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Food Security and Vulnerability to Climate Change in Eastern Ethiopia

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Abstract: Agricultural sector remains the main source of food and income for most rural communities in Ethiopia. Being dependent mainly on rainfall, this sector has been affected by climate change. Employing adaptation strategies to climate change within the agricultural sector is vital to ensure food security and to care for the livelihoods of farmers. This study has analyzed factors influencing the impact of climate change on food security and vulnerability of farm households to climate change in eastern Ethiopia. The study used data obtained from 330 households randomly and proportionately sampled from two agroecologies in East Hararghe Zone of Oromiya Region and Dire Dawa Administration, Ethiopia. The study used univariate probit models to identify factors affecting food security and vulnerability to climate change. Calorie intake per adult equivalent per day was employed as a food security indicator. The results indicated that the vulnerability of households to food insecurity due to climate change is likely to increase to 63% from its base year level of 55% suggesting that about 63% of the households are likely to fall into food insecurity in the near future. Food security status was determined by education of the household head, social participation, training to climate change, farming experience, family size, and fertilizer usage. The positive impact of climate change training sends a good signal to justify its intensification. The study also indicated the need to look into policies related to household food security enhancement and to minimizing vulnerability to climate change.

Keywords: Food Security, Vulnerability, Climate Change, Agroecology, Univariate Probit Model

1. Introduction

The links between food security and climate change are complex, because food security involves food and its production, trade and nutrition as well as how people and nations maintain access to food over time in the face of multiple stresses including climate change. The impact of climate change is a global issue because it affects all countries and sectors. Climate is an important factor for agricultural productivity. Its change affects all dimensions of food security (*i.e.* food availability, food accessibility, food utilization, and food systems stability). It has an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Climate change effects are already being felt in global food markets, and are likely to be particularly significant in specific rural locations where crops fail and yields decline. Its impact are felt in both rural and urban locations where supply chains are disrupted, market prices increase, assets and livelihood opportunities are lost, purchasing power falls, human health is endangered, and affected people are unable to cope (FAO, 2007).

People who are already vulnerable and food insecure are likely to be the first affected in climate change and those agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds, planting material and loss of livestock (Schipper and Pelling, 2006; IPCC, 2007).

Higher temperature and changing precipitation levels caused by climate change depress crop yields. This is particularly true in low-income countries where adaptive capacities are perceived to be low. Hence, many African countries, which have economies largely based on weather-sensitive agriculture, are vulnerable to climate change. Ethiopia with its rain-fed dependent agriculture together with low level of socioeconomic development is highly affected and vulnerable to climate change. Ethiopia's economy is based on agriculture, which accounts for 42.33% of GDP and 80% of total employment. The agricultural sector suffers from poor cultivation practices and frequent drought, but recent joint efforts by the Government of Ethiopia and donors have strengthened Ethiopia's agricultural resilience, contributing to a reduction in the number of Ethiopians threatened with starvation (MoFED, 2014).

The adverse effects of climate change on Ethiopia's agricultural sector are major concerns, particularly given the country's dependence on agricultural production (Assefa, et. al, 2011). Climate induced hazards in Ethiopia include drought, floods, heavy rains, strong winds, frost, and heat waves (high temperatures). According to the assessment by National Adaptation Program of Action (NAPA) of Ethiopia, the major adverse impacts of climate variability on the agricultural sector include food insecurity and land degradation (NAPA, 2011). The country is highly vulnerable to food insecurity as it periodically affects the country. For example, according to the National Bank of Ethiopia and Ethiopian Customs Authority, 390 districts or more than 10 million peoples in eight regions were under food insecurity in 2015 (PSNP, 2015).

This study focused on two districts*, one* from the highland of Eastern Hararghe Zone and the other from the lowland of Dire Dawa Administration (DDA), which are included under the productive safety net program (PSNP and it aims to look into the impact of climate change on smallholder farmers and its interaction with food security situation. Therefore, this study is undertaken with the objectives of identifying the food security status and vulnerability levels of households and assessing factors affecting food security status and vulnerability to climate change of rural households.

2. Research Methodology

2.1. The Study Area

East Hararghe Zone and Dire Dawa Administration (DDA) of Ethiopia were selected for this study mainly because these are among the areas highly affected by climate change. The specific study areas are Meta district from the highland of East Hararghe Zone and Dire Dawa Administration from the lowland. Both of these study areas are under the productive safety net program. East Hararghe and Dire Dawa are situated in the eastern part of Ethiopia, at 520 and 515 kilometers, respectively, east of Addis Ababa, the capital city of the country (CSA, 2011).

The land use pattern of Meta district consists 48% arable, 13% pasture and forest, and the rest 39% regarded as degraded (CSA, 2012). Sorghum, maize, barley, and wheat are the major crops in the district and *Khat* and coffee are the major cash crops. DDA is characterized by relatively high temperature throughout the year with minor seasonal variations. The farming system of the Administration consists of crop production (4.1%), livestock production (7.9%) and holders that are engaged in mixed crop and livestock production (88.0%). The DDA rural district have more or less homogenous characteristics in terms of agroecology and hence have similar agricultural production pattern.

2.2. Sampling Technique

In this study, a multi-stage sampling method was used to select respondents. In the first stage, eastern Ethiopia was stratified into two major agroecologies that are highland and lowland areas. Then East Hararghe zone and DDA were selected purposively to represent the highlands and lowlands, respectively. The largest part of this zone falls under highland agroecology and all DDA area is under lowland agroecology. In the second stage, listing all *districts* in each study agroecologies, one *district* from each agroecology was selected using a simple random sampling technique. In the third stage, sample *Kebeles* [1] were selected using lottery method. Finally, sample households were selected from each *Kebele* by preparing a comprehensive list of households and applying systematic random sampling method.

2.3. Analytical Methods

2.3.1. Measurement of Food Security

Food insecurity was captured by measuring the head count and food insecurity gap which enabled to capture successively more detailed aspects of food insecurity at household level, using the Foster-Greer-Thorbecke (FGT) decomposable indices (Foster *et al*., 1984) for computing incidence, depth and severity of food insecurity.

The FGT measure is given as:

$$FGT(\alpha) = \left(\frac{1}{n}\right)\sum_{i+1}^{q}\left[\frac{(Z - y_i)}{Z}\right]^{\alpha} \quad (1)$$

where: FGT is the index; n is the number of sample households; y_i is the measure of per adult equivalent food calorie intake of the i^{th} household; Z represents the cutoff point between food secure and food insecure households (expressed here in terms of caloric requirements of 2200kcal); q is the number of food-insecure households; and α is the weight attached to the severity of food insecurity. In FGT index, $y_i \geq Z$ that the specified household is food secure.

Within this FGT index, we compute the three most

[1] *Kebele* is the lowest administrative unit in Ethiopia.

commonly employed indices: head count ratio, food insecurity gap, and squared food insecurity gap (Hoddinott, 2001). Head count ratio describes the percentage of sampled households whose consumption is below the predetermined subsistence level of energy (2200kcal), means FGT (α=0)=q/n. The food insecurity gap, FGT (α=1), measures how far the food insecure households, on average, are below subsistence level of energy. Here, it means that, giving equal weight to severity of food insecurity among all the food insecure households will be equivalent to assuming that α =1. This index characterizes the amount of resources that will be required to bring all the food insecure households to this subsistence level. Finally, squared food insecurity gap, FGT (α=2), is a measure closely related to severity of food insecurity gap but giving those further away from the subsistence level a higher weight in aggregation than those closer to the subsistence level.

2.3.2. Determinants of Food Security

Household and socioeconomic determinants of household food security status and their likely effects were estimated by a univariate probit representation. The latent variable was specified by the structural equation (Maddala, 1983; Long, 1997; Cameron and Trivedi, 2009; Greene, 2012).

$$Y^* = X'\beta + \varepsilon_i \tag{2}$$

where Y^* is binary latent variable for food security status (observed if $Y^*>0$, 0 otherwise); X' is a vector of household specific and other socioeconomic factors determining food security status; β is a vector of parameters of interest, and ε_i is random error.

These equations are identical to those for the linear regression model with the important difference that the dependent variable is unobserved. The link between the observed binary Y and the latent Y* is made with a simple measurement equation:

$$Y_i = \begin{cases} 1\ if\ \ Y_i^* = X'\beta + \varepsilon_i > 0 \\ 0\ \ if\ \ \ Y_i^* \le 0 \end{cases} \tag{3}$$

Assuming the distribution of ε_i to be with mean 0 and variance 1 leads to the binary probit model.

2.3.3. Analysis of Vulnerability to Climate Change

Vulnerability is the degree to be susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (Carter *et al*., 2007). It is the likelihood that at a given time in the future, an individual will have a level of welfare below some norm or benchmark. The time horizon and welfare measure are general. One could think of vulnerability pertaining to the likelihood of being food insecure in the future. Although vulnerability assessments typically express welfare in terms of consumption, and the norm or benchmark as the food security line, the definition of vulnerability is sufficiently general so as to encompass many dimensions of well-being.

The vulnerability threshold involves generating a sample that is classified into two groups, that is those that are vulnerable and those that are not vulnerable to food insecurity. To establish a vulnerability threshold, a household is said to be vulnerable if its vulnerability probability is greater or equal to v, i.e. $v_h \geq v$. Chaudhuri *et al*. (2002) indicated that the choice of vulnerability threshold is quite arbitrary. A common choice in literature is a threshold vulnerability probability of 0.5. Thus, a household is considered vulnerable to food insecurity if the vulnerability probability is equal or greater than 0.5 and less likely to be vulnerable to food insecurity if the probability is less than 0.5.

The vulnerability level of a household at time *t* is defined as the probability that a household will find itself consumption food insecure at t+1 period. This is a basic formulation of vulnerability as the risk of food insecurity is expressed as:

$$V_{ht} = \Pr\left(C_{h,t+1} \le Z\right) = \int_{-\infty}^{Z} f\left(C_{h,t+1}\right) dc \tag{4}$$

where $C_{h,\,t+1}$, is the household's consumption at time $t+1$ and Z is the appropriate consumption for the household food security and is thus the *ex-ante* risk that a household will not be able to cope or adapt to an external pressure (in this case climate change). To assess a household's vulnerability to climate change, we need to make inferences about its future consumption levels. In order to do that we need a framework for thinking explicitly about both the inter-temporal aspects and cross-sectional determinants of the consumption pattern at the household level (Chaudhuri, et. al, 2002).

The food security status is dependent on the household's own production and income levels. Thus, production is influenced by a number of factors. Among them is labor availability, access to extension services, education status of the household head, and availability of production assets, among others. This suggests the following reduced form expression for production:

$$C_{ht} = C_{h,t+1}\left(X_h\right) \tag{5}$$

where X_h represents a bundle of observable household characteristics. The observable household characteristics include labor availability, access to extension, education status of the household head, age of the household head, etc. Substituting (5) into (6) we can rewrite the expression for vulnerability level as:

$$V_{ht} = \Pr\left(C_{h,t+1}\left(X_h\right) \le Z/X_h\right) \tag{6}$$

The expression in equation (5) suggests that a household's vulnerability level is derived from the household's observable characteristics and this is compared to the standard consumption requirements (Z) given the same household observable characteristics (Chaudhuri *et al.,* 2002).

$$\hat{V}_{ht} = \hat{\Pr}\left(\ln C_{h,t+1} < \ln Z/X_h\right) = \Phi\left(\frac{\ln Z - X_h\hat{\beta}}{\sqrt{X_h\hat{\theta}}}\right) \quad (7)$$

The outcome of the above model measures the degree of vulnerability to food insecurity for each household. The probability of a household being vulnerable to food insecurity is≥0.5 and the probability of a household not being vulnerable to food insecurity is < 0.5, using a threshold of 0.5 was used. Food insecurity increases the chances of being negatively impacted by climate change.

3. Results and Discussion

3.1. Characteristics of Households

The rural households in the two agroecologies of the study area basically differed in their major institutional and socioeconomic characteristics (Table 1). Households in the highland areas were significantly better off in their food security status, calorie intake, and distance to the nearest market and town. On the other hand, the lowland households were significantly better off in credit access, adapting crop variety selection, soil and water conservation, and distance to office of agricultural extension agents.

The mean differences of highland and lowland for crop variety selection and soil and water conservation were 0.04 and 0.52 proportions, respectively. These contribute to protection of soil erosion and increment of crop productivity ultimately increasing economic performances and livelihoods. Terracing or tree planting is common practice in the study area. In an attempt to improve soil fertility, organic fertilizer is used in addition to inorganic fertilizer, but the fertility level of the farm is decreasing from year to year. The rate of such investment varied from household to household depending on social engagement and wealth statuses.

Table 1. *Socioeconomic and institutional characteristics of sample households by agroecology.*

Variables	Highland	Lowland	Mean difference	Mean difference test (t-value)
Kilocalorie intake(Kcal)	2229.02	2168.26	60.76	2.27**
Food secured (proportion)	0.49	0.40	0.09	1.72*
Crop variety selection (proportion)	0.33	0.37	-0.04	0.75*
Soil and water conservation (proportion)	0.19	0.61	-0.52	11.75***
Distance to the nearest market(Km)	5.9	12.59	-6.69	11.36***
Distance to the nearest town(Km)	7.33	15.34	-8.01	-13.37***
Distance to the extension service (Km)	3.96	3.16	0.80	4.35***
Credit (proportion)	0.71	0.84	-0.13	-2.90***

Note: ***, **, and * signify significance levels of 1%, 5% and 10%, respectively.

Table 1 also indicated the results of respondents' calorie intake per adult equivalent per day. Households in the highlands and lowlands had on average 2229.02 and 2168.26 kilocalories food intake, respectively. This indicates that households in the study areas were not better off in calorie intake as compared to the required average kilocalorie intake for a healthy adult. Farmers in highland were able to practice mixing crop production and generate off-farm income and also adopt high yielding crop varieties, which might have resulted in better asset formation.

3.2. Farmers' Perception of Climate Change

Extensive literature reviews have revealed that a number of different socio-economic and natural factors have contributed to the increasing perception level of farmers about climate change variables like temperature, precipitation, etc. However, there were significant proportion of the respondents who did not recognize the effect of climate change.

Climate change is expected to influence crop and livestock production and other components of agricultural systems. In this study, farmers were asked if they had noticed any significant climate changes from the past ten to twenty years. Results shown in Table 2 indicate that almost more than 50% of the sample farmers had noticed significant changes in both agroecologies and they ascribed reduction in farm production. About 71% of the sample households have perceived changes of precipitation, 55% understood increasing temperature and 63% recognized the occurrence of untimely rain. In addition, farmers perceived that climate change affected direct crop production and livestock health, and resulted in land degradation and hence had negative impact on livelihoods.

Table 2. *Farmers' perception of changes in climate indicators.*

Variables	Frequency	Percentage
Reduction in precipitation	234	71
Increase in temperature	182	55
Untimely rain	209	63
Frequent drought	141	43
Flood	151	46
Livestock disease	265	80
Land degradation	144	44
Decreasing crop yield	212	64

Farmers noticed that over the last ten to twenty years, rainfall variability has been increasing substantially, as rains fail to come more frequently or come suddenly at abnormal times of the year. All farmers have also noticed more frequent droughts in the last ten years as compared to twenty years ago.

Flooding had a significant impact on the long-term productivity of their land as well. Much of the fertile topsoil was washed away and only hard-panned soil remains. The degraded land has hardly been supplying sufficient soil nutrient which improves farm productivity and requires more time for recovery.

From the farmers perception and supported by the literature, it is the climate-related hazards that significantly increased household vulnerability to climate change through reduced farmproductivity and household food security. Although farmers have been able to deal with past drought and floods, the increasing frequency and intensity of climate-related hazards is forcing farmers to engage more frequently in emergency coping strategies such as consuming seeds reserved for planting and selling farm implements to smooth their consumption.

3.3. Food Security Status and Its Determinants

Food security at a household level is analyzed and best measured by direct survey of income, expenditure, and consumption and comparing it with the minimum subsistence requirement (Von Braun, et. al, 1992). This study used daily calorie availability per adult equivalent (kilocalorie) as a measurement for food security. Accordingly, food security status was measured by comparing the level of the daily calorie availability per adult equivalent with the minimum acceptable weighted average food requirement per person per day for Ethiopia, which has been set at 2200 kcal (Kifle and Yoseph, 1999).

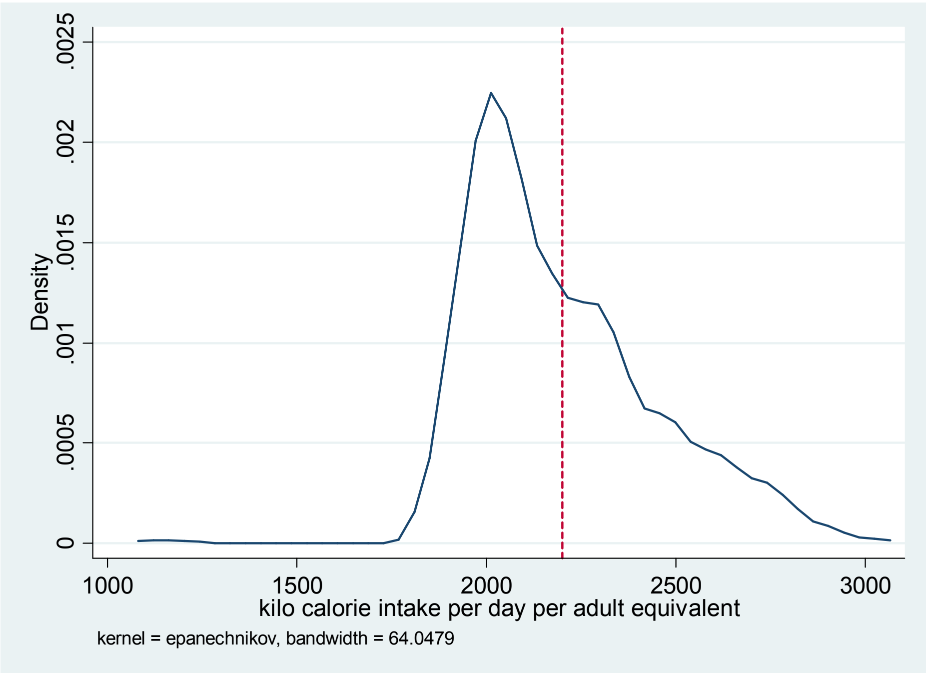

Figure 1. *Kernel density estimation of daily calorie intake per adult equivalent.*

The graph also shows the distribution of the estimated daily calorie availability per adult equivalent for all households, which is right-skewed indicating higher number of food insecure households falling below the mean value of 2200 kcal. The daily calorie availability per adult equivalent was low in the lowland than in the highland. The two agroecologies had a significant difference in terms of the deviation from the food security threshold. The mean of households in highland were relatively better-off to escape from the food security threshold by 250 kcal whereas the lowland rural households had 145 kcal deficits from the minimum daily calorie requirement of 2200kcal (Table 3).

Agricultural production is the source of rural households' income in Ethiopia and is mainly generated from crop production. In this regard, it was found that 63% and 37% of the households in the highland and lowland, respectively, have income inequality from agricultural production, which is higher than the national rural income inequality estimated at about 40% in the year 2013/2014(FDRE, 2014).

The incidence of the food insecurity in highland was 34.12% compared to the incidence in lowland (43.13%). Intensity of mean food insecurity gap or calorie measured by calorie adequacy also follows the same scenario. The severity of food insecurity (squared food insecurity gap) was 15% and 19% in highland and lowland, respectively.

Table 3. *Households' food security situation by agroecology.*

Variables	Highland	Lowland	All sample
Food insecure households (%)	58	69	64
Head count index (%)	34.12	43.13	37.625
Mean Food insecurity gap (kcal)	+250	-145	385
Squared food insecurity gap (%)	0.15	0.19	0.34
Daily calorie availability (kcal)	2229.02	2163.59	2197.297
Gross income inequality (Gini coefficient) (%)	0.63	0.37	0.50

Table 4 indicates that by randomly taking the significant explanatory variables, the predicted probability of sample households of being food secure was about 0.37. The predicted probability of households in highland agroecology to be food secure was about 0.61 which was higher as compared to that of predicted probability of the lowland agroecology which was about 0.41. The likelihood of food security in different parts of rural Ethiopia is different. This is because the food insecurity prevalence is different. It is difficult to obtain comparable and representative empirical evidences because there is significant difference in measurement and estimation biases in food security indicators.

The probability of households to be food secure with social participation was 0.58 which is greater than that without participation (0.45). The predicted probability of households to be food secure with irrigation water use was negative and significant (33.7%) compared with those without irrigation situations (60.8%). Irrigation is generally considered an effective way of increasing agricultural production. It can supply the water needed for crop growth when rainfall is limited or, in more humid climates, it can bridge dry spells and reduce agricultural risks. However, the negative sign shows that the mass production of irrigation products such as perishable vegetables ignoring the infrastructural facilities such as distance to the nearest market, road, transport, processing industries, and information access leads to reduced profitability of the sector even though there are sufficient resources such as water, labor and land.

Table 4. *Univariate probit estimation of determinants of household food security status.*

Variables	Coefficient	Robust Std. Err.	Marginal
Education	0.526*	0.295	0.207*
Social participation	0.329*	0.138	0.131*
Flood incidence	-2.792***	0.331	-0.836***
Family size	-0.249***	0.06	-0.099***
Credit access	0.205*	0.18	0.082
Sex of household head	0.986**	0.501	0.352**
Irrigation water use	-0.693**	0.289	-0.27**
Farming experience	0.174***	0.025	0.07***
Tropical livestock unit (tlu)	0.116	0.088	0.046
Fertilizer usage	0.04**	0.017	0.016
Off-farm income	-0.137	0.299	-0.055
Agroecologies	-0.507*	0.122	-0.2
_Constant	-2.351***	0.2711	
Predicted probability			0.374
Pr(highland agroecology)			0.609
Pr(lowland agroecology)			0.409
Pr(with Social participation)			0.583
Pr(without Social participation)			0.453
Log pseudo likelihood			-54.078
Wald χ^2 (12) 124.79			
Pseudo R^2 0.762			
goodness-of-fit test, Pr > χ^2 (318) 0.983			
Food security			0.45
Food insecurity			0.55
Pr(k <=148 or k >=182)=0.069 (two-sided test)			

Note: ***, **, and * signify significance levels at 1%, 5% and 10%, respectively.

Credit is an important factor for food security status. The probability that households are food secure with credit access in the study area was 63.1% and it was 41.5% for those who do not have access to credit. Access to credit enables to increase per capita incomes and food security status of households. The probability of univariate probit estimation output of the food security status is 45% for food secure household and 55% for food insecure household in the study areas.

3.4. Vulnerability to Climate Change

Vulnerability is thought of as the probability that the prospect of a household is becoming food insecure in the future, even if currently food insecure or not (Chaudhuri, et. al, 2002). Thus, food insecurity is used as the measure of consumption level of farm household in terms of the predicted kilo calorie intake per adult equivalent per day (Table 5). The assessment took into account that vulnerability to food insecurity is linked to vulnerability to climate change to help understand the status of household food security in the future.

As shown in the Table 5, sex of the household head influenced the level of consumption patterns. Female-headed households mainly constitute widows and single parents who take the responsibility for the household on their own. Women often lack assets and have limited social participation, particularly assets and knowledge or information transfer needed for agricultural production and these constrain their ability to diversify the agricultural production compared to male-headed households. Female headship thus increases vulnerability of the household to food insecurity (Horrel and Krishnam, 2006).

Table 5. *The univariate probit estimation of the predicted vulnerability to food security.*

Variables	Coefficient.	Robust Std. Err.
Sex of the household head	- 0.013***	0.002
Family size	- 0.014*	0.001
Farming experience	0.007***	0.001
Irrigation	0.002	0.001
The number of ox	- 0.001	0.002
Household head education	0.009***	0.001
Social participation	0.025***	0.001
Wealth status	-0.007***	0.001
Training	-0.006**	0.004
Off farm income	0.010***	0.001
Land cultivated	-0.020***	0.004
Total income (Log)	0.004***	0.001
fertilize used usage	0.001	0.001
Constant	7.450***	0.004
F(11, 319)	16913.45	
Pr> $\chi 2$	0.000	
R^2	0.9981	
Root MSE	0.004	
The prediction security	0.37	
The prediction insecurity	0.63	
Pr (K<=121 or K>=209=0.000001 (two-side test)		

Note: ***, **, and * respectively signify significance levels of 1%, 5% and 10%.

Farming experience of the household head is likely to improve efficiency through learning from mistakes and successes that could improve productivity over years. In addition, relatively good wealth status of the households increases the ability to hire labor which in turn increases the level of production. A household that affords to hire additional labor is more likely to be resource endowed. The results of this study were also in conformity with these hypotheses.

Family size was negatively and significantly correlated with food security status of households. Though increasing family size can be used as source of labor force, in the developing countries the number of population growth and employment opportunity are not correlated. The negative sign of this variable indicated that the increasing unproductive labor force of household reduces the quantity of production and increases consumption as well as aggravates food insecurity problem. In addition, the majority of farm households in Ethiopia are small-scale semi-subsistence producers with limited participation in non-agricultural activities. Therefore, the negative and significant relationship between size of the household and food security indicates that there were few people in the households who contribute to full time labor in relation to the dependent members. Thus, the increased size of the family increases food insecurity and this, compounded with future climate change, will worsen the livelihood of smallholder farmers in the study area.

Vulnerability index of a household shows the degree to which the household is exposed to food insecurity. If the estimated probability is equal or greater than 50%, the household is more likely to be food insecure but if the estimated probability is less than 50%, the household is less likely to experience food insecurity. Therefore, the probabilities of two side test of univariate probit model estimations showed that the probability of households to be vulnerable in near future in the study areas is 63%.

In the model, except oxen number, irrigation usage and use of fertilizer had strong significance in the predicted bivariate probit regression of vulnerability to climate change. The means, two side test of predicted vulnerability index showed that the degree of food insecurity will increase from the current status of 55% (Table 4) to 63% in near future and the food security status will decrease from45% to 37%.

4. Conclusion and Recommendations

This study has analyzed factors affecting food security and vulnerability to climate change based on a cross-sectional data collected from 330 farm households in Eastern Ethiopia during the 2014/2015 agricultural production year. The food security of rural households in the study areas is very poor and households depend on rain-fed agriculture for their livelihood. The study found that the current food insecurity is nearly 55% and this figure is likely to increase as predicted by the model to 63% in the near future. With the current and future climate changes, the vulnerability to food insecurity is expected to increase.

The vulnerability of rural households is largely determined by a variety of factors. Households living in different agroecologies exhibit vulnerability to different types of hazards. Therefore, the vulnerability and food security are affected by shocks and are also measured against the threshold. The probability to be food insecure increases from 55% to 63% indicating that the households are vulnerable.

The issue of climate change should beyond simple effort alone. Government policy and investment strategies should also work to support the provision of access to education, access to credit, and awareness creation on climate change. In addition, policy interventions that encourage social network participation which can promote group and community discussions and enhance better information flows are necessary. Future policy could also focus on creating awareness on climate change and facilitating the development and adoption of different strategies. The intensive awareness on climate change will be best achieved in the study area through extension agents, agricultural show, symposium, and the likes.

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References

[1] Assefa Admassie, Berhanu Adenew and Abebe Tadege. (2011). Perception of stakeholders on climate change and adaptation strategies in Ethiopia. Research brief Series Number 15: IFPRI.

[2] Cameron, C., and P. Trivedi. (2009). *Micro econometrics using stata*. College Station: Stata Press.

[3] Carter, T. R., R. N., Lu, X. Jones, S. Bhadwal, C. Conde, L. O. Mearns, B. C. O'Neill, M. D. A. Rounsevell, and M. B. Zurek. (2007). New assessment methods and the characterization of future conditions. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E.

[4] Chaudhuri, S., J. Jalan, and A. Suryahadi.(2002). Assessing household vulnerability to poverty: a methodology and estimates for Indonesia. Department of economics discussion Paper No. 0102-52. New York: Columbia University.

[5] CSA. (2011). Analytical report on the 2011 urban employment unemployment survey. Analytical Bulletin, Addis Ababa, Ethiopia

[6] CSA. (2012). The Federal Democratic Republic of Ethiopia statistical abstract. Addis Ababa, Ethiopia.

[7] FAO. (2007). Climate change and food security: a framework for action. FAO Interdepartmental working group on climate change. Rome.

[8] FDRE. (2014). Ethiopia's Progress towards Eradicating Poverty: An Interim Report on Poverty Analysis Study (2012/13). Addis Ababa, Ethiopia.

[9] Foster, J., J. Greere, and E. Thorbecke. (1984). *A class of decomposable poverty measures. Econometrical,* 52 (3): 761-766.

[10] Greene, W. (2012). *Econometric Analysis* 7thed. New Jersey: Pearson Hall, USA.

[11] Hoddinott, J.(2001). Method for Rural Development projects: FoodSecurity in practice, IFPRI, Washington D. C., 1: 80-100.

[12] Horrel, S. and P. Krishnan. (2006). Poverty and Productivity in Female-Headed Householdsin Zimbabwe. Faculty of Economics, University of Cambridge, Cambridge CB3 9DD.

[13] IPCC. (2007). Climate change, 2007. Impacts, adaptation and vulnerability. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge UK.

[14] Kifle Lemma and Yosef Gebrehiwot. (1999). The food security situation in Ethiopia. Concepts, status and Trends. In: Taye Assefa (ed): Food security through sustainable land use. Proceeding of the first National workshop of NOVIN partners. Forum on sustainable land use. NOVIN, Addis Ababa.

[15] Long JS. (1997). Regression Models for Categorical and Limited Dependent Variables (RMCLDV). Thousand Oaks, CA: Sage Press.

[16] Maddalla GS. (1983). Limited-dependent and qualitative variables in econometrics. Cambridge: Cambridge University press.

[17] Maddison, D. (2014). The perception of an adaptation to climate change in Africa. CEEPA. Discussion Paper No. 10. Center for environmental economics and policy in Africa. Pretoria: University of Pretoria.

[18] MoFED. (2014). Growth and Transformation Plan (available at http://www.ethiopians.com/Ethiopia_GTP_2015).

[19] National Adaptation Program of Action. (2011). Climate change: Uganda National adaptation program of action ministry of tourism. Environmental and Natural Resource.

[20] Nhemachena C and R Hassan. (2007). Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa. IFPRI Discussion Paper No. 00714. International Food Policy Research Institute. Washington DC.

[21] Productive Safety Net Programme. (2015). Shocks and social protection in the Horn of Africa: Analysis from the PSNP in Ethiopia.

[22] Schipper, E. L. F. and M. Pelling. (2006). Disaster risk, climate change, and international development: scope for, and challenges to, integration. *Disasters,* 30(7): 19-38.

[23] Von Braun, J., H. Bouis, S. Kumar and R. Pandya-Lorch. (1992). Improving Food Security of the Poor: Concept, Policy, and Programs. International Food Policy Research Institute. Washington, D. C.