SOCIO-ECOLOGICAL FUNCTIONING AND ECONOMIC PERFORMANCE OF RAIN-FED FARMING SYSTEMS IN ADAMI TULU JIDIKOMBOLCHA DISTRICT, ETHIOPIA

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Declaration

I hereby declare that this assignment is written by me and is a result of my own findings, unless otherwise it is acknowledged by quoting the author of the finding. It has not been used for another exam at another department/ university/ University College in Norway or elsewhere in the world. I am entirely responsible for any shortcomings and mistakes that may happen in this work.

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Dedication

To my parents, all the good things in me, it is from you. I wish you long lives to see more fruits from your children.

Acknowledgement

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Abstract

Similar to most parts of Ethiopia, food security situation of households in the Central Rift Valley (CRV) region of the country is greatly influenced by the performance of rain-fed farming systems, which fluctuates with variability in rainfall. In order to improve the livelihoods of people in the area, there will be a great need to improve the performance of this sector. Although farmers in the area face nearly similar environmental conditions, the situation of their food security is usually diverse: some are frequently food-insecure while others are food self-sufficient. Therefore, this study was conducted to describe and analyze the current food-secure and insecure rain-fed farming systems. It also aimed at identification of factors associated with food-secure and insecure farming systems, and exploring future research needs and actions to improve the performance of rain-fed farming systems. A holistic systems analytical approach was used to make the analysis and the description. Three food-secure and three food-insecure peasant associations (Kebeles) were purposively selected for a survey. From each set of Kebeles, thirty-nine households were randomly selected and interviewed about both biophysical and socioeconomic features of the rain-fed farming systems. This information was supplemented with data from repeated farm visits, discussions with selected key farmers, and other stakeholders as well as official records. Drought, shortage of agricultural land, and poor soil fertility were identified as major constraints in both food-secure and food-insecure Kebeles. On the other hand, the two categories of farmers were found to significantly differ ($P \leq 0.05$) in their farm management choices and decisions, coping mechanisms against shocks, time allocated to on-farm activities, soil fertility management practices, allocation of production resources towards more valuable crops, and manipulation of selling time of crops. Thus, it is not only what happens in their environment that creates differences between food security and in-security conditions among farmers, but also how they react to these environmental happenings and constraints can have great impacts. Therefore, focusing on socio-cultural issues in a way that improves farmers' perceptions and attitudes can contribute a significant part to any problem-solving agenda in the area, in addition to focusing on biophysical problems.

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List of Acronyms

CSA	Central Statistical Authority
CRV	Central Rift Valley
ETB	Ethiopian Birr
DA	Development Agents
EEDC	Ethiopian Economic Development and Cooperation
IWMI	International Water Management Institute
GO	Governmental Organization
NGO	Non-Governmental Organization

1. Introduction

Widespread poverty, food insecurity, and environmental degradation cause severe human suffering in considerable parts of the world (Pinstrup-Andersen and Pandya-Lorch, 1998). They result in instability of global, regional, and national economic and ecological conditions. In search of meeting basic needs, farmers over-exploit natural resources which is often driven by high population growth (Upton, 1996). This condition is of critical concern in sub-Saharan Africa where production of food for a rapidly increasing population in semi-arid agroecosystems is a massive challenge (Rockström et al., 2004). The majority of the population in this region depends on rain-fed agriculture. Rain-fed agriculture globally encompasses about 69% of all the cereal area and contributes to 58% of the total food production (Rosegrant et al., 2002), and almost 100% in Ethiopia. Low levels of productivity and limited inputs are common characteristics of rain-fed agriculture (Partap, 2004). Climate variability plays an important role in determining productivity of much of the world's rain-fed grown annual food crops in the tropics (Slingo et al., 2005). Recurrent drought and inconsistent distribution of rainfall makes rain-fed farming a highly risk-prone activity, resulting in food-insecure situations for a large number of people.

The Ethiopian Central Rift Valley (CRV) is dominated by rain-fed, mixed crop-livestock agriculture. The centre of the CRV is formed by Lake Ziway and the surrounding area, which is characterized by arid and semiarid climatic conditions and a rapidly growing population. Other agricultural production systems in this area comprise small-scale irrigated vegeTable and fruit production as well as large-scale greenhouses of floriculture. Complex environmental and socioeconomic interrelationships make this region highly vulnerable from both food security and natural resource point of view (Rembold et al., 2002). The area is further characterized by intricate problems of drought, weak institutions, resource degradation and low agricultural productivity (Croppenstendt et al., 2003; Holden and Bekele, 2004; Frankenberger et al., 2007). Many of the local mixed farming systems are frequently food-insecure. This is partly due to the erratic rainfall pattern on which farming activities depend. There is no significant declining trend of rainfall over the last four decades (Hengsdijk and Jansen, 2006), and food insecurity is a relatively recent phenomenon in the area (Girma, 2007). Thus, shortage of rainfall may not be the only cause of food in-security in this region.

Although food security in the area greatly depends on the performance of rain-fed farming systems, irrigated agriculture is rapidly growing. But increased water use by upstream irrigated agriculture causes periodically water-stressed situations downstream (Jansen et al., 2007). Irrigated agriculture increases because of increased population pressure and economic developments, which is associated to an increased competition for fresh water resources. Even though irrigation can play a significant role in improving food production in moisture stressed regions, the potential for increased water use for irrigation is often limited (Falkenmark et al., 2001), especially in areas with closed basins such as the CRV. These closed basins do not have an inflow and outflow of surface water and little changes in water use may have large consequences downstream (Jansen et al., 2007). In addition, previous studies showed that irrigation development in Ethiopia is commonly plagued by insecure land tenure and absence of adequate water-use legislations (Kloos, 1991). With these issues still remaining, irrigation may not be a realistic improvement option. Alternative livelihood strategies that are less reliant on irrigation should be identified. One such alternative may be improving rain-fed farming systems (Rockstro¨m, 2003). However, Rosegrant et al (2002), and IWMI[1] (2007) emphasized that little attention has been paid to the rain-fed production systems compared to its potential in improving food supply, especially in developing countries.

A number of studies on rain-fed agriculture have been carried out, though ‘not to the extent it deserves’ (Rosegrant et al., 2002). Most of the studies focused on individual farming system components like soils (Fritzsche et al., 2007), crop variety (Seboka et al., 2001), climate change (Zeray et al., 2006), and hydrology (Vallet-Coulomb et al., 2001; Ayenew, 2007), while interdisciplinary studies to analyze and improve the sustainability of such systems are scarce. Berkes and Folke (1998) argued that ‘many previous studies have analyzed the impact of human activities on the ecosystem, but few have studied the interdependence of social and ecological systems’. Most of the studies aimed at assessing

[1] IWMI refers to International Water Management Institute

and analyzing the biophysical conditions of the farming systems, while incorporation of the human component of the farming system was less emphasized (Colding, 1998).

There are also interactions between the livestock farming and crop production in the area. These interactions highly influence the activities of the farmers and the underlying land use systems that dictate the capability and sustainability of the ecosystems to maintain production or economic objectives and ecosystem services. Where the environment is significantly fragile, the production factors are erratic, and the population is growing, dealing with only individual production constraints may not be sufficient to solve the problems. Berkes and Folke (1998) characterized farming system problems as 'non-linear in nature, cross-scale in time and having an evolutionary character'. This characterization can also portray the solutions to farming system problems.

Addressing the problems of food insecurity requires sustainable productivity improvements and diversification of rain-fed production systems with due attention to environmental and socioeconomic issues. On the top of that, the preconditions to sustainable livelihood improvements are dynamic and complex (Rockström et al., 2004). Hence, a holistic systems approach in analyzing farming system constraints is needed. Additionally, there are various reasons for which systems analytical approach is a good option under such circumstances. According to Francis et al. (2003), it is not possible to deal with the design and improvement of future farming systems by only considering 'production aspects, short-term economics, and environmental impacts in the immediate vicinity of farm fields'. Thus, the authors recommend a methodology that focuses on the inter-linkages of social, economic, and environmental components. Von Wirén-Lehr (2001) explained that the systems approach is essential for two reasons. First, it is important to treat ecological, economic and social aspects on an equal footing. Second, it enables systemic investigations of single factors and complex functions and processes between components of the system. Bawden (1991) defined systems methodology as an approach 'in which people collaborate together to explore complex problematic situations critically with the aim of creating change that is socially desirable, culturally feasible, and ethically defensible'.

The aim of this study was to describe and analyze the current food-secure and insecure rain-fed, mixed crop-livestock farming systems in the CRV. Factors associated with food-secure and insecure farming systems were identified, and future research needs and potential actions to improve the performance of rain-fed farming systems were explored.

Specific research questions were:

What are the major farming system-external and –internal factors (production resources, socioeconomic, institutions, environment, cultural etc) contributing to the food security of the current rain-fed farming systems?

Why are some farmers food-insecure, while others are food self-sufficient, when they all are facing similar natural conditions?

What are the major coping mechanisms and/or behavioral adaptations of farmers in handling farming system uncertainties?

What are the current strengths of the system that can be capitalized on and what are the future opportunities that can be targeted in improving rain-fed farming systems?

2. Material and Method

2.1 Area description

Adami Tulu Jidokombolcha woreda[2], is located in the heart of CRV, Southwest of Lake Ziway at altitude of 1500-2300 m a.s.l. Ziway, one of the major towns in CRV, is the capital of this woreda. It is located at 150 km from the capital of Ethiopia, Addis Ababa. There are several seasonal and permanent rivers. Bulbula, the main river in the woreda, joins the upstream Lake Ziway and the terminal Lake Abiyata. The population density of the woreda is 139 person/km^2. 27% of the woreda is cultivated with crops, 22% is used for pasture, 10% forest, 16% is swampy and the remaining 25% is unproductive or degraded (CSA, 2005). Different types of small- and large-scale irrigated and rain-fed farming systems can be identified (Scholten, 2007). Usually, both farming systems are combined, i.e. rain-fed smallholder farmers also have irrigated plots. The woreda consists of 38 Kebeles among which some frequently experience food insecurity.

Minimum and maximum annual mean temperatures are 14 and 27 ^{0}C respectively. The woreda is characterized by bimodal pattern of rainfall; with short rainy season running from February to April and long rainy season from June to September. However, the pattern of rainfall is usually erratic with fluctuations in the start and end of the season, in addition to the total absence of rainfall at times.

2.2. Data Collection

Household and kebele level data were obtained from the woreda office of Agriculture. From the office's report, kebeles were grouped into food-secure and food insecure categories. This grouping was based on the food safety net program (woreda report, 2007). The safety net program included kebeles that were frequently food-insecure. However, the report did not clearly indicate the criteria up on which the kebeles were included in the safety net program. To address this issue, every household that was

[2] Woreda is a local administrative unit, which together form Zones. Adminstrative units below the woreda are Kebele, which consists of a number of villages.

included in the survey was asked a question about food security situation. The result of this question was statistically compared to the official report and presented in the first part of chapter three in this document. The assumption behind this question was that the more a household depended on food aid, the more food-insecure it would be. Six kebeles, three food-secure and three food-insecure, were selected. The included Kebeles were from different locations, and differed in the distances from the main road, from the main towns and the type of crops produced. Various studies show that these factors have great impact on the food security of a Kebele (e.g. Gebremedhina and Swinton, 2001). Thus kebeles were included from similar locations with respect to these factors.

Before implementation, draft questionnaires were tested and evaluated by consulting woreda officers, NGO representatives, development agents and a few farmers from each kebele. The questionnaires were edited and reformulated according to the local context and taking into account the comments. A systematic random sampling procedure[3] was used to select 78 households, 13 from each Kebele, using official records for households. Questions were thematically grouped and presented in such a way that it created a natural flow during the interview. In the first part, questions about personal information of the interviewee (age, gender, name, education level, and position in the community) were asked. Second, issues related to pressure on resource use (eg, family size, land holding and size) were included. Third, perceived constraints (food in-security, production resources, environmental resources[4], management practices, and policy issues), which could either be internal or external to the system, were asked. Fourth, factors considered important for the performance of rain-fed farming systems (eg. soil quality, fertility management, and on-farm or off-farm activities) were asked. Fifth, interaction between crop and livestock farming (perceived advantages, risk minimization, and complimentarily) were incorporated. Finally, questions about trends in per hectare productivity and variability of the rain-fed farming system were surveyed. Both open-ended and close-ended questions were included in the interviews (Appendix 6).

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[3] The sampling procedure was made by taking every 10th household from the list of a record document containing names of every household head in the kebeles, after the first household to begin with was spotted out randomly.

[4] Production resources; here means inputs such as fertilizer, capital for investment etc. Environmental resources refer to natural resources such as water, rain, vegetation, grasses, soil etc.

In addition, key households and other stakeholders (NGO members, woreda officials, and development agents) were interviewed informally. The qualitative information was used to supplement the (quantitative) information that was gathered through structured interviews. Three[5] farmers were randomly selected from different areas of the sample Kebeles and 2-3 farm visits were made to understan the farmers' own perceptions about the farming system constraints. During the farm visits, interviews were carried out in an open manner and only thematically structured and flexible interview guides were used. Key issues that were identified from the preliminary analysis of the first informal interviews (from previous farm visits) were presented to the clients during the re-visits and their comments were incorporated into final results. At all stages, the interviews were tape-recorded and notes were taken.

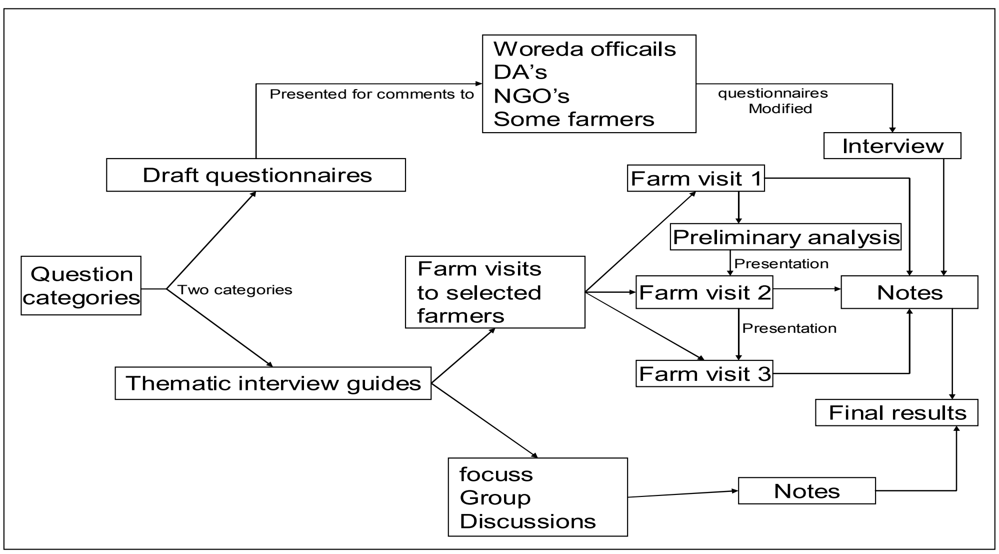

Figure 1: Pictorial presentation of the main activities during interview process

Focus groups with similar interests were interviewed to gain insight in general issues, for example, land tenure system. A total of seven focus groups were formed; six consisting of farmers and one of stakeholders operating in the area. This enabled recalling of the rain-fed farming system productivity trends from discussions among the group members,

[5] These farmers were different from those selected for the formal interviewing. The discussion with these key farmers was not only based on pre-formulated questions and it included open discussions on emergent issues originated from the discussion as well as on-farm observation of the farming system phenomena during the frequent farm visits.

which provided some understanding about the future scenario of the farming system under the current production practices.

Secondary temporal data were collected from local Woreda and Kebele level offices in the study area on variables such as weather, food aid extents, family size, land holdings size, and land area under cultivation, yields and related socioeconomic factors. Crop prices at different times of the season were collected from farmers, retailers and official records. The secondary data were combined with primary data from the present survey and used in the analyses of the current situation and performance of rain-fed farming systems.

2.3. Data analysis

Data from the questionnaire were analyzed in categories of factors belonging to farm, household, Kebele, Woreda and regional hierarchical levels. This was important because factors can be associated to each other at different levels in the system and sometimes even across hierarchies of systems. To make the Kebele level analysis of associations among factors, the woreda classifications of the kebeles as either food-secure or insecure was used. Household level analysis was derived from the responses of interviewed households. This was because there could be food-secure households in those kebeles labeled food-insecure according to the woreda classification and vice versa. Analysis of whether farmers' responses and the woreda classification were in agreement and presented in the first part of the results. For some factors (for example, farm management, manure application, family size) where there are clear variations among household members even in a single location, the household level analysis (which was obtained directly from interviewing a household) was used. For other factors, mainly kebele level analysis (based on the data from the official classification of kebeles) was used.

Chi-square analysis was carried out to identify differences among food-secure and insecure kebeles with regard to different socioeconomic and biophysical factors. Paired and single sample t-tests were also conducted to compare means of crop prices at the time when the farmers sell and at the off-season time when retailers sell. In addition, mean differences of per hectare productivity of different crops in food-secure and food-insecure kebeles were compared using paired-sample t-test. Correlation analysis was made to analyze interrelationships between prices and between per hectare yields of different crops for the two sets of kebeles. In addition, descriptive statistics for categories of variable, where adequate, were computed.

2.4. Scopes and limitations of the study

Although the study tried to approach farming system components in a holistic manner, the livestock component was not intensively dealt with. This was partly because of the farmers' lack of willing to supply important information regarding livestock because of local cultural limitations. The relatively short time spent on field limited having higher chance for detailed direct observation of seasonal variations in the farming system. The sole reliance of this study on responses from informants and on secondary data from offices can also be considered one of the major limitations.

Compared to an expectedly high influence of biophysical conditions on the performance of ran-fed farming systems, the current study mainly focused on socioeconomic factors in a more detailed manner. Quantitative experiments and measurements of the impacts of biophysical factors were lacking. Results may not be firmly conclusive. In spite of these limitations, every possible attempt was made with regard to data collection, analysis and summary to make a general characterization and analysis of the typical rain-fed farming system in the area. Thus, it should be construed that this study mainly dealt with the identification of trends and indicators that are correlated to food security of the farming systems rather than the identification of factors that could be precise causes of food insecurity.

3. Result and discussion

3.1 Basic assumptions and definitions

Responses from households living in different kebeles were inline with the woreda's classification of Kebeles as food-secure and food-insecure (P<0.001). From Table 1, it is evident that the majority of households in food-insecure kebeles were found to be less food self-sufficient as compared to those living in food-secure kebeles. However, the result also showed that there are food-insecure households in those kebeles classified as food-secure and vice versa. The basic assumption was that households who needed food aid more frequently are less food-secure compared to households who were food self-sufficient and produced more than their family need.

Table 1: Woreda's classification of food security situation of Kebeles and responses of households in respective kebeles

			Farmers' responses				
			Need food aid every year	Need food aid every 2-3 years	Self-sufficient	More than family need and for market	Total
Woreda's classification of Food security situations of Kebeles	Food-insecure	Count	14	7	17	1	39
		%	93.3%	77.8%	37.8%	11.1%	
	Food-secure	Count	1	2	28	8	39
		%	6.7%	22.2%	62.2%	88.9%	
Total		Count	15	9	45	9	78
		%	100.0%	100.0%	100.0%	100.0%	

Thus, the definition of food security for this study was based on the local context and understanding of food security. This was only considered a simple working definition for this work, while detailed debates on its concept and definition can be found elsewhere (Sen, 1981; Foster, 1992; Watts and Bohle, 1993; Maxwell, 1995; Maxwell, 1996; and Wolfe and Frongillo, 2001). Although the criterion for the classification of the kebeles into food-secure and food-insecure was not clearly indicated in the official report, farmers' responses strongly suggested that the official classification was based on sound criteria. Quensequently, household level (farmers' responses) and official categories of food security conditions of farmers were used interchangeably in some parts of the analysis. The majority of the sections in this study used the woreda's classification of food security to identify factors that are correlated to differences between the two groups of kebeles. However, under conditions where inter-household variations in a single kebele were considered important, farmers' responses were used to compute relationships between food security condition and the involved variables.

3.2 Internal and external farming systems characteristics

Identification of external and internal farming systems factors was one of the most important procedures undertaken in the analysis of the case farming system (Figure 2). One of the challenges to creating systems description is the choice of what to put into them and what to leave out, because it gives little sense to describe everything in detail (Waltner-Toews, 2001).

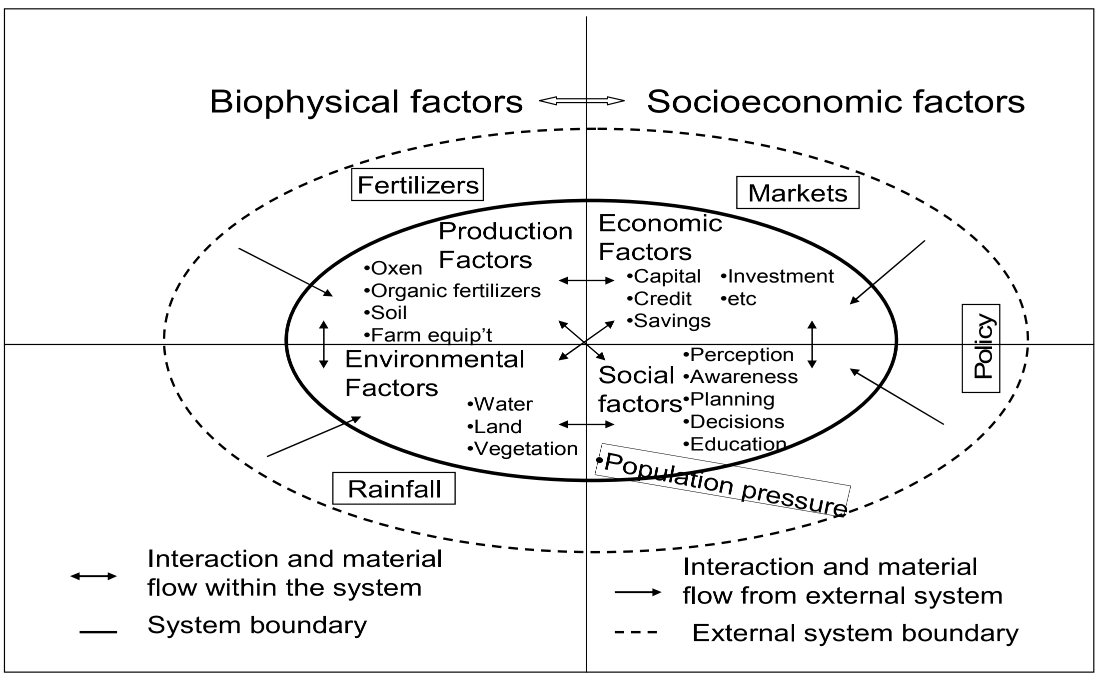

Figure 2: Internal and external system-components of rain-fed farming system

The model in Figure 2 is an attempt of capturing some of the most important factors that were found to influences the food security situations of the rain-fed farming system of the area. These factors were grouped into two main groups- biophysical and socioeconomic. Biophysical factors were farther classified into production and environmental factors, while socioeconomic factors were categorized into economic and social ones. Some factors can be categorized under more than a single class both in terms of its nature and in terms of its placement inside or outside of the system boundary. For example, soil can be a production factor as well as an environmental factor, while policy can be an economic and a social factor. On the other hand, population pressure can be considered as both external and internal socioeconomic factor.

The combination and interaction among these factors (internal-external and biophysical-socioeconomic) were found to be correlated to food security conditions of the farming system. The detailed statistical descriptions and discussions are presented in the following sections.

3.3 Biophysical factors

3.3.1 Drought

Drought and erratic distribution of rainfall are the main easily observable factors that pose food security problems in the woreda. However, even villages that are located next to each other were found to have differences in food security condition. Thus, rainfall related factors (shortage, erratic distribution, etc), may not be the only constraint that explain food security differences among farmers, although it can play an enormous role on its own and in amplifying the severity of other constraints. This justifies a shift in focus to other factors, which may interact with rainfall and with each other and thus create differences in food security situation among farmers. As shown in Table 1, there was no statistically significant difference in drought frequencies between kebeles as perceived by the farmers.

Table 2: Farmers' presentation of drought frequency in food-secure and food-insecure Kebeles

			Farmers' response to frequency of drought			
			Every year	Every 2 years	Every 3 years	Total
Food security situation	Food-insecure	Count	10	19	10	39
		%	41.7%	55.9%	50.0%	
	Food-secure	Count	14	15	10	39
		%	58.3%	44.1%	50.0%	
Total		Count	24	34	20	78
		%	100.0%	100.0%	100.0%	100.0%

Drought affects productivity of farming systems mostly at farm plot level where it affects soil conditions for the plant to utilize water and nutrient. It is an external factor to the system, so that it is not possible for the farmer to control, at least in the short term. However, it can also be considered an easily controllable factor if moisture conservation and efficient management of water are considered.

3.3.2 Productivity of crops

The productivity of some crops per unit area was found to vary significantly between food-secure and food-insecure kebeles (Fig. 2). Farmers from food-insecure villages produce significantly less teff[6] (P<0.05), wheat (P<0.01), and maize (P<0.05) (see appendix 3 & 5).

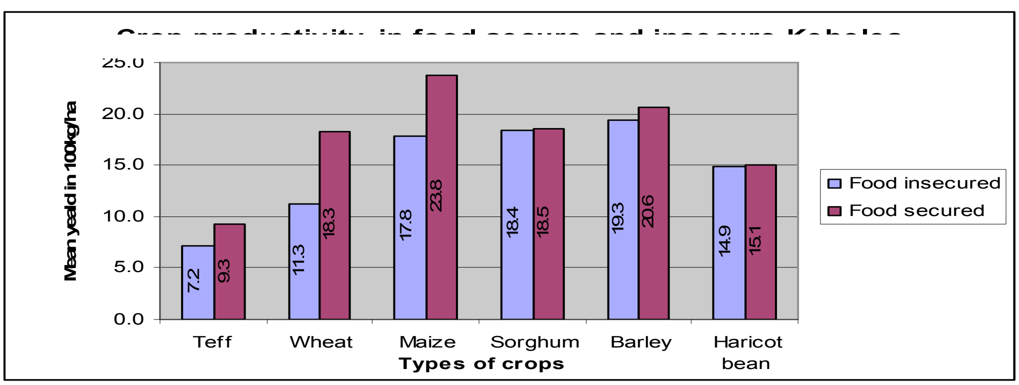

Figure 3: Productivities of the six main crops in food-secure and food-insecure Kebeles

[6] Teff is a local cereal crop well known as both cash and food crop in Ethiopia. Its scientific name is *Eragrostis tef.*

There were no significant productivity differences for sorghum, barley and haricot bean between the two groups of villages. As farmers from food-secure villages were found to use more commercial fertilizers as well as farmyard manure (see next section), the productivity difference for wheat, teff and maize can be explained by the fact that these crops are more responsive to fertilizer than the latter three types of crops (EEDC, 1997). Since teff and wheat are the major cash crops in the area, food-insecure farmers earn less income from sale of these crops. This can in turn result in reduced economic capacity to buy productivity-enhancing inputs. In addition, since maize is the most important crop in terms of area coverage and consumption in the area, farmers who produce less of maize can face food shortages to feed their family.

3.3.3 Land and soil fertility situations

Most households in both food-secure and food-insecure villages were found to use commercial fertilizers, although the type of fertilizers differed significantly (Appendix 2.7a). There was no significant difference between farmers in food-secure and food-insecure kebeles use with regard to their use of urea, while more farmers from food-secure kebeles were found to use DAP[7] ($P<0.001$). In addition, more farmers from food-secure kebeles were found to use the combination of the two types of fertilizer ($P<0.05$). Furthermore, farmers in food-secure kebeles apply fertilizers at significantly higher ($P<0.001$) rates (more than 90 kg/ha) than farmers in food-insecure kebeles (30-45 kg/ha) for both types of fertilizers (Appendix 2.7b).

The combinations of using different forms of fertilizer and varying fertilization rate can be one of the causes of differences in the yield that farmers can obtain from the same unit of land in food-secure and insecure villages (section 3.3.2). Food-insecure farmers choose to use either no fertilizer or lower rates to minimize risks due to crop failures. According to Dercon (1996), a common strategy for households is to take low-risk activities even if it may imply lower returns, especially in rural areas where insurance and credit markets are absent.

[7] DAP-Diamonium phosphate, which is a phosphorus and Nitrogen containing fertilizer

Farmers have different criteria for deciding on the rate of fertilizer application. In food-secure kebeles, market price of fertilizers was not found important to determine application rate, while it is a major factor in food-insecure kebeles ($P<0.001$) (appendix 2.8). This indicates that higher prices may limit application rates in food in-secured kebeles while food-secure kebeles respond less to fertilizer prices. More food-insecure farmers were found to base their application rate on their perception of soil fertility status than food-secure farmers ($P<0.001$) (appendix 2.9) and they perceive that soil fertility of their plots is increasing ($P<0.001$) (appendix 2.10) in contrast to food-secure farmers who were found to perceive a decline in the soil fertility of their plots. This may explain why food-insecure farmers respond more strongly to fertilizer price, as they may perceive that no extra cost is required for their already '*fertile*' soils. Previous studies also showed that perception about a decline in the overall fertility of soil is an important reason for Ethiopian farmers to increase their fertilizer use (Demeke et al., 1998). However, soil and plant material analysis is required to make conclusive comments about the differences in the soil fertility of farms in the area. On the other hand, the limited use of fertilizers by food-insecure farmers can also be explained by a likely reason that food-insecure farmers have limited cash as compared to food-secure farmers and they may use less fertilizer when the price of fertilizers rises.

Both groups of farmers were found to consider factors such as personal experience, recommendation from extension workers etc. as factors to be considered to determine rate of fertilization. However, food-secure farmers were found to consider a greater number of combined factors to determine their rate of application as compared to food-insecure farmers ($P<0.05$) (appendix 2.9a) who considered only one or two factors to determine their rates. This may in turn translate to the higher likelihood of food-secure farmers to make proper decision of applying fertilizers at appropriate rates, which can have an impact on the amount of production margins that they would obtain from fertilizer use.

There was no significant difference between food-secure and food-insecure farmers with regard to their use of common organic fertility management practices such as crop rotation, use of green manure, intercropping, use of compost, and residue management (appendix 2.11). However, significantly more ($P<0.001$) food-secured farmers were found to use farmyard manure (FYM) to fertilize their farms. FYM is an easily accessible resource in the area since all the farmers undertake mixed crop-livestock farming, and how they manage this resource can be one of the factors that create differences in per hectare productivities (see section 3.3.2).

3.4 Socioeconomic factors

3.4.1 General household characteristics

The average family size was 7.2 and 9 members per household in food-secure and insecure villages, respectively and it was found significantly different ($P<0.001$). Both groups of farmers were found to have similar land holding size of 2.5-3 ha. This can imply that there exists more pressure on resource base in food-insecure kebeles than in their food-secure counter parts.

Education level of the household head and members was not found significantly different between food-secure and insecure kebeles. However, from the analysis made at household level, more of less educated farmers were found to work off-farm as compared to more educated farmers ($P\leq0.05$) (appendix 2.5). On the other hand, more farmers in food-insecure kebeles work off-farm than in food-secure kebeles, regardless of their education level ($P\leq0.01$) (appendix 2.4). Income from off-farm activities is very low; the maximum is 900 Ethiopian Birr (about 100USD) and the minimum varying from 300-400 Ethiopian Birr per year. The off-farm work is mainly working as daily laborers on the farms of relatively food-secure farmers, reducing the time available for food-insecure farmers to manage their own farm. This can constrain the farmers from undertaking important activities that are time sensitive on their own farms. Management of FYM and timely plowing were some of such activities. These factors, among others, can form complex associations that can be interlinked in affecting the productive capacity of farms of different households.

3.4.2 Market conditions of common crops

There is significant difference in prices of crops between food-secure and food-insecure kebeles (Fig. 3). Prices of teff, maize and wheat were significantly lower for food-insecure farmers as compared to food-secure farmers ($P<0.01$) (appendices 4 & 5). However, there was no significant difference in prices between the two groups of kebeles for barley, sorghum and haricot bean.

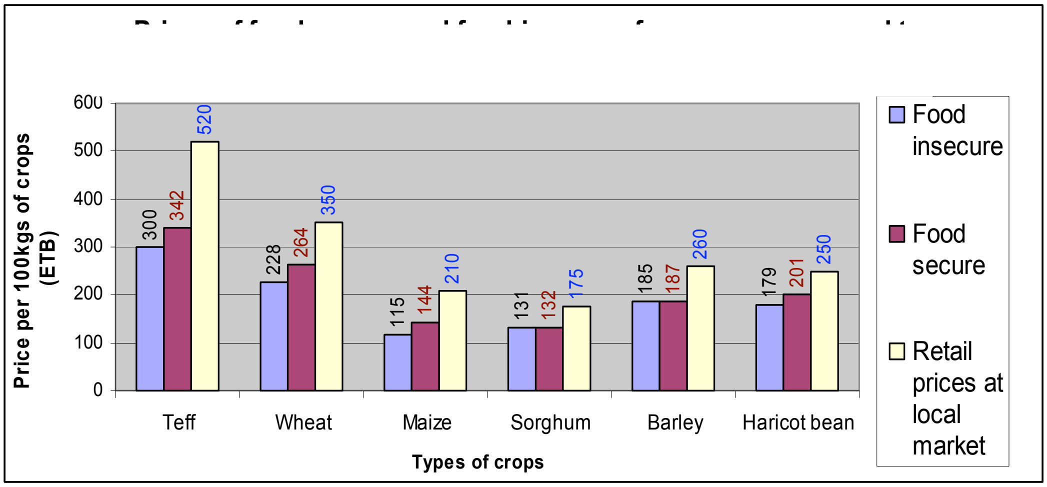

Figure 4: Prices of the six main crops in food-secure and food-insecure kebeles and retail prices.

The difference in prices results from the variation in the selling times of crops. Food-insecure farmers sell crops during harvesting time while food-secure farmers have a tendency to store and sell when crop prices rise. Since crops are the most important means of generating cash in the area, this can influence farmers' income level and their ability to invest in fertilizers and other production technologies. Under such circumstances, food-insecure farmers lack the capacity to produce more crops and they are more likely to remain food-insecure. This can result in a vicious cycle of food insecurity, limited production - the fact that they are food-insecure makes them unable to improve productivity of their farms, and limited productivity forces them to stay food-insecure.

On the other hand, crop price for both food-secure and insecure farmers were significantly lower than retail price for all crop types ($P<0.01$) (appendices 4 & 5). Although, crop prices were higher at the local market during off-seasons, the largest share of the returns goes to retailers who have relatively well-developed storage and marketing mechanisms. This can worsen the problems of local farmers because they have to buy food crops for family consumption by that time. They sell most of their crops during harvest time when they have to cover fertilizer credit, schooling expenses for children and other locally common expenses. Improvement can be made about this issue. Because, a minor credit service to the farmers during this time of the season may allow them to keep their crops for latter sales at better prices, hence has a potential to improve their food security situation. However, further research and cautious procedures should be made as credit services under Ethiopian condition are plagued by lack of proper training for the clients and inflexible repayment schemes (Vilei and Chisholm, 2005).

3.4.3 Relationships between productivities of crops

In this part, crops were categorized into two main groups for the matter of making discussion easier. The first group[8] consists of main crops (teff, maize and wheat) and the second group comprises minor crops (Barley, haricot bean, and Sorghum).

From Table 3, productivities of crops in food-insecure villages are positively correlated to each other. This can imply that in these villages, farmers who can produce more of main crops also try to produce more of the minor crops and the vice versa. In relation to their food insecurity condition, this can be explained in at least two possible ways. First, those who try to produce more of every crop may face problems of resource distribution (eg. land, fertilizer, time, etc) between different crop types, which can result in poor productivity of each type of crops. This can in turn increase the chance of farmers becoming less food-secure. Secondly, those who produce less of every crop may only produce small amount of each, which is not sufficient to cover their needs. Hence, they become more likely to be food-insecure.

[8] This grouping is by no means a compulsory and generalized definition of the importance of these crops. Those crops, which are named ‘major’ here, are labeled so because they were important in the area both in terms of consumption and cash generation capacities. Thus, this classification is just made for the matter of making the discussion in this part easier and has no intension of implying any differences in the use or consumption values of these crops.

Table 3: Correlations between per hectare productivities of crops in food-secure and insecure villages

Food-insecure villages (I)	Wheat	Maize	Sorghum	Barley	Haricot bean
Teff	.513(**)	.470(**)	.476(**)	.486(**)	.288
Wheat		.596(**)	.605(**)	.402(*)	.397(*)
Maize			.719(**)	.462(**)	.505(**)
Barley					.311
Food-secure villages(II)	**Wheat**	**Maize**	**Sorghum**	**Barley**	**Haricot bean**
Teff	-.058	-.030	-.428(**)	-.344(*)	-.188
Wheat		-.317(*)	.106	-.084	-.294
Maize			.303	.064	.563(**)
Sorghum				.403(*)	.690(**)
Barley					.356(*)
N[9]	39	39	39	39	39

** Correlation is significant at 0.01 level (2-tailed).
* Correlation is significant at 0.05 level (2-tailed).

In food-secure villages, significant correlations between productivities of major crops and minor crops are negative, except for the relationship between Haricot beans and the less important ones. Farmers who were found to produce more teff per unit area, for example, produced less of the others and vice versa. This can contribute to the food security of the farmers in different ways. First, farmers may concentrate productivity-enhancing resources like fertilizers on the types of crops that are more valuable in terms of both consumption and cash generation at the expense of minor crops. Secondly, they get better bargaining power since they produce crops with superior demand at both the local and the mainstream markets (urban markets).

3.4.4 Perceived livelihood constraints and coping mechanisms[10]

There is a significant difference in perception of the causes of soil fertility decline in the two groups of kebeles. This may have a bearing on how they go for the management of soil fertility. More farmers from food-secure kebeles were found to believe that soil

[9] N is the same for all entries and that is why it is used only once
[10] Detailed statistical presentations and data summary are found in appendix 2.

erosion, continuous cropping, lack of fertilizer (P<0.01); poor soil management (P<0.001), and untimely plowing (P<0.05) are major constraints of soil fertility. In contrast, more farmers from food-insecure Kebeles were found to perceive that cultivation of marginal lands and removal of crop residues (P<0.01) as major concerns. Both sets of farmers agreed that monocropping and lack of fallow periods are among the major threats to soil fertility (appendices 32 & 33).

Although there are differences in perception between food-secure and food-insecure farmers concerning some of the factors that constrain their livelihoods, there was no significant difference between the groups of farmers with regard to drought, poor soil fertility and shortage of agricultural land as being massive livelihood constraints. Diseases and pests (P<0.01), lack of improved inputs (P<0.01), seasonality of market (P<0.01), tenure uncertainty (P<0.1), poor crop storage structures (P<0.05) and insufficient capital (P<0.01) were significantly identified as major constraints by food-secure farmers. However, food-insecure farmers considered these factors less important in constraining livelihoods in the area (appendices 2.19-2.31).

The way they perceive constraints appear to have impacts on the way they design coping mechanisms against livelihood problems. Because, understanding of constraints and their nature is important to understand the possibilities to deal with its consequences (Dercon, 2002). More farmers from food-secure kebeles were found to favor migration (P<0.05), use of drought resistant varieties (P<0.01), planting of early maturing varieties (P<0.01), sale of cattle (P≤0.001), and storing crops from relatively better years (P<0.001) as major coping mechanisms against crop failures. Food-insecure farmers were found to favor food aid (P<0.001), relying on traditional system of helping each other ("hirphaa") (P<0.001), seed sources from GO's and NGO's (P<0.01) and getting credit (P<0.01) as their main coping mechanisms in the case of crop failures or other environmental shocks (appendices 2.12-2.18). This shows that food-secured farmers rely on their own mechanisms against risks while food in-secured farmers appear to rely on external helps to survive risky conditions. The mechanisms that farmers use to survive risky conditions can depend on how they perceive their environment, among other things.

Figure 5 shows how farmers' perception of reality can be associated with their food security or insecurity situation. Farmers' perception of the real world in their farming system affects not only how they understand the problem, but also how they design its possible solution. This understanding of problems and solutions affects their choice of ways of doing things. Farmers choose certain ways of doing things based on their perceptions. The ways of doing things can in turn have an effect on the farmer being food-secure or insecure. For example, farmers in food-insecure villages perceive that seasonality of market is not a livelihood constraint, which means they may not choose manipulation of the selling time of their crops as a solution to improve their food security situations. In addition perceptions about soil fertility, livelihood constraints and coping mechanism were found to be significantly correlated to food security situations of households (see the above findings). Indeed, their perception of the real world surrounding them can also be related to the degree of awareness they have, which in turn can be associated with other factors such as the extent of extension services they get.

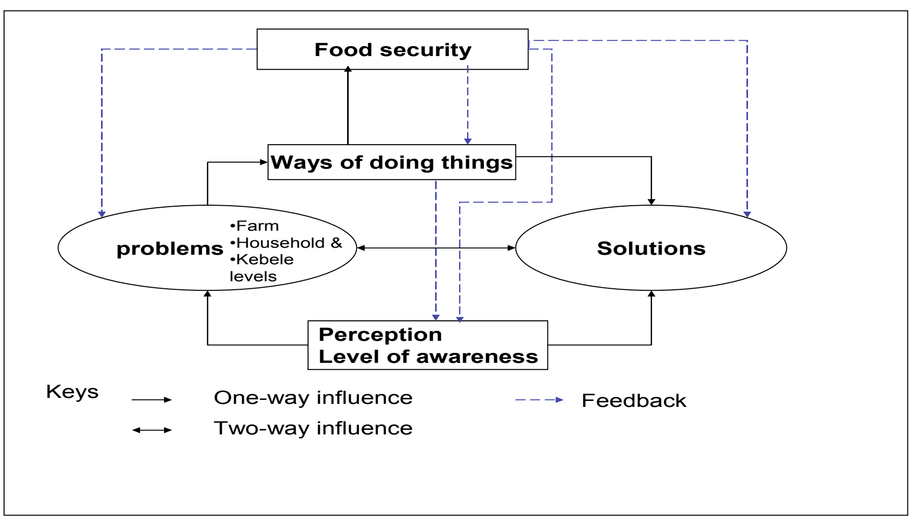

Figure 5: Relationships between perception of farmers and their food security situation

Once they start doing things in a certain way, they may affect their food security situation (become food-secure or insecure). The food security situation in turn can influence the farmers' ways of doing things and even their perception of problems and choice of solutions. This may explain why more of food-insecure farmers rely on mechanisms such as food aid, getting credit, and traditional system of helping each other unlike food-secure farmers who opted for use of drought resistant varieties, storing crops from relatively good production seasons, sale of cattle, etc to cope against shocks. As the coping mechanisms chosen by food-insecure households are out of their control, it becomes difficult for them to make flexible decisions that would improve their food security situation. In addition, the reliance on traditional[11] system of helping each other cannot work well, especially when the shock is of large scale (for example drought) so that it affects every individual in the system.

[11] Families in the area have traditional system of helping a farmer in the case of unexpected shocks. They collect crops and cattle from non-affected members and contribute to the farmer facing shock.

3.4.5 Policy factors

Government policies such as land tenure, family planning, resource use and deforestation or forestation policies can be associated with the food security situation of villages. Although these policies are made at a macro (national) level, their impact can be reflected lower to the micro levels (eg. farm level). It can influence resource use patterns by farmers at farm, household and landscape levels. This in turn can influence farm productivity. Farm productivity can also be correlated to other policies such as fertilizer market policies. According to Jayne et al (2003), government control of fertilizer markets through its parastatal trade organizations avoided competition from fertilizer market and made its prices untouchable, especially for smallholder Ethiopian farmers. Policies can result in multitudes of intended and unintended outcomes on prices of inputs and outputs, efficiency in production and consumption, income distribution, nature and environment (Keulen et al., 1998). Land tenure policies, for example, have a great impact on resource conservation activities of farmers. A farmer during an interview explained this issue as:

> *'…development agents come and tell me to plant these trees…* (referring to leguminous trees provided by local development workers to enhance soil fertility)*... The trees waste a large part of my farm, which I would have used for crops. They talk about these trees improving the fertility of the farm, but, after all, why do I worry about the fertility of the farm at the expense of what I could produce? Tomorrow morning, another official may come and give it to someone else who did nothing to improve the fertility of the farm…'*

Farmers are not willing to make long-term investments in their land. Several farmers gave the impression that the land could be given to another farmer (see appendix 2.29). This state ownership of land and the underlying fear of future redistribution have created much uncertainty among farmers. This in turn resulted in farmers' reluctance to invest in long-term land improvement measures (Belay, 2003), although investment in land conservation efforts were found to be affected by many factors in Ethiopia (Pender and Fafchamps, 2000).

3.5 Interactions among factors within and across hierarchies[12]

Complex interactions of environmental, social and economic factors are likely to contribute to either food security or insecurity of the system. Figure 6[13] summarizes the interlinkedness of factors at different levels in the hierarchy of the systems. The interaction among factors begins with complex relations of socioeconomic and, biophysical features at all levels in the system. These factors extend their associations to other factors at different levels and finally lead a household to food security problems. These associations may not be simple linear events that run from lower hierarchy to the higher. They rather form what Maani and Maharaj (2004) called 'closed loop' . Under such circumstances, even tiny factors at farm level can affect huge factors at a national level. In turn, the regional factor can affect the farm level factor through 'feedback mechanism'. These feedback mechanisms can be either positive, in which case they are expected to amplify lower level happenings, or negative where they tend to weaken lower level processes (Younga et al., 2006). For example, field level activities to utilize production resources (eg. fertilizers) and environmental resources (eg. soils) can be affected by decisions of farmers at household level. These decisions potentially affect food security of the household in various ways. First, poor decisions can lead to deterioration of these resources. This can result in declined farm productivity, which can in turn create food-insecure situations. Farmers may respond to the food insecurity situation by modifying their decision actions, which can be a negative feedback. On the other hand, once they are trapped in food insecurity, farmers may act in a further resource-deteriorating manner, which can be a positive feedback. Second, government may develop a policy that either modify or limit those resource use decisions by farmers. Again, this can have either positive or negative feedback effects, based on the direction of the outcome it brings.

[12] This part is more of a discussion in that most of the explanations are made based the findings in the above sections.
[13] The components of this picture are derived from the results discussed in previous sections of this paper and constitute a summary of the findings

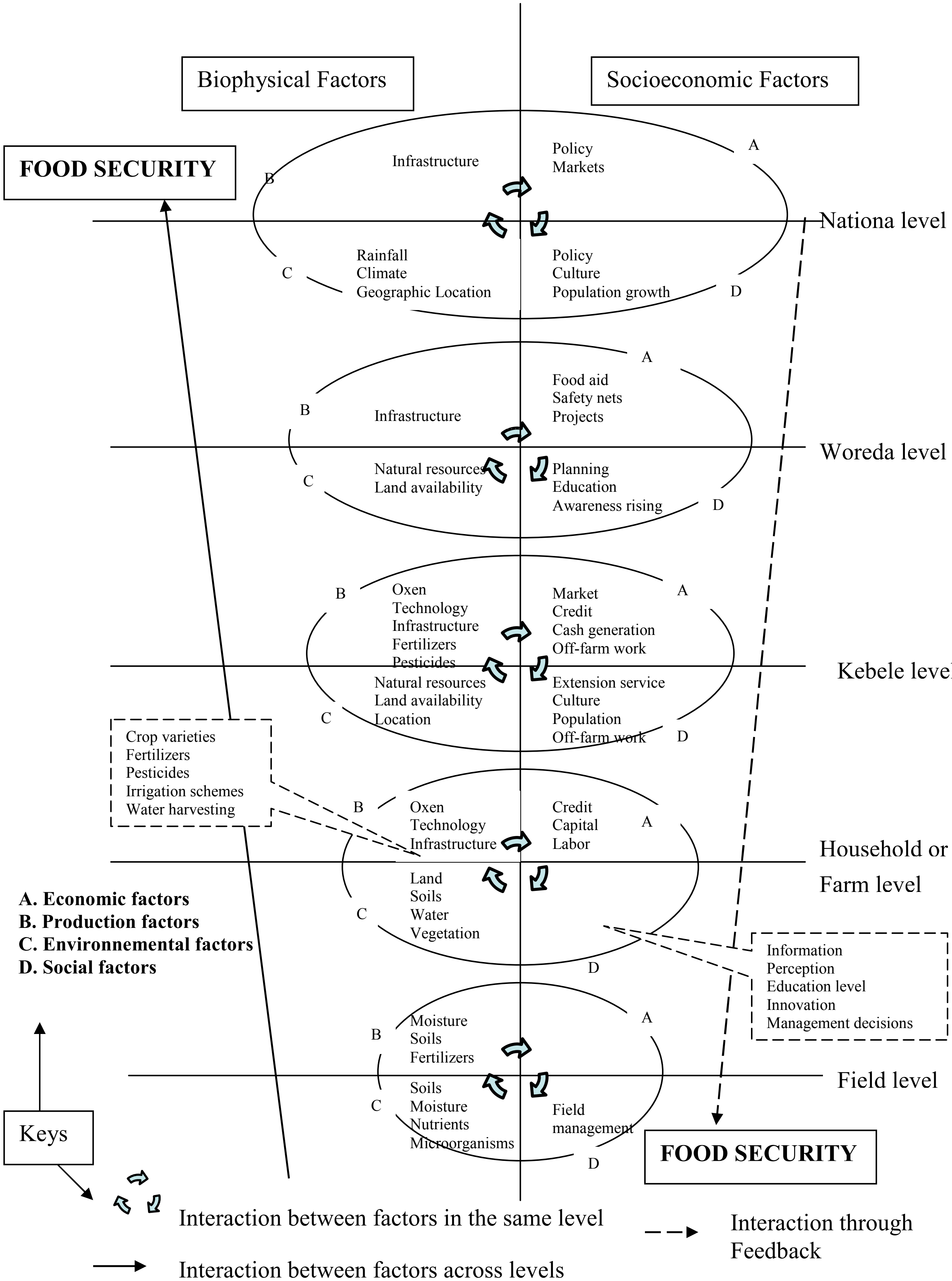

Figure 7: Interactions of factors within and across hierarchies to affect food security situation

There are examples from the findings in the previous sections that can be positive feedback or negative feedback. First, farmers perceive that their plots are fertile. Thus, they never make fertility amendment measures such as use of farmyard manure. This results in lower productivity of their plots. As a result, they become food insecure. Low production also means they cannot afford improved inputs. This forces them to choose short-term income generating activities like working off-farm. They have reduced time to manage their farm and this in turn worsens their food insecurity. This is a positive feedback mechanism where food insecurity situation amplifies the things that have caused it. In this case, soil fertility is a field level biophysical factor; management decision a household level socioeconomic factor and food security situation can be considered both kebele level and household level factor.

Secondly, sale of crops at lower prices during harvesting time reduces the returns from crops, making the farmers more likely to be food insecure. In response, farmers may choose to store the crop and sale cattle instead. This can allow the farmers to sale their crops at higher prices latter, which in turn provide them with improved capacity to invest in the production of more crops. This is a negative feedback, where the initial phase of food insecurity modifies farmers' reaction in such a way that it avoids the food security situation from amplifying itself. A number of such examples can be drawn from the present findings.

Societies can influence resource utilization through their perceptions and management decisions. This can have implications on the resource base, which can be of direct implication on the resource in a way that they exploit it. Humans can also indirectly influence their resource use through increased population pressure. The pressure on resources can further be linked to their perceptions about family planning and the actions they are willing to take in the limits of the local socio-cultural contexts. Increased pressure on the local resource base can result in low productivity of the farming systems directly via deterioration of production resources or indirectly through its enhancing effects on environmental constraints such as drought. Since human factor is an unavoidable entity in the farming system, it can also influence all the other factors (physical, economic, policy) at all scales in the farming system.

Although the relationship between biophysical and socioeconomic factors in affecting food security is obviously complex, at least two things can be deducted from the model in Figure 6. First, the interaction among production, environmental, social and economic resources, both within levels and across levels, can have impacts on food security of households. Second, actions made at lower levels in the hierarchy can create effects along higher hierarchies that in turn can influence food security situations down the lower hierarchy through feedback mechanisms: positive or negative feedbacks.

4. Conclusions

The present study showed that there are differences in food security conditions of farmers. Drought, poor soil fertility, diseases and pests were identified as common threats to livelihoods in both food-secure and food-insecure kebeles. On the other hand, perceptions about constraints, coping mechanisms against shocks, time allocated to on-farm activities, soil management practices, allocation of production resources towards more valuable crops, and manipulation of selling time of crops were found correlated to differences in food security conditions of households. Thus, environmental happenings may not be the only responsible factors for differences in food insecurity problems among farmers. In addition, how they react to these environmental happenings and constraints can have great impacts.

Farming system in the study area is constrained by multitudes of interacting social, environmental and economic factors. Factors ranging from a tiny field management decision to huge national level policy choices create complex interrelationships in affecting farming system performances. This can make some villages food-insecure while others remain food self-sufficient. Indeed, the differences can be created by differences in households' reactions and decisions to different real world situations. This can imply aiming at solving biophysical conditions that appear responsible for the food insecurity of some farmers in the area may not be sufficient to reduce food security problems. In addition, focusing on socio-cultural issues that improve farmers' attitude can contribute a significant part to any problem-solving agenda in the area. Thus, food security problems can only be reduced in a sustainable manor, if these dynamic interactions between biophysical and socioeconomic factors are considered and accounted for.

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Appendix 1: Review of Literature[14]

Stepping into the twenty first Century, widespread poverty, food insecurity, and environmental degradation are still threatening stability of global, regional, and national economic and ecological conditions and cause severe human suffering (Pinstrup-Andersen and Pandya-Lorch, 1998). Rosegrant and Cline (2003) predicted food security will remain a global challenge for the coming 50 years caused by water scarcity, among other things. Most of the challenges prevail in areas, which mainly depend on rainfall for production. Rain-fed agriculture encompasses about 69% of all the cereal area and contributes to 58% of the world food production (Rosegrant et al., 2002), and almost 100% in Ethiopia. Climate variability plays an important role in determining productivity of much of the world's rain-fed grown annual food crops in the tropics (Slingo et al., 2005). Low levels of productivity and limited inputs are common characteristics of rain-fed agriculture (Partap, 2004).

Ethiopian Central Rift valley (CRV) is a region, which depends on rainfall for its crop-livestock agricultural systems. This region is further characterized by complex environmental and socioeconomic interrelationships which make it highly vulnerable from both a food security and natural resource point of view (Rembold et al., 2002). Food security is hugely affected by the performance of rain-fed farming systems. Many of the local mixed farming systems are frequently food-insecure (WFP, 2003). This is partly due to the erratic rainfall pattern on which the farming activities depend. As there is no significant reduction in trends of rainfall over the last 40 years (Hengsdijk and Jansen, 2006), while food insecurity is a relatively recent phenomenon in the area (as compared to highland areas of Ethiopia), shortage of rainfall alone may not be the sole cause of food in-security. A combination of land degradation, Poverty and institutional malfunctioning (Holden and Bekele, 2004), low agricultural productivity and high rate of population growth (Croppenstendt et al., 2003), and recurrent drought (Frankenberger et

[14] I presented the bibliography of this section along with the main reference in the previous section; hence, there was no need to reconstruct a Table of reference list for this section separately.

al., 2007) pose major livelihood problems in most parts of rural Ethiopia, although it is not easy to draw a simple one-way cause-and-effect relationships among these factors (Dasgupta, 1995). In search of meeting basic needs, farmers over-exploit natural resources which is often driven by high population growth (Upton, 1996). This makes preconditions to sustainable livelihood improvements complex and dynamic in areas experiencing continuous social–ecological changes that can alter the capacity of ecosystems to generate goods and services on which society depends (Rockström et al., 2004).

Irrigated agriculture is rapidly growing in the CRV, but increased water use by upstream irrigated agriculture causes periodically water-stressed situations downstream (Jansen et al., 2007). Irrigated agriculture increases because of increased population pressure and economic developments, which is associated with an increased competition for "the precious fresh water resources". Even though irrigation can play a significant role in improving food production in moisture stressed regions, the potential for increased water use for irrigation is often limited (Falkenmark et al., 2001), especially in areas with closed basins such as the CRV. These close basins do not have an outflow of surface water and little changes in water use may have large consequences downstream (Jansen et al., 2007). In addition, previous studies showed that irrigation development in Ethiopia is commonly plagued by insecure land tenure and absence of adequate water-use legislations (Kloos, 1991). With these issues still unimproved, irrigation might not be a possible improvement option for farming systems in the CRV. Rain-fed agriculture becomes a point where improvement options are both visible and feasible.

According to Rosegrant et al (2002), and IWMI[15] (2007), little attention is paid to the rain-fed production systems compared to its potential in improving food supply, especially in developing countries. Rockstro¨m (2003) calls for a decisive "New Green Revolution" that concentrates on the improvement of rain-fed agriculture. Addressing the problems of resource degradation, poverty and food insecurity in this fragile environment, such as the CRV, requires sustainable productivity improvements and

[15] IWMI refers to International Water Management Institute

diversification of rain-fed production systems with due attention to environmental and socioeconomic issues.

Recurrent drought and inconsistent distribution of rainfall makes rain-fed farming systems a highly risk prone activity, frequently resulting in food-insecure situations. Many studies on rain-fed agriculture have been carried out, though 'not to the extent it deserves' (Rosegrant et al., 2002). Most of the studies appear to focus on individual farming system components, for example, soils (Fritzsche et al., 2007), crop variety (Seboka et al., 2001), climate change (Zeray et al., 2006), hydrology (Vallet-Coulomb et al., 2001) and (Ayenew, 2007), while inter-disciplinary studies required to analyze and improve the sustainability of such systems are scarce.

Berkes and Folke (1998) argue that 'many previous studies have analyzed the impact of human activities on the ecosystem, but few have studied the interdependence of social and ecological systems'. Most of the studies aim at assessing and analyzing the biophysical conditions of the farming systems, while incorporation of the human component of the farming system is less emphasized (Colding, 1998). Unfortunately, the omission of this crucial component limits proper understanding of a farming systems because the responses of people to their economic and social environment ultimately determines the other outputs of agricultural systems(Dent et al., 1995).

Moreover, there are also interactions between the livestock farming and crop production in the area. With inputs from one sector being supplied to others, there is marked complementarity in resource use within these systems (Devendraa and Thomas, 2002); and these interactions highly influence the activities of the farmers and underlying land use systems that dictate the capability and sustainability of the ecosystems to maintain production/economic objectives and ecosystem services.

The interaction between the livestock sector and the crop subsystem, coupled by the management influences from farmers, makes the rain-fed mixed farming systems more dynamic and complex to deal with (Figure 1). The physical environmental factor also plays its part, in the case of CRV. Under such conditions, where the environment is significantly fragile and the production factors are erratic enhanced by a rising population, dealing with only individual production constraints may not be good enough to solve the problems.

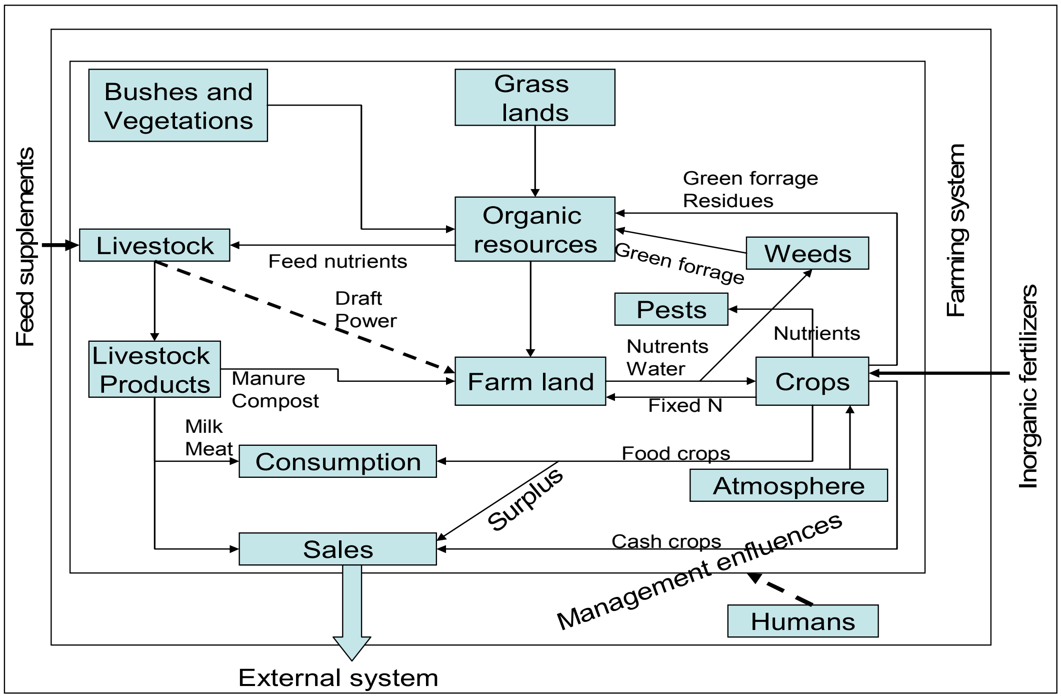

Figure 1: A model showing complimentarity and complex interactions between livestock and crop in mixed farming systems, modified from Thorne and Tanner (2002).

This interaction, on its part, adds to the complexity of the farming system. Berkes and Folke (1998), characterize farming system problems as 'non-linear in nature, cross-scale in time and having an evolutionary character'. So are the solutions to farming system problems. Thus, a holistic systems approach in analyzing farming system constraints is the basic methodology implemented in this study.

There are various reasons for which systems approach is a good option. According to Francis et al (2003), it is not possible to deal with the design and improvement of future farming systems by only considering 'production aspects, short-term economics, and environmental impacts in the immediate vicinity of farm fields'. Thus, the authors recommend a methodology that focuses on the inter-linked edges of social, economic, and environmental components. Von Wirén-Lehr (2001) explains that systems approach is important for two reasons. First, it is important to treat ecological, economic and social aspects on an equal footing. Second, it enables systemic investigations of single factors and of complex functions and processes between components of the system. Bawden (1991) explains systems methodology as an approach ‘in which people collaborate together to explore complex problematic situations critically with the aim of creating change that is socially desirable, culturally feasible, and ethically defensible’.

Appendix 2: Statistical computations of the results

Appendix 2.1[16]: χ^2-values for different factors associated to differences in food security situations of Kebeles

S/No	Factors	Chi-square value[17]	Likelihood ratios	Probability of significance
1	Use of commercial fertilizer	0.21^{NS}	0.21	0.65
2	Type of commercial fertilizer	24.85^{***}	34.13	0.000
3	Use of DAP	11.82^{***}	12.17	0.001
4	Rate of fertilization	23.24^{***}	31.11	0.001
5	Market price to determine fertilization rate	14.13^{***}	18.10	0.001
6	Recommendation of extension workers to affect rate of fertilization	0.21^{NS}	0.22	0.89
7	Extent of soil fertility to affect fertilizer rate	15.07^{***}	19.75	0.004
8	Soil fertility trend	21.87***	25.12	0.002
9	Organic soil fertility management	1.41^{NS}		0.56
10	Use of farm yard manure	9.43^{***}	9.59	0.009
11	Different types of organic fertility management (No of types)	22.98^{***}	27.27	0.001
12	Number of combination factors considered to decide rate of fertilization	12.18^{**}	16.82	0.016
13	Drought frequency	2.56^{NS}	2.95	0.465
14	Family size	28.63^{**}	37.45	0.012
15	Level of education of farmers	5.69^{NS}	6.18	0.337
16	Off-farm activity	7.46^{***}	7.69	0.006
17	Average income from off-farm	14.8^{NS}	18.97	0.63
18	Migration as coping mechanism	10.97^{*}	11.09	0.034
19	Use of resistant variety as copping mechanism	17.67^{***}	21.00	0.001
20	Traditional way of helping each other	23.67^{***}	28.57	0.000
21	Secondary cropping after crop fails	13.56^{***}	15.06	0.009
22	Food aid as copping mechanism	36.96^{***}	44.57	0.000
23	Sale of cattle as copping mechanism	25.67^{***}	29.05	0.000
24	Storing food from relatively better production years	18.02^{***}	19.68	0.001

[16] This Table shows the summary of the statistical significance of the factors to compare differences of these factors between food-secure and insecure Kebeles. However, the details of numbers, frequencies, trends and percentages of the exact differences among the variables are provided in subsequent Tables for each of the variables listed in this Table. Thus, Tables 2, 3, 4….are the extension of Table 1. They provide details of the means and other important statistics, but not the significance of the differences.

[17] Chi-square values marked NS show no significant association between food security situation and the factor considered, ∗ shows the association is significant at $P<0.1$, ** shows association that is significant at $P<0.05$, while *** shows an association that is significant at $P<0.01$.

25	Credit as copping mechanism	17.60^{***}	21.07	0.002
26	Soil erosion	19.42^{***}	22.90	0.002
27	Continuous cropping	15.90^{***}	17.28	0.007
28	Lack of fertilizer	19.23^{***}	12.22	0.039
29	Poor soil management	19.84^{***}	21.52	0.003
30	Removing crop residues	16.05^{***}	17.43	0.007
31	Untimely plowing	10.94^{**}	13.20	0.027
32	Drought	12.13^{NS}	7.32	0.137
33	Poor soil fertility	11.45^{NS}	6.25	0.198
34	Shortage of farm land	9.47^{NS}	4.07	0.412
35	Disease and pests	19.30^{**}	17.17	0.003
36	Lack of improved inputs	17.17^{***}	12.25	0.002
37	Seasonality of market	12.72^{**}	13.48	0.013
38	Lack of capital	15.58^{***}	16.24	0.004
39	Tenure uncertainty	9.40^{*}	12.88	0.052
40	Poor crop storage structures	9.88^{**}	10.52	0.042

Appendix 2.2: Relationship between food security and education levels of households

		Education levels (counts)						Total
		Illiterate	Non-formal	Basic	Primary	Junior secondary	High school	
Food security situation	Food-insecure	2	10	9	12	6	0	39
	Food-secure	3	4	7	19	5	1	39
Total		5	14	16	31	11	1	78

Appendix 2.3: Relationship between food security and off-farm activities of households

		Off-farm workers (Count)		Total
		No	Yes	No
Food security situation	Food-insecure	22	17	39
	Food-secure	33	6	39
Total		55	23	78

Appendix 2.4: Relationship between food security, off-farm activities and education levels of households

Food security situations				Education levels						Total
				Illiterate	Non-formal	Basic	Primary	Junior secondary	High school	
Food-insecure	Off-farm	No	Count	2	2	4	10	4		22
			%	9.1%	9.1%	18.2%	45.5%	18.2%		100.0 %
		Yes	Count	0	8	5	2	2		17
			%	.0%	47.1%	29.4%	11.8%	11.8%		100.0 %
Total			Count	2	10	9	12	6		39
			%	5.1%	25.6%	23.1%	30.8%	15.4%		100.0 %
Food-secured	Off-farm	No	Count	1	4	7	18	2	1	33
			%	3.0%	12.1%	21.2%	54.5%	6.1%	3.0%	100.0 %
		Yes	Count	2	0	0	1	3	0	6
			%	33.3%	.0%	.0%	16.7%	50.0%	.0%	100.0 %
Total			Count	3	4	7	19	5	1	39
			%	7.7%	10.3%	17.9%	48.7%	12.8%	2.6%	100.0 %

Appendix 2.5: Relationships between household responses of food security, education level and off-farm activities

Food security situation				Education levels						Total
				Illiterate	Non-formal	Basic	Primary	Junior secondary	High school	
Need food aid every year	Off-farm	No	Count		0	2	6	3		11
			%		.0%	18.2%	54.5%	27.3%		100.0 %
		Yes	Count		2	2	0	0		4
			%		50.0%	50.0%	.0%	.0%		100.0 %
Total			Count		2	4	6	3		15
			%		13.3%	26.7%	40.0%	20.0%		100.0 %
Need food aid every 2-3 years	Off-farm	No	Count	0	1	0	2	0		3
			%	.0%	33.3%	.0%	66.7%	.0%		100.0 %
		Yes	Count	1	2	2	0	1		6
			%	16.7%	33.3%	33.3%	.0%	16.7%		100.0 %
Total			Count	1	3	2	2	1		9
			%	11.1%	33.3%	22.2%	22.2%	11.1%		100.0 %

Self-sufficient	Off-farm	No	Count	3	4	6	18	3	1	35
			%	8.6%	11.4%	17.1%	51.4%	8.6%	2.9%	100.0 %
		Yes	Count	1	3	1	2	3	0	10
			%	10.0%	30.0%	10.0%	20.0%	30.0%	.0%	100.0 %
Total			Count	4	7	7	20	6	1	45
			%	8.9%	15.6%	15.6%	44.4%	13.3%	2.2%	100.0 %
More than family need and for market	Off-farm	No	Count		1	3	2	0		6
			%		16.7%	50.0%	33.3%	.0%		100.0 %
		Yes	Count		1	0	1	1		3
			%		33.3%	.0%	33.3%	33.3%		100.0 %
Total			Count		2	3	3	1		9
			%		22.2%	33.3%	33.3%	11.1%		100.0 %

Appendix 2.6: Comparison of commercial fertilizer uses by food-secure and food-insecure Kebeles

		Use Commercial fertilizers (Count)		Total
		No	Yes	
Food security situation	Food-insecure	17	22	39
	Food-secured	15	24	39
Total		32	46	78

Appendix 2.7a: Comparison of households using DAP and urea in food-secure and food-insecure Kebeles

		Use DAP			Use urea		
		No	Yes	Total	No	Yes	Total
Food security situation	Food-insecure	30	9	39	26	13	39
	Food-secured	15	24	39	28	11	39
Total		45	33	78	54	24	78

Appendix 2.7b: Rates of fertilization in food-secure and food-insecure Kebeles

		Rate (Kg/ha)						Total
		< 30	30-45	45-60	60-75	75-90	> 90	
Food security situation	Food insecure	0	4	12	5	1	0	22
	Food secure	2	1	7	0	1	13	24
Total		2	5	19	5	2	13	46

Appendix 2.8: Market price as determinant of fertilizer rate in food-secure and food-insecure Kebeles

		Market price		Total
		No	Yes	
Food security situation	Food-insecure	12	10	22
	Food-secured	24	0	24
Total		36	10	46

Appendix 2.9: Soil fertility extent as determinant of fertilizer rate in food-secure and food-insecure Kebeles

		soil fertility to determine rate		Total
		No	Yes	
Food security situation	Food-insecure	0	22	22
	Food-secure	12	12	24
Total		12	34	46

Appendix 2.9a Number of factors considered

		Number of factors considered in deciding fertilization rate				Total
		1	2	3	4	
Food security coded	Food insecure	19	3	0	0	22
	Food secured	0	4	13	5	22
Total		19	7	13	7	44

Appendix 2.10: Farmers' perception of soil fertility trends in food-secure and food-insecure Kebeles

		Soil fertility			Total
		Decreasing	No change	Increasing	
Food security situation	Food-insecure	17	2	20	39
	Food-secure	36	1	2	39
Total		53	3	22	78

Appendix 2.11: Number of farmers in food-secure and food-insecure Kebeles that used different organic management practices

		Use FYM			Use of compost			Crop rotation			Intercropping		
		Never	Use	Total	Never	Use	Total	Never	Use	Total	Never	Use	Total
Food security situation	Food-insecure	12	27	39	5	34	39	6	33	39	17	22	39
	Food-secured	2	37	39	6	33	39	11	28	39	15	24	39
Total		14	63	78	11	67	78	17	61	78	32	46	78

Appendix 2.12: Differences in attitudes of farmers towards migration as coping mechanism

		Migrate					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security situation	Food-insecure	11	13	3	11	1	39
	Food-secured	6	11	10	6	6	39
Total		17	24	13	17	7	78

Appendix 2.13: Differences in attitudes of farmers towards use of drought resistant varieties as coping mechanism

		Resistant Variety					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security situation	Food-insecure	0	6	0	21	12	39
	Food-secured	1	0	1	10	27	39
Total		1	6	1	31	39	78

Appendix 2.14: Differences in attitudes of farmers towards use of traditional system as coping mechanism

		Traditional system of helping each other						Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	No response	
Food security situation	Food-insecure	5	10	9	14	1	0	39
	Food-secured	1	6	3	10	11	8	39
Total		6	16	12	24	12	8	78

Appendix 2.15: Differences in attitudes of farmers towards use of food aid as coping mechanism

		Food aid					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security situation	Food-insecure	1	10	10	17	1	39
	Food-secure	13	22	0	2	2	39
Total		14	32	10	19	3	78

Appendix 2.16: Differences in attitudes of farmers towards use of seeds from other organizations as coping mechanism

		Obtaining food from GO's and NGO's in cases of crop failure					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security situation	Food-insecure	0	4	10	16	9	39
	Food-secured	6	13	3	9	8	39

Total	6	17	13	25	17	78

Appendix 2.17: Differences in attitudes of farmers towards sale of cattle as coping mechanism

		Cattle sale				Total
		Disagree	Neutral	Agree	Agree fully	
Food security situation	Food-insecure	10	11	15	3	39
	Food-secured	4	1	12	22	39
Total		14	12	27	25	78

Appendix 2.18: Differences in attitudes of farmers towards storage of crops as coping mechanism

		Store food from relatively better years					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security coded	Food-insecure	1	3	8	23	4	39
	Food-secured	0	1	3	14	21	39
Total		1	4	11	37	25	78

Appendix 2.19: Differences in attitudes of farmers towards credit services as coping mechanism

		Credit as coping mechanism						Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	No response	
Food security coded	Food-insecure	0	4	7	20	8	0	39
	Food-secured	7	12	2	13	4	1	39
Total		7	16	9	33	12	1	78

Appendix 2.20: Farmers' attitudes of soil erosion as a productivity constraint in food-secure and food-insecure Kebeles

		Soil erosion as productivity constraint						Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	No response	
Food security coded	Food-insecure	17	4	3	2	0	13	39
	Food-secured	12	5	7	7	6	2	39
Total		29	9	10	9	6	15	78

Appendix 2.21: Farmers' attitudes of continuous cropping as a productivity constraint in food-secure and food-insecure Kebeles

		Continuous cropping as productivity constraint						Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	No response	
Food security coded	Food-insecure	5	2	6	3	10	13	39
	Food-secured	2	9	7	2	17	2	39

Total		7	11	13	5	27	15	78

Appendix 2.22: Farmers' attitudes towards availability of fertilizer as a productivity constraint in food-secure and food-insecure Kebeles

		Lack of fertilizers as a constraint						Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	No response	
Food security coded	Food-insecure	9	3	3	3	8	13	39
	Food-secured	8	9	3	10	4	5	39
Total		17	12	6	13	12	18	78

Appendix 2.23: Farmers' attitudes toward farm management decisions as productivity constraint in food-secure and food-insecure Kebeles

		Poor farm management as a constraint						Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	No response	
Food security coded	Food-insecure	7	8	10	1	0	13	39
	Food-secured	11	9	5	3	8	3	39
Total		18	17	15	4	8	16	78

Appendix 2.24: Farmers' attitudes toward untimely plowing as productivity constraint in food-secure and food-insecure Kebeles

		untimely plowing as productivity constraint						Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	No response	
Food security coded	Food-insecure	20	3	3	0	0	13	39
	Food-secured	13	8	8	4	2	4	39
Total		33	11	11	4	2	17	78

Appendix 2.25: Farmers' attitudes toward marginality of land as productivity constraint in food-secure and food-insecure Kebeles

		Cultivation of marginal lands as productivity constraints						Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	99	
Food security coded	Food-insecure	19	4	3	0	0	13	39
	Food-secured	26	5	2	2	2	2	39
Total		45	9	5	2	2	15	78

Appendix 2.26: Farmers' attitudes toward shortage cultivation of land as productivity constraint in food-secure and food-insecure Kebeles

		Shortage of farm land					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security coded	Food-insecure	11	3	6	7	12	39

	Food-secured	10	6	2	5	16	39
Total		21	9	8	12	28	78

Appendix 2.26: Farmers' attitudes toward diseases and pests as productivity constraint in food-secure and food-insecure Kebeles

		Disease and pest as production constraints					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security coded	Food-insecure	18	15	5	1	0	39
	Food-secured	11	6	12	6	4	39
Total		29	21	17	7	4	78

Appendix 2.27: Farmers' attitudes toward seasonality of markets as productivity constraint in food-secure and food-insecure Kebeles

		Seasonality of market as a limit to improved income					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security coded	Food-insecure	14	6	10	5	4	39
	Food-secured	3	11	7	7	11	39
Total		17	17	17	12	15	78

Appendix 2.28: Farmers' attitudes toward capital accessibility as productivity constraint in food-secure and food-insecure Kebeles

		Lack of capital as a limit to improved productivity					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security coded	Food-insecure	3	3	19	5	9	39
	Food-secured	1	5	6	3	24	39
Total		4	8	25	8	33	78

Appendix 2.29: Farmers' attitudes toward land tenure as productivity constraint in food-secure and food-insecure Kebeles

		Tenure uncertainty as a constraint to productivity improvement					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security coded	Food-insecure	10	0	4	23	2	39
	Food-secured	3	1	3	12	20	39
Total		13	1	7	35	22	78

Appendix 2.30: Farmers' attitudes toward market distance as a constraint to increased returns in food-secure and food-insecure Kebeles

		Long distance to market as a limit to returns from agriculture					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security coded	Food-insecure	23	10	5	1	0	39
	Food-secured	25	7	2	3	2	39

Total		48	17	7	4	2	78

Appendix 2.31: Farmers' attitudes toward crop storage as a constraint to increased return in food-secure and food-insecure Kebeles

		Poor crop storage as a limit to returns from agriculture					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security coded	Food-insecure	18	2	14	0	5	39
	Food-secured	11	5	8	1	14	39
Total		29	7	22	1	19	78

Appendix 2.32: Factor responsible for decline in soil fertility

		Soil erosion as a reason for fertility decline					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security situation	Food insecure	17	4	3	2	0	26
	Food secured	2	5	7	7	16	38
Total		29	9	10	9	6	64

Appendix 2.33: Factor responsible for decline in soil fertility

		Continuous cropping as a cause of fertility decline					Total
		Totally disagree	Disagree	Neutral	Agree	Agree fully	
Food security situation	Food insecure	11	2	0	3	10	39
	Food secure	2	9	7	2	17	39
Total		7	11	13	5	27	78

Appendix 3: Descriptive Statistics for per hectare productivity of different crops in food-secure and food-insecure villages

Type of crops	Food security category of the village	N	Per hectare yield in 100kgs			
			Minimum	Maximum	Mean	Std. Deviation

Teff	Food-insecure	39	2	18	7.23	2.795
	Food-secure	39	4	20	9.28	3.699
Maize	Food-insecure	39	1	44	17.85	11.641
	Food-secure	39	10	40	23.79	6.379
Sorghum	Food-insecure	39	2	44	18.36	12.642
	Food-secure	39	6	40	18.51	9.503
Barley	Food-insecure	39	10	30	19.33	3.936
	Food-secure	39	12	30	20.64	3.580
Haricot bean	Food-insecure	39	2	28	14.92	6.454
	Food-secure	39	8	35	15.05	4.915

Appendix 4: Descriptive Statistics for prices of different crops in food-secure and food-insecure villages

Types of crop	Food security category of the village	N	Prices of crops (Birr/100Kg of crop)			
			Minimum	Maximum	Mean	Std. Deviation
Teff	Food-insecure	39	200	380	300.46	45.549
	Food-secure	39	220	425	341.80	64.345
Wheat	Food-insecure	39	180	280	228.15	29.613
	Food-secure	39	150	335	264.44	55.908
Maize	Food-insecure	39	50	150	115.49	24.396
	Food-secure	39	100	183	144.08	33.062
Sorghum	Food-insecure	39	74	169	131.10	20.887
	Food-secure	39	75	190	131.79	25.144
Barley	Food-insecure	39	140	200	185.28	9.774
	Food-secure	39	180	270	187.03	15.078
Haricot bean	Food-insecure	39	80	300	179.08	73.357
	Food-secure	39	120	330	201.28	54.637

Appendix 5: Mean comparison for crop productivity and their prices using two-sample and one-sample T-tests

Type of crop	**Per hectare productivity of crops in food-insecure and food-secure and kebeles (in 100Kg/ha)**	Paired Differences					t	df	Sig. (2-tailed)
		Mean difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Teff	Food in-secure vs. food-secure Kebeles	-2.051	4.828	.773	-3.616	-.486	-2.653	38	.012
Maize	Food in-secure vs. food-secure Kebeles	-5.949	14.620	2.341	-10.688	-1.210	-2.541	38	.015
Sorghum	Food in-secure vs. food-secure Kebeles	-.154	15.099	2.418	-5.048	4.741	-.064	38	.950
Barley	Food in-secure vs. food-secure Kebeles	-1.308	5.357	.858	-3.044	.429	-1.525	38	.136
Haricot Beans	Food in-secure vs. food-secure Kebeles	-.128	8.256	1.322	-2.805	2.548	-.097	38	.923
Prices in Birr/100kgs of crops in food-insecure and food-secure Kebeles									
Teff	Prices in Food in-secure vs. food-secure Kebeles	-41.282	92.853	14.868	-71.381	-11.183	-2.777	38	.008
Wheat	Prices in Food in-secure vs. food-secure Kebeles	-36.282	65.329	10.461	-57.459	-15.105	-3.468	38	.001
Maize	Prices in Food in-secure vs. food-secure Kebeles	-28.590	34.747	5.564	-39.853	-17.326	-5.138	38	.000
Barley	Prices in Food in-secure vs. food-secure Kebeles	-1.744	20.326	3.255	-8.332	4.845	-.536	38	.595
Sorghum	Prices in Food in-secure vs. food-secure Kebeles	-.692	30.889	4.946	-10.705	9.321	-.140	38	.889
Haricot beans	Prices in Food in-secure vs. food-secure Kebeles	-22.205	97.247	15.572	-53.729	9.319	-1.426	38	.162

Appendix 6: Questionnaires used for data collection

1. Personal information of the interviewee

Name____

Kebele: ____

Woreda: ____

Age (in years)

a. less than 20 ☐
b. 20-25 ☐
c. 26-30 ☐
d. 31-35 ☐
e. 36-40 ☐
f. 41-45 ☐
g. older than 45 ☐

Sex: M ☐ F ☐

2. Family size_______________
3. How many wives do you have?
   a. one ☐
   b. Two ☐
   c. Three ☐
   d. More than 3 ☐
4. What is your educational background? (tick the proper box)
   a. Illiterate ☐
   b. No formal education ☐
   c. Basic education ☐
   d. Primary education ☐
   e. Junior secondary school complete ☐
   f. High school complete ☐
   g. College level education ☐
   h. Other (specify)____________________________________
5. How food-secured is your household?(please tick the proper box)
   a. More than family need and for market ☐

b. Self-sufficient ☐
c. Need food aid every year ☐
d. Need food aid every 2-3 year ☐
e. Need food aid every 3-4 years ☐
f. Need food aid every 4-5 yea ☐

6. What mechanisms do you use to withstand unexpected yield losses that are resulted from fluctuation in conditions such as drought, disease outbreak, etc?

	Agree fully	Agree	Neutral	Disagree	Totally disagree	No idea
a. Migrate to relatives at unaffected areas	☐	☐	☐	☐	☐	☐
b. Use of resistant varieties	☐	☐	☐	☐	☐	☐
c. Use of different crop type after one fails	☐	☐	☐	☐	☐	☐
d. Traditional system to help one (Hirphaa)	☐	☐	☐	☐	☐	☐
e. Asking for relief food aid	☐	☐	☐	☐	☐	☐
f. NGO and government provide seed	☐	☐	☐	☐	☐	☐
g. Sale of cattle	☐	☐	☐	☐	☐	☐
h. Store food from "good" seasons	☐	☐	☐	☐	☐	☐
i. Get credit from government	☐	☐	☐	☐	☐	☐

j. Others mechanisms (please specify) ____

7. What are the major types of crops produced on your farm? (tick the proper boxes)

a. Teff ☐
b. Maize ☐
c. Wheat ☐
d. Sorghum ☐
e. Barely ☐
f. Haricot bean ☐
g. Pasture ☐
h. VegeTables ☐
i. Perennials ☐
j. Others (specify)____

8. What is the average per hectare productivity of each of the above mentioned products?
    a. Teff ________________________
    b. Maize_______________________
    c. Wheat_______________________
    d. sorghum______________________
    e. Barely _______________________
    f. Haricot bean___________________
    g. Pasture_______________________
    h. VegeTables_____________________
    i. Others (specify)____
9. What is the average market price for each of these crops? (write in Birr/100kg of the product)
    a. Teff [ ]
    b. Maize [ ]
    c. Wheat [ ]
    d. Sorghum [ ]
    e. Barely [ ]
    f. Haricot bean [ ]
    g. VegeTables [ ]
    h. Perennials (Birr/yr) [ ]
    i. Others (specify)____

10. How many hectares of land did you use for each of the following products this year?

	Land used per crop (in hectares)						
	Less than 0.25	0.25-0.5	0.51-1	1.1-2	2.1-3	3.1-4	More than 4
A. Teff	☐	☐	☐	☐	☐	☐	☐
B. maize	☐	☐	☐	☐	☐	☐	☐
C. Wheat	☐	☐	☐	☐	☐	☐	☐
D. Barely	☐	☐	☐	☐	☐	☐	☐
E. Haricot bean	☐	☐	☐	☐	☐	☐	☐
F. Pasture	☐	☐	☐	☐	☐	☐	☐
G. Un cropped	☐	☐	☐	☐	☐	☐	☐
H. VegeTables	☐	☐	☐	☐	☐	☐	☐
I. Perennials	☐	☐	☐	☐	☐	☐	☐
J. others	☐	☐	☐	☐	☐	☐	☐

11. Do you work off-farm?
    A. yes
    B. No
    C. No answer
12. If your answer to question 11 is "yes", what kind of off-farm activities do you perform? (Please tick the kind of off-farm activities listed, ticking more than one activity is possible if you participate in more than one)?
    a. Petty trade ☐
    b. Fishing ☐
    c. Labor sale ☐
    d. Others (specify)______________________
13. How much income do you obtain from the off-farm activities? (please tick the approximate average yearly income in Birr)

	Approximate yearly income (Birr)					
	Less than 100	100-300	301-500	501-700	701-900	More than 900
a. Petty trade	☐	☐	☐	☐	☐	☐
b. Fishing	☐	☐	☐	☐	☐	☐

c. Labor sale ☐ ☐ ☐ ☐ ☐ ☐

d. Other (pleases mention the off-farm activity and write its income) ________

________ ____________________ ____________________________

14. What are the common livestock products on your farm? (please fill the following Table)

Type of livestock	No. owned	Total production of milk/ day(liters)	Production of milk by product Cheese / Butter	Consumption of milk /HH/daily(liters)	Sale of milk and milk products		Sale of livestock		Market where you sale products
					Quantity	price	Quantity	price	
Heifers									
Oxen for fattening									
Oxen for drought/work									
Calves Born per year									
Sheep									
Goats									
Poultries									
Donkeys									
Bee hives									

15. Do you use commercial fertilizers?

A. yes

B. No

16. If your answer to question 15 is "yes", what type of fertilizers do you use and at what rate?

Rates (Kg/ha)

	Less than 30	30.1-45	45.1-60	60.1-75	75.1-90	more than 90
a. Urea ☐	☐	☐	☐	☐	☐	☐
b. DAP ☐	☐	☐	☐	☐	☐	☐
c. Orga ☐	☐	☐	☐	☐	☐	☐
d. TSP[18] ☐	☐	☐	☐	☐	☐	☐

e. Other (please specify)____

17. What determines the rate at which you use fertilizers? (tick the box, you can tick more than one box if the factors are many)
    a. Recommendation from extension workers ☐
    b. Market price for fertilizers ☐
    c. Soil fertility extent ☐
    d. Based on own personal experience ☐
    e. Other (please specify)____

18. Do you undertake mixed crop livestock farming?
    a. Yes
    b. No

19. If your answer to question 18 is "yes", what is the advantage of being a mixed farmer, according to your view?(please tick the boxes)

	Agree fully	Agree	Neutral	Disagree	Totally disagree	No idea
a. To minimize risk of crop failures	☐	☐	☐	☐	☐	☐
b. To use cattle manure as fertilizers	☐	☐	☐	☐	☐	☐
c. To diversify household income source	☐	☐	☐	☐	☐	☐
d. For cultural reasons	☐	☐	☐	☐	☐	☐
e. The easiness of the area for combined farming	☐	☐	☐	☐	☐	☐

[18] TSP refers to Triple Super Phosphate which is a phosphorous fertilizer

f. Animal as draught power ☐ ☐ ☐ ☐ ☐ ☐

g. To use crop byproducts as animal feed ☐ ☐ ☐ ☐ ☐ ☐

h. Others (specify)____

20. How do you explain productivity trends in yield of rain-fed farming in recent times?

A. Increasing ☐

B. Decreasing ☐

C. No change ☐

21. If your answer is "decreasing" in question 20 above, what do you think is the major reason/s?

	Agree fully	Agree	Neutral	Disagree	Totally disagree	No idea
a. Drought	☐	☐	☐	☐	☐	☐
b. Fragmented land size	☐	☐	☐	☐	☐	☐
c. Climatic hazards (flood, rain…)	☐	☐	☐	☐	☐	☐
d. Disease and pests	☐	☐	☐	☐	☐	☐
e. Lack of improved variety	☐	☐	☐	☐	☐	☐
f. Lack of oxen used for farming	☐	☐	☐	☐	☐	☐
g. Variability of rainy season (start-end)	☐	☐	☐	☐	☐	☐
h. Increased cost of fertilizer	☐	☐	☐	☐	☐	☐

i. Others (specify)____

22. According to your evaluation, what is happening to soil fertility in your farm land?

a. Increasing ☐

b. Decreasing ☐

c. No change ☐

23. If your answer to question 22 is "Decreasing", what is the main reason/s? (Tick 1 for least important factors and 5 for highly important factors)

		Weights					
ID	factors	1	2	3	4	5	Not important at all
a	Soil erosion						
b	Continuous cropping						
c	No use of fertilizers						

d	Poor management						
e	Untimely plowing						
f	Improved varieties deplete soil						
g	Commercial fertilizers weaken soil's natural fertility						
h	Crop residues completely removed for other purposes						
i	Continuous mono cropping						
j	Cultivation of marginal lands						
k	Unidentified reason						
l	others						

24. If you have given a weight larger than 3 for the option "others" in question 23*l*, then list these other factors in their order of importance in reducing the fertility of soil.

____

____

____

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____

25. According to your view, which of the following production constraints are important in limiting the returns you would obtain from farming? (Tick 1 for least important factors and 5 for highly important factors)

		Weights					
ID	factors	1	2	3	4	5	Not important at all
a	Drought						
b	Lack of soil fertility						
c	Shortage of land						
d	Disease and pests						
e	Lack of improved inputs						
f	Seasonality of market						

g	Lack of capital						
h	Uncertainty in tenure systems						
i	Long distance to market places						
j	Poor crop storage						
k	Weeds						
l	Unknown reason						
m	others						

26. If you have given a weight larger than 3, for the option "others" in question 25m above, list the other factors in their order of importance.

____

____

____

27. What is the approximate frequency of drought/crop failures in this area for the last few years?
    a. Every year ☐
    b. Every two years ☐
    c. Every three years ☐
    d. Not more than once in 4 years ☐
28. Do you use organic fertility management practices (farm yard manure, crop rotation, green manure, compost, etc)?
    a. yes
    b. no
29. If your answer to question 28 above is yes, what types of organic fertility management do you usually practice?
    a. Farm yard manure ☐
    b. Green manure ☐
    c. Crop rotation ☐
    d. Use of compost ☐
    e. Crop residue management ☐
    f. Intercropping ☐

g. Other (write it)____

30. Do you practice different farming alternatives? (please tick all the kind of farming systems you practice)

A. Rain-fed farming, ☐
B. Open field irrigated farming, ☐
C. Pasture grazing, ☐
D. Confined animal raring ☐
E. Others (specify)____

31. How do you compare the productivity of each of the above farming systems in terms of monitory values? (Rank according to their productivity)

1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________
5. ____________________________

32. To improve your food security situation, what do you propose for the future?

____
____
____
____
____
____