castles in Gondar, constructed in the 15-16th century, which used for religious rituals by the kings.

Even to this day, there are several traditional RWH technologies in Ethiopia, which have been used by communities in areas of water shortage since the time immemorial. For many traditional communities in rural areas where natural sources of water are scarce, collection of rainwater from pits and excavated ponds are common practices. For instance, *Birkas* used for storage of rainwater in Ogaden, runoff irrigation practices in Churcher plains, around Mahoni and Waja near Alamata, the Geto valley in North Omo, parts of Eastern and Western Hararghe and in many other places of the country there are similar practices. Similarly, the people in Konso, Gidole and many other parts of the former Gamo-gofa region have been exercising the art of conserving soil and water (Habtamu, 1999). In south of the country, the Konso people have had a long and well established tradition of building level terraces to harvest rainwater to produce sorghum successfully under extremely harsh environment (low, erratic and unreliable rainfall conditions). It is indeed one of the wonders of this country, and it has been practiced for millennia. Hence, it is a symbol of struggle for survival by the Konso people against the adversaries of nature (Getechew, 1999).

In response to 1971-1974, drought years the government took RWH as an alternative way of intervention for water scarcity and water management with the introduction of food-for-work (Kebede, 1995, as quoted in Nigigi, 2003).

Currently, the Ministry of Agriculture of FDRE has launched the National Agricultural Extension Programme (NAEP), and water management in particular RWH is included as one of the packages contained in the extension system which designed to enable attainments of food self sufficiency (Birhanu et al., 2002). Relevant interventions in this regard have been included in the soil and water conservation action plan (2001-2006) of the MoA. Objectives of the action plan are focus on the rainfall regimes of the target areas. Such specific technologies are designated with respect to the interventions for moist and moisture stressed areas. RWH interventions intended for moisture stressed and pastoral areas including both on-farm rainwater conservation and off-farm RWH (MoA, 2001). These interventions include conservation of rainwater by making use of physical structures

and RWH for domestic and irrigation purposes through pond and micro-dam construction and roof catchments schemes (MoA, 2001).

2.3 Challenges of RWH implementation

The integration of different forms of RWH structures would enable to maximize promotion and adoption of RWH systems. The best way of adopting RWH is either by improving or upgrading the existing type of system is the most viable option of technological innovation (Nigigi, 2003).

Thus, the adoption of RWH technology irrespective of the benefit accrues from it, the knowledge of socio-economic and cultural dynamics on the part of the technology adopters and the farmers or the community perception is important. This integrated approach makes possible the challenge to be averted.

The other problem of adoption of RWH is the lack of awareness creation and sensitization. RWH having been for round hundreds years still no sufficient attention has been given the parts of policy makers. As a result, no sufficient documentations that shows different experience, and professionals in the field. Thus, the adoption of may be hampered (Nigigi, 2003; Rami, 2003).

The level of economic situation or the degree of impoverishment of the adopter is one of essential factor that can affect the rate of adoption. For instance, the adopters in *Kobo* reveals that due to the high level of farmers in the area were sub-letting and offering their labor for survival as a result they were not engaging to the implementation of RWH (Nigigi, 2003).

The knowledge of the technology and their specification and its suitability to the adopters matter most to foster the adoption of RWH (Nigigi, 2003). Lack of expertise in the constructions and build up of RWH ponds as well as inadequate and lack of sufficient training has got a paramount negative effect to the adopters (Rami, 2003; Nigigi, 2003).

The absence of appropriate legal framework, policy and institutional issues may also significantly affect the adoption of RWH. For instance, in Tanzania the social development

committee responsible for the promotion RWH found to have no legal support and the committee has no knowledge about RWH. Thus, the result that may obtain from such group may be distorted (Nigigi, 2003; Danile, 2007). Similarly, Rami (2003) reveal the same fact that the lack of policy focus, inadequate policy and institutional issue can significantly affect RWH adoption.

Depending on the local context the adoption of RWH may be affected by gender differential (Nigigi, 2003; Danile, 2007). For instance, in Kobo both male and female have equal chance of access to resource; however, the responsibility for decision making is given to male. The experience from Uganda indicated that both female and have equal decision make power for the adoption of RWH (Nigigi, 2003).

The availability of building materials, financial strength to have access for complementary in put and to have a structure that much to the local soil geology type are the other important factors for the promotion of RWH. Experience from Dalanta Ethiopia indicated that 1000 ponds have been collapsed because the structures were built in a soil type that does not support it (Rami, 2003).

2.4. Empirical evidences on determinants of household food security

The access that a household has to food depends on whether the household has enough income to purchase food at prevailing prices or has sufficient land and other resources to grow their own food (Garrett and Ruel, 1999). Or assistance received from formal programmes or informal networks to compensate any shortfall.

Factors other than income and prices can also affect household calorie availability. These factors include household demographic structure, Educational status of household members and location (Garrett and Ruel, 1999). In a similar manner, Workneh (2006) argue that household food security needs to be seen from dimension of availability /production and access (the ability to purchase food from market). Further elaborates that food security of the farming household is determined by the ability of the household to produce its own food and the increase in purchasing power they have with the increasing in their income (Workneh, 2006).

According to Nyariki and Wiggins (1997) access for food in household implicitly depend on the ability to make use of natural, physical and human resources efficiently. This means the availability of resources such as land and labor play a prominent role in food production and the capacity to sufficiently make use of these resources determines the food security of the household.

When land is a limiting factor, the labor resources of a household determine the income to be earned from employment to have food access. That means if the household depend on food markets, they are obliged to raise a substantial amount of additional income from elsewhere. It could be by selling what they harvested or engaging in off-farm activities (Nyariki and Wiggins, 1997). Similarly, Workneh (2006) stated that off-farm activities are essential means to attain food security by enhancing purchasing power or in-kind income. He further argues that what affect farm production, farm income and off-farm activities, does affect household food security status indirectly.

The types of qualities and quantities of food accessed in a market will depend on the characteristics of the market. The infrastructure of the market situation affects the food accessibility. Therefore, the market situations of different households in different infrastructure development area have different access for food. Hence, food security is determined by infrastructure accessibility (Islam, 1988, as quoted in Nyariki and Wiggins, 1997). A similar argument, given by Webb et al. (1992, as quoted in Worhneh,2006) show that famine in Ethiopian is caused by a multiple factors one being the isolation of farm households from major markets.

The other factors that affect the household caloric availability include household demographic structure such as the presence of dependent children and elders, HH gender, education level of the HH and other members of the household (Iram, and Butt, 2004).

The availability of technologies at the household level affect the crop production capacity, conditions of production and productivity of resources. These include availability and ability to use improved crop varieties, associated inputs like fertilizers and pesticides, and irrigation water in semi-arid areas (Nyariki and Wiggins, 1997).

RWH and its utilization have become a strategic measure for social and economic development in this semi-arid region, providing an effective means of alleviating poverty and allowing a breakthrough in dry land farming (Deng, et al., 2006). It serves two purposes: to raise vegetable as well as fruit seedlings during the dry season and to provide water as supplementary irrigation whenever there is a shortfall in wet seasons, especially to the time of maturity (Lakew, 2004).

Supplementary irrigation using RWH can improve the productivity of water if it is applied in critical crop growing stages. As the research result from international center of agriculture research in the dry areas reveals the same fact that the harvest from fields, increase substantially in response to the application of relatively very small amount of irrigation water. Furthermore, it is concluded that the impact of supplementary irrigation using RWH transgressed beyond what is the yield should increase. However, the productivity of RWH will be improved when they are used in a combination with other water conservation techniques (Oweis, et al., 2006; Zhu and Li (1998, as quoted in Deng et al., 2006); Senkondo et al., 2004).

The yield increase in production as the result of introducing practices such as RWH, conservation tillage, and drip irrigation, amounted to 50-100% on average (Nigigi, 2003). The study in Lare division located in the Central Rift Valley of Nakuru district in Kenya further consolidate that use of RWH happen to be linked with increase in food security and income level (Odhiambo, 2005; Senkondo et al., 2004). Odhiambo (2005) further indicated that the income level of the specified society happens to be in excess of 500,000 Kenyan Shilling. They diversify crop variety from two to four, attained food security, and able to reap substantial amount of income from cash crops, and capacity to purchase household needs like sugar, cooking fat, rice and wheat flour increased considerably.

The research result done on wheat in Gansu province of China indicates that the Water Productivity (WP) increased by 20% using RWH as a supplementary irrigation that means on average there is about $1.6 \text{ Kgha}^{-1}\text{mm}^{-1}$ incremental in productivity. In the same province, the result obtained in maize shows a WP of 20-88 % that gives 15 to $62 \text{ Kgha}^{-1}\text{mm}^{-1}$ using RWH as a supplementary irrigation mechanism (Rockstrom et al., 2003).

Access to land, land tenure system and the capacity to use, land productivity affects the food security and poverty reduction in a country (ECA, 2004). In a similar fashion, Maxwell and Wiebe (1999) stated that it is important to notice right for resources shape the opportunity to meet short-term consumption needs and to maintain holding of assets over the longer term. According to Lemma and Gebrehiwot (1999, as quoted in Workneh, 2006) among those factors, which affects food security is land tenure insecurity; while other are inaccessibility to productive resources, diminishing land holdings, low Educational status, inaccessibility to transport infrastructure, low productivity of livestock, lack of information for appropriate interventions, poor storage technologies, and high level of unemployment. Other factors assumed to affect the food security situation are drought, crop pests, and unexpected torrential rainfall and untimely, lack of draught oxen, increasing population number and land shortage (Amare et al., 1999, as quoted in Workneh, 2006).

The assessment made by Kebede et al. (2002) on the impact of micro-finance credit service on household income in Oromia Credit and Saving Share Company-Kuyu branch reveals that from total household sampled credit users 86% of them happen to show improvement in their living condition, the remaining 14% of them showed no improvement and of which 3% of them showed no change at whole, while the remaining 11% of them showed a deterioration of their life condition. Furthermore, Nyariki and Wiggins (1997) argued that the availability of cash from credit services also determine the use of improved seed, fertilizer and pesticide, which enter affects the production capacity of farm households.

In general, a number of interrelated factors determine food security that ranges from immediate factors which affect the food supply at the household level to the basic factors that can condition the over all economic system of the country (IFAD, 1992, as quoted in Debebe, 1995).

2.5. Conceptual framework

There are many ways by which RWH increase the food security status of a society who are engaged in it. To begin with, it helps to produce substantial amount of production during

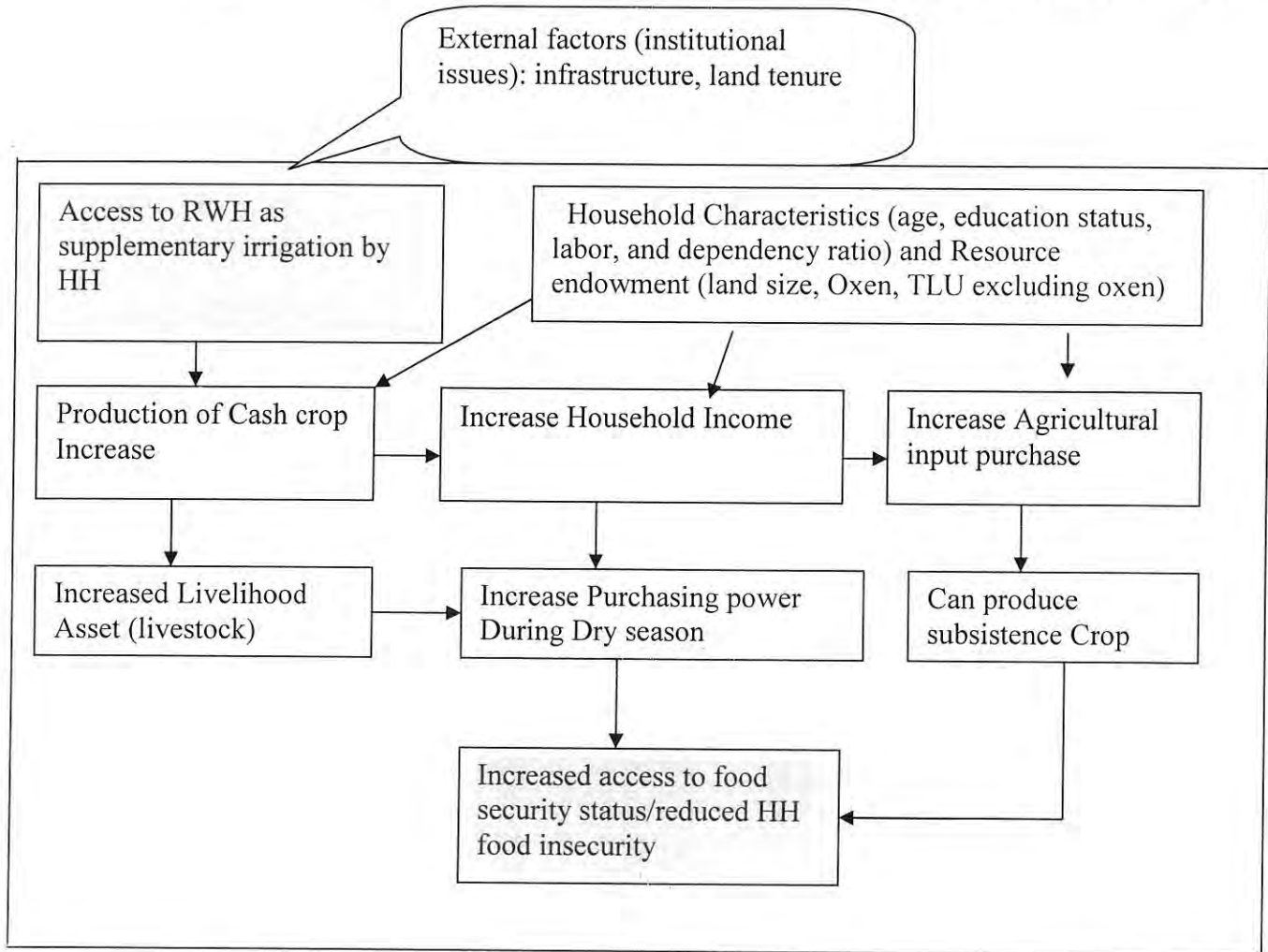
erratic rainfall, increase household income, diversify production, and produce cash crop. Thus, the overall contribution improves the welfare of the society.

The following conceptual frame work (see figure 2 below) is developed to show how access to RWH increases the food security status of the household. Farm households who have access to RWH can increase cash crop production during dry seasons. As a result, they will generate substantial amount of income, which help them to purchase food items during dry season. In addition, the income that they generate from cash crop may help them to purchase agricultural inputs such as high yielding variety seeds, fertilizers, pesticides, and so on, which in turn increase their subsistence production.

Thus, in order the above assumption to be materialized there should be other factors that need to be fulfilled. These are availability of inputs that are related to the households (age, dependency ratio, and education status of the HH), socio-economic (income of the household), resources endowment (labor, oxen, non oxen livestock and farm land size), and inputs (fertilizer, and credit service). In addition, institutional issues such as land tenure issue and market situation (infrastructure) are important pillars that can consolidate the food security status of the households.

Increase in income through high value crop production using RWH increase capacity of households to purchase food items during dry season. In the mean time, increased cash income enables farm households to purchase variable agricultural inputs for subsistence crop production, which increase the productivity. It there by, increases the availability of food for consumption at household level. Furthermore, the participant farmers in RWH can also increase their asset base through saving their income in the form of livestock and other household assets and this lead households to be safe in the case of shortage of food where the farmers able to sale their asset and generate income to purchase food items.

Figure 2 RWH, Household characteristics, External factors and Food Security Linkages



Source: Modified from Hussein (2004).

Chapter Three

Description of the study area

This chapter gives the summary picture of the study area location, major economic activity carried out, land use and the major crop type produce. Further, it presents vegetation, geology of the soil, climate, population and the condition of food security in the area.

3.1. Location

The study was conducted in Adami Tulu-Jido Kombolcha *Woreda*, which is part of the East Showa Zone of the Oromia Regional State. Geographically the area is located between 38°20' and 38.5°5' E and 7°35' and 8°05' N. The *Woreda* covers an area of 1403.3 km², and is bordered by Southern Nations, Nationalities and Peoples' Regional State (SNNPRS) in the west and North West, Dugda-Bora *Woreda* in the north, Arsi Zone in the east and Arsi-Negele *Woreda* in the south (Figure 3). Zeway (Battu) town is the administrative center of the *Woreda*.

Ecologically Adami Tulu-Jido kombolcha is found in Central Rift Valley. Significant parts of the main rift valley lakes of Ziway, Abijata and Langano are also found in the *Woreda*. The *Woreda's* land mass lies between 1500 and 2300 masl except area around Mount Aluto. Major rivers in the *Woreda* include Bulbula, Jido, Hora Kalio and Gogessa. The *Woreda* is within sub-tropical agro-climatic Zone (OSG, 1999).

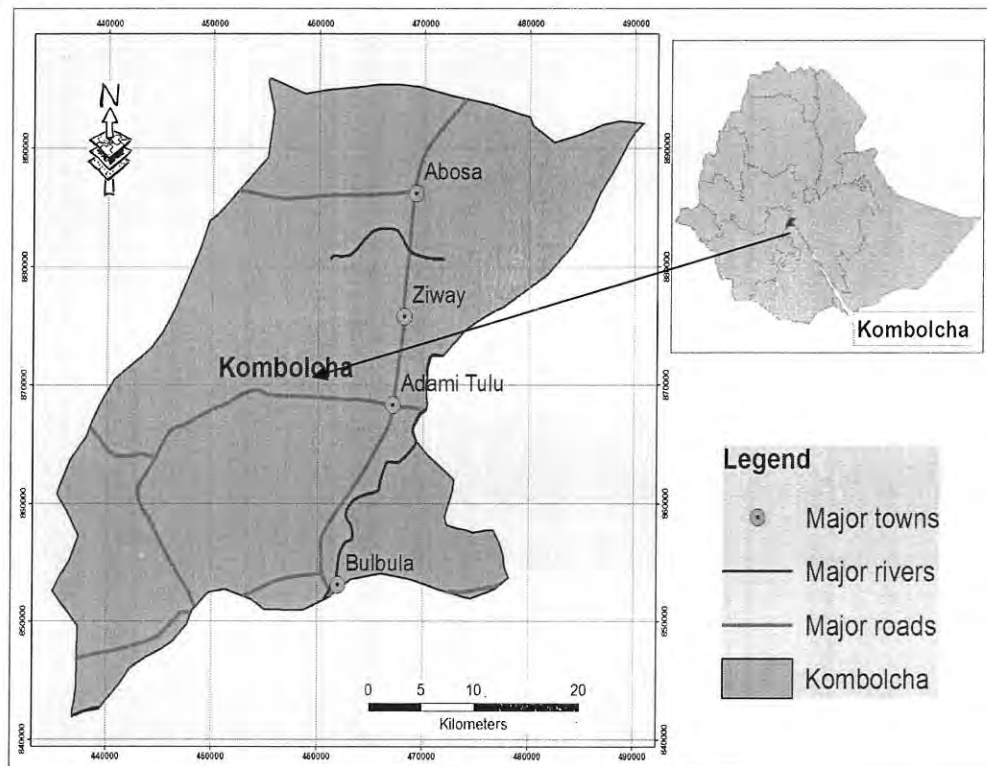
3.2. Major economic sector, land use, crop and cash crop type

Major economic sector of the *Woreda* are crop production, animal husbandry, and fishery. The main crop types produced are maze, haricot bean, *tef* and wheat and cash crop are hot paper, tomato, and onion.

The total of 80% of the land in the *Woreda* is occupied by rural dwellers. Of the total land in the *Woreda* 44.2% is currently cultivated in which 3.7% of it is occupied by the state farm, 0.2% is cultivated by private investors and the remaining 96.1% is being cultivated by the small hold peasants. The remaining 55.8% of the *Woreda*, 15.75% is covered by

water body, 18.1% is covered by grazing land, 8.5% is covered by forest and the remaining 13% of the *Woreda* is occupied by degraded, range, potential, land and home building.

Figure 3. Map of Adami Tulu-Jido Kombolcha *Woreda*



Source: own by generating data from Adam Tulu jido kombolcha *Woreda* the study (2008)

3.3. Vegetation and wild life

The major natural vegetation of the *Woreda* belongs to woodland and savanna (Acacia-wood land and Savannah and Cenchrus- grasslands). Species composing the vegetation predominantly belong to the genera *Acacia* and *Balanites*. Major wildlife of the *Woreda* are warthog, duiker, monkey, tortoise, ape, greater kudu, great white pelican, flamingo, hippopotamus, ostrich, bush buck, duck, hyena, rabbit, and kerkerero. A small part of the Shalla-Abijata National Park is in the *Woreda* (OSG, 1999).

3.4. Geology and Soil

The parent material consists of volcanic rocks of basalt and tuffs with rare rhyolites and soils are whitish with coarse texture and freely draining. About 60.4%, 30.4% and 9.2% of the *Woreda* were covered by Andosols, Rendzinas and phaeozems, and Luvisol soils respectively (OSG, 1999). However, Vitric Andosols and Mollic Andosols dominate the *Woreda*. Provided that there is adequate moisture, most of these soils are among the most productive soils in the world. Other soils that are found in the *Woreda* include luvic phaeozems and lithosols. Andosols soils originate from volcano-lacustrine deposits with volcanic ashes, cinders, pumic (graves) lapilli. Fluvisols are derived from alluvium on the lakes shores and along the Meki River. Gleyic-Mollic fluvisols are derived from lacustrine deposited along the shore of Lake Zeway. They are deep, black, fine loamy and partly sodic (OSG, 1999).

3.5. Climate

The *Woreda* has semi-arid and arid agro-climatic Zones. It receives an average annual precipitation of 759.7 mm (OSG, 1999). The annual rainfall varies from a low of 513.92 mm in 1979 to a high of 1096.1 mm in 1976. About 41.49% of the annual rainfall is recorded during the period from June to September. The driest months are November and December; only 0.58% of the annual rainfall is recorded during this period. The mean monthly temperature varies from 18.5°C to 21.6°C. May is the hottest month with mean maximum temperature of 28°C. The coolest month is December with minimum temperature of 10.7°C. The average air relative humidity is 72.75%, varying from 68% (November) to 78% (July and September) on the monthly average (OSG, 1999). Based on the data obtained from Ethiopian metrology indicates a relative increase in the rain distribution since 2003 up to 2005.

3.6. Population

The total population of Adami Tulu-Jido Kombolcha was 111,926 (28.5% urban) in 2008 projected data. The economically active (15-64) were 50% of the total population. Children below 15 years were 48%, while the elderly (65 years and above) were only 2%. Females were 49.3% of the urban and 50.3% of the rural population. The average household size in the *Woreda* was 4.6, with 4.9 and 4.2 for rural and urban respectively. The population density was 86 persons per km² in the mentioned year (OSG, 1999).

3.7. Food security situation of the study area

According to Disaster Prevention and Preparedness Commission (DPPC) report on Adami-Tulu Jido Kombolcha *Woreda* in early warning system in the year 2000 there was high number of population, which is about 71,000 people exposed to emergency food aid and most of the victims' were reported from *Bulbula* (DPPC, 2000).

However, in 2002 those who needed immediate food aid dropped to 24,200. In addition, 13,100 people were in need of close monitoring of their life situation. Still most of the affected people were from *Bulbula* (DPPC, 2002).

In the following year (2003), food aid needy people increased dramatically reaching to 48,800. As a result, most of them particularly from the rural area moved to urban areas in search of employment. Most of them were from low land of Adami-Tulu Jido Kombolcha namely *Bulbula*, Adami-Tulu and Jido. Nevertheless, due to the drought opportunities for daily labors decreased and off-farm jobs were rare (DPPC, 2003).

In 2004, people in need of immediate food aid sharply dropped to 12,600 (DPPC, 2004). In 2005 the number significantly decreased to 3,650 (DPPC, 2005). It was stated that the major cause of food insecurity in low lands of the *Woreda* is due to adverse weather condition such as late on set, erratic, uneven distribution and early cessation of rainfall.

Thus, the above facts make *Bulbula* as one of the area stricken by repeated famine, drought and food insecurity. Owing to these facts, the regional government decided to implement RWH to combat food insecurity in the area since 2002.

Chapter Four

Research Methodology

This chapter presents the sampling techniques, data collection methods, method of data analysis, definition of variables with their underline assumption followed by specification of the model. First it describes sampling designs, sampling methods used and the study population. Following data collection instruments and its sources have been depicted. Following, under the method of data analysis the over all analysis methods used under this study are presented. Then the underlying assumption about the each explanatory variables presented, which latter the specific model used in the study to hold the situation.

4.1 Sampling design, the study population and sampling method

In this study, a multi-stage purposive sampling and random sampling techniques were employed for the selection of the study site and respondents respectively. In the first stage the study site-Bulbula was purposively selected. For the reason that it comprise more than 35% of RWH structure in the *Woreda*, relatively low land from the *Woreda*, “no” other water sources found other than rain fall, has relatively high climate variability and has shown an increase in self initiated number of adopters.

In the second stage, from the total of 11 *Kebeles* in Bulbula 6 of them were found to be participants in RWH. Of these, 5 of them were purposively selected giving due attention to the participants number. Namely these *Kebeles* are: Korme-Bugure, kertefa-Weransa, Jela-Aluto, Araba, and Hurgo-Mechafera.

In the third stage, the total households in the 5 selected *kebeles* further were stratified as the participants in RWH and non-participants in RWH. The list of the total households in the selected *Kebeles*’ and list of participants in RWH in these *kebeles*’ were obtained from the *Woreda* office of finance and Economic development and office of irrigation development respectively.

Following, simple random sampling techniques were used to sample the individual respondents from the respective strata as they are homogenous in their strata. Care was

taken to consider the female headed households in the study sample. However, there were only 5 female participants in RWH from the entire selected *kebeles* as their numbers are insignificant they were totally excluded from the sample study survey.

Based on the data obtained from the respective office there are nearly equal number of participants and non-participants in RWH in the selected *kebeles* (1347 participants and 1529 non-participants). Thus, giving due emphasis to financial constraint and comparison purpose between the two groups equal sample size, which is a moderate sample size was taken specified in table 1. Accordingly, 70 respondents from the participants and the non-participants taken using the method developed by Carvalho (1984, as cited in Zelalem, 2005:8) see below table 1. As a result, a total of 140 sample respondents were taken in the study.

Table 1. Sample size determination from Homogenous population.

Population size	Sample Size		
	Low	Medium	High
51-90	5	13	20
91 – 150	8	20	32
151- 280	13	32	50
281 – 500	20	50	80
501 – 1200	32	80	125
1201 – 3200	50	125	200
3201– 10000	80	200	315
10001-35000	125	315	500
35001- 150000	200	500	800

Source: Zelalem, 2005.

Taking small sample size of the household will cause high variance and the cost of taking high samples size is high. Thus, a moderate sample size was taken in accordance with the population size of the selected area.

4.2 Data collection

Both primary and secondary data were collected from the respective sources.

4.2.1 Primary data

Household survey: To generate information at household level, semi-structured and structured questionnaires were used. Prior to conducting the survey, pre-test of the survey schedule was under taken and accordingly remedial action was made and finalized. Then the survey conducted to the selected respondents in the study site.

Focused group discussion & key informant: To elicit the required information, open ended and general questions were used.

Key informants (KI): A group consisting of 8 members: 2 elder from each category, 2 irrigation experts from the *Woreda* level and 4 DAs (development workers) who were actively participant on the implementation process were selected purposively based on their merit to RWH.

Focus Group Discussion (FGD): A group consisting of 10 individuals were purposively sampled and due attention was given to heterogeneity and specific experience on the issue. Accordingly, 5 individual from each category were used. Following, the two groups (participants and non-participants) first subjected to discuss separately and later both groups subjected for further discussion being in a group.

4.2.2. Secondary data

Secondary data that are relevant to the research work were used such as published, thesis, books, unpublished and transcription of magazine. In addition, relevant documents were obtained from the *Woreda* finance and economic office and irrigation development office.

4. 3. Method of data analysis

In order to meet the specific and general objective of the study multiple methods were used ranging from pure quantitative to qualitative methods for the reason that factors that determine the households food security are multiple and complex. To determine the level of food security/insecurity Household Calorie Acquisition (HCA) method for 14 days was used. Following the gross household food consumption for 14 days was converted into calorie. Then it is divided by the number of Adult Equivalent in the household (see Annex Table A-2 and A-4). Furthermore, the Adult Equivalent divided by 14 days to obtain the

average calorie consumed per Adult Equivalent per day in a household. Thus, based on the amount of calorie that households have they are categorized into food secured and food insecure taking 2100 kcal consumption per Adult Equivalent per day as cut off point (Hoddinott, 1999).

The availability of livestock in each household was converted in to TLU (Tropical Livestock Unit) prior to actual analysis (see Annex Table A-1). In addition, the availability of labor in the households converts in to Person-days equivalence unit (see Annex Table A-3).

The data analysis part mainly was done by using both qualitative and quantitative data analysis techniques. The method of triangulation (cross checking) was used to analyses the qualitative data obtained from FGD and KI. Descriptive statistics (such as percentage, mean, standard deviation, paired t-test) were used for comparison purposes. Bivariate analysis: analysis of independent t-test, paired t-test and Pearson χ^2 -square test were taken to show the mean difference between continuous and dependent variables and the association of categorical and dependent variables respectively. Multivariate (Logistic regression) model analysis employed to determine the food security determinants in the study area (see the detail of the specific model in section 4.5 below). Besides, SPSS 15.0 software package was used to organize, arrange and analysis the data.

4.4. Definition of variables and hypothesis

Dependent Variable

Household food security Status (HFS): is a dummy dependent variable in the model assigned value of 1 for food secured (>2100 Kcal) households and 0 otherwise (< 2100 kcal). To obtain the actual calorie consumption by the HH, Household Calorie Acquisition method was used. Thus, the gross household food consumption was converted into calories by using the conversion factor for each 100g of the food items consumed, and dividing the calories figure by the number of adult equivalents in the household and per 14 days resulted in a concise figure for average calories consumed per adult equivalent per day, then compared with an estimate of threshold kilo caloric level requirement (i.e. 2100 Kcal).

Independent variables: Various household characteristics, resource endowment, institutional issue and socio-economic variables are expected to affect households' food security in the study area. The major explanatory variables hypothesized to influence positively and negatively on the household to be food secure or not are described below.

Age of HH (AGE): most of the time rural households spent much of their time on agriculture and they base their livelihood on agriculture. Thus, the more aged the HH, the more experience he/she has to be food secured by avoiding risk and diversifying their production.

Literacy or Status of Education (LEDUC): there is an expectation that an educated HH has the capacity to innovate and to adopt timely technology and has better understanding of the cash crops that can help them to have a better income than the non-educated HH. Thus, there is a positive relation between HH education and food security.

Dependency ratio (RATIO): the higher the number of HH members whose age less than 15 and greater than 64 are economically in active and hence, they are believed to be affecting HH food security negatively.

Number of livestock owned (excluding oxen) (TLU): the number of livestock and household food security expected to show positive relation. Direct contribution is meat, milk, and milk products and the indirect one is manure and de-stocking during crop failure season and drought time so that the food security of the household improved.

Number of oxen own (OXEN): oxen play important role in land cultivation. Households who own more oxen have better chance to be food secured than others. This is because oxen possession allows undertaking farm activities on time and when required. The number of oxen available to the household is, therefore, hypothesized to enhance the probability of being food secure.

Land size (LANDSI): this refers to the total available land that can be cultivated. The larger land size the HH give more chance for food security. Because the HH either can cultivate to obtain more production, or may rent it to people in short of cultivable land that may generate more income to the HH.

Land security (LANDESE): HH who has land tenure security can invest on their farm, and protect their farm plot by terracing, intercropping planting trees, and the perception and attitude that the farmers have. Thus, the HH can better sustain their agriculture and produce

with out any doubt. They can sell their land at any time they want. Hence, land security is directly related with their willingness to invest and to protect their land. Therefore, land security is directly related or indirectly with food security.

Credit Service (CRDSE): The availability of institutional credit service is a vital element for the HH to get timely purchase of agricultural inputs such as pesticides, herbicides, and improved seeds that enhance the productivity of the HH. Thus, the availability, of credit service is directly related with food security.

Engagement in rainwater harvesting (ENRWH): those farmers who are engaged in RWH will have a better chance for food security than the non- participant; since they can relies on the collected water during dry season to produce as well as protect crop failure during dry spell.

Income (REALINCOME): This variable refers to the aggregate income from livestock (asset), rainwater harvesting and rain fed. Framers who have got better income can get agricultural inputs on time and they can also purchase food during dry season. Thus, income assumed to have positive relation with food security status of the households.

Use of fertilizer (FERZER): Farmers are using fertilizer as one of input that supports them to improve farm productivity. Uses of fertilizer increase productivity of crop per unit area, which would improve total production per household and more food, will be available for farmers who use fertilizer. Therefore, it is expected to have a positive relationship with household food security.

Market accessibility (MARKA): the distance they travel to sell their agricultural products, to purchase other food items and the reasonability of price for their product matter most for the rural HH to get the benefit they want. Thus, the accessibility of market has a positive relation with food security and income.

Table 2 below summary of the code, variable definition, expected sign (the direction of relation that explanatory variables affect the dependent variable) and unit of measure in the model has been given.

Table 2. Variable codes, Definitions and Measurement of Independent variables

Variable codes	Variables type & expected sign	Definition	Measurement
AGE	Continuous (+)	Age of the HH head	years
LEDUC	Dummy (+)	literacy status of the HH head	1=literate, 0=otherwise
RATIO	Continuous (-)	Family size in AE consuming unit	Adult equivalence
TLU	Continuous (+)	Livestock size (excluding oxen)	Tropical livestock unit(TLU)
OXEN	Continuous (+)	Number of oxen in the HH	Count
LANDSI	Continuous (+)	Total farm size operated during the cropping year	Hectare
LANDSE	Dummy (+)	The property right to use land owned	1= secured; 0=otherwise
CRDSE	Dummy (+)	Credit use or not	1=uses; 0= otherwise
ENRWH	Dummy (+)	The involvement in RWH	1= RWH participant 0= non-participant
R EALINCOME	Categorical (+)	Income from (Livestock(asset), RWH and rain fed)	Birr
FERZER	Dummy (+)	Fertilizer use or not	1=user 0=non-users
MARKA	Continuous (-)	Distance travel from home to market	Km

4.5. Model specification

To test the stated hypotheses, a probabilistic model was specified with food security as a function of series of socio-economic, household, input supply, demographic and institutional issues variables. The dependent variable is dummy variable, which takes a value of 0 or 1 depending on the households' food security status. Here, the main purpose is to determine the probability that an individual with a given set of attribute will fall in one choice rather than the alternative, i.e., either food secure or insecure not both.

There are approaches developed for a probability model whose response variable is dummy one. These are: the Linear Probability Model (LPM), Logit Model, and Probit Model. The choice of these models depends on the suitability to fit the data. LPM has inherent drawbacks. To mention some of these downside of: it lacks to show the uniformity of error terms, heteroscedasticity (the variance of the error term is not constant) of the error term, possibility of the getting the probability function result out of 0 and 1, and the general lower R² value. Owing to these fundamental problems, LPM is not logically attractive model for dummy responsive variables (Gujarati, 1995).

Thus, one can use Cumulative Distribution Function (CDF) namely Logit or Probit models (Gujarati, 1995). The question is that which CDF model to use. However, both can be used for dummy responsive variable most researchers choose Logit than Probit regression model (Gujarati, 1995). Therefore, Logit model guarantee the estimated probabilities increases and never steps outside 0 to 1 interval and the relationship between probability (p_i) and explanatory variable (X_i) is non-linear (Gujarati, 1995). Thus, a logistic model was used to identify the determinants of food security and to assess their relative importance in determining the probability of being in food secure situation or not.

The functional form of Logit model is specified as follow, Gujarati (1995)

$$P_i = E(Y=1/x_i) = 1/1+e^{-(\beta_0+\beta_1x_i)} \dots\dots\dots 1$$

For simplicity (1) can be expressed

$$P_i = 1/1+e^{-z_i} \dots\dots\dots 2$$

The probability that given household is food secure is expressed by (2) while, the probability for food insecure as: -

$$1 - P_i = \frac{1}{1 + e^{-Z_i}}$$

After some steps

$$\ln \left[\frac{P_i}{1 - P_i} \right] = L_i = Z_i = \beta_0 + \beta_1 x_1 + \dots + \beta_n x_n$$

If the disturbance term (U_i) is introduced, the Logit model becomes

$$Z_i = \beta_0 + \beta_1 x_1 + \dots + \beta_n x_n + U_i$$

Where β_0 = intercept

$\beta_1, \beta_2, \dots, \beta_n$ slopes of the equation in the model

L_i = is log of the odd ratio, which is not only linear in X_i but also linear in the parameters.

X_i = is vector of relevant socio-economic, demographic and institutional issues explanatory variables

Z_i = the function of n explanatory variables (x); in this case Z_i = Household food security status

Therefore,

$$Z_i = \beta_0 + \beta_1(\text{AGE}) + \beta_2(\text{RATIO}) + \beta_3(\text{LABOUR}) + \beta_4(\text{TENURE}) + \beta_5(\text{LANDSISI}) + \beta_6(\text{OXEN}) + \beta_7(\text{TLU}) + \beta_8(\text{ENRWH}) + \beta_9(\text{REALINCOME}) + \beta_{10}(\text{LEDUC}) + \beta_{11}(\text{FERZER}) + \beta_{12}(\text{MARKTA}) + \beta_{13}(\text{CRDSE}) + U_i$$

is this the particular expression used in this study.

Prior to the estimation of the logistic regression model that the explanatory variables was checked for the existence of multicollinearity. In this study among the other methods, Variance Inflation Factor (VIF) was used to measure the degree of linear relationships among the continuous explanatory variables. Where each continuous explanatory variable was regressed on all the other continuous explanatory variables and coefficient of determination for each axillary or subsidiary regression was computed.

Following Gujarati (1995), VIF is defined as:

$$VIF (X_j) = \left(\frac{1}{1 - R_j^2} \right)$$

Where:

X_j = the j^{th} quantitative explanatory variable regressed on the other quantitative explanatory variables. R_j^2 = the coefficient of determination when the variable X_j regressed on the remaining explanatory variables. As a rule of thumb, if the VIF of a variable exceeds 10 that variable is said to be highly collinear and it can be concluded that multicollinearity is a problem (Gujarati, 1995). In a similar manner, to avoid the multicollinearity problem among dummy (qualitative) variables Contingency Coefficients (C) was computed.

It is defined as follows: $C = \sqrt{\frac{\chi^2}{n + \chi^2}}$ Where, C= coefficient of contingency, χ^2 = a Chi-

square random variable and n = total sample size.

Chapter Five

Over view of practice and challenges of RWH in Bulbula

This chapter describes the major finding and discussion on the trend of RWH implementation, types of RWH practices and challenges of RWH in the study area. It mainly focuses the technique or the way followed by the *Woreda* bureau to implement the package. Further more, it explores the type of RWH structures and techniques found and the challenges of RWH in the study area.

5.1. Over view of RWH implementation and trends in the study area

RWH implementation was taken place in the *Woreda* since 2002 in the selected 15 rural PA's. The selection was made based on the soil type suitability to the structure, willingness of the farmers and rainfall pattern as a pilot. It was designed for supplementary irrigation, which can irrigate about 300m² areas with a capacity of holding 120m³ volume of water. During the same year, it was intended to implement 1050 RWH structures in the selected PA's. Of these, only 476(45.3%) was successfully implemented and 372(37.4%) started but not finished. To encourage the adopters, incentives have been given by the district rural development office these; includes provision of improved cash crops seeds, plastic sheets and pumps as informed by KI.

According to KI and FGD the performance that was observed in the beginning of the package implementation was not a picture that shows the broadest segment of the society achievement. Rather it was the picture of economically strong and political elites groups. Similar scenario has been reported by Danile (2007). This might be due to the fact that lower level officials were playing "more attention on controlling and extractive roles of the state than its developmental or facilitative functions", as stated Abeje (2004:206). However, the adopters were able to benefit from multiple services from the package. Some of these benefits are: water for livestock, domestic purpose and partly to the supplementary irrigation. This has been reported by 63.02% of the participants in the same year.

In the following year (2003), unlike the previous year the implementation was taken as the campaign to include every single household in the programme through 'quota' system. During the same year it was intended to implement 2800 harvesting ponds. Of these,

1964(70.14%) was implemented successfully, not considering the quality of the ponds to meet the intended objective. The performance observed in implementing the structure is very much considerable compared to that of the previous year. However, the FGD as well as the KI agree without any but that despite the sheer number increase in the structure, the quality of the structure was poor.

The justifications for the poor quality of those structures were ascribed to different reasons. The first reason was due to the fact that the implementation was taken place in a 'quota', where farmers were not having enough time to understand and to decide the importance of it. As a result, the package was imposed on the framers before they took the initiative to implement by their own. This in turn led the farmers to build the structure in area far from their farm place, which they think useless and improper place to harvest water as the KI and FGD expressed. Thus, the 'quota' problem has aggravated the weak performance and the quality of the structure. Abeje (2004) has indicated that most developmental programs which has been implemented as the directive to the country as a whole when it reach in the hands of lower official and extension workers (DA) it will be changed into quota form, which in turn induces rough relation between lower officials and the farmers in the implementation process. It also corroborate Rami (2003) finding that 'ponds filled with challenges experience from Tigray and Amhara' that 'quota' system held the pivotal responsibility for the weak performance of pond structures. Hune (2004) had also come up with the same conclusion.

The second reason was lack of skilled labor to guide and train the farmers. As a result, ponds sited in an improper places, which is subjected to collapse. In addition, lack of proper channel for the catchments of the structures. This corroborates Rami (2003) finding that the rapid expansion of the structures led to blemish in the design of the structure and in a similar manner Daniel (2007) has found that most of the RWH structures ponds of the country were expanded without appraisal of the technology at the local context. It has been substantiated by Abeje (2004) finding that the absence of local specificity in the technology and lack of accommodating the local farmers' indigenous knowledge has exacerbated the weak performance and smooth implementation of the programs.

In the year 2004, the irrigation bureau was intending to implement 1500 ponds. Of these, 768(51.2%) were successfully implemented. Up until then the adoption was taken by imposing on the farmers. As a result, the performance was very weak and the repercussion from the previous year affected significantly and negatively the implementation process. The major phenomena, which explains the farmers opposition to the package was the selling of plastic covering for cash as the KI indicated. It is a phenomena attributed to lack of the sense of ownership as the farmers were not convinced with the importance of the package.

In the year, 2005 attention on RWH was declining from the government side, which revealed by lack of provision of plastic covering, improved cash crop seeds and pumps. Yet, the bureau was intended to implement 750 ponds of these 200(26.6%) were successfully implemented. Because of lack of plastic covering, the harvested water soon seeped and not used for productive purpose as KI and FGD disclosed it.

The dramatic decline in the number of adopters may be attributed to the lack of attention by the government or the inappropriate (quota) way of pursuing the package implementation as the KI and FGD revealed the situation.

In the following year (2006) there was a total absence of proper attention for the package from the government side. Yet, the bureau still was having the intention to implement 350 ponds. Of these 50(14.30%) were implemented. The overall picture of the package implementation in the *Woreda* is declining. Despite this, a different scenario has been observed in the two extreme semi-arid of the *Woreda* namely Bulbula and partly in two PA's of Jido. This different scenario is the increase in the number of volunteers' adopters in RWH in mainly Bulbula and partly in Jido than in the rest of the *Woreda*.

This increase in the number of volunteer adopters in the area attributed to the following reasons. First, unlike the other parts of the *Woreda* the two areas had severe water shortage. As a result, engagement into any possible activities that can produce a source of water is not a choice. Second, cash crop that the adopters produced using RWH has considerable market opportunity during the dry season as there are no competitors or producers, which in turn helps them to earn substantial amount of income. As a result, the adopters were

encouraged to replicate more ponds and yet not adopters show their willingness to adopt the structure. Third, there is a better soil geology, which is suitable to the structure around Bulbula than in other places in the *Woreda*. As a result, a problem that is pertinent to the technologies was not observed. Fourth, the participants in Bulbula and its surrounding do not have any alternative means of getting water. Thus, the farmers tend to use the harvested water economically, which enable them to reap considerable benefit. All the above facts encouraged the participants in the study area to duplicate and the non-participants were also motivated to do like the participants as the KI, and FGD revealed.

Unlike the increase in the self initiated adopters in Bulbula, the adopters in Jido are attributed to the safety net programme (work for food).

5.2. Types of RWH method in Bulbula

Historically, farmers in the study area make use of different water harvesting methods for agriculture work, livestock and domestic uses as FGD and KI disclosed. Some of these techniques were rivers diversion, lake diversion, ground water harvesting, and flood diversion. The most prominent being flood diversion, river diversion and ground water harvesting. As a result of high fluoride contamination of the ground water and contamination of the river with soda ash factory and floriculture industry there is little interest in the farmers' part to make use of these sources of the water for any production and consumption activities. Currently, government is assisting the farmers by building up a flood diversion structure in the study area.

There are three types of modern RWH ponds being practiced currently in the study area. These are: ponds without plastic covering but compacted beneath, ponds with plastic covering and hemispherical. The most common type of RWH ponds are ponds without plastic covering followed by those with plastic covering as the KI revealed; very few hemispherical ponds are found, which is sponsored by government, EU and JICA and given for model farmers.

5.3. Challenges of RWH implementation in Bulbula

According to the KI and FGD, the challenges of implementation in RWH explained in three major ways. These are challenges to the adopters, to the structures (technologies), and institutional.

The challenges to the adopters in not efficiently engaging in the harvesting system was first lack of the labor, since excavating and other activities in the construction of RWH ponds demands sufficient amount of labor.

For instance, there are only 5 females HH engaged in RWH (since, their number is insignificant are totally avoided from the study). However, the core point is that RWH is less practiced in female-headed households and it is gender biased. This is in line with Daniel (2007) finding that women headed households are not as muscular as their counter part. As result, nearly all female household were not able to benefit from RWH.

Second problem is financial, which was the other constraint that underscored by the FGD in not engaging in the adoption process. This means the availability of sufficient amount of financial support is need to purchase complementary in puts to RWH such as plastic covering, fertilizer, improved seeds and so on. This is in harmony with Oweis et al (2006) work that the success of RWH would be impossible unless it is combined with other water management methods like drip irrigation, conservation tillage, and complementary inputs.

Third, FGD underscored that 'quota' system of implementation was not appealing to the farmers. As a result, the adoption rate was slow and even the implemented structures shows flaws. This means the farmers were not having enough time to understand the issue and take the self initiative rather too much of indoctrination was the pivotal means to get the structure implemented. Owing to the above factors, the achievement that was intended was not materialized. Similarly, Rami (2003) has concluded that all what was opted for in Tigray and Amhara region has failed due to the 'quota' approach pursued by government to get the package implemented.

The last challenge revealed by the FGD was the cultural problem. Regardless of the interest of the adopters to share the collected water it is a must to share water as a culture.

Otherwise any deviation from that will make of individual subject to total out casting. As a result, the adopter will be reluctant in further excavating ponds and may not be able to use the collected water to the intended purpose.

The other underscoring challenges forwarded by the FGD and KI were challenges that are pertinent to the structures or the technologies. In the beginning of the package implementation most of the structure were collapsing due to the structure unfitness to the local soil geology. Besides, most of the structures were open type structures. As a result, the collected water was subjected to high evaporation, and it became an incubation site for malaria. Furthermore, the most of the structures lack de-siltation means. This is may be the lack of appraisal of the technologies in the local context as what Daniel (2007) expressed it or the assumption that the single trial outcome from the research site (Adama) will work to every context as Rami (2003) underscored it.

In spite of these, as time goes by farmers in the study area started to invent a new type of structures based on their experience that can withstand the challenge they encountered. These new types of technologies obtained by molding the shape of the structure and by covering the pond from local made roofing to protect from evaporation and malaria incubation. Similarly, Daniel (2007) in his study came up with the same type conclusion that farmers started to learn by doing and also shape the structure, which can meet the local context.

The last type of challenge that was revealed by KI was the institutional challenges. Since, the package was a recent phenomenon; the lack of trained manpower that can guide the local community in the implementation process has been reported as a major constraint. As a result, the ponds were located in improper places, which has negligible or no catchments to the excavated ponds.

Furthermore, most of the excavated ponds collapsed immediately as the KI and FGD witnessed. The inability of the expertise to understand the local soil geology and selection of the structure type that is suitable to the local soil geology type played prominent role as one of the institutional challenges.

Lack of administrative coordination and incapability to meet the plan and implementation had pivotal role in the institutional challenges. This has been reported by Rami (2003) as one of the crucial problem. Besides, biasness to a certain group, and politically driven interest of the local administrative had a significant role in hampering the implementation of the package. This corroborates Danile (2007) finding that biasness to a particular group has played its main role in hampering the smooth implementation.

Chapter Six

Background of sample households

This chapter describes the major finding and discussion on household characteristics, resource endowment per the sample HH, inputs, institutional issues, engagement in RWH and socio-economic characteristics in relation to food security status of the households. In addition, the food security status of the sample population as per their category is described.

6.1. Description of household, demographic and socio-economic characteristics of the sample households

In the sample households there are 1133 members of the household of which 574(50.7%) are males and 559(49.3%) are females. This sex ratio indicates nearly equal proportion, which is in harmony with the national average sex ratio (see Table 3). According to the survey result, the sample population has a dependency ratio (the proportion of economically inactive persons to economically active person within the family) of one to one. Hence, each economically active individual should support one economically inactive household member (see Table 3). The average family size in the sample households is 8.1 individuals with the minimum family size 2 and maximum 17. This average family size is higher than the national average family size of 5, which shows the presence of extended family in the study area (see Table 5). This disparity could be as a result of high rate of polygamy culture in the study area. All of them with the exception to a single HH from the sample population revealed that they are Muslim and ethnic Oromo.

Table 3. Sex and Age composition of the sample Households (N=140)

Sex	N (%)
Male	574(50.7)
Female	559(49.3)
Total	1133(100)
Age (years)	N (%)
0-14	521(46)
15-64	589(52)
64+	23(2)

Source: own survey (2008)

The availability of cultivated land on average is 2.7 hectares with the minimum and maximum farm size 0.5 and 9 hectares respectively. This indicates a potential fragmentation when the average family size of 8.1 is considered in the study area (see Table 5).

As to the education status of the household members and the HH 65% of the sample HH are literate. On a gender base 44% of school age the female and 70.6% of school age male household member are literate. This result indicates there is a clear disparity in the education status of male and female. This is a common scenario in most part of the developing countries including Ethiopia. The weak association of the females with education could be cultural problem. The mean age of literate and illiterate household members is 17.7 and 20.8 with a standard deviation of 9.9 and 17.5 years respectively. The relative high variability in the age of illiterate household members is due to the presence of old age individuals in the illiterate households. The average age of the family members including the HH in the sample households is 19.18 years, which means young are the dominant group in the sample households (see Table 4).

Livestock availability of the sample household excluding oxen is on average 10.60 TLU with the minimum livestock being none and maximum available livestock is 38.3 TLU. This result indicates very high variability in the availability of livestock's among

households. In a similar fashion, the availability of oxen on average is about 2.4 TLU with standard deviation of 0.9 TLU where the minimum number of oxen available being 1 and maximum is 4 TLU. The availability of oxen per household does not show a considerable variation unlike the livestock availability. This may be that to have oxen is a must than to have non-oxen livestock for the farm activity.

In the sample households the average labor available is 3.80 PE (Person-days Equivalence) with standard deviation of 1.90 PE where the minimum labor available registered to be 1.30 PE and the maximum is 9.70 PE (see Table 5).

Table 4. Education status and age in sample households

Age of the members		Educational status	
		Literate	Illiterate
Mean		17.7 yrs	20.8 yrs
SD		9.9 yrs	17.5 yrs
HH (n=140)		91(65)	49(35)
Female members(n=559)	264(44)	313(56)	
Male members(n=574)	405(70.6)	169(29.4)	

Source: own survey (2008)

Table 5. Oxen, livestock (excluding oxen), labor and farm land size per sample households

	Oxen ownership	livestock Owned (excluding Oxen)(TLU)	Labor(PE)	Family size (count)	Farm land size(ha)
Mean	2.40	10.60	3.80	8.1	2.70
SD	0.90	8.00	1.90	2.7	1.80
Minimum	1	0.00	1.30	2	0.50
Maximum	4	38.30	9.65	17	9.00

Source: own survey (2008)

6.2. Bivariate association of some households characteristics, socio-economic, resources endowment, inputs supply and institutional issue factors with food security status of the households

6.2.1. Households characteristics

Characteristics which peculiar to the household- age of the household head, dependency ratio, and educational status of the household head in relation with food security status of the household are presented below.

6.2.1.1. Age and food security

Farmers acquire experience and knowledge through devoting their time on farm activities. Therefore, older age means better experience, better coping strategy in the case of adverse climatic condition and better food security. This test was taken to see whether there is a significant mean difference between the age of the food insecure and the food secured in the sample households. The result in Table 6 portrays that the mean age of the HH who are the food insecure and the food secured household is 43.57 and 38.31 years with standard deviation of 12.60 and 12.18 years respectively. The independent t-test shows there is a significant difference between the mean ages of the food insecure and the food secured HH. This result indicates that the food secured households are relatively younger than the food insecure HH. This phenomenon in the study area is explained by the presence of high rate of polygamy in the older HH (see annex Table A-7). This means more large family size and then food insecure.

Table 6. Age in the sample Households by status of food security

Age Of HH (Years)	Food insecure (n=49)	Food secured (n=91)
Mean	43.57	38.31
SD	12.60	12.18
t -value	2.442	
p-value	0.016	

Source: own survey (2008)

6.2.1.2 Dependency ratio and food Security

The presence of high dependent member in the farming household on the active labor is a burden, as there is little labor in the HH. As a result, the food security status and other high labor demanding farm activities will be affected negatively. The analysis was taken in order to see whether there is a significant mean difference in the presence of dependent household members between the food insecure and the food secured households. The result in Table 7 below indicates that the mean dependency ratio of the food insecure households as well as the food secured households is 1.66 with standard deviation of 0.85 and 0.88 respectively. The independent t-test between the food insecure and the food secured households shows insignificant mean difference in the presence of dependent household members at 5% significant level.

Table 7. Dependency ratio in the sample households by status of food security

Dependency Ratio	Food insecure (n=49)	Food secured (n=91)
Mean	1.66	1.66
SD	0.85	0.88
t-value	0.260	
p-value	0.795	

Source: own survey (2008)

6.2.1.3. Educational status of the HH and food Security

Education is essential to understand and implement new technologies. As a result, an educated HH is assumed to be better adopter of new technologies such RWH, use of fertilizer, improved seeds and so on, which in turn increase the production of farmers and the level of food security status. The analysis was taken in order to see the association between education status of the HH and the food security status of the households.

Table 8 below reveal that 28.6% of the food insecure households are literate and 46.9% of them are illiterate. Similarly, from the secured HH 71.4% are literate households and 53.1% of the illiterate households are food secured. The Pearson χ^2 -square test of

association shows that there is a significant association between the educational status of the HH and the food security status of the households at 5% significant level.

Table 8. Education Status of the HH by status of food security

Educational status of the HH	Food insecure (n=49)	Food secured (n=91)
	Literate	26(28.6)
Illiterate	23 (46.9)	26(53.1)
Pearson χ^2 -chi square value 4.723		
P-value 0.03		

Source: own survey (2008)

6.2.2. Resource endowment

Under this section the association of basic resource endowment availability-labor, oxen, livestock and farm land size in the household with food security status of the household are presented.

6.2.2.1. Labor availability and food security

The availability of labor is an essential component of a farm household since enough labor indicates that the capability of the farmer to engage in farm activities demands high labor such as RWH or they can intensively utilize their labor in the farm to increase production (See annex Table A-3 how the labor adjusted to PE). The analysis was taken to see whether there is a significant association between the availability of labor and food security status of the households.

Table 9 below depicts that the mean labor availability in the food insecure households was 4.50 in PE and the food secured households has a mean labor availability of 3.47 in PE with a standard deviation of 2.04 and 1.71 in PE respectively. The independent t-test indicates that there is a significant mean difference in the availability of labor between the food insecure and the food secured households at 1% significant level. This result indicates

the excess availability of labor in the food insecure households than the food secured households. This may be that the relative small ratio of farm (land) to labor availability in the food insecure households than the food secured households, which in turn shows that no sufficient land to operate their farm activity. Or there is no enough land to fully utilize the labor in the food insecure households as compared to the food secured households.

Table 9. Labor availability in sample HH by status of food security

Labor availability in Person-per equivalence (PE)	Food insecure (n=49)	Food secured (n=91)
Mean	4.50	3.47
SD	2.04	1.71
t-value	3.037	
P-value	0.003	

Source: own survey (2008)

Attempt was done to see the term of engagement that the households' labor has. Accordingly, the farm households indicated that 75.7% of the labor engaged in the farm activity as a part time base where as the remaining 24.3% of the households revealed that they are engaging as a full time worker (see annex A-12below).

Further, analysis to see the possible way how the farm households get labor is also examined. The result portrays that 97.1% of the households whose labor engagement were in a full time have shown no interest to hire households labor while households whose labor are engaged as a part time, 69.2% of them have shown no interest to hire labor (see annex A-12).

6.2.2.2. Oxen availability, livestock availability and food security

Oxen availability is vital in farming household as the agriculture depends on traditional farming system and it is also a source of income for the household. The analysis was taken to see whether there is a significant mean difference in oxen availability between the food insecure and the food secured households.

Table 10 below indicates that the mean oxen available in the food insecure and the food secured households are 2.12 and 2.51 in TLU with standard deviation of 0.93 and 0.91 in TLU respectively. The independent t-test between the mean oxen availability in the food insecure and the food secured households shows a significant mean difference between the two groups at 5% significant level. This result indicates that the oxen availability in food secured households relatively higher than the food insecure households.

Table 10. Oxen availability in the sample HH by status of food security

Oxen availability in TLU	Food insecure (n=49)	Food secured (n=91)
Mean	2.12	2.51
SD	0.93	0.91
t-value	-2.345	
p-value	0.021	

Source: own survey (2008)

In a similar manner, the availability of livestock excluding oxen is also checked to see whether there is a significant association with the food security status of the households (see annex Table A-1 how it is converted into TLU).

The result in Table 11 below depicts that the range (5.01-10) TLU comprise the highest livestock availability which accounts 39.3% of the total livestock availability. Of these 58.2% of the livestock's availability in TLU found in the hands of food secured households. Followed by the second highest category (0-5 TLU), which accounts 22.1% of the total livestock's availability of the sample households. However, in the category that contains livestock greater than 15 TLU the food secured households entirely dominate in the number of livestock's ownership as compare to the food insecure households. The Pearson χ^2 association test portrays that there is a significant association between the availability of livestock and the status of food security in the households at 5% significant level. This result indicates that households with a relatively high number of livestock are found to be food secured than food insecure households.

Table 11. Livestock's availability in the sample HH by status of food security

Livestock availability excluding Oxen)	Category	Food insecure n=49(%)	Food secured n=91(%)	Total n=140(%)
	0-5	11 (35.5)	20 (64.5)	31(22.1)
	5.01-10	23 (41.8)	32 (58.2)	55(39.3)
	10.01-15	12 (44.4)	15 (55.6)	27(19.3)
	15 +	3 (11.1)	24(89.9)	27(19.3)
Pearson χ^2 -Square 8.959 p-value 0.030				

Source: own survey (2008)

6.2.2.3. Farm land size and food security

The presences of sufficient farm land size in the farm households determine the food security status of the household and also encourage them to use new agricultural technologies such as RWH, fertilizer, pesticides and so on. The analysis was carried out to see whether there is a significant mean farmland size difference between the food insecure and the food secured households.

Table 12 below indicates that the mean farm land size in the food insecure and the food secured households are 2.4 and 2.9 hectares with standard deviation of 1.4 and 1.9 in hectares respectively. The independent t-test shows that there is a significant mean difference in farm land size holding by the food secured and the food insecure households at 10% significant level. The food secured households have a relative larger farm land size than the food insecure households.

Table 12. Farmland size in the sample HH by status of food security

Farm land size in hectares	Food insecure (n=49)	Food secured (n=91)
Mean	2.4	2.9
SD	1.4	1.9
t-value	-1.743	
p-value	0.084	

Source: own survey (2008)

6.2.3. Inputs Supply

This section describes fertilizer and credit uses of the household in relation with the food security status of the households.

6.2.3.1. Use of fertilizer and food security

Use of fertilizer for crop production plays a vital role to increases production of the farmers. In the study area use of fertilizer is one of the major inputs for crop and cash crop production. The analysis was taken to see the association of fertilizer users and non-users with the food security status of the households.

Table 13 below portrays that a total of 57.9% of the sample HH are fertilizer users. Of these, 75.3% of them were food secured households and remaining 24.7% of them are the food insecure households. Similarly, of the total 42.1% of the non-users of fertilizer 50.8% of them are the food secured and 49.2% of them are the food insecure households. The Pearson χ^2 -square association test indicates that there is a significant association between the food security status and fertilizer users at 1% significant level. This association difference in the users of fertilizer between the food insecure and the food secured households that fertilizer utilizes might got the better opportunity to increase their production and productivity as compared to their counterpart.

Table 13. Fertilizer users in the sample HH by status of food security

Make use of fertilizer		Food insecure n=49(%)	Food secured n=91(%)	Total n=140(%)
	Yes		20(24.7)	61(75.3)
No		29(49.2)	30(50.8)	59(42.1)
Pearson χ^2 -square value 8.98 P-value 0.003				

Source: own survey (2008)

6.2.3.2. Credit service and food security

Access to credit service helps the farmers to purchase agricultural inputs such as fertilizer, improved seeds, and oxen, which in turn increases production and secure the calorie level of the credit users. In addition, access to credit may also helps the farmer to improve the RWH structure by building it with concrete, to scale up the size of the structure and to cover with plastic sheet, which in turn helps to sustain water availability during dry season.

The result in Table 14 depicts that 25% and 75% from the food insecure and the food secured households respectively are credit-service users that on aggregate accounted 28.6% from the total sample households. Where as, 39% and 61% from the food insecure and the food secured households are not credit users that give on aggregate 71.4% of the total sample households non-users. The Pearson χ^2 -square test indicates that there is insignificant statistical association in the credit service utilization and the food security status at 5% significant level.

Table 14. Credit service utilization in the sample HH

Credit service utilization		Food insecure n=49(%)	Food secured n=91(%)	Total n=140(%)
	Yes		10(25)	30(75)
No		39(39)	61(61)	100(71.4)
Pearson χ^2 -chi square 2.46 p-value 0.117				

Source: own survey (2008)

Table 15 below indicates that 62.5% of the sample household farmers from the credit users make use of the credit for more than two purposes such as for the purchase of oxen, seed and fertilizer. The remaining households used the credit for the purchasing of oxen are 10%, the other 15% of the credit used for the purchasing of seed and 12.5% purchasing of fertilizer. However, 64% of the non-users reveal the absence of institutions to provide the credit service was one of the reasons that hamper them in not using the credit. In addition, 18% of them indicated fear of high interest rate.

Table 15. Purpose of credit used and reason for not using credit service in the sample HH

Purpose of credit taking	N (%)
To purchase oxen	4(10)
To purchase seed	6(15)
To purchase fertilizer	5(12.5)
For multiple reason	25(62.5)
Total	40(100)
Reason for not taking Credit	N (%)
Fear of inability to pay	9(9)
Lack of asset for collateral	1(1)
No institute to give the service	64(64)
High interest rate	18(18)
No need for credit	6(6)
Total	100(100)

Source: own survey (2008)

6.2.4. Institutional issue

Institutional issues which are related to land tenure and market accessibility in association with the food security status of the household are described under this section.

6.2.4.1. Land tenure issue and food security

The existence of land tenure security encourages the farmers to protect their farm land, and to invest on it by way of tree planting. The security of land tenure will also encourage the

farmer to build long lasting structure like RWH, which in turn supplement the food security status of the households.

Tables 16 below indicate that 64.1% of the total sample households have expressed their ownership feeling on land. Owing to the provision of a license that can secure the ownership of the land in which they are currently operating on it. Despite the provision of the security license by the government, still 35.9% of the samples households have expressed their insecurity of the land they possessed currently. Of the total sample households who have land tenure security 64.4% of them are food secured. Similarly, of the total households who have expressed their insecurity of the land in which they are operating, 66.7% of them were food secured households. The Pearson χ^2 -square association test reveals that there is no any statistical significant association between land tenure security and food security status at 5% significant level.

As to the reason of the farmers insecurity of the land in which they are operating the following reasons were forwarded. The main reason for their insecurity is the fear of eviction from their land by the expanding flower industry around their vicinity, which accounts 50% the respondents feeling. While 10%, 18% 22% are due to pollution threat, competition over the usable water for domestic and livestock's and the aggregate thereof of the above three respectively (see Table 17 below).

Contrary to what the land insecure households secured households were expressed their positive expectation from the flower industry expansion. These expectations are employment (11.1%), improve infrastructure development like hospital, road, school and water point (23.3%) and the remaining 65.6% of the participants expect the above multiple benefits (see Table 17 below).

Table 16. Land Tenure security in the sample HH by status of food security

Land tenure secured		Food insecure n=49(%)	Food secured n=91(%)	Total n=140(%)
	Yes	32(35.6)	58(64.4)	90(64.3)
	No	16(33.3)	34(66.7)	50(35.7)
Pearson χ^2 -square value 0.089 P-value 0.765				

Source: own survey (2008)

Table 17. Land insecure/secured HH felling of threat /expectation in the sample study HH

Threats	N (%)
Eviction from own land	25(50)
Pollution threat	5(10)
Competition on usable water	9(18)
All the above threat	11(22)
Total	50(100)
Benefits	N (%)
Employment	10(11.1)
Infrastructures	21(23.3)
The above multiple benefits	59(65.6)
Total	90(100)

Source: own survey (2008)

6.2.4.2. Market accessibility and food security

The distance the farmers travel to sale their agricultural products, to purchase other food items and the market information that the farm households getting is a crucial determinant for the food security status of the households and to have a reasonable price. Thus, the accessibility of market has a positive relation with food security status of the households. The analysis was carried out to see whether there is a significant mean difference in the average distance the farmer travel from their home with in the food secured and the food insecure households.

The result in Table 18 below indicates that the food insecure households are on average 12.7 km away from the main market place. However, the food secured households are located on average 10.6 km from the main market location with less than nearly 2 Km from the insecure household. The independent t-test indicates that there is a significant mean difference in the distance the farmers situated from the main market location by the food secured and the food insecure households at 1% significant level. This result shows that food secured households are located in a relatively near place from the main market than the food insecure households.

Table 18. Market accessibility in the sample households by status of food security

Market accessibility in (Km)	Food insecure (n=49)	Food secured (n=91)
Mean	12.65	10.60
SD	3.80	3.20
t-value	3.761	
p-value	0.000	

Source: own survey (2008)

6.2.5. Role and association of RWH to Income and food security of the household

Rural people derive income from multiple sources-both from within the and without the agriculture. The sources of these incomes are off-farm activity, remittance, income from rain fed crop and cash crop. In the following section, explanation is given for income from RWH agriculture by the participants in RWH and income generated from asset base (livestock) and rain fed agriculture by the participants and the non-participants in RWH and later the aggregate income association with the food security status will be considered. However, for both groups income from remittance and off-farm income were found to be none.

As shown in Table 19, participants of RWH have generated median income of Birr 2300, the maximum being Birr 17,000. The majority of the RWH participants (71.4%) income

fall in the category (Birr 0_2000). Of the total participants, only 28.5% of the farmers were managed to get income greater than Birr 2000. Considering these facts majorities of the participants in RWH are getting income below the median income, which indicates that there are individual participants who are getting a substantial amount of money greater than the median. Or their income shows a high variation where very few of them are benefiting a lot out of it while the majorities are unable to do so.

Table 19. Annual income generated by sample households from the RWH participants

Income from RWH (Birr)/Household/year		N=70 (%)
0-2000		30(71.4)
2001-4000		23(16.4)
4001+		17(12.1)
Median	2300.00	
SD	4009.73	
Maximum	17,000	
Minimum	0	

Source: own survey (2008)

In association with the particular product the participants can produce using the harvested water, 52.9% of them divulges that their income is generated from a new cash crops-hot pepper, cabbage and potato while the remain households reveal that their income was obtained without a new type of cash crop production. This indicates that the use of RWH encouraged the participants to produce new type of cash crop (see annex Table A-5).

6.2.5.1. Rain fed income in the participants and the non-participants in RWH

As Table 20 portrays below sample households income from rain fed crop production. It is possible to discern that the majorities of the sample households' income was found within income range of Birr 1200-7000, which accounts 45.7% of the participants in RWH and 50% of the non-participants were also in the same category. The second highest income category of the participants is the category greater than Birr 18600 which comprises 24.3%.

This category contains the least number of the non-participants in RWH, which is nearly none. The Pearson χ^2 -square association test indicates that participants in RWH reap significantly high income than the non-participants in RWH from rain fed agriculture at 5% level.

Thus, considerable number of the participants are reaping substantial amount of income as compared to the non-participants in RWH. It is no surprising to see such a stark difference in the amount of income that the participants generate, because to begin with the participants were well to do economical and political elites, which is witnessed by FGD and KI in the previous chapter (5). However, let this shall not be take as there are no rich or political elite guys from the non-participants. In addition, their engagement in RWH will further exacerbate the disparity as they can get hold of enough amount of money from cash crop production, which possibly help them to purchase agricultural inputs like fertilizer, pesticides and improved seed. In turn, it can increase the production and productivity and there by increase the income that the participants could possibly reap from rain fed agriculture; otherwise they would have been like their counter parts.

Table 20. Annual income generated from rain fed in the sample Households survey

Income from rain fed crops Birr/year	Participants in RWH n=70(%)	Non-participants in RWH n=70(%)	Total n=140(%)
1200-7000	32(45.7)	35(50)	67(47.9)
7001-12800	13(18.6)	20(28.6)	33(23.6)
12801-18600	8(11.4)	10(14.3)	18(12.9)
18600+	17(24.3)	5(7.1)	22(15.7)
Median income	8800	7100	7600
Pearson χ^2 -square 8.387 p-value 0.039			

Source: own survey (2008)

6.2.5.2. Income from Asset (livestock) in the Participants and Non-participants in RWH

Farm households can also reap income through the sale of asset such as livestock. Table 21 below indicates that the participants and the non-participants in RWH have performed nearly equal in amount of income they generate from livestock sale with a median income of Birr 1000. However, the paired t-test indicated a strong significant difference in the availability of livestock (excluding oxen) and oxen before and after engagement in RWH which its impact was not observed (see annex Table A-6).

Table 21. Annual income from Livestock sale in the sample households

Livestock income Birr/year	Participants in RWH n=70(%)	Non-participants in RWH n=70(%)	Total n=140(%)
0-1090	38(54.3)	36(51.4)	74(52.9)
1091-2180	12(17.1)	13(18.6)	25(17.9)
2181-3270	3(4.3)	4(5.7)	7(5)
3270+	17(24.3)	17(24.3)	34(24.3)
Pearson χ^2 -square 0.237 p-value 0.971			
Median income 1000 SD 2721.85 Minimum 0 Maximum 13,115			

Source: own survey (2008)

6.2.5.3. Aggregate income and food security

The amount of income that the household has effect on the food security status in order to see this effect all the above three sources of income (asset-livestock, rain fed income, and RWH-cash crop income) are aggregated together. The result indicates that from low income category groups 74.5% of them are food secured, 53.2% of the middle income groups and 67.4% of high income groups are food secured (see Table 22 below).

Irrespective of their income category all the groups performed some how in equal manner, which could probably has some thing to do with how the income used or economically utilized. Thus, this result led to speculate that income by its own right may not alleviate food security problem, which is going to be treated in the next chapter (7). The Pearson χ^2 -square association test indicates that there is a significant association between the income group and food security status of the household at 10% significant level.

Table 22. Aggregate income of the sample households by status of food security

Aggregate income category in(Birr/ year)	Food insecure n=49(%)	Food secured n=91(%)	Total n=140(%)
(4000-19660)Low	12(25.5)	35(74.5)	47(33.6)
(19661-49890)Middle	22(46.8)	25(53.2)	47(33.6)
(49890+)High	15(32.6)	31(67.4)	46(32.9)
Pearson χ^2 -square value 4.848			
p-value 0.089			

Source: own survey (2008)

Further, the contribution of each source of income to the total household income was considered, accordingly 3.2% of the total income of the households was steamed from RWH, 23.4% was from livestock sale and 74.4% was from rain fed income.

6.2.5.4. Engagement in RWH and food Security Status

From the total sample households, 65% of them were food secured, of which 67.1% of the participants in RWH and 62.9% of the non-participants were food secured. Participants were in a relative better position with respect to food security status because nearly 4% additional food secured individual found in the participants' category as compared to the non-participants in RWH (see Table 23 below). The Pearson χ^2 -square test indicates that there was insignificant association between engagement in RWH and status of food security at 5% significant level. This may be due to confound factor effect problem that

need to be disentangle by the multivariate analysis in the following chapter (7) as bivariate results are having inherent problem of disentangling.

Table 23. Food security status in the sample household by the engagement in RWH

Food Security status	Participants	Non-participants	Total
	RWH n=70(%)	in RWH n=70(%)	n=140(%)
Food secured	47(67.1%)	44(62.9%)	91(65%)
Food insecure	23(32.9%)	26(37.1%)	49(35%)
Pearson χ^2 -square value 0.283			
P-value 0.595			

Source: own survey (2008)

Further analysis was made to see the position of sample households referring to the calorie consumption. To this effect, the data on household calories consumption per Adult Equivalence per day was categorized taking 2100 Kcal as a cut off point. Those household whose Kilo calorie consumption (consumption irrespective of the nutritional content) is above 2100 Kilo calorie were assumed as food secured and below that threshold considered as food insecure (see Table 23 below).

Out of 35% of food insecure households 12.86% of them had calorie consumption in the range of 300-1199.99 Kcal per Adult Equivalent per day. In the same range 11.43% of the participants in RWH and 14.29% of the non-participants in RWH were found, which indicates the presence of nearly 3% more individuals who are food insecure from non-participants category. In the second category (1200-2099.99 Kcal per adult equivalent per day) relatively equal numbers of households were found from both categories. However, this category accommodates majorities of the food insecure households. In the next two subsequent categories (2100-2999.99 and 3000-3899.99 Kcal AE per day) on aggregate the number food secured households in the participants in RWH were 55.71% and 47.14% were the non-participants in RWH. This shows that there is no any clear difference in the amount of calorie consumption between the two categories in the mentioned intervals. The last category (3500+ Kcal AE) includes 11.43% of the participants in RWH and 15.71% of the non-participants in RWH. In addition, the Pearson χ^2 -square test depicts that there is

insignificant statistical association between food security status of the households and engagement in RWH at 5% significant level (see Table 24).

Table 24. Households Calorie Consumption per AE per day by engagement in RWH

calorie consumption in Kcal per AE	Participants in RWH N=70(%)	Non-participants in RWH N=70(%)	Total N=140(%)
300-1199.99	8(11.43)	10(14.29)	18(12.86)
1200-2099.99	15(21.43)	16(22.86)	31(22.14)
2100-2999.99	13(18.57)	12(17.14)	25(17.86)
3000-3899.99	26(37.14)	21(30.00)	47(33.57)
3900+	8(11.43)	11(15.71)	19(13.57)
Pearson χ^2 -square value 1.817 p-value 0.769			

Source: own survey (2008)

Chapter Seven

Econometric model estimation

This chapter presents the major determinants of food security in the study area context. In this particular subsection, first description is given on the existence of multi co-linearity problems among the continuous and categorical variables. Following, brief explanation is given for the result of obtained from the model.

For bivariate association/relation tests are only direction indicator and at the same time has inherent limitation to effectively disentangle the effect of each variable over the dependent variable. It is problematic to accept the effect of each variable over household food security status on bivariate analysis. Furthermore, the variables which were significant in bivariate analysis may be insignificant in the multivariate analysis or insignificant in bivariate analysis may be significant in multivariate analysis due to the confound factor effect. Thus, in order to overcome these limitations econometric model was employed.

7.1. Food security determinants

Based on the theoretical frame work that is developed in section 2.5 factors that are expected to affect the food security status of the households were employed in the model. However, before the actual commencement of the data analysis in the logistic regression model the following diagnosis were taken.

Multicollinearity diagnosis test was taken to filter for variables that are dependent to each other. To this effect, the presence of high co-linearity was checked for continuous variables using Variance of Inflation Factor (VIF) and Contingency Coefficient (CC) test was taken for categorical variables (see annex Table A-8 and A-9). Accordingly, annex Table A-8 indicates no multicollinearity problem found among continuous variables. Nevertheless, in categorical variables there happen to be a problem of multicollinearity between fertilizer utilization and credit service utilization, credit with land tenure issue and credit with income as indicated in annex Table A-9. As a result, credit service utilization omitted from the binary logistic regression model. In addition, the sex of the households

and extension service were not used in the model as the response given to these variables are entirely the same.

Goodness of fit of the model was carried out. Accordingly, Hosmer and Lemeshow test for goodness of the model indicates chi-square association is insignificant. Thus, model is a good fit since the chi-square value is insignificant. The overall correctly prediction of the logit regression model is 83.6% and model prediction for food secured 91.2% and for food insecure 69.4% (see Table 25).

Instead of separate income obtained from asset (livestock sale), RWH and rain fed, the aggregate of them used in the model for the reason that the separate effect of the variables on the model was none (β 's of the separate variables was zero). Furthermore, the existence of interacting variables between continuous with continuous, continuous with dummy, and dummy with dummy variables were checked. The result obtained indicates that there is a significant interaction effect between the dummy variables education attainment of the HH (LEDUC) and aggregate income of the household HH (REALINCOME). Thus, the product of LEDUC and REALCOME was used in the model as one variable together with other socio-economic, inputs, resource endowment and demographic variables that are expected to affect food security of the households.

The model result in Table 25 below shows that Exp (β) values for ten out of fifteen variables significantly affect food security status of the sample households at different significant level. However, some of the variables shown unexpected sign such as AGE (age of the HH) and LABOUR (labor availability of the households).

Table 25. The maximum likelihood estimates of Binary Logit Model (BLM)

Variables	B	Standard Error (S.E)	P-value	Odds Ratio
AGE	-.059	.031	.060	.943
RATIO	-.408	.355	.250	.665
LABOUR	-.889	.235	.000	.411
TENURE(1); 1=secure; 0=otherwise	-.959	.640	.134	.383
LANDSI	.535	.271	.048	1.708
OXEN	.376	.411	.360	1.456
TLU	.082	.056	.142	1.086
ENRWH(1); 1= participants; 0=otherwise	1.213	.570	.033	3.364
REALINCOME(1); 1=high;0=low	4.244	1.388	.002	69.707
REALINCOME(2); 2=middle;0=low	2.021	1.407	.151	7.546
LEDUC(1); 1=literate; 0=otherwise	2.621	1.139	.021	13.752
FERZER(1); 1=users; 0=otherwise	1.565	.653	.017	4.780
MARKTA	-.274	.094	.004	.760
LEDUC(1) * REALINCOME(1)	-4.668	1.507	.002	.009
LEDUC(1) * REALINCOME(2)	-2.679	1.515	.077	.069
Constant	4.275	2.332	.067	71.851
Hosmer and Lemeshow test				
chi-square (χ^2) 10.623				
p-value 0.224				
Sensitivity ^a 91.2%				
Specificity ^b 69.4%				
Overall percentage prediction 83.6%				

^a Correctly predicted food secure groups based on a 50-50 probability classification scheme

^b Correctly predicted food insecure groups based on a 50-50 probability classification scheme

Age (AGE): It is one of the basic components of food security determinant in rural households. The older the HH what is expected is the more experience that he/she has in farming, more risk averters and mostly they intensify production and diversify their production.

However, the result of the model indicates that keeping all other factors constant for one year increase in the age of the household is associated with a decreasing of food security status of the household by the factor of 0.943, which is significant at 10% level. This may be that when the HH is getting older and older apart from the experience that he/she acquired the HH will be resistant to new information and innovation, which may affect to utilize his/her experience for averting risk. In addition, the significant relation that is found between old age HH and polygamy might probably play a deterring role in the status of food security the household; there by increasing the family size of the household (see annex Table A-7). Workneh (2006) has also found in his study of determinants of small farm household food security in south Wollo employing OLS regression model that the age of the household is significantly and negatively related to food security in 2000/01 cropping years.

Labor Availability in the household (LABOR): The availability of sufficient labor plays a pivotal role for food security status of the household. More laboring unit in the household indicates the household can intensify their production. Hence, the food security status of the household is expected to be bettering high labor available households than in the lower.

Nevertheless, the result of the model indicates that increasing the availability of labor has negative and statistical significant relation with food security status of the household at 1% level. The odd ratio indicates that a unit increase in labor availability in PE in the households would result in decreasing food security by the factor of 0.411.

This could probably be the attainment of marginal return of labor that means for what ever unit labor incremental in the farm activity the production will remain the same, which may not encourage them to engage on the farm activity. Thus, the presence of high labor beyond the available cultivable land seems a sheer unproductive number and high number of

consuming unit. This corroborates Workneh argument in the interview given to Zerihun (2008, June 14: 10) in Addis Neger weekly Amharic version news paper presented that the presence of surplus labor in the household has a “pressure on consuming pattern, deters the creativity of the labor, hamper technological transfer and also create social instability”, which in turn affects the food security status negatively. Or the ratio of land to labor is 0.79, which means there is excess unit of labor per household than cultivable land. In addition, had the average family size were considered the situation would have been worse to show the potential fragmentation of the farm land, which pressurize in order to pursue subsistence livelihood pattern. Therefore, they will not have sufficient land to fully utilize their labor.

Cultivable Land Size (LANDSI): this refers to the total available land that can be cultivated. The higher land sizes in the HH, the higher the chance for food security in the HH, which enables the HH either to cultivate so that to obtain production or may rent it to generate income.

The result from the odd ratio of the LANDSI indicated that for one hectare increase in cultivable land size is associated with 1.708 fold increase in the odds of having food security in the households, which is significant at 5% level. Kidane et al (2005) in their study of cause of household food insecurity in Koredegaga peasant association in Oromiya zone applying logistic regression, they have found that farm land size is positively and significantly related to the probability of the household to be food secure. In addition, it was indicated that the probability of food security would increase by 6% for one-hectare increase in frame size. Similarly, Workneh (2006) has found that keeping all other factors constant the food security of the household increase by a factor of 205.034 and 188.161 in 2000/01 and 2001/02 cropping years respectively for the unit increase in land farm size.

Engagement in RWH (ERWH): those farmers who are engaged in RWH have a better chance for food security than the non-participants. The participants can rely on the collected water during dry season to produce and to generate income through cash crop production; they can also produce seedling before the on set of rain season as well as protect crop failure during dry spell depending on the volume of the water collected.

The odds ratio of the food security status of the participants as compared to the non-participants in RWH indicates 3.364 fold increase in the odds of the food security status in the participants than in the non-participants, which is significant at 5% level. This increase in the food security of the former as compared to the later could be that the formers engagement in cash crop production helped them to reap substantial amount of money, which in turn help them to purchase consumable food during dry season. Or the income that the participants obtained from RWH might have given them the opportunity to purchase essential agricultural inputs such as fertilizer, improved seeds and pesticides which in turn increased their productivity and better food security status than their counterparts. Odhiambo (2005) in his study in Lare division located in a central rift valley of Nakuru district in Kenya indicated that the use of RWH as a supplemental irrigation happen to be linked with increase in food security and income level of the participants in RWH.

Furthermore, he found out that the participants were able to diversify their production, which enables them to reap substantial amount of income from cash crops. Similarly Senkondo et al (2004) in their study in Makanya, Hedaru and Bukangilija regions in Tanzanian have concluded that RWH availability has brought a potential option for production in semi-arid areas. The research done by Rockstrom et al (2003) in Gansu province of China reveals the same fact that the water productivity increased by 20% (Which means there is about $1.6 \text{ Kgha}^{-1}\text{mm}^{-1}$ incremental in productivity) using RWH as a supplementary irrigation. Nigigi (2003) indicated that RWH in Kobo has led production of *tef*, pepper and sorghum in 100-200%, 100-500% and 100% respectively.

Use of fertilizer (FERZER): Farmers use fertilizer as an input to improve their farm productivity. Uses of fertilizer increase productivity of crop per unit area, which would improve total production per household and more food will be available for farmers who use fertilize as compared to the non-users. Therefore, it has a positive relationship with household food security.

The result from the model indicates that keeping all other factors constant the food security of fertilizer users increased by a factor of 4.780 fold as compared to the odd of food security status of the non-users of fertilizer, which is significant at 5% level. Kidane et al (2005) have attested the same fact that the food security of fertilizer user households is positively and significantly affected unlike their counterparts. The empirical evidence that they have obtained indicated that the probability of food security of the households who are fertilizer users increased by 11% as compared with their counter part.

Market accessibility (MARKA): the distance they travel to sell their agricultural products, to purchase other food items and the reasonability of price for their products matter most for the rural HH to get their right benefit. Thus, the accessibility of market has a positive relation with food security and income. In other words, as the distance the farmers travel increase, there will be a negative relation to food security because they can not easily transport their agricultural and livestock products and at the same time information about the market situation is not accessible.

The result from the model indicates that keeping all other variables constant for one kilometer increase in the distance that the framer travel from the market is associated with a 0.76 factor decrease in the food security status of the household. Islam (1988, as cited in Nyariki and Wiggins, 1997) has documented that the market situation of different households in different infrastructure development area have different access to food. A similar argument, given by Webb et al. (1992, as quoted in Workneh, 2006) has shown that famine in Ethiopia is induced by isolation of farm households from the major markets together with other limiting factors.

Effect of Interaction terms Educational Status of the HH and Income level of the Households

Interaction term effect means the effect of a certain independent variable (call it X) on the dependent variable (call it Y) depend on the value of another independent variable (call it Z). Thus, what it means is in order to interpret the effect of LEDUC for food security, REALINCOME will be used to explain and similarly to interpret the effect of

REALINCOME on food security, LEDUC will be used as they are intermingled factors to explain food security.

Accordingly, the first step in doing so was to calculate the coefficient (β) of interaction term. Once the coefficient is obtained the calculated value of e^β gives as the respective odd ratio (Exp (β)) of the interaction term. Thus, the effect of having education for higher, middle and low income categories for food security are 2.621, -0.058 and -2.047 with their respective Exp (β) values 13.7500, 0.9436 and 0.1290. Whereas, the effect of high and middle income to have education for food security is -0.424 and -0.658 with their respective odd ratio value (Exp (β)) value of 0.6542 and 0.5189 respectively. The effect of high and middle-income category for illiterate households for food security is 4.244 and 2.021 with Exp (β) values 69.686 and 7.546 respectively.

The interpretation is using education status of HH as a focus variable, the effect of being educated on having food security is greater in high-income groups than in the rest groups. This means the availability of sufficient income to the HH as a single variable may not warrant food security of the household. Instead, the way that money managed and utilized to the priority area matters or the way that income allocated to high return giving projects matters most. That is why the result shows educational status of the HH is important to affect how the money spent efficiently. By the same token to have sufficient amount of income is a precondition to attain food security but not an end by it self, when it is supported by education there will be better management of the available income and efficient utilization, which in turn paves the way to have food security. However, to lower income groups to begin with, they need to have the threshold level of income in order the education status of the HH could affect it.

Similarly, using income as a focus variable, the effect of being from middle and high income group on having food security is greater in illiterate households than the literate. While for low income groups the effect remains the same.

This may be that the illiterate households work without discriminating the type of the job as their self-esteems is relatively lower compared to the literate. For instance working being hired as laborer for the haves household, selling fuel wood, charcoal and sending their kids

to work as herders to generate income is much acceptable in the illiterate than the literate households in the study area. This is in harmony with Sen (1989) work on food and freedom that “the compulsion to acquire enough food may force the vulnerable people to do things, which they resent doing and may make them to accept lives with little freedom”. Or the tendency of illiterate households to spend their income on non-food item is less likely, which might help them to sustain the threshold level of their daily calorie as compared to their counterparts.

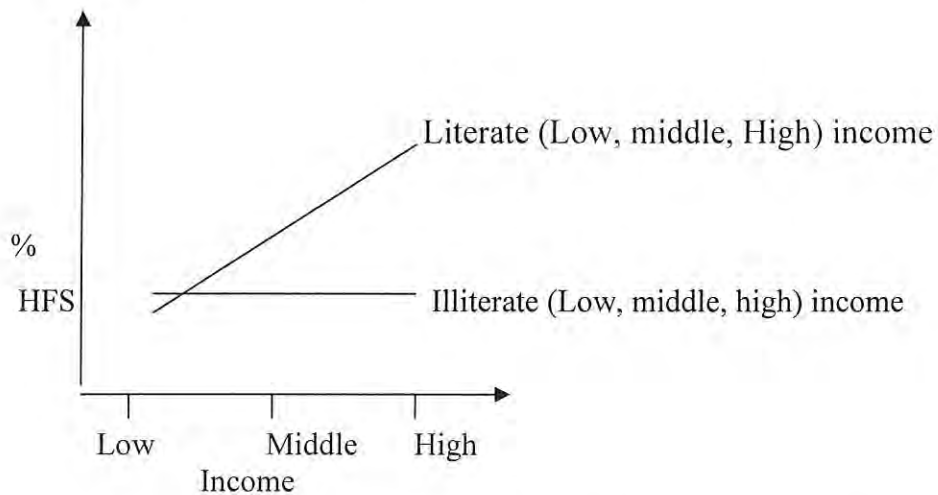


Figure 3. The effect of education on having food security taking income as a focus variable

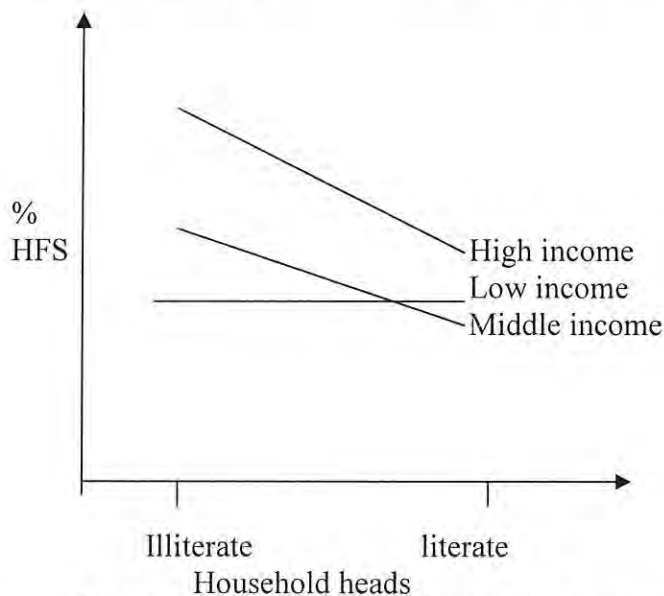


Figure 4. The effect of income on having food security taking education status as a focus variable

Chapter Eight

Conclusion and Recommendation

The author come up with the following major conclusions as per the three research questions-what are the determinants of household food security, what is the contribution of RWH for food security, and what are the practices and challenges of RWH? In order to arrive at a conclusive answer for those basic research questions the author has employed multiple methods ranging between core quantitative such as descriptive statistics (bivariate, percentage, mean, SD, and median) and multivariate analysis (logistic regression). In addition, qualitative (triangulation) analysis is used.

8.1. Conclusion

This study demonstrates that household food security in the study area is determined by seven key socio-economic, household, resource endowment, inputs and institutional issue factors as depicted below. Yet, the author believes that this is not a complete study to come up with solid solution to address the food security situation in the area under this study. For the reason that the causes of food security issue is so complex, have several intermingled factors and subjected to seasonal variation. However, considering all these factors is beyond the scope of this study. Moreover, the study has knowledge gap as to how political, economical, cultural and social sphere of influence has impact on the utilization of basic resources and how this sphere of influence are also hindering/ promoting to translate those basic resources into food security attainment. There is also a knowledge gap as to what the impact of the harvested water has on up/ down the stream, to the hydrological cycle and the effect of it on the environment.

The multivariate statistical estimator portrays that households led by relatively young heads were better in the status of food security than the household led by the aged ones. This implies that, aged HHs are influenced by polygamy culture that in turn increases the family size and creates food insecurity. Higher labor availability in the household is also associated with a decrease in the food security status of the households. Because the existence of high labor may indicates surplus labor beyond the carrying capacity of the

parcel in the household, which thus implicitly indicate high consuming unit and deepen the food insecurity problem in the household. In addition, the food insecurity of the area aggravated by the distance in which the farmers travel. Households who dwelled near to the main market area have shown better food security status than those households located far as they are exposed to information distortion as well as transportation problem.

However, fertilizer using households in comparison with non-fertilizer users' households the former were better in food security status of the household than the later. It can be concluded that fertilizer utilization fosters the production capacity, which in turn shows better food security status. Farmers with a better endowment of farm land size showed better food security status than the less endowed households. Having large farm land size is not only essential to produce enough crops but also is a determinant factor for farmers to use new technologies such as fertilizers, improved seeds and so on.

From the interaction term using education as a focused variable being from a high income group may not necessarily warrant the betterment in food security status. It can be concluded that having high income is a means to have food security but it is not an end by its own right. Thus, scientific knowledge of money utilization is needed that could be shaped through education. Whereas, taking income as a focused variable from low and middle income earning households the illiterate are better in food security status than literate. It is possible to conclude that lack of freedom of choice for literate households in low and middle income group makes them vulnerable to food insecurity problem while illiterate households are secure by relinquishing their freedom for daily bread.

High rate of population growth clustered with increasing global climate variability, the need to attain enough food is a pivotal point. In this regard, RWH is believed to be one of the means to cope up with erratic and uneven distribution of rain fall in semi-arid and arid areas. This is owing to the fact that additional water source gives better chance to produce crops and cash crops during dry season and simultaneously increase soil moisture. The study reveals that there is a stark difference in the income that the participant farmers obtained from rain fed crop production and in food security status and also encouraged the

participants in the engagement of new cash crop production. Yet, it is not a “neutral achievement”, which is neither pro-poor nor gender unbiased.

The gap between plan and implementation of the package (RWH) is widening over time in most parts of the *Woreda* except in Bulbula, where self initiated adopters are increasing recently. For this absurd scenario observed in Bulbula three reasons are attributed. First, there is a sever shortage of water in Bulbula, which encourage them to have RWH. Second, the comparative advantage that the producer in cash crop has using RWH encourages the non-participants to do the same. Third, the better soil geology that exists in the Bulbula relatively matches with the structure. However, a number of challenges were observed that threaten the smooth implementation of the package (RWH). These challenges are pertinent to institutional, technological and adopter based. On the top of that, government attention has been significantly declining over time. As to the types of practice in RWH in Bulbula, the farmers were acquainted with their own traditional knowledge of harvesting rain by diverting of flood through channels, river into the farm (spate irrigation) and ground water utilization. However, presently the farmers are exposed to a package of different pond systems for water harvesting such as hemispherical ponds, ponds with plastic covering and without but compacted from beneath, where without and with plastic covering ponds are dominant practice.

From the descriptive statistical analysis it was found out that there is a large family size (8.1 individuals per household) above average national size (5 individuals per household). This has a potential implication for land fragmentation and increase the pressure of subsistence farming system. In addition, 65% of the households happened to have food security, while 35% of them were food insecure. Thus, the majority of the households could be considered as food secure. However, this result might have been different if the data had not been collected just after harvesting season. In addition, the absence of women headed households from the study might have contributed this good performance in the status of food security.

8.2. Recommendation

As per the finding of this study the following recommendations need to apply:

- ❖ Presence of high family size is significantly jeopardizing the food security of the households. Thus, it is needed to create awareness on the negative large family size by all concerned stakeholders and it is essential also to launch health extension service that can work on sustainable manner on family planning to the society.
- ❖ The presence of surplus labor also happens to deter the food security situation of the household in the area. Therefore, in a short term there is a need to utilize the excessive available labor by adopting agricultural policy that is less dependent on rain fall such as small scale irrigation, which may help them to produce more than two times in a year so that the excess labor can intensively be exploited. In addition, it is important to propagate non-farm activities in the area.
- ❖ The longer the distance that the farmers travel from their home to the market the more food insecure they are. It is needed to formulate intervention strategies by the local and federal governments to work jointly in order to alleviate the transportation problems and build a corporate institute that can provide information about the market situation to avert information distortion.
- ❖ It was found that fertilizer use happens to supplement the food security of the household. Thus, as a policy implication, there is a need to increase fertilizer users' among the poor households through the provision of a credit services at a lower interest rate. In addition, it is essential to introduce organic fertilizers, which can be made locally with a relatively low cost and at the same time ensuring sustainability for the environment.
- ❖ The result portrays farm land size increase improves the food security of the household. Thus, it is essential to build a conducive situation where by the farmers can have effective means to transfer cultivable land. Furthermore, increasing opportunity by which the farmers can have non-farm activities.

- ❖ As to the interaction term where education taken as a focused variable, the effect of it on having food security is better for high-income than for the rest groups. It has been indicated that having high-income is not an end by itself rather effective use/ management of money is needed. Besides, there is a need to create awareness on farmers about saving by government extension workers and concerned NGOs. Whereas, taking income as a focused variable the effect of income on having food security of the household is better in illiterate than literate while the literate households were insecure. The implication is that literate households need to have enough basket of choice to discharge their skills through creation of entrepreneurship by providing micro-credit service. In addition, as the literate are better in understanding new technologies and foster production, promoting industrial led growth economy will benefit from them with a little investment.

- ❖ RWH has shown a significant contribution in the household food security and also encouraged the households to engage in new cash crop production. However, it has been witnessed by FGD and KI that it is not a “neutral achievement”, which means neither pro-poor nor gender unbiased. Whence, a considerable policy improvement is sought from local level executers and federal government level policy designers in order to consider the vulnerable part of the society-poor and women headed households and to solve the problem that is pertinent to institutional, technological and adopters in the implementation process is needed as follows:
 - ✓ Solving the problems related to institutional capacity by providing training for the DAs, well documented manual and alleviating partiality of local elites. In addition solving unhealthy relationship of the local officials and farmers is needed as Abeje (2004) indicated.

 - ✓ Increasing adopter’s financial capacity to purchase essential inputs like plastic covering, other rudimentary agricultural supplements such as labor to women headed households through the provision of credit is another factor which should be carefully handled.

- ✓ As to the technological problem, it is quite essential to focus more on how to integrate the local community experience (such as spate irrigation or flood diversion) with modern type of knowledge (new type of RWH) rather than imposing alien procedures and systems to the adopters. Furthermore, all implemented technologies need to be tested under the local context.
- ✓ RWH need to be supplemented by other water management technologies such as conservation tillage, drip irrigation and use the harvested water during the critical stage of crops growth.
- ❖ In general, food security is a complex issue that needs extensive researches to see the status of food security variation over different harvesting seasons and seasonal determinates food security of the households.

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Annex

Annex I. Tables

Table A-1 Conversion factor used to estimate Tropical Livestock Unit (TLU)

Livestock Type	TLU(Tropical Livestock Unit)
Calf	0.20
Weaned Calf	0.34
Heifer	0.75
Cows/Oxen	1.00
Horse/Mule	1.10
Donkey	0.70
Sheep/Goat	0.13
Camel	1.25

Source: Storck et al.(1991)

Table A-2. Conversion factor used to calculate Adult Equivalence (AE)

Age category(Years)	Female	Male
Less than 10 Years	0.60	0.60
10-13	0.80	0.90
14-16	0.75	1.00
17-50	0.75	1.00
Greater than 50	0.75	1.00

Source: Institute Pan African Pour le Development (1981); cited in Storck et al. (1991)

Table A-3. Conversion factor used to estimate Person-per Equivalent (PE)

Age category(Years)	Male	Female
Less than 10 Years	0.00	0.00
10-13	0.20	0.20
14-16	0.50	0.40
17-50	1.00	0.80
Greater than 50	0.70	0.50

Source: John (1982), Ruthenberg (1983), Nair (1985) and Here (1986); as cited in Storck et al.(1991)

Table A-4. Caloric content of the food consumed in the study area

No	Food items	Food energy in Kcal per 100 grams edible portion(kg)
A	Cereals	
1	Maize	
	*white porridge	154.70
	*white bread	223.40
	*Ingera	153.00
	*whole roasted	88.10
	*white <i>kitaa</i>	223.4
2	Wheat	
	*Bread	222.00
	* <i>kitta</i>	222.00
3	Teff	
	*Ingera	358.80
	*porridge	165.40
4	Haricot	
	* boiled	170.30
B	Vegetables	
1	*onion	71.30
2	*Cabbage	40.10
3	* Carrot	27.80
4	*Tomato	30.70
5	*green pepper	46.50
C	ivestock products	
1	*Milk	73.70
2	*Meat	212.30
3	*Egg	295.10
4	*cheese	132.40
5	* Butter	736.40

D	others	
	*oil	896.40

Source: Ethiopian health and nutrition research institute (EHNRI) (1997).

Table A-5. Engagement in the new Cash crop producers in RWH participants

New cash crop	N (%)
Yes	37(52.9)
No	33(47.1)
Total	70(100)

Table A-6. Comparison of oxen and Livestock (excluding oxen) before and after engagement in RWH

	Mean difference	SD	t-value	P-value
Livestock After-livestock Before	1.6	1.7	4.18	0.000
Oxen After-Oxen Before	2.2	2.02	8.99	0.000

Table A-7. Marriage status per age of the household head

Age of the household head	Monogamy (n=98)	Polygamy (n=42)
Mean	37.18	47.07
SD	10.93	12.92
	t-value	-4.339
	p-value	0.000

Table A-8. Variance Infiltration Factor for the test of co-linearity among Continuous Variables

Variables	Tolerance	VIF
LANDSI	0.446	2.241
RATIO	0.779	1.283
OXEN	0.436	2.295
TLU	0.390	2.564
AGE	0.117	1.394
LABOUR	0.627	1.596
MARKA	0.950	1.052

Source: own survey (2008)

Table A-9. Contingency coefficient test for co-linearity between categorical variable

Variables	TENURE	LEDUC	REALINCOME	ERWH	FERZER	CREDIT
TENURE	1	0.190	0.108	0.077	0.211	0.308
LEDUC		1	0.015	0.045	0.189	0.000
REALINCOME			1	0.141	0.239	0.405
ERWH				1	0.185	0.063
FERZER					1	0.355
CREDIT						1

Source: own survey (2008)

Table A-10. Bivariate Association of some Continuous Households characteristics, Socio-economic, Demographic and Institutional issue factors with Food Security Status of the Households

Factors	Household food security status	Mean	t-value
Age of the HH	Food secured	38.31	2.442**
	Food insecure	43.57	
Dependency ratio	Food insecure	1.66	0.260
	Food secured	1.66	
Labor availability	Food insecure	4.50	3.037***
	Food secured	3.47	
Oxen	Food insecure	2.12	-2.345**
	Food secured	2.51	
Land size availability	Food insecure	2.40	-1.743**
	Food secured	2.90	
Market accessibility	Food insecure	12.65	3.761***
	Food secured	10.65	

Source: own survey (2008)

Table A-11. Bivariate Association of Categorical variables: household characteristics, socio-economic, Demographic and Institutional issue Factors with Food Security Status of the Households

Factors	Pearson χ^2 -square value
Education Vs Food security	4.723**
Livestock(excluding) Vs Food security	8.959**
Fertilizer Vs Food security	8.980***
Land tenure issue Vs Food security	0.089
Aggregate income Vs Food security	4.848*
Engagement in RWH Vs Food security	0.283

Source: own survey (2008)

Table A-12 Relation between labor engagement and Tendency to hire labor in the households and labor engagement in the sample households

Term of labor engagement in the household		Tendency to Hire labor(n=140)	
		Yes N=34(%)	NO N=106(%)
		Part time (n=106)	33(30.8)
Full time (n=34)	1(2.9)	33(97.1)	
Pearson χ^2 -square value 10.609 P-value 0.001			
Labor Engagement in the Sample Households N (%)			
Part time worker		106(75.7)	
Full time worker		34(24.3)	

Source: own survey (2008)

Annex II. Questionnaire

I) Household identification

- 1.1 Questionnaire Number _____
 1.2 Category _____ 1.RWH participant 2.Non-participant
 1.3 Name of HH _____
 1.4 Date of interview _____
 1.5 Enumerator's name _____ signature _____
 1.6 Checked by _____ signature _____

II) Household information

2.1 Information on HH head

- 2.1.1 Age of the HH _____(yrs)
 2.1.2 Sex 1. Male 2. Female
 2.1.3 Ethnicity 1.Oromo 2.Amhara 3.Others (specify) _____
 2.1.4 Religion 1.Islam 2.Orthodox 3.Others (specify) _____
 2.1.5 What is the level of education of the HH head?
 1. Literate 2. Illiterate.

2.16 Family size _____

2.2 Information on HH members

/no	Name of the HH members	Relation** to HH	Education***	sex*	Age

Code: Sex *1= Male 2=Female

Relation ship** 1 =Husband 2=wife 3=daughter 4=son 5= grandchildren

6= parent 7=laborer 8= sister 9=brother 10=stepchildren 11=others

Level of education*** 1=literate 2= illiterate

III) Resources Endowment

3.1 Land resource

3.1.1 Do you have your own land? 1. Yes 2.No

3.1.2 If no, what is the source of land cultivation? _____

3.1.3 If yes, what is the total size of land you have? _____ in ha/local unit

3.1.4 What is the total land you cultivate in 1999 E.C? _____

1. Owned _____ 2.Rented in _____ 3. Share cropped _____

4. Received as gift _____ 5. Other (specify) _____

3.1.5 Do you feel that you have Tenure security?..... 1. Yes 2. No

3.1.6 If no, do you invest on the land? 1. Yes 2.No

3.1.7 If yes, how do you invest?

1. By terracing 2. By planting 3.By building more RWH ponds

4.Other (specify)

3.1.8 For how long do you think the land you have now will remain with you?

1. Less than 5Years 2. 5- 10 years 3. For life time 4. I don't know.

3.1.9 Do you think the ownership of land by the state helps you produce more? 1. Yes

2. No

3.1.10 If No, in what way(s) does it affected you?-----

3.1.11 If Yes, in what way(s)?-----

3.1.12 Do you expect some benefit as the result of Floriculture expansion in your woreda?

1. Yes 2. No

3.1.13 If yes, what benefit do you expect?

1. Employment as the part time

2. Infrastructure facilities (Clinic, water point, road, school, etc)

3. Other (specify)

3.1.14 If no, what threats do you see?

1. Eviction from own land 2. Pollution threats (any type) 3. Completion on usable water

4. Others (specify)

3.2 Livestock

3.2.1 Do you own livestock? _____ 1. Yes 2. No

3.2.2 If yes, indicate the type and the number of livestock owned currently and five years back

Types of Livestock		Number of livestock currently	Before you engaged in RWH
Cattle	Oxen		
	Cows		
	Heifer		
	Bull		
	Calves		
Sub total			
Sheep and Goats	Sheep		
	Goat		
Equines	Horses		
	Mules		
	Donkeys		
Apiculture	Beehives		

3.2.3 If you don't have enough oxen, how do you get additional oxen you need?

1. Hire from some one
2. Coupling with other farmer
3. Borrow from friends
4. By contributing labor to a person who has oxen
5. Other (specify)

3.2.4 Do you have enough feed for your animals? _____ 1. Yes 2. No

3.2.5 If yes, what are the sources? _____

1. Own grazing land
2. Communal grazing land
3. Crop by products
4. Others (specify)

3.2.6 If no, how do cover the deficit? _____

1. Limit the number of livestock
2. Purchase of additional fodder from other source
3. Leave the problem as it is
4. Other (specify)

3.2.7 Is animal disease is a problem to you? 1. Yes 2.No

3.2.8 If yes, what is the type of disease?

3.2.9 Do you get enough drugs to treat your livestock? 1. Yes 2.No

3.3 Other household assets

3.3.1 If you have the following items currently, please complete the table

Valuables	Amount	Before you engaged in RWH	Estimated value in Birr	Before you engaged in RWH
Jewelry				
Wrist watches				
Agricultural equipment	Current	engaged in RWH	Current	engaged in RWH
Hoe				
House				
maresha				
Stored agriculture products				
Sickle				

Axe				
others				
Non agricultural equipment				
Carpenter equipment				
Building equipment				
Others				
Household goods				
Bed				
Tables and Chairs				
Radio/table recorder				
Sanduk, Kumsaten				
Other kitchen equipment				

IV.) Agricultural services

4.1 Credit services

4.1.1 Have you received any types of credit in 1999 E.C ----- 1. Yes 2.No

4.1.2 If yes, would you give us the source of credit?-----

4.1.3 If yes how much do you get?-----

4.1.4 For what purpose you obtained? -----

1. To purchase oxen 2. To purchase seed 3.to purchase agricultural inputs 4. Others (specify)

4.1.5 If no, what is your reason that in not obtaining credit ? -----

1. Fear of inability to pay 2.Lack of asset for the collateral 3. No one is to give the credit 4. High interest rate 5. No need of credit 6. Others (specify)

4.1.6 Do you save ? ----- 1. Yes 2. No

4.1.7 If yes in what form you save? 1. Ikub 2. In the form of livestock

3. Save in bank 4. Others

4.1.8 Have you trained about credit, interest rate and commitment? -----1.Yes 2. No

4.2. Extension Services

4.2.1 Have you got advices in agricultural activities from extension services in the Year 1999E.C? ----- 1. Yes 2.NO

4.2.2. If Yes, who provided you the advices? (Multiple choices is possible)

1. Government extension workers 2. Farmer group 3. NGOs (specify) 4. Marketing agents 5. Others (specify)

4.2.3 On which are the advice was given? 1. Crop Husbandry 2. Crop Diversification 3. Animal husbandry 4. Marketing 5.RWH development 6.Post harvest 7. Others

4.2.4 How often do you get advice?-----1.Once a week 2. Every 15 days 3. Once in a month 4. Once in three months 5. Once in a season

4.3 Use of fertilizer

4.3.1 Do you use chemical fertilizer? ----- 1. Yes 2.NO

4.3.2 If no, state your reason in the order of their importance?

1. Not necessary for cultivation crops 2. Too expensive 3. Not available 4. Shortage of income 5. Lack of credit 6 specify other

4.3.3 If yes, complete the table below please?

Type of crop	1999 E.C	
	Fertilizer(kg)	Area(ha)

V) Household Incomes

5.1 off-farm income (which includes non-farm too)

5.1.1 Do you or any member of your family have off-farm job? ----- 1. Yes 2.NO

5.1.2 If yes, indicate the type of work and duration for the year 1999 E.C

Family member	Type of job (see below)	Annual income
Total		

***If payment was done in kind, convert them to birr at the prevailing price.**

Types of jobs 1. Livestock trade 2. Sale of local drinks

3. Pity trade (grain, vegetables, fruit, etc) 4. Sell of fire wood and grass 5. Daily labor

7. Others (Specify)

5.2 Other source of Income

5.2.1 Remittance -----Birr

5.2.2 Others specify-----

5.3 Income from livestock

5.3.1 Complete the income that you can obtain from livestock production

Income from	Amount (birr)
Sales of chickens	
Sales of eggs	
Sales of milk	
Sales of cheese	
Sales of butter	
Sales of hide and skin	
Sales of calves	
Sales of heifer	
Sales of oxen	
Sales of cow	
Sales of sheep	
Sales of goat	
Sales of honey	

Others, specify

5.4 Crop Income

5.4.1 Would you give information on cropping on your RWH schemes plots for year 1999 E.C?

Plot no	Crop type	Area (ha)	Input							Amount harvested	Unit price (Birr)
			seed		fertilizer		Herbicides & pesticides		RWH seeds & other materials for RWH		
			Amount (Kg)	Cost (birr)	Amount (kg)	Cost (birr)	Amount (Kg)	Cost (birr)	Cost (birr)		

Crop types 1. Onion 2. Carrot 3. Cabbage 4. Pepper 5. Keyser 6. Lettuce 7. others (specify)

5.4.2 Have you engaged in production of new crops due to RWH?----- 1. Yes 2. NO

5.4.3 If yes indicate the type of new crops grow 1. Carrot 2. Pepper 3. Lentil 4. Onion 5. Other (specify)

5.4.4 Do your family labor force utilized due to participation of RWH irrigation introduction? 1. Yes 2. NO

5.4.5 Do you use hired labor?----- 1. Yes 2. NO

5.4.6 If yes, how do you put the trend since the last five years? 1. Increasing 2. Decreasing 3. No change

5.4.7 Did you participate in rain fed agriculture activity in 1999 E.C?--- 1. Yes 2. NO

5.4.8 If yes, please provide the following information on cropping year 1999 E.C?

Plot no	Crop type	Area (ha)	Input								Amount harvested	Unit price (Birr)
			seed		fertilizer		Herbicides & pesticides		Fuel			
			Amount (Kg)	Cost (birr)	Amount (kg)	Cost (birr)	Amount (Kg)	Cost (birr)	Amount (kg)	Cost (birr)		

Crops types 1. Maize 2. Teff 3. Wheat 4. Haricot bean 5. Barely 6. Others (specify)

5.4.10 Number of family members permanently working 1. Full-time on farm 2. Part time on farm

- 5.4.11. Is the family labor enough for agricultural operation 1. Yes 2.No
 5.4.12. If no, how do you get additional labor? 1. Hire 2. Exchange 3.others (specify)

5.5 Expenditure

- 5.5.1 How many do you spent your income on
1. Schooling ----- Birr
 2. For fertilizer, pesticides, and improved seed ----- Birr
 3. for consumable food ----- Birr.
 4. for clothing-----Birr
 5. for tax ----- Birr
 6. for kitchen materials----- Birr
 - 7 .others (specification) -----Birr

VI). Market Accessibility

- 6.6.1 How far is the market from you home? ----- Km
 6.6.2 Do you think the distance is problem for you?
 1. Yes 2. No
 6.6.3 If Yes, what types of problem it is-----?

VII). Engagement in RWH

- 7.7.1 Is your engagement on RWH helped you for food security? 1. Yes 2. No
 7.7.2 If yes, in what way it does?
 1. Helps us to produce during dry spell 2.It avoids crop failure during dry season
 3. It helps us to generate income 4. Other (specify)
 7.7.3 If No, what do you think the reason is?
 1. Lack of market for the product 2. The collected water is not enough
 3. High evaporation 4. Others (specify).

VIII) Household food consumption

1)Indicate the type and amount of consumed in the past 14 days in your home?

No	Food items	nit	Purchased food(kg)	Own production(kg)	Total quantity consumed
A	Cereals				
1	Maize				
	*white porridge				
	*white bread				
	*Ingera				
	*kitaa				
	* boiled				
2	Wheat				
	*Bread				
	*Kitaa				
3	Teff				
	*Ingera				
	* porridge				
4	Haricot				
	*boiled				

5	Barley				
	*White porridge				
	*				
B	Vegetables				
1	*onion				
2	*Cabbage				
3	* Carrot				
4	*Tomato				
5	*green pepper				
C	vestock products				
1	*Milk				
2	*Meat				
3	*Egg				
4	*cheese				
5	* Butter				
D	Other food items				
1	*oil				

8.2 Is what you produced last year enough for your family? ----- 1. Yes 2. NO

8.2.1 If no, for how long does it last ----- months?

8.2.2 In the last five years availability of food in the household 1. Decreased. 2. Increased 3. Increased substantially


8.2.3 Have your household faced food deficits in the last five years? 1. Yes 2. No

Open and General Questions for FGD and KI

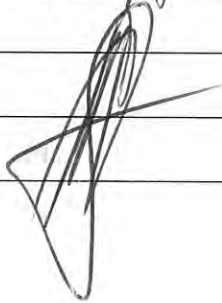
- ❖ When did you start implementing RWH package?
- ❖ Why did you engaged in RWH?
- ❖ How much does it cost to construct RWH structure?
- ❖ What is the trend in Adoption of RWH?
- ❖ Did you get what you opt for?
- ❖ Do you get assistance?
- ❖ What is your, the adopters and the society in general attitude to RWH?
- ❖ Are you going to excavate more harvesting Ponds?
- ❖ What are the challenges in implementing RWH?
- ❖ How is the trend of Rain around your hinterland?
- ❖ How vulnerable people manage to sustain their life?

Declaration

I declare that this thesis is my original work and has not been presented for a degree in any University. All the sources of material used for the thesis are duly acknowledged.

Name: Fekadu Wignessie
Signature: 
Date: 22/07/08
Place: _____

This thesis has been submitted for examination with my approval as a University advisor.

Name: Getnet Alemu
Signature: 
Date: _____
Place: _____