Determinants of Household Food Security in Drought Prone Areas of Ethiopia

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Abstract: This paper documents the determinants of household-level food security based on the data collected in 2003 from 954 randomly-selected households in major drought-prone areas of Ethiopia; namely from the West and East Haraghe zones of Oromiya and South Gonder zone of Amhara. The food security is assessed using the calorie intake, anthropometrical measures and based on household-declared perceptions about the food security situation. The Probit model for factors affecting the food security level and the Tobit model for factors affecting the incidence of food security were employed. Factors that significantly affected the food security level are agro-ecology, family size, number of crops grown, number of plots owned, access to drinking water, the wealth status of the household and the number of community-based organizations (CBOs) in the village. The incidence of food security was significantly affected by agro-ecology, number and types of crops grown, access to climatic information, proportion of household members with formal education, number of CBOs in the village and the adoption of soil conservation measures. The results confirm the important role of some of the development interventions of both government and non- governmental organizations (NGOs) to promote food security through formal education, soil and water conservation measures and production diversification. In addition, important factors that need to be considered are access to climatic information and strengthening the role of CBOs.

Keywords: Food Security; Calorie Intake; Anthropometric Measures; Ethiopia; Probit; Tobit

1. Introduction

Food security exists when "all people at all times have access to safe nutritious food to maintain a healthy and active life" (FAO, 1996). The main goal of food security is for individuals to be able to obtain adequate food needed at all times, and to be able to utilise the food to meet the body's needs. Food security is multifaceted. In general, there are three pillars underpinning food security; these are food availability, food accessibility, and food utilization. Food security is, therefore, not only a production issue. In addition, Maxwell (1996) suggests including related concepts of access, sufficiency, vulnerability, and sustainability in defining food security

Food availability for the subsistent farm household means ensuring food availability for the household through its own production. However, due to lack of adequate storage facilities and pressing needs, most households are forced to sell excess produce during the harvesting period and sometimes rely on market purchases during the hungry season.

Food access means reducing poverty. Simply making food available is not enough; one must also be able to purchase it, especially the low-income households. D'Silva and Bysouth (1992) defined absolute poverty as lack of access to resources required for obtaining the minimum necessities essential for the maintenance of physical efficiency. This implies that the poor farmers will have little access to food, either produced or purchased. Farm families with limited access to productive resources such as land, inputs and capital required for attaining physical efficiency in food production could be food insecure i.e. resource poverty could lead to low productivity, food insufficiency, and lack of income to purchase the required calories.

Food utilization means ensuring a good nutritional outcome, which is nutrition security. Having sufficient food will not ensure a good nutritional outcome if poor health results in frequent sickness. Building this pillar means investing in complementary resources such as nutrition education, health care, provision of safe water and better sanitation, instituting gender symmetry, and removal of child abuse practices (Doppler, 2002).

Therefore, food security can be defined in terms of food availability, food access and/or food utilization, taking into consideration the factors of farm and farmers' characteristics, access to services (education, market, credit, health, water, extension etc) and other related factors that emanate from the interplay of ecological, social, demographic and economic factors.

The food security situation in Ethiopia has been deteriorating from time to time due to the degradation of natural resources, dependence on rain-fed agriculture, and unbalanced population growth. In 2003, Ethiopia's population was estimated to be approximately 67 million people. In 2001, UNDP estimated that 81.9% of that population lived on under US$1 per day and placed Ethiopia 92nd out of 94 countries on the Human Poverty Index, 169th out of 175 countries on the Human Development Index. The numbers underlying those indices are sobering: Ethiopians' life expectancy is 45.7

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years, HIV/AIDS affects 6.4% of adults, one of every six children dies before age 5 and 52% of children under-five are growth-stunted.

The overall objective of the paper is to assess the level of food security and its determinants among the rural households in the drought-prone areas of Ethiopia. The specific objectives are to:

- document the level of household-level food security using anthropometric measures, level of calorie intake, and based on the farmers' declared level of food security; and
- identify the determinants of the level and incidence (intensity) of household food security

2. Methodology

2.1. The Data set

A classic two-stage cluster sampling design based on Magnani (1997) was used to collect the data used in the three drought-prone and CARE Ethiopia target zone, namely the West Hararghe and East Haraghe areas in Oromiya Region and the South Gonder zone in Amhara region. Primary clusters were localities, selected using PPS (Probability Proportional to Size). Secondary units were households which were selected using random sampling methods. Accordingly, a total sample size of 954 households was selected for primary data collection and the data was collected between May and August 2003. The distribution of the sample size by District (woreda), zone and region is summarized in Table 1.

Table 1. Number of sample households by region, zone and district.

Region	Zone	District	Sample size	%
Oromia	West Hararghe	Chiro	155	16
		Doba	92	10
	East Hararghe	Bedeno	185	19
		Kurfachellee	93	10
Amhara	South Gonder	Laygaint	429	45
Total			954	100

2.2. Approaches for Measuring Food Security

In general, the available literature suggests four approaches for measuring food security (Maxwell, 1996; Aldrerman and Marito, 1994; Shiferaw and Tesfaye, 2004). The first approach is for measuring food consumption (often calorie intake), which normally uses two methods: the "disappearance" method and 24- h recalls of food consumption. The second approach follows anthropometrical measurements, where the level of food security is estimated based on the height for age, weight for age, and/or weight for height Z-scores. The third approach is based on the measurement of coping strategies as a food security index. The fourth approach is based on the household's perception about the level of food security over the year.

In this paper, the food security situation is assessed using the calorie intake and anthropometrical measures and is also based on household-declared perceptions about the food security situation.

2.3. Methods of Data Analysis

The study employs descriptive statistics on the indicators of food security and socioeconomic characteristics of the sampled households. Factors affecting the household-level food security indicators are determined using limited dependent variable models as the dependent variables are categorical or range in value between zero and one.

The first model uses a dependent variable quantified based on the level of calories consumed per head and day. Dietary allowances of nutrients have been recommended by national and international bodies from time to time, based on the available scientific information on human requirements. Dietary standards may vary from country to country and serve as guidelines for planning and procuring food supplies for population subgroups, for interpreting food consumption records of individuals and populations, for establishing standards for food assistance programs, for evaluating the adequacy of food supplies in meeting national nutritional needs, for planning diets, for designing nutrition education programs and for developing new products in the food industry (Mohammad and Mohammad, 1998). Based on the WHO recommendation, an adult-equivalent person should consume at least 2000 k calories of energy per day, even though this varies from country to country and region to region. Maxwell (1996) recommends that households that get about 80% of the recommended level of calorie intake can be considered as food-secured. Thus, those households that are able to get at least 80% of the recommended rate were considered as food secured (value = 1) and those with less than the recommended value were considered as food insecure (value = 0) for this analysis. The functional form appropriate for such a type of analysis is the binary choice model, where the dependent variable takes only two values (zero and one). The most frequently-applied models are *Logit* and *Probit* (Greene, 1997; Aldrich and Nelson, 1984; Amemiya, 1981). This helps to identify the factors affecting the general food security level of households. Both models give comparable results, particularly when the sample size is high. In this report, the probit model is used mainly because it best fitted the data. The probit model is specified as:

$$Z = \beta' X + \varepsilon \quad \varepsilon \sim \mathrm{N}(0,1)$$

$$Y = 1 \text{ if } Z > 0 \text{ and } Y = 0 \text{ if } Z \leq 0$$

Where:

β' –vector of parameter to be estimated
Z is observed probability of adoption
Y is estimated probability of adoption
X – vector of independent variables
E – Error term

The second model is based on the households' perceptions of the food security situation and the proportion of months the household considers as food-secured in a year is used as a dependent variable. In this case, the value 1 represents the fact that the household is food-secured throughout the whole year. In such a situation, *Tobit* is the appropriate functional form (Green, 1997), which enables the identification of factors affecting the intensity (incidence) of food security level of the households. This is because the proportion of months that the household is food-secured to the year shows how the food insecurity situation is severe among households. The Tobit model is specified in terms of an index function as follows:

$$Y_i^* = \beta^I X_i + \varepsilon_i \quad \varepsilon_i \sim N[0, \sigma^2]$$

$$Y_i = 0 \text{ if } Y_i^* \leq 0$$

$$Y_i = Y_i^* \text{ if } Y_i^* \geq 0$$

Where Y_i is a limited dependent variable,

Y_i^* is an underlying latent variable that indexes the level of the food security

X_i is independent variable,

β^I is a vector of parameters to be estimated

ε_i is the error term

The two models were arranged independently for Hararghe, Laygaint and for the whole sample in order to see the difference in the importance of the hypothesized determinants across the two locations. Thus, it is important to test whether there is a significant difference in the coefficients of the food security level determinants between the equations for Hararghe and Laygaint. For this purpose, the Chow test was employed. For each case, a test for multi-collinearity among the respective explanatory variables was checked using Variance Inflation Factor (VIF).

3. Results and Discussion

3.1. The Status of Food Security

3.1.1. Anthropometrical Measures

The anthropometrical measures of a child from 6 - 59 months of age in each household were taken during the survey. If there was more than one child in the stated age range, a child was randomly selected in each household. The result of the nutritional status of the child is summarized in terms of weight-height (WHZ), weight-age (WAZ) and height- age (HAZ) z-score in Table 2. Comparisons can be made using the standard cut-off points for the nutritional and dietary indicators. The widely accepted cut-off point for height for age (HAZ) and weight for age (WAZ) z- score value is - 2.00, where for values of HAZ and WAZ less than -2.00 the household is considered to have growth-stunted and underweight children respectively. For weight-for-height z-score (WHZ) the cut-off point is - 1.00, where for values less than -1 the household is considered to have wasted children (Maxwell, 1996). However, the author Cogill (2001) recommends using -2.00 as a cut-of point for all three anthropometric measures. In this report, Cogill's recommendation was used.

The average values of WHZ, WAZ and HAZ show that the average household in the study area had no wasted, stunted or underweight children as the values are below the cut-off points. When the data is separated according to district, however, the average household in Laygaint has wasted, underweight and stunted children and in Kurfachelle there is also evidence that there are households with underweight and stunted children (Table 3.)

Using a cut-of point in the nutritional measures (a Z-score of -2.00 for height for age, weight for age, and for weight for height), the proportion of households with underweight, stunted and wasted children is presented in Table 3. In the study area 26%, 22% and 7.13% of the households had underweight, stunted and wasted children respectively.

Calorie Intake

The self-declared level of total consumption and production for the different crops was used to estimate the actual level of calorie intake per head in each household. The family size was first converted into adult equivalent[1] in order to estimate the calorie intake per head in a comparable manner. The conversion factor used to convert the different types of crops into calorie was based on Asrat and Lakech (1994) and Burton (1989).

In general, categorizing households based on the level of per capita calorie intake depends on the age and sex of the household members, which requires the conversion of different household members into comparable indicators. Accordingly, adult-equivalent figures were used to calculate the calorie intake per head in each household. The standard calorie requirement for an adult equivalent (2000 kcalorie/day/head) was compared to the actual calorie intake. Some authors recommend considering households who get at least 80% of the recommended calorie intake as food secure. Maxwell (1999) suggests considering a household that provides less than 80% of the calorie requirement for its total number of adult equivalents as food-insecure. Accordingly, the same figure has been adapted to categorize households into food secure and insecure.

[1]The factor used to convert household members into adult equivalent is 0.4 for 0-24 months old, 0.48 for 25-48 months, 0.56 for 49-59 months, 0.56 for 5-6 years old, 0.64 for 7-8 years, 0.76 for 9-10 years, 0.8 for 11-12 years, 1 for 13-14 years, 1.2 for males 15-18 years, 1 for females 15-18 years, 1 for males 19-59 years, 0.88 for females 19-59 years, 0.88 for males older than 60 years, and 0.72 for females older than 60 years old.

Table 2. Nutritional status of children (6 - 59 months old) by district.

District		WHZ (Wasted)	WAZ (Underweight)	HAZ (Stunted)
Chiro	Mean	-0.82	-1.79	-1.87
	Std. Deviation	0.97	1.06	1.25
	N	92	92	92
Doba	Mean	-0.83	-1.46	-1.24
	Std. Deviation	0.79	1.02	1.61
	N	38	38	38
Laygaint	Mean	-1.03	-2.06	-2.04
	Std. Deviation	0.83	0.94	1.18
	N	219	219	219
Bedeno	Mean	-0.98	-1.77	-1.59
	Std. Deviation	0.93	1.10	1.46
	N	115	115	115
Kurfachelle	Mean	-1.04	-1.99	-1.89
	Std. Deviation	0.97	1.02	1.33
	N	50	50	50
Total	Mean	-0.97	-1.90	-1.83
	Std. Deviation	0.89	1.02	1.33
	N	514	514	514
F-value		1.17	4.06***	4.33***

*Note: *** shows significant difference among districts at p < 1%*

Table 3. Health status of households (% of households with children underweight, stunted and wasted).

Anthropometric measures		District					Total
		Chiro	Doba	Laygaint	Bedeno	Kurfachell	
Underweight	Yes	26.45	9.78	29.14	24.32	30.11	26.00
	No	32.90	31.52	21.91	37.84	23.66	27.88
	No child	40.65	58.70	48.95	37.84	46.24	46.12
Stunted	Yes	28.39	6.52	24.94	20.54	22.58	22.64
	No	30.97	34.78	26.11	41.62	31.18	31.24
	No child	40.65	58.70	48.95	37.84	46.24	46.12
Wasted	Yes	5.81		7.46	10.81	7.53	7.13
	No	53.55	41.30	43.59	51.35	46.24	46.75
	No child	40.65	58.70	48.95	37.84	46.24	46.12

Source: Survey result

In calculating the amount of calorie intake per adult equivalent in each household, two estimates of consumption were taken into consideration. The first was the self-declared level of consumption by crop type and the second was the total production of crops in each household. The production level is assumed to estimate the level of actual consumption, more effectively as the amount sold is usually substituted by consumption good. The result in Table 4 shows that the average proportion of food-secured households is about 21% of the total households, considering total consumption declared by the households; whereas about 33% of the households were food-secure, considering total production to estimate the calorie intake. Thus, on average, the proportion of food-secure households ranges from 21 to 33% of the total households based on the level of calorie intake. There are statistically-significant differences among districts for both estimates of calorie intake using consumption and production (Table 4).

Taking into consideration the dominance of the agricultural sector in the rural communities in the country in general, and in the study area in particular, it is expected that most of the farmers will produce more than their requirement so that there will be excess production over the household requirement. However, only 33% of households were able to produce enough to fulfill their calorie requirements from their own production. In other words, household-level self-sufficiency is achieved by only 33% of the sampled households. The highest proportion of households that secure their calorie requirements from their own production was observed in Laygaint (38%) and the least in Doba (18%).

Table 4. Proportion of food secure households based on calorie intake.

	Basis for Calorie intake calculation			
	Consumption		Production	
District	Mean (Std)	N	Mean (Std)	N
Chiro	0.17 (0.38)	130	0.24 (0.43)	129
Doba	0.07 (0.26)	83	0.18 (0.39)	84
Laygaint	0.22 (0.41)	382	0.38 (0.49)	390
Bedeno	0.30 (0.46)	176	0.36 (0.48)	175
Kurfachelle	0.18 (0.38)	85	0.27 (0.45)	86
Total	0.21 (0.41)	856	0.33 (0.47)	864
F-value	5.18***		5.22***	

*Note: *** significant at P<1%, N = number of households*

Farmers' Perceptions of Food Security

In this case the self-declared level of food security for each month in a year was considered to identify whether the household was food-secured or not. The perceptions were assessed considering the respondent's lifetime experience for a typical year. The number of months in a year the household declared it was food-secured is used to calculate the proportion of food-secured months to the year, which is used as a proxy for the level of food security. A household with a value of one is then food-secured throughout the whole year.

Table 5. Average proportion of a year with food security by district.

District	Mean	Std. Deviation	N
Chiro	0.28	0.20	155
Doba	0.38	0.21	92
Laygaint	0.51	0.19	429
Bedeno	0.49	0.20	185
Kurfachell	0.44	0.23	93
Total	0.45	0.22	954
F-Value	41.97***		

*Note: *** indicates significance at P <1%*

On average, households in the study area are food-secured for 45% of the time in a year. However, there is significant variation among districts; the lowest period of time in the year can be observed in Chiro (28%) and the highest in Laygaint (51%).

Moreover, the proportion of households with food security to the total sample households was quantified for each month by district to see the distribution of food insecurity level over the year. The trend in Figure 1 shows that a relatively higher proportion of households is food insecure from May to October (68% - 91%) and a lower proportion during November to April (6% - 46%). This is line with the crop production pattern, which is associated again with the rainfall pattern.

The highest proportion of food-unsecured households was observed in August and September in Chiro and Laygaint; in July and August in Doba and Kurfachelle; and in June in Bedeno. Overall in the study area, severe food insecurity can be observed from June to September in a year, based on the proportion of food-insecure households. Out of all the months, August can be seen to be the critical period of food insecurity.

Looking into the trend of the proportion of food insecure households in Bedeno, it shows that the food insecurity problem starts to increase in January and diminishes at the beginning of June, whereas in Laygaint it starts to increase in early February and starts to diminish late in October in the year (Figure 1). This is due to the difference in the cropping patterns because in Bedeno farmers usually grow crops that mature early compared to the crops grown in Laygaint. Thus, in Laygaint there is a need to incorporate into the farming system early-maturing field crops and also horticultural crops like alternative root crops (Yam, Anchote and cassava) that can supply edible parts for a considerably longer period.

Determinants of Food Security

The descriptive statistics of the variables used in the regression analysis of the determinants of food security are presented in Table 6. The dependant variable, dummy variable, is determined based on the level of calorie intake, which is quantified based on the household level of crop production.

The maximum likelihood estimates of the probit[2] models shown in Table 7 indicate that seven factors are found to significantly affect the level of food security in the study area. Among the demographic factors, family size negatively affects the food security status of households. The number of plots and crops grown influenced the level of food security positively. This is due to the fact that crop diversification in a drought prone area is one of the major strategies for minimizing production risk. Similarly, as the number of plots increases, their allocation is expected to be in different places with difference in soil productivity, climate and other production factors. Thus, an increased number of plots can also serve as a means to reduce production risk. In addition to reducing factor productivity, increased fragmentation was also found to reduce production risk.

[2] Probit model is used instead of logit due to its better fit to the data

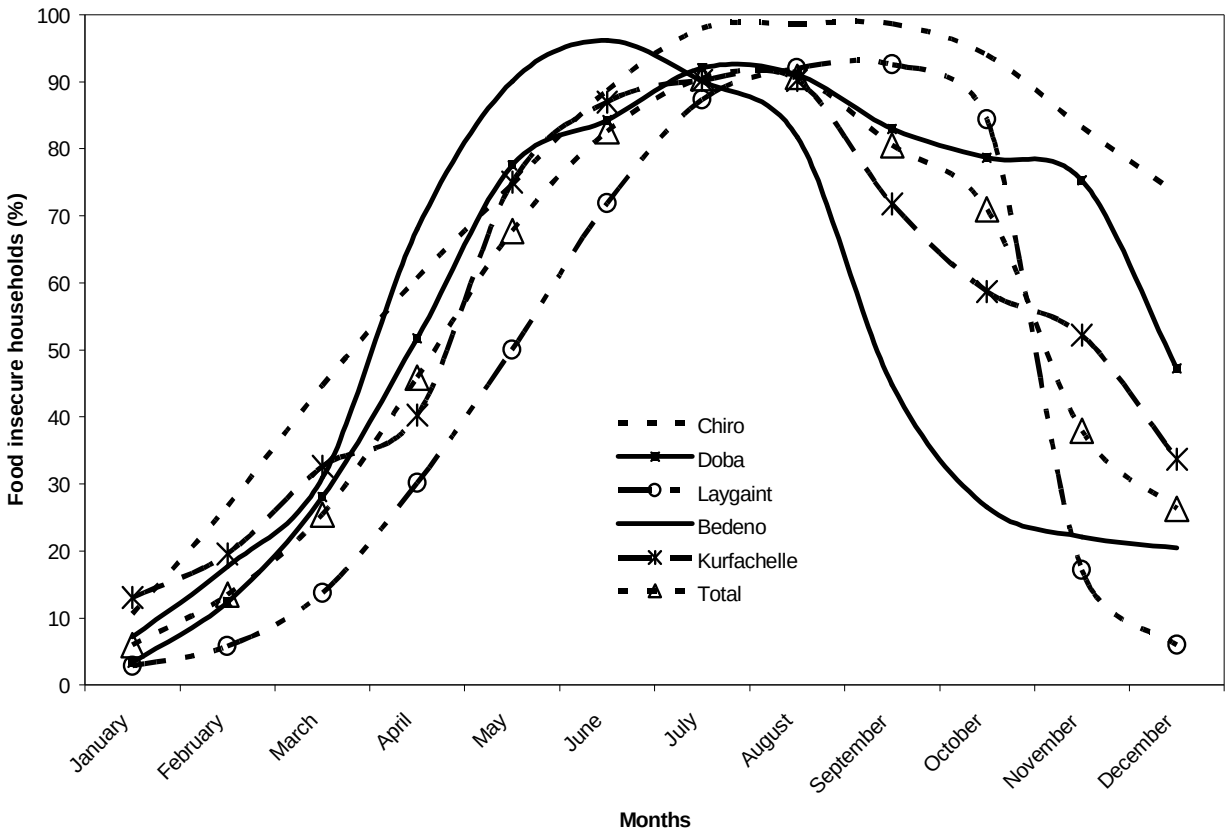

Figure 1. Proportion of food insecure households of the total sample households (%)

Access to drinking water proxied by minutes of walk also negatively affected the food security level, showing that households that are near to water sources are more food-secure than those who need to travel larger distances. Therefore, interventions that can improve access to drinking water are very important for improving the food security situation in the study area. The number of community-based organizations in the village also affected positively the level of food security in the study area (Table7)

The effect of agro-ecology can also be seen as significant where, on average, households in mid highland (woina Dega) areas are less food-secure compared to those in highland (Dega) and lowland (kola) areas.

Due to the expectation that there will be variation in factors affecting the food security level between Laygaint (more of highland with long period intensive cultivation and very poor soil) and Hararghe (Chiro, Doba, Bedeno and Kurfachelle, which are more lowland with shortages of rainfall), a probit model was arranged for both areas independently (Table 7). The result shows that in Laygaint only family size, farm size, the number of cultivated crops and the number of CBOs in the village affected the level of food security. Significant agro-ecological differences were also observed. In Hararghe, on the other hand, agro-ecology, family size, the number of crops grown, access to drinking water, access to information about credit, the wealth status of the household, the proportion of household members with a formal education, and the number of community based organizations in a village were found to be significant. All the factors that significantly affected the food security situation show the expected signs except the proportion of household members with formal education in Hararghe. This could be due to the fact that according to the current mentality which prevails socially, a person with a formal education does not intend to work on a farm but the opportunities of finding work off-farm are very limited, causing households with more members with a formal education to be less food secured. This needs intervention to change the prevailing mentality that rural people have a limited formal education level and encourage youngsters to work hard.

In general, family size, number of crops grown by the household, number of CBOs and Woina Dega agro ecology are found to be consistently significant factors affecting the food security situation. As family size increases, the level of household food security diminishes. Increased number of crops grown is very important because it reduces the risks that may arise due to weather conditions and thus, farmers with more crops are relatively food secure. Similarly, CBOs help in different

ways to enable farmers to be food-secured and so there could be advantages to being assisted by some organizations. Since CBOs are engaged in assisting communities, their existence will increase the probability of households being food secured. In terms of agro ecology, compared to the highland farmers, those in the mid-highland areas are less food secured. In Laygaint, those in the lowlands are also food insecure. This is the case as there is more reliable rainfall in the highlands and measures should be considered in the lowlands to improve the level of food security.

Determinants of the Intensity (Incidence[3]) of Food Security

The *tobit* model on the intensity of food security (Table 8), proxied by the proportion of the number of months in the year a household is food secured, was found to be significantly affected by the type of crops grown (Sorghum and teff), access to information, especially to climatic information, the educational level of household members, CBOs, and the adoption of soil conservation technologies.

Due to the expected socioeconomic and biophysical differences between Laygaint and the other districts, independent *Tobit* models were arranged for Laygaint and Hararghe (Chiro, Doba, Bedeno and Kurfachelle togather). The results show that the factors that determine the intensity of food security varied between the two locations. In the case of Laygaint, the significant variables that determined the intensity are sorghum production, the number of household members with a formal education, the number of CBOs in the village and the adoption of soil conservation measures. Whereas, for Hararghe, the significant variables were the number of crops grown, the number of CBOs, the agro ecology, and the adoption of soil conservation measures.

Crop Type Produced: On overage, households growing sorghum had a lower incidence of food security level, whereas those who grow teff had a higher level. The most probable reason is the fact that sorghum has a low level of storability compared to teff, which can be kept for a longer period of time without any damage from storage pests. Moreover, sorghum is mainly produced in the lowland and mid-highland areas, where food insecurity is more severe.

Access to Climatic Information: usually farmers in drought-prone areas are responsive to changes in climatic conditions through what is commonly called "response farming", where farmers change their cropping patterns based on the climatic conditions they anticipate and observe, reducing the production risk of total crop failure. Farmers who had access to climatic information had better intensity of food security. However, this was not the case in Hararghe as this factor was not significant in the model.

Education: The proportion of households with a formal education was found to positively affect the intensity of food security in the study area. The same was observed in Laygaint. This could be due to the fact that households who have more members with a formal education are expected to have a consumption and resource utilization plan compared to those with less formally-educated household members.

Adoption of Soil Conservation Measures: Adopters of soil conservation measures had improved intensity of food security compared to non-adopters in general. This was observed particularly in Hararghe.

Community Based Organization: CBOs are believed to improve the food security level through their role of supporting group work and improving access to rural services. In both Hararghe and Laygaint the number of CBOs had a positive effect on the intensity/ incidence of food security. This means that households with an increased number of CBOs in the village tend to have a higher intensity food security level. This could be due to the fact that CBOs can serve as a counterpart for government institutions so as to promote good governance, resulting in effective utilization of resources and transfer of information. This implies that promotion of CBOs in rural areas could be an option for improving the food security situation.

Agro-ecology: households in areas with "woina dega" agro-ecology achieved consistently lower intensity/incidence of food security compared to those households in "dega" agro-ecology. Households in areas with "kolla" agro ecology did not show significant differences in the incidence of food security compared to those in "dega" agro-ecology, except in Laygaint where significant differences were observed with lower incidences in "kolla" followed by "woina dega" agro-ecology. This implies that households in areas with "woina dega" agro-ecology need to be paid special attention compared to those in dega agro-ecology.

[3] Food security/incidence is here defined as the proportion of time in a year a household is food secured

Table 6. Description of food security determinants (total sample).

Variable		Expected sign	Rationale	Mean	Std. Dev.
Status of food security (1= food secured, 0 = food insecured)		Dependent variable		0.32	0.47
Agro ecology (Dega as base)	Woina Dega (1= Woina Dega 0= otherwise)	-	For the study *dega* areas are less susceptible to drought and crop failure compared to *woinadega*	0.45	0.50
	Kolla (1=Kolla 0=otherwise)	-	For the study dega areas are less susceptible to drought and crop failure compared to *kolla*	0.13	0.34
Gender (1 = male headed, 0 = female headed household)		±	Gender could have a different effect based on the socioeconomic context	0.86	0.35
Age in years		+	Age is a proxy for experience, which can positively influence food security status	45.34	14.93
Family size		-	As family size increases, household resources per head decreases creating a burden on food security	5.32	2.07
Farm size in hectares		+	The higher the farm size, the better the production level, leading to better food security	0.64	0.51
Number of plots		±	Fragmentation of farms can negatively affect the level of production, but it can also positively affect it through the diversification of production	3.00	1.34
Number of crops grown		±	Specialization of production positively can affect the level of production, but it can also affect it negatively due to increased risk	3.22	1.33
Number of income generating activities		+	Increased options of income sources can positively influence food security	0.63	0.74
Access to drinking water in minutes of walk		-	Poor access to drinking water can negatively affect food security through reduction of labor productivity	20.62	20.97
Access to information about prices (1 = yes, 0 = no)		+	Helps farmers to design better marketing strategies that, in turn, positively influence food security	0.91	0.29
Access to information about climate (1= yes, 0 = no)		+	Access to this information enables farmers to plan their production	0.58	0.49
Access to information about credit (1 = yes, 0 = no		+	This information helps to plan household finances and budget for purchases and sales	0.52	0.50
Value of livestock, consumables and farm tools in *birr*		+	The wealthier a farm household, the better the food security	2214.61	1825.58
Proportion of household members with formal education		+	Education is a source of skills for undertaking economic activity	0.17	0.21
Adoption of crop technology (1= adopter, 0 otherwise)		+	Use of improved technology promotes productivity thereby food security	0.69	0.46
Adoption of soil conservation measures (1= adopter, 0 = otherwise)		+		0.62	0.49
Number of Community based organizations in the village		+	CBOs serve to address social problems	2.65	2.81

Table 7 *Probit* maximum Likelihood Estimates of food security determinants.

Variable	Hararghe		Laygaint		Total sample	
	Coefficient	T-value	Coefficient	T-value	Coefficient	T-value
Constant	-0.1077	-0.25	-1.429***	-2.94	-0.291	-1.06
Woinadaga	-0.4645***	-3.64	-0.216***	-4.48	-0.053***	-2.56
Kolla	-0.2456	-1.22	-1.081***	-3.53	-0.224	-1.53
Gender	0.0081	0.62	0.003	0.59	0.002	0.49
Age in years	-0.0026	-0.54	-0.003	-0.59	-0.001	-0.37
Family size	-0.2549***	-6.17	-0.220***	-5.10	-0.221***	-7.97
Farm size in hectares	-0.0026	-0.54	0.512***	2.44	-0.001	-1.03
Number of plots	0.1041	1.47	-0.037	-0.48	0.076**	1.80
Number of crops grown	0.2520***	4.50	0.383***	4.39	0.200***	4.79
Number of income generating activities	-0.1591	-1.68	-0.032	-0.30	0.001	0.32
Access to drinking water in minutes of walk	-0.0050*	-1.62	-0.010	-1.61	-0.005**	-2.03
Access to information about prices	0.0202	0.07	-0.029	-0.12	-0.045	-0.26
Access to information about climate	-0.0055	-0.03	-0.032	-0.21	0.099	0.93
Access to information about credit	0.3386*	1.94	-0.017	-0.09	0.073	0.63
Wealth	0.0001***	2.76	0.0001	1.51	0.0001***	2.69
Proportion of household members with formal education	-1.2947***	-3.38	0.066	0.18	-0.380	-1.61
Adoption of crop technology	-0.0005	-1.19	-0.0003	-0.41	0.000	-0.73
Number of CBOs	0.6262***	4.87	0.215***	4.49	0.053***	2.60
Adoption of soil conservation measures	0.0006	1.52	0.0003	0.42	0.0004	1.36
Number of observations	474		390		864	
Log likelihood function	-216.56		-212.144		-468.10	
Restricted log likelihood	-279.42		-258.89		-543.49	
Chi-squared	125.72***		93.48***		150.79***	
Degrees of freedom	18		18		18	
Significance level	0.00		0.00		0.00	
Correct prediction (%)	80%		73%		72%	
Chow test	X^2 (2)		=	28.03***		

*Note: the dependent variable was quantified based on total crop production, P significant *** at 1%, ** at 5% and * at 10%. The Chow test shows the significant difference in the coefficients between Hararghe and Laygaint.*

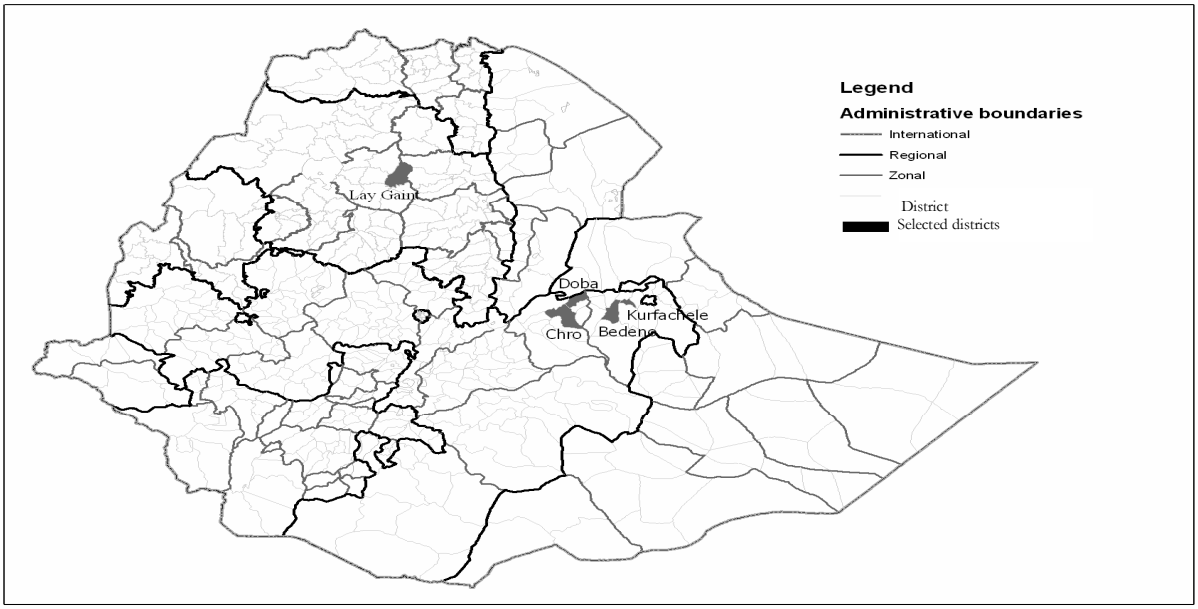

Figure 2. Shaded area shows map of the study area.

Table 8. Factors affecting the intensity of food security (*Tobit* estimates).

Variable	Hararghe		Laygaint		Total sample	
	Coefficient	T-values	Coefficient	T-values	Coefficient	T-values
Constant	0.3883***	7.57	0.2795***	4.91	0.3929***	11.34
Woinadega	-0.0006***	-3.34	-0.0232**	-3.95	-0.0005***	-3.63
Kolla	0.0142	0.57	-0.0648*	-1.72	0.0051	0.25
Gender of the household head	-0.0010	-1.47	-0.0005	-0.82	-0.0008	-1.63
Age of the household head	0.0010	1.54	0.0004	0.58	0.0006	1.43
Number of adult equivalent household members	0.0071	1.55	0.0038	0.81	0.0049	1.47
Number of crops grown	0.0001**	2.19	0.0001	1.28	0.0001**	2.40
Sorghum grower (1 = grower, 0 = otherwise)	-0.0855	-3.83	0.0806*	1.68	-0.0917***	-5.72
Teff growing household (1= grower, 0 =otherwise)	0.0228	0.28	0.0250	0.84	0.0460*	1.68
Access to price information	-0.0079	-0.23	0.0459	1.54	0.0131	0.57
Access to climate information	0.0320	1.34	0.0399**	2.11	0.0292**	1.97
Access to credit information	0.0143	0.59	-0.0278	-1.22	0.0074	0.50
Proportion of household members with formal education	0.0231	0.90	0.1595***	3.67	0.0995***	4.59
Number of CBOs in the village	0.0004***	2.71	0.0229***	3.94	0.0004***	3.03
Adoption of soil conservation measures (1= adopter, 0 = Otherwise)	0.0001***	5.56	0.0000	0.53	0.0001***	5.40
Sigma	0.2121***	30.82	0.1823***	28.59	0.2040***	42.09
Number of observations	525		429		954	
Log likelihood function	27.39		99.57		98.66	
Chow test	F (2, 711) = 9.67***					

*Note: P significant *** at 1%, ** at 5% and * at 10%. The Chow test shows the significant difference in the coefficients between Hararghe and Laygaint.*

4. Conclusion

In this paper, the food security situation is assessed using calorie intake, anthropometrical measures and based on household-declared perceptions about the food security situation. Factors affecting these indicators are determined using limited dependent variable models as the dependent variables are categorical or range in value between zero and one. Factors that significantly affect the food security level are agro ecology, family size, number of crops grown, number of plots the household owns, access to drinking water, the wealth status of the household and the number of community-based organizations in the village where the household lives. The intensity/incidence of food security was significantly affected by agro ecology, the number and types of crops grown, access to climatic information, the proportion of household members with a formal education, the number of CBOs in the village and the adoption of soil conservation measures by the household.

In order to improve the food security situation in the study areas, measures should be implemented in the area of household demographics, especially family planning, improving service provision especially climatic information and access to credit, and promotion of crop diversification that will minimize the prevalent production risks.

When considering the proportion of household members with a formal education as a factor influencing food security, it was found that negative effects on the food security level, but has a positive influence with regard to the intensity/incidence of food security. This shows that, even though, households with more formally educated members are food insecure, the time period when they are food insecure in a year is less than those households with fewer formally-educated members. In making such households food secure, efforts should be made to educate youngsters.

As agro ecology is a significant factor, there is a need to target intervention, taking into consideration the agro ecological specifics, especially the adoption of soil conservation measures as they are a significant factor in improving the intensity of food security. Community-based organizations are also an important factor in promoting the intensity of the food security level. Thus, promotion of CBOs should be given due attention.

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