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Smallholders' Vulnerability to Food Insecurity and Coping Strategies: In the face of climate change, East Hararghe, Ethiopia

Lemma Zemedu & Wondimagegn Mesfin
Asst. Professor, School of Agricultural Economics and Agribusiness
E-mail: zemedul@yahoo.com
Lecturer, School of Agricultural Economics and Agribusiness
E-mail: wondie22@gmail.com

Abstract
Agriculture and food security in developing countries particularly in East Africa are key areas for intervention under climate change. Agricultural production in Ethiopia is highly vulnerable to climate change with major implications for food security. Earlier empirical studies conducted in the country merely emphasized on the static dimensions of food insecurity that have not adequately addressed the linkage between climate change and vulnerability to food insecurity. In recent years, there has been increasing awareness that the analysis of food insecurity should be carried out in a dynamic context. It is, therefore, important to identify the households who are at risk of suffering in the future in addition to looking at the current incidence of food insecurity. The present study analyzed the food security status of households and its determinant factors, vulnerability to food insecurity and coping strategies. Data were gathered from rural households in east Hararghe zone of Ethiopia with reference Kersa, Fedis and Babile districts. Descriptive statistics and probit model were the analytical tools employed. Besides, the Value at Risk approach was used to analyze vulnerability to food insecurity in the study area. For the probit model, the food security status of households was calculated using the calorie intake method. The descriptive statistics result indicates that there is high rate of food insecurity in Fedis district followed by Kersa. The vulnerability analysis also revealed that more households are to be food insecure in the future (40.5%) than present (37.3%), the case will be severe in Fedis district that changes from present (54%) to future (64%). Probit regression result shows that male headed households, per capita income and climate change adaptation through changing planting dates are likely to augment food security. However, increase in household members and location (Fedis) is likely to reduce food security status of the households. Climate change perception is found to have no significant relation with food security status. Importantly, households who adopt climate change adaptation strategies such as soil and water conservation measures and changing planting dates are food secure than the non users. The common strategies food insecure household use to mitigate and cope up with food security problems are building savings, accumulating assets, seeking alternative livelihood sources and reducing household consumption. Hence, it is advisable to diversify livelihood sources, adapt to climate change and promote activities that can increase percapita income.
Keywords: climate change, food insecurity, vulnerability, coping strategies, Ethiopia.

1. Introduction

1.1. Background and Rationale

Empirical evidence is mounted showing that our climate is changing and, given the levels of green house gases (GHGs) already in our atmosphere, will continue to do so, presenting threats of serious social, economic and ecological consequence. The planet is experiencing more extreme weather in terms of heavy precipitation events, geographic shifts in storm and drought patterns and warmer temperatures (IPCC, 2012; Maarten *et al.*, 2007). Projections indicate that global change and variability in global climate will have an adverse overall effect on agricultural food production in the coming decades (Parry *et al.,* 2007; Kotschi, 2007, Morton, 2007; Brown and Funk, 2008; Lobell *et al*., 2008). Climate change is projected to negatively impact crop yields in developing countries and this is likely to leave 25 million additional children undernourished by 2050 (Nelson *et al*., 2009). Smallholders and the poor in the developing countries will be affected the most because of their geographical and climatic conditions, their high dependence on agriculture and natural resources driven activities and their limited capacity to adapt to the changing climate (Diaz *et al*., 2006; Morton, 2007; Schmidhuber and Tubiello, 2007; Brown and Funk, 2008; Mutsvangwa, 2010*).*

Food security is not a new concept. It has been defined in a variety of ways by different authors and organizations. However, the most comprehensive definition comes from FAO (2004) stating *"Food that is available to everyone at all times, that they have means of access to it, that it is nutritionally adequate in terms of quantity, quality and variety, and is acceptable within the given culture. Only when all these conditions are in place it can be said that a population is food secure"*. Absence of any of these conditions at household, regional and national levels causes food insecurity. It can be considered as severe food insecurity when food intakes are continuously insufficient to meet the daily dietary energy requirements leading to a most severe stage of food insecurity called as 'hunger'. Due to food insecurity, at a global scale, the number of undernourished people have increased from 848 million (during 2003 to 2005) to 925 million in 2010 (FAO, 2010b).

Progress has been made towards the Millennium Development Goal of reducing the global poverty rate below 23% (United Nations, 2011). However, climate change remains a threat to attain the goal since it generates a profound impact on the food insecure that are already vulnerable to the impacts of fluctuating food prices, population growth and environmental degradation (FAO, 2010a; Mutsvangwa*,* 2010). Extreme weather events and climate change will exacerbate the fragility of food production systems and the natural resource base, particularly in areas prone to degradation and desertification, water stress and wherever lack of resources, technology and poverty undermines the capacity of rural people to take adaptive measures (IPCC, 2012). Due to effects of climate change, areas currently suffering from food insecurity are expected to experience disproportionately negative effects. The majorities of the world's poor and food insecure people live in rural area and they are directly or indirectly dependent on agriculture for their livelihoods (UNCTAD, 2011). In such areas, the poor are most affected since they lack the resources and capacity to mitigate the negative impacts of climate change and are thus the most vulnerable (Eriksen *et al.*, 2008).

The likelihood of food insecurity is influenced by household level conditions such as education, harvests, health, assets and expenses as well as by regional level conditions such as infrastructure, markets, enabling institutions and conflict or disasters (IFAD, 2011). Assuming that the current trend in population growth and the distribution of wealth continue, it is expected that 10-20% more people may be at risk of hunger by 2050 of which 65% are expected to reside in Africa (Parry *et al*., 2009). Africa, especially sub Saharan Africa (SSA) is considered very vulnerable to effects of climate change because of widespread poverty (Eriksen *et al*., 2008), dependence of the population on marginal areas and lack of technology which facilitates coping and adaptation.

Agriculture is the major sector on which most countries in Sub-Saharan Africa rely for employment and food security for their economies. The sector is dominated by smallholder farmers who produce under unfavorable conditions characterized by low and erratic rainfall and poor soils. Agriculture is highly sensitive to climate which manifests itself in terms of longer-term trends in the average conditions of rainfall and temperature, inter-annual variability and the occurrence of droughts, floods, frosts and other extreme events (IPCC 2012). Rainfed agriculture and agro-pastoral systems are particularly vulnerable to climatic variability. Climate change is likely to change rainfall patterns, resulting in shorter growing seasons in the future, particularly for subsistence farmers in Africa who rely on rainfed agriculture (World Bank, 2008). Extreme weather events such as droughts and floods are predicted to become more frequent, adding to the global burden of hunger caused by poverty, weak governance, conflict and poor market access (Beddington *et al*., 2012; IPCC, 2007).

A recent vulnerability mapping in Africa cited Ethiopia as one of the most vulnerable countries to climate change, food insecurity and with the least adaptive capacity (Stige *et al*., 2006; Oluoko *et al*., 2011). Its geographical and climatic conditions, high dependence on agriculture and weak adaptive capacity were stated as the major reasons for its vulnerability (Eriksen *et al*., 2008; Oluoko *et al*., 2011). Although agriculture represents the mainstay of the Ethiopian economy, food production has failed to keep up to high population growth rates, resulting in high levels of food insecurity. Decline in soil fertility, severe land degradation and recurrent weather-induced shocks are the main causes of food production deficits especially in the densely populated areas in the eastern highlands. The history of Ethiopia is known to have a very long series of famines and food shortages which took place in two wide areas of the country: the first covers the central and northern highlands (laying from northern Shoa through Wollo and Tigray), the second covers agropastoral low lands areas from Wollo through Hararghe and Bale to Sidamo and Gamo Gofa in the south (Webb and Von Braun, 1994). The current study area is also part of chronically affected areas of Ethiopia, which falls in the second loop.

Most of the empirical studies conducted in Ethiopia have given attention to study of static food insecurity with no concern on vulnerability of households to future food insecurity. However, there has been increasing awareness that the analysis of food insecurity should be carried out in a dynamic context. Needless to say, reducing vulnerability is a pre-condition for ensuring food security and poverty reduction (Lovendal and Knowles, 2005). Although lot of efforts are exerted to study and document determinants of food (in)security in different parts of Ethiopia, there has been no attempt to examine the degree of households' vulnerability to food insecurity. Hence, this study is motivated to add to the existing body of knowledge in the area. The study is initiated to examine the vulnerability of households to climate change-induced food insecurity by examining the pre-existing food security status of the households. The study suggests options for the current food insecure rise out of food insecurity and to reduce the likelihood of their being vulnerable to food insecurity.

1.2. Research questions

The study was initiated in an attempt to address the following main research questions.

- What are the current rates of food insecurity in the research area?
- To what degree are households in the study area vulnerable to food insecurity?
- What are the covariates of vulnerability to food insecurity?

1.3. Objectives of the study

The overall objective of the study was to analyze determinants of households' food security status and examine degree of vulnerability to food insecurity in the face of climate change in east Hararghe zone of Ethiopia. The specific objectives were to:

- examine the current rate of food insecurity in the study areas;
- analyze the degree of households' vulnerability to food insecurity;
- examine the determinants of households' food insecurity;
- identify most effective food insecurity coping strategies

2. Research Methodology

2.1. Description of the Study Areas

The study is conducted in eastern Hararghe zone, Oromiya regional state of Ethiopia. The zone has a total population of 2,723,850, of which about 51% are men. About 8% are urban inhabitants; a further 1% are pastoralists. With an area of 17,935.40 square kilometers, the zone has a population density of 151.87. A total of 580,735 households were counted in this zone, which results in an average of 4.69 persons to a household.

The zone has a complex agro-ecological area in which heavy population density, unpredictable rainfall and significant differences between the agricultural practices within the three main altitude zones create a complicated agricultural profile and at the same time support a population that is in general highly vulnerable to food insecurity. Food shortages are often difficult to detect, as green fields tend to mask vulnerability, and pockets of extreme hunger may exist literally a few kilometers from areas of relative food stability. In the zone, food emergency is largely attributed to drought and pest infestations, which have affected the zone.

Fedis district has total area of 2193.8 km^2 and located in the central part of East Hararghe zone. Altitudinally, the district stretches between 500 and 2100 meters above sea level. The district has a total population of about 157,000 of which about 98% are rural (48.5% females). Populations aged 0-14, 15-64 and 65+ years accounted for 49.7%, 49.1% and 1.2% respectively. Average rural family size is 5.2 persons, equivalent to the national average (CSA, 2012). The district's crude population density is estimated at 72 persons per km^2.The district is classified into *woinadega* (15%) and *kola* (85%) agro climatic zones. The population's livelihood mainly consists of agriculture, husbandry and small - scale trade. The farm units are small family holdings with an average agricultural land area of less than one hectare. Major crops cultivated include maize, haricot bean, sorghum and groundnut. There is high incidence of crop pests and livestock disease. Variations in the amount and occurrence of rainfall, low utilization of modern agricultural inputs, inadequate infrastructural facilities, shortage of schools (mainly lack of senior high school), health institutions, veterinary services and water and deterioration of natural resources are some of the major problems in the district.

Having an area of 3022.2 km^2, Babile district is found in the eastern part of East Hararghe Zone. It stretches between 950 and 2000 meters above sea level. The district falls under *woinadega* (15%) and *kola* (85%) agro climatic zones. Babile had about 52,800 population of which about 81% are rural (49% females). The average family size for rural areas is 5.7 persons. Young, economically independent and old age populations accounted for 51.1%, 47.1% and 1.8% respectively. The district's crude population density is estimated at 17 persons per km^2. Sorghum, maize and haricot bean are the most widely cultivated crops. Stalk borer, weevils, grasshopper, cricket, birds and army worm are major crop pests. Commonly prevalent livestock diseases are blackleg, anthrax, pasteurelosis, and internal and external parasites. Variability in the amount and occurrence of rainfall, traditional farming method, low adoption of modern agricultural inputs, shortage of school, health institutions and veterinary services, and backward infrastructural facilities are the major problems in the district.

Having an area of 544.9 km^2, Kersa district is found in the northern part of East Hararghe zone. Altitudinally, it extends between 1400 and 3200 meters above sea level. Kersa is classified into *dega* (7%), *woinadega* (91%) and *kola* (2%) agro climatic zones. The population of the district is estimated at about 126,900 of which about 94% are rural (48.5% females). Young, economically active and old age populations accounted for 44.6%, 53.1% and 2.3% respectively. Average family sizes for rural and urban area are 4.3 and 4.0 persons respectively. The crude population density of the district is estimated at 233 persons per km^2. Sorghum, maize, haricot bean barley and wheat are the dominant crops in Kersa. Crop pests and livestock disease are prevalent in the district. Unreliability of rainfall, low adoption of modern agricultural inputs due to low purchasing power of the farmers and lack of credit facilities, shortage of schools, health institutions, potable water supply and veterinary services, backward infrastructural facilities and resource deterioration (deforestation and low soil fertility) are the major problems in the district. On the other hand, the district has large tracts of irrigable land.

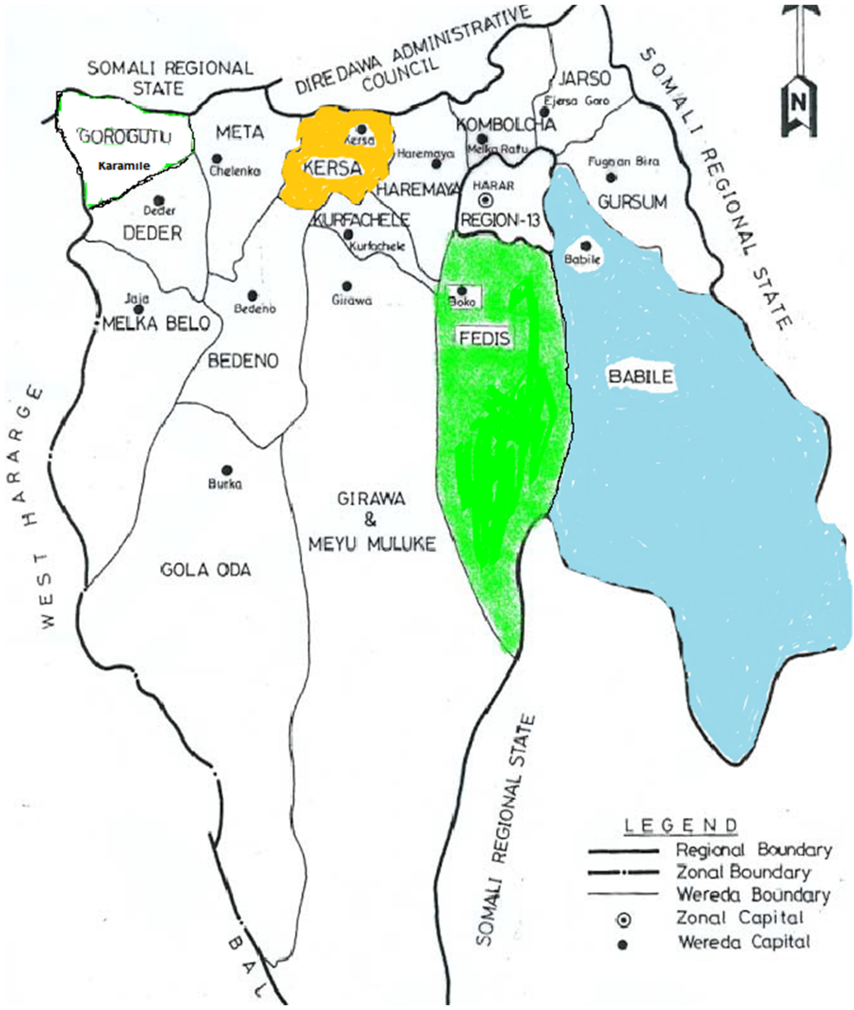

Figure 1: Map of the study districts

Source: Adapted from (Canali and Slaviero, 2010) with modification

2.2. Data Type and Sources

Data used in this analysis were collected from a household survey conducted in Kersa, Babile and Fedis districts of east Hararghe zone. Data were gathered at household level pertaining to social, economic and demographic characteristics of the households, access to inputs, institutional and market characteristics, agricultural activities, sources of income and livelihoods, geographic features, food consumption, farmers' perception of climate change and adaptation strategies. Secondary data regarding the cropping pattern and other information were collected from district agricultural offices through desk review and review of published reports by Central Statistical Agency of Ethiopia.

2.3. Sampling Design

A multi-stage sampling technique was used to randomly select sample households from the three districts. The selection of the districts was through purposive sampling, which took into consideration the agro-ecological setting, location of the district, food security condition and farming system. Proportional sample was taken from each district with sample frame list collected from the district Agricultural Offices. Fourteen rural villages (5 from Kersa, 5 from Fedis and 4 from Babile) were randomly selected from each of the districts. The sample was drawn randomly from the villages using a probability proportional sampling method. Hence, the data was generated through a survey of 279 households.

2.4. Methods of Data Collection

The primary data were collected through household survey questionnaire (interview schedule). Before the actual survey, the questionnaires were pre-tested. For the data collection, enumerators were employed and trained on the ways they approach the respondents and execute the interview. Secondary data were collected through desk review, interview of key officers at district level and reviewing published reports and documents.

2.5. Methods of Data Analysis

Data analysis was carried out using descriptive statistics and econometric models accompanied by SPSS and STATA softwares. Descriptive statistics tools such as mean, standard deviation and percentages were used to describe and analyze household characteristics, food security status and its link with climate change perception and adaptation strategies, food security coping strategies. Mean comparison (t-test) and χ^2 (chi-square) test were used to compare groups with respect to variables of interest.

2.5.1. Food security indicators

A fair proportion of the literature on food security has remained committed to the measurement of food security and factors affecting it (Che and Chen, 2002; Onianwa and Wheelock, 2006; Babatunde *et al.*, 2007; Sindhu *et al.*, 2008; Bashir *et al.*, 2010; Bashir *et al*., 2012). Empirical studies employed different econometric models to estimate determinants of food security. The choice of the model is based on the nature of the dependent variable which in turn depends on the measurement type used. Proper measurement of food security is of clear policy concern, primarily because such measures are used to both assess progress in a given region and to target assistance where needed. However, given the multiple interacting components of food security above, measurement of food security is both difficult and controversial. To measure food security, different methods have been highlighted in the literature such as actual food consumption at the household level by a 24 hour recall, coping strategies index, calorie intake, household income, household expenditure, productive assets, number of months of enough food, dietary diversity and crop diversity (Ramarkishna and Assefa, 2002; Ericksen *et al*., 2008; Kristjanson *et al*., 2012), they capture a small portion of the problem. Majority of these methods, directly or indirectly, use calorie intake method to assess the household food security.

Despite the continued refinement of the definition of food security over the past three decades in response to improved empirical evidence to bring a greater understanding of the components and the underlying causes of food insecurity, the measurement and evaluation of food insecurity remains difficult (Ericksen *et al*., 2011). Proxy indicators are mostly used to measure food security because no perfect single measure that captures all dimensions of food security concept has yet been found (Webb *et al*., 2006). This study employed daily calorie intake per adult measured at household level (7 days recall method) to classify households into food secure and food insecure. To this end, the food security threshold for Ethiopia i.e. 2200 kcal per day per adult equivalent is used as a cut-off point. Households with daily calorie intake per adult equivalent of greater or equal to the threshold are considered as food secure (taking value of 1) and 0 otherwise. Hence, the dependent variable in the study (food security) status is binary.

2.5.2. Empirical model for determinants of food insecurity

Most previous studies on determinants of food in(security) employed logit and probit models, multivariate models and other regression models such as interval regression model (Mazbahul and Rezai, 2010). Logit and Probit are appropriate models to use when the dependent variable is a binary. For the study, probit model was used to analyze the determinants of food security status of households. It models the influence of the set of explanatory variables on food security status of households in the study area.

The probit econometric approach for this study was characterized by a set of binary dependent variables y_i such that:

$$y_i = \begin{cases} 1 & if \quad x'\beta_i + \varepsilon_i > 0 \\ 0 & if \quad x'\beta_i + \varepsilon_i \le 0 \end{cases}$$

where *x* is a vector of explanatory variables, $\beta_1, \beta_2, ..., \beta_n$ are vector of parameter to be estimated, and $\varepsilon_1, \varepsilon_2, ..., \varepsilon_n$ are random error terms.

The coefficients of the probit regression estimators only dictate the direction of the effects of the explanatory variables on the dependent variable(s). Hence, marginal effects were calculated to measure the effect of the explanatory variables on the probability of being food secure or insecure. Since econometric analysis with cross-sectional data is usually associated with problems of heteroskedasticity and multicollinearity, such suspicions were tested using appropriate STATA commands (Nhemachena and Hassan, 2007).

The explanatory variables of the model were extracted from empirical studies, literature, policy documents and economic theory. They include socio-economic and demographic characteristics of the household, market and institutional related factors, farm and agro-ecological and other characteristics.

2.5.3. Vulnerability to food insecurity

Vulnerability to food insecurity is the propensity that a household will, if currently food secure, fall below the food security threshold or if currently food insecure remain in food insecurity and is determined by exposure to risks, sensitivity and adaptive capacity of a household (Ahmad *et al.,* 2001; Chaudhuri *et al*., 2002; Christiansen and Subbarao, 2004). Unlike the traditional food security analysis which offers an *ex-post* view on who the food insecure are and why they are so, looking food insecurity from a vulnerability perspective provides a dynamic and forward-looking way of analyzing causes and options for reducing food insecurity.

The existing literature on vulnerability analysis indicates that there is no consensus on the framework to define

and measure vulnerability and adopt empirical methods that are most appropriate for evaluation of policies targeted at reducing vulnerability. Most of the existing approaches are theoretically and empirically difficult in that they are not sufficiently distinct from a static analysis of food insecurity (Scaramozzino, 2006). Hence, the current study will use Value at Risk (VaR) approach which is a rigorous novel approach to the analysis of vulnerability in the context of food security.
The VaR approach provides a quantitative measure of the incidence of vulnerability which is useful in placing households with respect to the reference threshold (Scaramozzino, 2006). It will also enable household to assess the amount of resources that ought to be set aside in order to achieve food security for any chosen level of confidence. It can also be employed to identify most effective risk management strategies in reducing the likelihood of occurrence of food insecurity or severity of its consequences.
A two-stage least squares regression model can be used to find estimates and measure the degree of each household's vulnerability to food insecurity. The estimated probability is given by:

$$\hat{v}_h = \hat{\Pr}(\ln c_h < z | X_h) = \Phi\left(\frac{\ln z - X_h\hat{\beta}}{\sqrt{X_h\hat{\theta}}}\right)$$

Where: $\ln c_h = X_h\beta + \varepsilon_h$

V_{ht} is the probability associated with the household's vulnerability; c_h is the per-capita consumption of the household; z is the appropriate consumption for the household; X_h represents a set of household characteristics; β is a vector of parameters to be estimated, and ε_h is disturbance term that captures idiosyncratic risks.
In order to classify households into vulnerable and non vulnerable to food insecurity, the percapita calorie intake was modeled against the explanatory variables used in determining food security status of households to predict new value of calorie intake. A household requires minimum of 2200 kcal per day per adult to be food secure. A household that has a daily calorie intake less than 2200 kcal per adult is food insecure. Based on Chaudhuri *et al.* (2002), a household's vulnerability to food insecurity can be expressed as a probability that household fails to attain the minimum level of calorie intake in the future.

3. Results and Discussions

3.1. Characteristics of the sample households

The relationship between different household, social, economic and location characteristics of the sample households and food security status was analyzed using descriptive statistics. The following tables summarize the characteristics of the sample households based on their food security status.

Table 2: Household characteristics by food security status (dummy variables)

Variable	Category	Food security status			χ^2
		Food secure (n = 175)	Food insecure (n=104)	Total (n=279)	
Gender of the household head	Male (%)	64.0	36.0	86.7	2.21
	Female (%)	51.4	48.6	13.3	
Education status	Illiterate (%)	59.2	40.8	62.4	1.98
	Literate (%)	67.6	32.4	37.6	
Access to off farm income	Yes (%)	64.6	35.4	29.4	0.26
	No (%)	61.7	38.6	70.6	
Access to credit	Access (%)	59.4	40.6	38.0	0.40
	No access (%)	64.2	35.8	62.0	
Access to climate information	Access (%)	61.8	38.2	76.0	0.12
	No access (%)	64.2	35.8	24.0	
Farmers' organizations	Member (%)	42.1	57.9	45.2	1.92
	Not member (%)	66.0	34.0	54.8	
Agroecology	Mid highland (%)	64.4	35.6	47.3	0.44
	Lowland (%)	63.3	36.7	52.7	
District	Babile (% of 82)	70.7	29.3	29.4	5.43*
	Fedis (% of 93)	46.2	53.8	33.3	
	Kersa (% of 104)	63.5	36.5	37.3	

The study result indicates that about 37.3% of the sample households are food insecure. This is very close to finding of recent study by Degye *et al.* (2012) who found the degree of food insecurity to be about 35.9%. The

descriptive statistics result shows that more proportion of male headed households are food secure (64%) than female headed households (51%). There is high proportion of food secure literate households (68%) than their illiterate counterparts (59%). Nevertheless, there is no statistically significant difference between food security status of households with respect to the aforementioned variables. Besides, households with access to off farm income, credit and climate information exhibit statistically insignificant difference in their food security status. Being member of farmers' organization or groups is found to put farmers in the food insecurity group (66%) and statistically significant relationship is found. More proportion of farmers in the lowlands are food secure than those in the highlands and mid-highlands. Besides, the degree of food security seems higher in Babile district (71%) followed by Kersa (63.5%) and food insecurity is found to be prevalent in Fedis district (46%) (Table 1).
The average daily calorie intake per adult equivalent is very close to the country's threshold (2200 kcal) but lower than the regional average (3102.5). There is statistically significant (at 1% level of probability) in the average daily calorie intake between the food secure and insecure households (Table 2).

Table 3: Distribution of households by food security status (continuous variables)

Characteristics	Food security status+			
	Food Secure (n = 175)	Food Insecure (n = 104)	Total (n = 279)	t
Daily calorie intake (kcal)	2516.42 (181.93)	1775.11 (356.82)	2237.03(443.17)	19.72***
Farming experience	21.18 (7.45)	21.31(8.61)	21.21(7.76)	-0.13
Distance to road	10.30(10.31)	6.11(6.97)	8.92(9.63)	4.05***
Distance to main market	9.89 (10.56)	6.57(6.77)	8.88(9.65)	3.20***
Distance from health center	5.45(4.04)	3.31(3.05)	4.77(3.87)	4.99***
Extension contact	37.62(41.82)	43.99(37.86)	42.15(41.68)	-1.28
Percapita income (000's)	5.316(5.69)	2.635(2.075)	4.418(4.89)	5.63***
Household member	5.39(1.52)	5.98(1.93)	5.59(1.67)	-2.84***
Household size	4.24(1.20)	4.73(1.57)	4.41(1.34)	-2.74***
Farm plots owned	2.42(1.10)	2.23(1.28)	2.34(1.16)	1.33
Land holding	1.07(0.90)	0.88(0.78)	1.01(0.85)	1.78*
Trees planted on farms	272.87(1775.24)	75.24(363.40)	193.63(1384.55)	1.42
Number of crops grown	3.44(0.88)	3.27(0.84)	3.38(0.86)	1.62
Marketed surplus	21.63(18.44)	18.47(16.21)	20.43(17.51)	1.43
Livestock owned	6.27(8.53)	3.51(3.05)	5.40(7.02)	3.88***

+ Figures in parentheses are standard deviations. *** and *, statistically significant at 1% and 10% level of Significance (Table 1 and Table 2).

Descriptive statistics indicates that there is statistically significant difference in distance from main road, main market and health centers among food secure and insecure households. Food secure households are located at far distance than the food insecure. This is probably due to the reason that households who lack access to institutional support, inputs and market produce only for their consumption; hence, they become self sufficient and more food secure. Food insecure households have larger household size. This indicates that increase in household size poses problem of food insecurity than its contribution to labor. The higher extension contact by food insecure households indicates that such households need more frequent contact with extension agents since they need advice. Food secure households have higher percapita income, cultivated land and livestock than the insecure households. Although statistically insignificant, food secure households plant more number of trees on their farms than food insecure households.

3.2. Climate change perception, adaptation and food security status

The relationship between farmers' perception of climate change and clime change effects and food security status of households is summarized and presented in Table 3.

Table 4: Climate change perception and food security status

Climate change indicators	Perception	Food security status		Total	χ^2
		Food secure	Food insecure		
Crop failure	Yes (%)	62.2	37.8	70.3	0.01
	No (%)	62.7	37.3	29.7	
Disease incidence	Yes (%)	64.1	35.9	87.8	2.52
	No (%)	50.0	50.0	12.2	
Drought	Yes (%)	61.5	38.5	68.8	0.22
	No (%)	64.4	35.6	31.2	
Temperature change	Yes (%)	62.0	38.0	98.2	0.67
	No (%)	80.0	20.0	1.8	
Rainfall pattern change	Yes (%)	62.0	38.0	97.1	0.56
	No (%)	75.0	25.0	2.9	

Households who perceive effects of climate change such as disease incidence and crop failure are more food secure than those who do not perceive. On the other hand, farmers who perceive change in temperature and rainfall (precipitation) patterns are less food secure than those who perceive. There is no statistically significant difference between perception of climate change and food security status. An attempt was made to see if there is statistical relationship between adaptation to climate change and food security status of households. The results are presented in Table 4.

Table 5: Climate change adaptation and food security status

Climate change adaption	**Adoption/Use**	**Food security status**		**Total**	χ^2
		Food secure	**Food insecure**		
Cultivating different crops	Yes (%)	65.3	34.7	60.9	1.59
	No (%)	57.8	42.2	39.1	
Planting different crop varieties	Yes (%)	65.2	34.8	55.6	1.16
	No (%)	58.9	41.1	44.4	
Soil & water conservation measures	Yes (%)	55.7	44.3	47.0	4.64**
	No (%)	68.2	31.8	53.0	
Changing planting dates	Yes (%)	73.0	27.0	43.7	10.35***
	No (%)	54.1	45.9	56.3	

The descriptive result revealed that households who adopt climate change adaptation strategies are more food secure than those who do not adopt. Statistically significant relationship is found between adoption of soil and water conservation measures and changing planting dates and food security status of households. This indicates that adaption to climate change has significant effect in improving food security status of households. However, further investigation is needed to quantify the impact of each adaptation strategy on food security status.

3.3. Determinants of household food (in) security

Probit model was used to estimate determinants of food (in) security. The model explanatory variables were checked if there are problems of heteroscedasticity, multicollinearity and omission of important variables. Accordingly, the Breusch-Pagan test for heteroscedasticity indicated that there was no heteroscedasticity problem with the data. The variance inflation factor (VIF) and contingency coefficient (CC) tests of multicollinearity revealed that it is not a severe problem. The Ramsey RESET test using powers of the fitted values of the dependent variable indicated that there is no problem of omitting important variables. The log pseudo likelihood test indicated that the model is significant in determining food security. Of all the explanatory variables entered the model, six were found to significantly affect household's food security status.

Table 6: Probit estimates for determinants of food security

Variables	**Coeff.**	**Std. Error**	**Marg. Effect**
Gender of household head	0.7146**	0.2899	0.2757
Farming experience	0.0042	0.0043	0.0115
Training	0.2477	0.2503	0.0929
Family size	-0.2256***	0.0602	-0.0823
*ln*Farm size	-0.2482	0.1816	-0.0905
Livestock size	0.0309	0.0273	0.0113
Per capita income ('000)	0.0870***	0.0298	0.0317
Farmer organization	-0.0217	0.1842	-0.0079
Climate information	-0.0299	0.2095	-0.0109
Off farm income	-0.2939	0.2413	-0.1094
Fertilizer use	0.2238	0.2785	0.0841
Farm plot	-0.0452	0.0921	-0.0165
Marketed surplus	-0.0027	0.0058	-0.0010
Soil& water Conservation	0.2484	0.2161	0.2213
Changing planting dates	0.6254***	0.1956	0.2213
Crop type	0.2050	0.1891	0.0753
Crop variety	0.2490	0.1923	0.0912
Kersa dummy	-0.3073	0.3892	-0.1135
Fedis dummy	-0.9636***	0.3509	-0.3584
Intercept	-0.1272	0.5766	

Number of observations	279
LR χ^2 (17)	63.05
Prob > χ^2	0.0000
Log likelihood	-148.13
Pseudo R^2	0.20

Table 5 presents determinant factors for household food security in the study area. The positive and significant coefficient of gender of the household head indicates that male headed households are more likely to be food secure than female headed households (27.5%). This might be due to the fact that female headed households do have less access to and control over major agricultural resources even though they do much of the agricultural work. In addition, plowing (digging) of land is done manually in the study area as opposite to other parts of the country, where oxen are used for this purpose. Female headed households are traditional and physically incapable of performing plowing activities as such, hence, they are found among the poor and lack income and resources that constrain their productivity. The finding of the study is consistent with findings of Kassie *et al.* (2012); and Demeke *et al.* (2011) and Canali and Slaverie (2010).

Family size (number of household members) is found to have a negative and significant (at 1% significant level) effect on food security, implying that the probability of food security decreases with increase in family size. Possible explanation is that large family size exerts more pressure on food consumption than it contributes to production (Paddy, 2003). This means that each additional member of a household increases household food insecurity. The marginal effect indicates that a one adult equivalent increase in household size is, on average, will lead to 8% probability of being food insecure, *ceteris paribus*. An increase means more people to feed and indirectly reduces income per head, expenditure per head and per capita food consumption. This demand, however, cannot be matched with the existing food supply from own production and this ultimately end up with the household becoming food insecure. This finding is consistent with theoretical and empirical evidences which revealed that food security status of households is predominantly decreased by family size (Ikpi and Kormawa, 2004; Haile *et al*., 2005; Sikwela, 2008; Asogwa and Umeh, 2012; Degye *et al*., 2012; Bashir *et al*., 2012; Mensah *et al*., 2013).

Changing planting dates is one of climate change adaptation strategy that significantly (1%) and positively affects food security. Those households who are flexible in planting dates with respect to change in climatic conditions were found better in terms of food security. These households' food security level is better off by probability of over 22 % as compared to those who did not use changing planting date as strategy against climate variability.

Percapita income is found to have a positive and significant effect (1%) on household food security status. The positive effect indicates that an increase in monthly income will increase the chances of a household becoming food secure. Income is often used to buy inputs such as improved seed varieties and fertilizer that increase production levels of the household. In addition, households that have access to better income opportunities are less likely to become food insecure than households who have less or little access. The finding is consistent with previous studies (Bogale and Shimelis, 2009; Arene and Anyaeji, 2010; Bashir *et al*., 2012);

The coefficient for district dummies (Fedis) is found significant (1%) and negatively related to food security. The result indicates that households in Fedis districts are less food secure compared to those in Babile district (the reference category). This complements the existing knowledge about Fedis district, one of the most risk prone and food insecure area in eastern Hararghe zone of Ethiopia (Belaineh, 2003; Canali and Slaviero, 2010). Households in Babile are keeping large stock of animals which can serve as a hedge against crop failure risks caused by climate changes and which aggravates food insecurity.

3.4. Households' vulnerability to food insecurity

Vulnerability analysis helps to estimate the proportion of people who will be at the risk of food insecurity in the future. Accordingly, the degree of households' vulnerability to food insecurity was estimated using the method stated in the data analysis part of this report. The following table summarizes the distribution of households in the study areas based on degree of vulnerability to food insecurity.

Table 7: Distribution of households based on vulnerability status in the study area

	Kersa (%)	**Fedis (%)**	**Babile (%)**	**% of sample**	χ^2
Non-vulnerable (n=113)	56.7	35.7	88.3	59.8	55.81***
Vulnerable (n =166)	43.3	64.3	11.7	40.2	

The analysis of vulnerability to food insecurity indicates that the average degree of vulnerability in the study area is about 40%. Households in Fedis district are highly vulnerable to food insecurity (64.3%) followed by those in Kersa district (43.3%). However, households in Babile are supposed to be less vulnerable to food insecurity (11.7%). There is statistically significant difference in vulnerability to food insecurity across the districts. This indicates that district specific coping strategies are needed. Hence, food security intervention programs should give priority to highly vulnerable areas like Fedis and Kersa districts.

The relationship between current food security status and vulnerability to food insecurity revealed statistically significant association between the two (Table 7).

Table 8: Current food security status and vulnerability to future food insecurity

	Vulnerability status (%)			
Food security status (%)	Vulnerable	Non vulnerable	**Total**	χ^2
Food insecure	60.0	40.0	**37.7**	26.56^{***}
Food secure	28.7	71.3	**62.3**	
Total	**40.5**	**59.5**		

Accordingly, of the current food insecure households, about 60% are likely to remain food insecure in the future (vulnerable) where as the remaining are not vulnerable to future food insecurity. On the other hand, about 29% of the current food secure households are vulnerable to food insecurity (likely to be food insecure in the future).

Table 9: Current food security status and vulnerability to future food insecurity (joint probability)

	Vulnerability status (%)		
Food security status (%)	Vulnerable	Non vulnerable	**Total**
Food insecure	22.3	15.0	**37.3**
Food secure	18.2	44.5	**62.7**
Total	**40.5**	**59.5**	**100.0**

Another possible explanation of the vulnerability to insecurity is using the joint probability of food security and vulnerability status. Table 8 shows this for the study area. Accordingly, about 22% of the total sample households are both food insecure and will remain food insecure. About 18% of the total sample households are food secure and vulnerable to food insecurity. By the same token, about 15% of the total sample are food insecure but non-vulnerable to food insecurity in the future. Out of the total sample households, about 45% are food secure and non-vulnerable to food insecurity.

3.5. Food insecurity coping strategies

Households employ different mitigation and coping strategies in times of food deficit. Food insecurity is climate induced shock or risk and coping mechanisms are those commonly used in risk management. The potential food insecurity coping strategies practiced in the study areas include accumulating livestock or other assets; invest in social capital and seeking alternative sources of food or income than farming. There is statistically significant difference among the districts in terms of use of coping and mitigation strategies.

Households in Kersa district, most often accumulate wealth or asset, build savings, seek off farm or nonfarm sources of food and income or reduce household food consumption. Fedis district is focused on investing in social capital and food aid from government effective strategies as compared to other districts. While for Babile district, most effective coping and mitigation strategies reported are accumulation of assets (livestock) and engaging in off/nonfarm activities.

Table 10: Food insecurity coping and mitigation strategies by smallholder farmers in the study areas

Mitigation or coping strategies	**District**				χ^2
	Kersa	**Fedis**	**Babile**	**Whole**	
Accumulate livestock or other assets	63.5	32.7	56.2	50.5	32.71^{***}
Build savings^{++}	64.4	19.7	19.4	38.8	57.61^{***}
Invest in Social Capital [1]	27.9	54.4	10.9	33.6	40.33^{***}
Seek alternative income sources^{++}	57.7	26.7	57.1	47.0	25.56^{***}
Food aid, credit, inputs from Government^{+}	27.9	33.0	17.2	27.2	11.84^{**}
Food sharing, gifts, credits from relatives or friends^{+}	14.4	13.8	15.4	14.4	0.49
Reduction in household food consumption^{+}	56.7	5.3	20.6	29.4	84.39^{***}
Reduction in frequency of daily food consumption, quality, order of food sharing	26.9	6.4	28.6	19.7	34.78^{***}
Sale of livestock or other assets^{+}	55.8	16.5	29.1	36.1	71.02^{***}
Exchange of animals for cereals^{+}	12.5	3.6	12.5	9.2	6.70
Migration^{++}	1.0	1.2	17.9	4.0	27.78^{***}

Note: + represents coping strategy, ++ represents both coping and mitigation strategy

3.6. Consumption smoothing strategy

Consumption coping strategies index (CSI) explains a quick qualitative method and rank on food insecurity mitigating options. It is an index tool that provides real-time (at lean period actually) information to researchers, which is relatively quick and easy to use, can be administered and correlated subsequently with more complex measures of food insecurity at regional level. Even though a comprehensive investigation of households' food insecurity would require a detailed consideration of livelihoods and assets, the CSI is entirely satisfactory as a rapid indicator of household food insecurity status.

[1] Investing in social capital includes joining community groups and keeping good relationship with community members

Table 11: Consumption smoothing index for food insecurity

Consumption strategy	**% used the strategy**			
	Kersa	**Fedis**	**Babile**	**Total**
Turn to the consumption of low quality and cheaper food stuff (shift to less preferred food)	76.8	37.2	45.7	53.7
Borrow food from relatives, friends and neighbors	62.1	56.2	37.6	52.1
Buy food by debt	60.0	14.6	31.5	34.4
Sell some food ration items to buy other food items	50.0	46.9	46.3	47.7
Consume less food within the meals	71.0	3.2	50.6	42.0
Reduce number of daily meals	82.6	6.5	50.5	46.6
Reduce adults' food consumption to secure the need of children for food	68.4	40.0	43.6	51.3
Reduce the expenditure of the household to the least to buy food	76.4	64.6	55.4	65.3
Send some members of the household to live with relatives or with other household	7.5	9.4	34.1	17.0
Ensure feeding the employed members of the household rather than those not working	60.2	25.0	37.1	40.6
Attend religious, death, weddings occasions to eat	25.5	13.2	46.8	28.7

Sample households were asked how often their household had to do with the particular coping mechanisms, if there was times when they did not have enough food or money to buy food in the past 30 days. The major consumption smoothing strategies used in the present study areas are reduce the expenditure of the household to the least to buy food, borrow food from relatives, friends and neighbors, and reduce number of daily meals in order of importance. Households with less CSI scores applied those consumption coping strategies less frequently than households with high CSI scores (Mjonono *et al*., 2009).
The analysis revealed that most food insecure households tend to reduce the expenditure of the household to the least to buy food (65.3%), turn to the consumption of low quality and cheaper food stuff (Shift to less preferred food) (53.7%), borrow food from relatives, friends and neighbors (52.1%) and reduce adults' food consumption to secure the need of children for food (51.3%) in times of food deficit.
Food insecure households in Kersa district are more likely to reduce the number of daily meals (82.6%), turn to consumption of low quality and cheaper food stuff (76.8%), reduce expenditure of household (76.4%) and consume less food (71.0%). In Fedis district, reducing household consumption (65%) and borrowing food from friends, neighbors and relatives (56%) are reported as consumption smoothing strategies. In Babile, reducing household expenditure, consuming less food and reducing number of meals are reported to be consumption smoothing strategies in times of food deficit.

4. Conclusions and Recommendations

4.2. Conclusion

Empirical evidence revealed that climate is changing and farmers already aware about it. There is also evidence that climate change is likely to have adverse effect on the food security status of people especially those in the developing world and rely on agriculture for their livelihoods. The present study was conducted in east Hararghe zone of Ethiopia in order to examine the current rate of food insecurity and its determinant factors and household's vulnerability to future food insecurity. It also covers the coping and mitigation strategies households use in times of food insecurity and consumption smoothing strategy.
Climate perception is found to have no statistical relationship with households' food security status. However, climate change adaptation is found to have significant and positive effect on food security status. It is evident that households who applied changing planting dates as strategy against climate change have high probability of being food secured as compared to the effect of other explanatory variables used in this study. Although needs further investigation, this result has important implication.
The descriptive statistics result reveals that the current rate of food insecurity is about 37.3% with difference across locations. Fedis district is found to be prone to food insecurity. The same analysis indicated that the degree of households' vulnerability to future food insecurity will be about 40.5%, of which 22% attributed to the current food insecure people. Besides, only 15% of the current food insecure are likely to be non vulnerable to food insecurity. Results of the probit model indicated that having male headed household, farming experience and percapita income positively affect food security of the household. On the other hand, household size and farm size are found to negatively and significantly influence food security status.
The strategies most frequently used to cope up with the negative impact of climate induced shocks on food security are district specific and include accumulation of assets, reducing consumption, borrowing from others, building savings and seeking alternative sources of income and food.

4.3. Recommendation

The present study identified important variables that positively or negatively affect food security and that are used for mitigating and coping up of risks. Hence, in order to reduce the risks of food insecurity among vulnerable populations, the poor people must have access to instruments that not only help them manage risks and respond to shocks in the short term, but that also improve their resilience and promote their food security in the long run. Accordingly, governments, donors, and the private sector must develop and scale up approaches that are specifically adapted to the needs of vulnerable populations.

It should be noted that household size is known to be one of the leading causes of food insecurity in the study area. This implies that policy measures directed towards the provision of better family planning to optimize family size should be given adequate attention and priority by the federal and regional governments.

Perception of climate change alone does not help to reduce food insecurity; however, adapting to the climate change through application of changing planting dates was found significantly contributing to reduction of food insecurity. Thus, concerned development organization should train and facilitate households in the study area to adapt such important climate change adaptation strategies.

Interventions that contribute toward improvement of income on top of existing households income is vital to reduce vulnerability to food insecurity and, at the same time, to increase their resilience from climate change effects.

Babile district is less vulnerable to food insecurity and their risk mitigation and coping strategies are also more plausible for maintaining food security in sustainable way than the Fedis district. Hence, intervention is needed in Fedis area to create opportunities of income diversification than relying on food aid from government and neighborhoods.

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Appendix Y: Determinants of choice of food insecurity and vulnerability to food insecurity

Table 1: Variables hypothesized to affect food insecurity in the study area

Variable	**Variable type**	**Description and measurement**	**Expected sign**
Gender of head	Dummy	1, if the household head is male; 0, otherwise	+
Farming experience	Continuous	Farming experience of the household head	+
Family size	Continuous	Number of household members	-
Training	Dummy	1, if the household head has access to training; 0 otherwise	
Farmer organization	Dummy	1, if the household head is member of organization; 0 otherwise	+
Climate information	Dummy	1, if there is access to climate information; 0 otherwise	+
Off farm income	Dummy	1, if household has access to off farm/non farm income sources; 0 otherwise	+
Fertilizer use	Dummy	1, if household uses fertilizer; 0 otherwise,	+
Farm plots	Discrete	Number of farm plots owed by the household	+
Percapita income ('000)	Continuous	Annual income in thousands Birr from on farm activities	+
Farm size (ln)	Continuous	Size of cultivated land in hectares	+
Marketed surplus	Continuous	Proportion of production marketed	-
Livestock holding	Continuous	Total livestock holding in TLU	+
Soil and water conservation	Dummy	1, if the strategy is adopted by the household; 0 otherwise	+
Changing planting dates	Dummy	1, if the strategy is adopted by the household; 0 otherwise	+
Crop type	Dummy	1, if the strategy is adopted by the household; 0 otherwise	+
Crop variety	Dummy	1, if the strategy is adopted by the household; 0 otherwise	+
Fedis	Dummy	1, if household is in Fedis district ; 0 otherwise	+/-
Kersa	Dummy	1, if household is in Kersa district ; 0 otherwise	+/-
Babile	Dummy	1, if household is in Babile district ; 0 otherwise	+/-