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Analysis of households' vulnerability to food insecurity and its influencing factors in East Hararghe, Ethiopia

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Abstract

Previous studies on food insecurity in many developing countries, including Ethiopia, have mainly focused on current food insecurity, lacking the *ex-ante* analysis. An understanding of household vulnerability to food insecurity is critically important to inform the formulation of policies and strategies to enhance food security and reduce vulnerability to food insecurity among smallholder farmers. This paper analyses vulnerability to food insecurity of farming households using the vulnerability as expected poverty (VEP) approach. The paper is based on cross-section data collected from a sample of 408 households in East Hararghe, Ethiopia, selected using a multi-stage sampling procedure. The factors which influenced vulnerability to food insecurity were analyzed using the Feasible General Least Squares regression model. The results of analysis indicate that vulnerability to food insecurity increased with the age of household head ($P < 0.1$), and family size ($P < 0.01$). It decreased with access to improved seeds ($P < 0.01$), adoption of soil and water conservation ($P < 0.01$), size of cultivated land ($P < 0.1$), and access to credits ($P < 0.1$). Based on the intensity of their vulnerability, households were grouped as chronic food insecure (24.27%), transient food insecure (11.77%), highly vulnerable-food secure (18.38%), and low vulnerable-food secure (45.59%). Overall, about 54% of households were categorized as vulnerable to food insecurity. These included households who were food insecure at the time of the survey (36.02%) and those who were categorized as transient food secure group (18.38%). These findings imply that food insecurity policies and interventions in developing countries should focus not only on households that are currently food insecure, but also on those categorized as transient food insecure or households that are more likely to be food insecure in the near future.

Keywords: Vulnerability as expected poverty, Vulnerability to food insecurity, Food insecurity, Ethiopia

1 Introduction

Despite her double-digit economic growth rate since 2005, Ethiopia ranks 174th out of 188 countries in the 2015 UN Human Development Index and 104th out of 119 countries in the Global Hunger Index classified as suffering from a 'serious' level of hunger (IFPRI 2017). The rate of rural poverty is also high, with 26% of rural households living below the poverty line (UNDP 2018). Stunting and wasting in children younger than 5

constitute 40.4 and 8.7%, respectively (IFPRI 2015) which suggests that food insecurity is a serious problem in the country and that many households are vulnerable to it.

Although there are efforts to reduce the prevalence of poverty and vulnerability to food insecurity (VFI), both chronic and transitory food insecurity persist at the household level and millions of people are still vulnerable due to different shocks and stresses. Between the time when the current government [the Ethiopian People's Revolutionary Democratic Front (EPRDF)] came to power in 1991 and 2003, most Ethiopian food security policies have focused on relief and emergency plans. Thereafter, the food security program was launched in 2003 under the framework of the federal government's food security strategy, and the productive safety net program formally launched in 2005 in selected chronically food-insecure districts. The main goal of these programs is to improve the food security status of chronically and transitory food-insecure people through resettlement programs, household asset building programs, as well as complimentary community investment, including public works projects such as soil and water conservation (SWC) practices, road construction, and natural resource rehabilitation. However, studies indicate that levels of poverty and vulnerability in Ethiopia remain very high (IFPRI 2015; FAO 2016; Dercon and Christiaensen 2011; Fentaw et al. 2013; Dercon et al. 2012; Kumar and Quisumbing 2012). On average, 32% and 40% of the Ethiopia's population are undernourished and consume less than the recommended daily calories, respectively (IFPRI 2015). Moreover, the FAO (2016) situation report indicates that more than 10.2 million people needed food assistance in 2016, more than at any other time since 2006.

The prevalence of food insecurity and related vulnerability is generally high in rural parts of Ethiopia, where 79% of the population live (World Bank 2018), with rain-fed subsistence farming dominating agricultural production. The level of vulnerability and food insecurity mainly depends on the performance of agriculture (Demeke et al. 2011; Collier et al. 2008; Di Falco et al. 2011). Therefore, household vulnerability and food security largely depends on a combination of both natural and man-made factors, including rainfall patterns, land degradation, population density, climate change, low levels of rural investment, volatile input and grain prices, drought, pest hazard, frost, and flooding (Gelaw and Sileshi 2013; WFP 2011; Dercon and Christiaensen 2007; Dercon and Krishnan 1998). In addition, access to different resources and institutional factors, such as access to land and labor, infrastructure, technologies, credit, and geographic suitability also affect the level of vulnerability and food insecurity though the channels of agricultural production and rural income (Gelaw 2010; Bevan 2000; Dercon and Krishnan 1998).

Furthermore, empirical findings by Dercon and Christiaensen (2007), Dercon and Krishnan (1998), and Capaldo et al. (2010) also show that in many developing countries, such as Ethiopia, food security is mostly unstable, fluctuating over time. According to Capaldo et al. (2010) and Dercon and Krishnan (2000), access to adequate food for many households varies over time due to households' proneness to shocks and other risks, such as floods, land degradation, and extreme climate conditions, and their capacity to recover and respond. This implies that the concept of food insecurity is best thought of as dynamic rather than static in nature (Capaldo et al. 2010). It is no surprise that the dynamic nature of food insecurity persists in rural population of Ethiopia where

livelihood is derived mainly from agriculture, which is rainfall dependent and highly erratic. As such, it is important to analyze VFI and identify households that are currently food insecure and those likely to be food insecure in the near future. A proper approach to this would be to carry out a more disaggregated analysis of VFI rather than merely categorizing households as either food secure or food insecure. This is particularly important if the aim is to design and implement inclusive food security policies and strategies that are intended to serve different groups.

This also implies that food security studies that aim to inform the formulation and implementation of policies and programs to address VFI should be based not just on the assessment of households' current conditions, but also on the expected situation of access to food in the near future (Capaldo et al. 2010). In addition, although the emphasis is on analyses of dynamic nature of food insecurity for better and effective policy action, most of the past studies have focused on vulnerability to poverty, not food insecurity (Scaramozzino 2006; Chaudhuri 2003). Most food security strategies and program studies conducted in Ethiopia focus on the evaluation of current food insecurity with respect to who is currently food insecure and why (Agidew and Singh 2018; Bogale and Shimelis 2009; Motbainor et al. 2016; Jaleta et al. 2018). They do not go further and attempt to determine who are likely to be VFI in the near future.

Therefore, this paper analyses households' VFI and its influencing factors using the vulnerability as expected poverty (VEP) approach. Thereafter, implications for effective policy interventions to enhance food security and reduce the VFI in the study areas are drawn.

2 The concept of vulnerability

In the broad academic literature, vulnerability is a term with a variety of discipline-specific implications. The disaster management literature generally associates vulnerability with natural hazards (Alwang 2001), while both human geography and human ecology relate vulnerability to environmental change (Adger 2006). Food insecurity and poverty literature, as well as social risk management literature, define vulnerability in terms of future negative effects on welfare (Mansuri and Healy 2001; Dercon 2001; Holzmann and Jørgensen 2000; World Bank 2000). Others define vulnerability in terms of the level of risk and capacity to recover and respond to it. Thus, not only does vulnerability imply a measure of risk associated with physical, social, and economic aspects, but also describes the ability to cope with different risks and shocks (Chambers 1989; Proag 2014). Accordingly, there are two components of vulnerability: the external side referring to the structural elements that determine sensitivity and risk to exposure (Moser 1998; McCarthy et al. 2001; Chambers 1989), while the internal side concerns the ability of households to respond and cope with stressors and the actions required to overcome them (Bohle 2001; Hart 2009; Chambers 1989).

In the framework of social risk management, vulnerability to poverty was first applied in early 2000s and thereafter, thus increasing awareness about vulnerability in the context of food insecurity (Scaramozzino 2006; Bogale 2012; Sharaunga et al. 2015; Ozughalu 2016). In the context of food insecurity, vulnerability is defined as a household's probability to fall, or stay, below food poverty line within a given period time (Capaldo et al. 2010; Løvendal et al. 2004; Løvendal and Knowles 2005).

Equally important is vulnerability to poverty which can be determined based on the frequency of household transitioning in and out of poverty over a given period of time (Alwang et al. 2001). Households can, therefore, be considered vulnerable if they remain poor in all the years considered in the study, otherwise they are considered as falling under transient poverty if they are poor or fall below the poverty line for only few times during the years of study (*ibid*).

Overall, vulnerability analysis has two main advantages. First, it is explicitly dynamic; vulnerability analysis does not just focus on the current status, but it is also forward-looking (*ex-ante*). Second, it also focuses on a given shock or set of shocks along with the coping strategies that households and communities can adopt to reduce the probability of being food insecure (Bogale 2012; Mutabazi et al. 2015; Ozughalu 2016; Scaramozzino 2006).

The main difference between food insecurity and VFI analysis is that the former summarizes food insecurity as a deficiency of food for a given household or society at a particular point in time, and hence a static measure of welfare that categorizes households as either "food secure" or "food insecure." On the other hand, VFI takes into account the different shocks and risks, such as climate change, land degradation, drought, erratic rainfall, and environmental degradation, that may affect households and society in the future, determining if consumption will move below a given threshold level. Further vulnerability analysis will sort households into four food security statuses: "chronically food insecure," "transitory food insecure," "permanently food secure," and "transitory food secure" (Scaramozzino 2006; Bogale 2012).

It is important to note that, just as there is no unique indicator of food security, there is also no single method to analyze VFI (FAO 2002; Løvendal and Knowles 2005; Ligon and Schechter 2004). The literature shows three principal methods for assessing VFI namely: vulnerability as expected poverty (VEP), vulnerability as low expected utility (VEU), and vulnerability as uninsured exposure to risk (VER) (Deressa et al. 2009; Hoddinott and Quisumbing 2003; Scaramozzino 2006).

VEP focuses on the probability that a given shock or set of shocks will move the well-being of individuals or households below the benchmark (such as below the food poverty line) in the near future (Chaudhuri et al. 2002; Christiaensen and Subbarao 2005; Pritchett et al. 2000; Chaudhuri 2003; Bogale 2012). VEU focuses on the change of utility derived from a certainty equivalent level of consumption (a benchmark) to the household's own expected utility (Ligon and Schechter 2003; Hoddinott and Quisumbing 2003). VER is a measure of the extent to which a given shock or set of shocks impose a welfare loss due to the absence of effective and efficient risk management tools. In addition, this approach is in essence an *ex post*-assessment and not an attempt to construct an overall measure of vulnerability (Hoogeveen et al. 2004).

In the estimation, all the three approaches are based on expected mean and variance of household's consumption or income. While VEP can be evaluated using both cross-sectional and panel data, VEU and VER require lengthy panel data. Due to the lack of appropriate panel data, we analyze the VFI of households and examine the factors associated with vulnerability of households to food insecurity using the VEP approach and cross-sectional data. However, obtaining a good estimate of household VFI requires consideration of the distribution of food consumption across

households and ensuring that the household characteristics at one time capture the time-series variation of food consumption of the household (Gaiha and Imai 2008; Chaudhuri et al. 2002).

Previous studies have analyzed vulnerability to poverty as well as food insecurity and its determinants using a variety of econometric tools (Demeke et al. 2011; Bogale 2012; Proag, 2014; Ellis 2003; Gelaw and Sileshi 2013; Sen 1981; World Bank 2000; Sharaunga et al. 2015; Chaudhuri et al. 2002; Chaudhuri 2003; Mutabazi et al. 2015; Ogundari 2017; Demeke et al. 2011; Bayudan-Dacuycuy and Lim 2014).

The findings from these studies attribute food insecurity and vulnerability to various factors. Using the entitlement theory, Sen (1981) for example, associated household food insecurity and vulnerability with the portfolio of current or existing and expected factors of production, including household's own production, assets, and reciprocal arrangements. Access to production resources and the available adaptation strategies against shocks and risks are the most important factors for shifting the poor households out of poverty and food insecurity (Proag 2014; Ellis 2003). Sharaunga et al. (2015), viewed women's economic empowerment, including economic and physical capital empowerment, as vital in combating food insecurity among rural households in developing countries.

Using a three-stage Feasible General Least Squares (FGLS), Mutabazi et al. (2015) assessed the vulnerability of smallholder farmers in Morogoro region, Tanzania. They found that farmers who perceived climate change as human induced were less likely to be vulnerable to poverty. In addition, households with stable incomes were also less likely to be vulnerable to external shocks (Mutabazi et al. 2015; Alwang et al. 2001). Other empirical research that has measured vulnerability using income patterns and sources include the studies by Jenkins et al. (2003), Finnie and Sweetman (2003), and Devicienti (2002). There is also a rich body of the literature which shows that food insecurity and vulnerability is determined by climate-related factor. Demeke et al. (2011) for example, used panel data to estimate the effect of rainfall shocks on smallholders' food security and vulnerability in rural Ethiopia. They found rainfall pattern to be an important factor determining household's food security status over time.

Elsewhere in Indonesia, Chaudhuri et al. (2002) and Chaudhuri (2003) used the VEP approach to analyze VFI based on the country's cross-sectional data. They concluded that the true poverty cost of risk was higher than the observed outcome and there was also a difference between current poverty head counts and vulnerability across different population characteristics. In Ethiopia, Gelaw and Sileshi (2013) found grain price hikes to have significant effects on households transitioning in and out of poverty. Similarly, in the urban slums of Kenya, Kimani-Murage et al. (2014) found prices of staple foods, such as maize flour, and unemployment to be one of the key factors affecting VFI. Other factors found to determine vulnerability to poverty and food insecurity are gender of household head, income, household size, source of household food (purchased or own produce), geographical location, conflicts, access to remittances, educational level, economic stability, and riskiness of occupation (Bogale 2012; Mutabazi et al. 2015; Ogundari 2017; Azeem et al. 2017; Bayudan-Dacuycuy and Lim 2014).

3 Research methodology

3.1 Description of the study area

The study was conducted in East Hararghe, Ethiopia, in August and September, 2017. East Hararghe is located between latitudes 7° 32′ and 9° 44′ North and longitudes 41° 10′ and 43° 16′ East. The zone is characterized by three agro-ecological zones: the semi-arid (62.2%), the semi-temperate (26.4%), and the temperate tropical highlands (11.4%). This wide range of agro-ecological zones allows the area to produce a variety of products, including cereal crops such as sorghum, maize, wheat, and *teff*; vegetables such as potatoes, onions, shallots, and cabbage; as well as perennial crops such as coffee and *Khat* (*Catha edulis*). Livestock keeping is also an integral activity of farmers in the study area. Among the cereals grown, sorghum and maize constitute the dominant crops, particularly in terms of the size of cultivated land and the number of households growing them. For example, in 2015/16, the land under sorghum and maize crops amounted to 134,708.26 and 49,979.80 ha with average yields of 19.69 and 26.67 qt/ha, respectively. Overall, these were generally much lower than the average national yields of 23.31 and 33.87 qt/ha for sorghum and maize, respectively.

Despite the favorable climatic conditions, soils and existence of diverse ecologies, which allow extended crop growing seasons, the East Hararge area is still vulnerable to food insecurity mainly as a result of high population pressures, rampant land degradation deterioration of other natural resources. Recognizing this, the central and regional governments together with other development partners, have implemented different policies and programs intended to reverse this situation. For instance, several food security and productive safety net programs have been introduced and implemented since the early 2000s; yet, food insecurity and VFI still persist.

3.2 Sampling technique and data collection

The empirical analysis in this paper is based on cross-sectional data collected from 408 households in East Hararge, Ethiopia. A multi-stage sampling procedure was used to select the study districts, *kebeles*[1] and sample households. In the first stage, three districts (Deder, Gorogutu and Haramaya) were purposively selected to capture the existing variations in human population, socioeconomic and existing agro-ecologies. The basic idea was to establish a sampling frame that closely represents the different characteristics of the total population in the study area. In the second stage, three representative *kebeles* from each district, were randomly selected. In the third stage, a representative sample of 408 households (i.e., 157; 124 and 127 households from Deder, Gorogutu, and Haramaya districts, respectively) was randomly selected using the proportionate probability sampling approach which relied on the respective sizes of districts and *kebeles*.

For the household survey, data were collected using a semi-structured questionnaire prepared and pretested before the actual survey. The questionnaire was intended to gather different information related to the households' socioeconomic and institutional characteristics, SWC, livelihood shocks and coping strategies, food consumption and expenditure, geographic and weather variables, education levels

[1] The term *Kebele* is usually used to refer to a named peasant association and is considered as the lowest administrative unit in Ethiopia.

for the head of household, existing social infrastructure, food security programs and related activities.

3.3 Econometric modeling strategy

It is important to note that food security and vulnerability analysis primarily requires a method of discriminating the food secure status from the food-insecure one or the highly vulnerable status from the low vulnerable one. To determine the food security status of households in the study area, we used the amount of money required to achieve the daily minimum dietary requirement. The government of Ethiopia set the minimum acceptable level of per capita calorie intake per day at 2200 (MoFED 2002). Thus, a household is considered to be food insecure if the amount of money it spends on food and the value of consumption from own produce are not sufficient or nutritionally adequate for a basic diet.

Basically, there are two types of approach to investigate the determinants of food insecurity at household level. The first approach is to evaluate household's food security status using discrete choice models (Logit, Probit, Multinomial, and Order models) that use a dummy dependent variable taking a value of zero if food insecure, or one if the household is food secure, that is, the household has an acceptable status of food security (Kimani-Murage et al. 2014; Magaña-Lemus et al. 2016; Agidew and Singh 2018; Motbainor et al. 2016; Ogundari 2017). However, this approach does not consider the extent of food insecurity. Bogale (2012), Mutabazi et al. (2015), Ogundari (2017), and the World Bank (2002) express the degree of households' food security using food consumption expenditure as an indicator of wellbeing. Accordingly, they define food insecurity in terms of the household's Per Capita Food Consumption Expenditure (PCFCE). We adopted the same measure (PCFCE) to determine household welfare and status of food insecurity in the study area.

We analyzed the household's VFI using an econometric model proposed by Christiaensen and Subbarao (2005) and Chaudhuri et al. (2002). The model applies the vulnerability as expected poverty (VEP) approach using PCFCE as a measure of household welfare. It also accounts for household risk exposure and coping strategies that may lead a household to fall below a given minimum level of welfare, for example, food poverty line. The vulnerability of households during the current period is expressed as

$$V_{ht} = P(c_{it+1} < z). \tag{1}$$

The current vulnerability of a household (V_{it}) is determined by the likelihood that the future household food consumption expenditure (C_{it+1}) will be less than the threshold level (Z). Thus, the estimation of vulnerability involves the determination of the probability distribution of future consumption. Assuming that the probability distribution is log normal, then the estimation of mean and variances of future consumption will effectively determine this distribution.

VEP approach estimates are always a function of the expected mean and variance of household PCFCE. The expected mean of PCFCE is determined by household and community characteristics, while the variance (also known as volatility) in household

consumption captures the idiosyncratic shocks that contribute to the difference in PCFCE levels for households that have the similar characteristics (Gunther and Harttgen 2009; Bogale 2012; Echevin 2013).

Following Chaudhuri et al. (2002), Gaiha and Imai (2008), and Günther and Harttgen (2009), we estimate empirically a variant of VEP from the food consumption expenditure function as

$$\ln c_i = x_i\beta + \varepsilon_i, \tag{2}$$

where $\ln c_i$ represents the log of PCFCE for the ith household, x_i represents an array of household and farm characteristics, selected based on a review of relevant literature, β is a vector of parameters, and ε_i is a disturbance term with a mean of zero and heteroscedastic, and non-homoscedastically, the usual regression techniques may yield estimates that are inefficient, but not biased in the main parameters of interest. This implies that the variances of the error term vary across households depending on x_i. Then, the squared residuals from Eq. (2) are regressed on household characteristics (x_i) to generate estimates for the expected variances, specified as

$$\sigma^2\varepsilon_i = x_i\theta + \tau_i, \tag{3}$$

where θ represents the vector of parameters and τ represents the error term for estimation of Eq. (3).

As proposed by Amemiya (1977), Christiaensen and Subbarao (2005), Chaudhuri (2003), and Chaudhuri et al. (2002), the estimates of β and θ can be obtained using the three-step FGLS. This starts by estimating Eq. (2) using Ordinary Least Squares (OLS). Thereafter, Eq. (3) is estimated, using the square of error term from Eq. (2) as dependent variables. To obtain asymptotically efficient estimates of θ, we re-estimate Eq. (3) with OLS using predations of Eq. (2) after weighting each residual by $x_i\theta$ (Chaudhuri et al. 2002). We adopt the approach used by Bogale (2012), Chaudhuri et al. (2002), Mutabazi et al. (2015) to get asymptotically efficient estimates of β by re-estimating Eq. (2) after using efficient θ and weighted least squares.

$$\frac{\hat{\varepsilon}^2_{\mathrm{OLS},i}}{x_h\hat{\theta}_{\mathrm{OLS}}} = \left(\frac{x_h}{x_h\hat{\theta}_{\mathrm{OLS}}}\right)\theta + \frac{\tau_i}{x_h\hat{\theta}_{\mathrm{OLS}}}. \tag{4}$$

The standard deviation of the variance can then be obtained by the following equation:

$$\hat{\sigma}_{\varepsilon,i} = \sqrt{x_i\hat{\theta}_{\mathrm{FGLS}}} \tag{5}$$

Finally, Eq. (2) is transformed, as given in Eq. 6 to estimate β.

$$\frac{\ln c_i}{\hat{\sigma}_{\varepsilon,i}} = \left(\frac{x_i}{\hat{\sigma}_{\varepsilon,i}}\right)\beta + \frac{\varepsilon_i}{\hat{\sigma}_{\varepsilon,i}}. \tag{6}$$

Using the estimates of β and θ, we are able to directly estimate the expected log PCFCE and the variance of log PCFCE for each household as in the below equations, respectively.

$$E[\ln c_i/x_i] = x_i\hat{\beta}, \tag{7}$$

$$V[\ln c_i/x_i] = x_i\hat{\theta}. \tag{8}$$

Assuming that consumption is log-normally distributed, each household's VFI at time $t+1$ can be expressed as in the following equation:

$$\hat{V} = \hat{P}(\ln c_i < \ln z/x_i) = \emptyset\left(\frac{\ln Z - \ln x_i\hat{\theta}}{\sqrt{x_i\hat{\beta}}}\right), \tag{9}$$

where Φ is the cumulative density of the standard normal distribution; $x_i\hat{\theta}$ and $x_i\hat{\beta}$ are the expected household food consumption expenditure and the standard error of the regression, respectively, Z is threshold level, and V is the probability that each household VFI ranges between zero and one. Chaudhuri et al. (2002), justify a threshold measure that is used to define vulnerable households as those with an estimated vulnerability coefficient above or equal to 0.5. Thus, we classify households as vulnerable if $\hat{V}$ is above or equal to 0.5 and otherwise, if not vulnerable.

As specified earlier, we used the household food expenditure to determine the current food security status of a household, compared to the daily minimum dietary requirement (food poverty line) set in the literature for Ethiopia. Stated differently, we compared the household dietary intake with the food poverty line for Ethiopia. In addition, we adopted the approach used by Bogale (2012) to determine the food poverty line (threshold), by first picking a 'basket' of the food items typically consumed by the poor. We then determined the quantity of the 'basket,' which was considered as the bundle that meets the predetermined minimum per capital calorie requirement of 2200 kcal per day according to MoFED (2002). Finally, we used the local prices to estimate both the cost of basket and the value of the food poverty line. Accordingly, the food poverty line was estimated at Birr[2] 2637.86 per annum. In other words, a total of Birr 2637.86 per annum was needed to purchase food that could meet the basic daily food-energy requirements of an adult person. It should be mentioned here that based on sex and age, each member of household was assigned a specific adult equivalent figure calculated using standard conversion factors available in the literature.

Based on the CSA (2017)'s report of the country and regional consumer price indices, the study area (Oromia regional state) had a Consumer Price Index (CPI) of 171.4% (December 2011 = 100). Thus, we used this CPI to deflate the food poverty line in the study taking into account the effect of inflation. Consequently, we adjusted the food poverty line at Birr 1539 per adult equivalent, per year, using the end of 2011 constant price.

4 Results and discussion

4.1 Descriptive statistics

Based on a desk review of relevant literature (Demeke et al. 2011; Bogale 2012; Bogale et al. 2005; Mutabazi et al. 2015; Pritchett et al. 2000; Christiaensen and Boisvert 2000; Deressa et al. 2009), we included a range of household and farm characteristics as independent variables in the vulnerability analysis at household level. The summary of descriptive statistics is given in Table 1.

[2] Birr is Ethiopia currency (1USD = 23.32 Birr).

Table 1 Variable specification and summary statistics of household characteristics. Source: computed from the survey data

Variable	Viable label	Mean	Std. Dev.
lnFCE	Natural log of consumption expenditure per adult equivalent	8.00	0.40
Sex	Dummy of sex of household sex (1 = male)	0.87	0.34
Age	Age of the household head in years	40.19	12.73
Education	Level of education in numbers of years	3.65	3.67
Adult equivalent	Size of household in adult equivalent	4.89	1.65
Dependence ratio	Dependence ratio	1.29	0.96
Annual income	Total annual income in birr	16,878.67	13,263.07
Off-farm activity	Dummy for participation to off farm activity (yes = 1)	0.46	0.50
Use of fertilizer	Dummy for use to fertilizer (yes = 1)	0.54	0.50
Use of improved seed	Dummy for use to improved seed (yes = 1)	0.51	0.50
Use of irrigation	Dummy for use to irrigation (yes = 1)	0.35	0.48
Cultivated land	Total cultivated land holding	0.29	0.17
Adoption of SWC	Dummy for use to SWC (yes = 1)	0.49	0.50
Total Assets	Total assets in birr	24,627.73	48,081.69
Livestock TLU	Livestock owned (Tropical Livestock Unit)	1.78	1.90
Crop diversification	Number of crop growth	2.46	0.70
Coping strategy index[3]	Coping strategy index	16.46	4.93
Number of sick	Number of sick person in 1 year	0.36	0.66
Received credit	Dummy for receiving credit (yes = 1)	0.13	0.34
Contact with DA	Number of contacts with extension agent, per month	2.28	2.08

The average age of household heads was 40.19 years. However, the majority of family members were younger than 15 or older than 64 years, meaning that the dependency ratio was very high (averaging at 1.29, with standard deviation of 0.96). The average family size was 4.82 adult equivalents, though there were families with as large sizes as 10.85 adult equivalents. In sense, a large adult equivalent would imply insufficiency food available for consumption especially, where the household's dependency ratio is large (Bogale 2012; Mutabazi et al. 2015). Most households were headed by men, with only 13% being headed by women. Although education can equip and enhance access to information and technology which in turn would help households to combat food insecurity and vulnerability, 40.69% of household heads never attended any formal education. On average, the heads of household in the study area attended 3.65 years of formal education.

The value of household assets and use of productivity-enhancing inputs (e.g. fertilizers, improved seeds, and irrigation water), size of cultivated land livestock holdings, as well as adoption of SWC constituted the important factors in analyzing VFI. On average, the study households cultivated 0.29 hectares of land and owned 1.78 TLUs. Furthermore, 54, 51, 35, and 49% of households used fertilizers, improved seeds, irrigation

[3] The coping strategies index is a tool that measures what households do when they cannot access adequate food. Food insecure households may change their diet, which means switching food consumption from preferred to cheaper and even less preferred substitutes, as well as others means like purchasing food on credit, consuming wild foods and immature crops or even seed stocks, favoring certain household members over others or going an entire day without eating food, just to mention few (Maxwell et al. 2003).

water, and SWC, respectively. About 13% received credits from formal credit institutions and each household was contacted or visited by an extension agent for about 2.28 times a month on average.

Recognizing the importance of crop diversification in smallholder production systems, especially its role of ensuring that farmers do not depend solely on production and revenue from a single crop, we also evaluate the extent to which farmers in the study area diversified crop production. Our descriptive statistics indicate that, on average, households grew 2.48 crops during the last production season of the year under study. Moreover, 46% of households participated in off-farm activities. The income generated from off-farm activities backed up the farmers' income and enabled them to smoothen their food consumption pattern.

It is important to highlight the role of family labor in smallholder farming systems as these farms depend predominantly on family labor. However, the number of family labor alone does not tell the whole story as a household may have many sick people who are unable to contribute their labor during a specific period of cropping season. Our analysis of family labor shows that on average, about 0.36 of the household's members were reported sick during the last 12 months before the survey date. We included this information in our model as an idiosyncratic shock.

4.2 Empirical results

In this section, we present and discuss the results of analysis of household VFI and factors that influence VFI. We used the three-step FGLS to predict the probability of a household to fall below the minimum food consumption expenditure and determine the factors affecting the expected food consumption expenditure or VFI. The model showed a good overall fit with most variables performing as expected [i.e. $F(19, 388) = 8.12$, $P < 0.001$]. To test for multicollinearity, we used the Variance Inflation Factor (VIF) and Contingency Coefficient for continuous variables and dummy variables, respectively. The results indicated nonexistence of a serious multicollinearity problem (i.e. a mean VIF of 1.46).

Out of the 19 explanatory variables specified in our econometric model, 6 variables were significantly influencing the expected food consumption expenditure (Table 2). The results of the model suggest that future food consumption was decreasing with the age of household head and family size (adult equivalents), and it was increasing with the use of improved seeds, size of cultivated land, adoption of SWC, and access to credits.

The expected food consumption expenditure decreased with family size or adult equivalent ($P < 0.01$). The possible explanation is that family size determines the expected food consumption expenditure: when the marginal productivity of household members and their contribution to household income is less than the food consumption expenditure then the share of consumption of each member of the household consumption is expected to decline. Our results of the model, for example, suggest that a unit increase in family size (AE) would reduce the expected food consumption expenditure by 10.70%. A similar relationship is also reported by Ogundari (2017) and Capaldo et al. (2010).

The results of analysis also show that the expected food consumption expenditure increased with the size of cultivated land ($P < 0.1$). This relationship was not astonishing as land is a basic farming input and binding resource for farm households. It is, therefore, directly associated with the ability of a household to produce enough produce for

Table 2 Three-step Feasible Generalized Least Squares result for determinant of vulnerability to food insecurity (*N* = 408). Source: computed from the survey data

Variables	Log food consumption expenditure			Variance of food consumption expenditure		
	Coef.	Robust Std. Err.	*t*	Coef.	Robust Std. Err.	*t*
Sex	−0.017	0.065	−0.26	−0.073	0.042	−1.75*
Age	−0.003	0.002	−1.75*	0.001	0.001	0.72
Education	−0.001	0.005	−0.16	−0.001	0.002	−0.25
Adult equivalent	−0.107	0.014	−7.65***	0.002	0.006	0.29
Dependence ratio	1.93E−04	1.82E−04	1.06	1.98E−05	8.57E−05	0.23
Annual income	1.94E−07	2.20E−06	0.09	1.06E−08	9.14E−07	0.01
Off-farm activity	−0.003	0.039	−0.08	−0.002	0.019	−0.1
Use of fertilizer	0.005	0.045	0.1	−0.004	0.018	−0.23
Use of improved seed	0.129	0.045	2.89***	0.026	0.020	1.28
Use of irrigation	0.057	0.037	1.53	−0.025	0.018	−1.39
Cultivated land	0.243	0.134	1.81*	−0.012	0.071	−0.17
Adoption of SWC	0.100	0.038	2.62***	0.022	0.019	1.13
Total Asset	0.000	0.000	0.94	2.65E−07	1.81E−07	1.46
Livestock TLU	0.015	0.012	1.25	−0.006	0.006	−1.03
Crop diversification	0.008	0.024	0.33	−0.014	0.011	−1.23
Coping strategy index	−0.003	0.004	−0.68	0.001	0.002	0.40
Number of sick	0.038	0.028	1.39	−0.006	0.014	−0.40
Received credit	0.094	0.057	1.66*	0.020	0.028	0.71
Contact with DA	2.90E−04	0.009	0.03	4.70E−04	0.004	0.12
_cons	8.384	0.122	68.68***	0.162	0.060	2.68***
$F(19, 388) = 8.12$				$F(19, 388) = 1.51$		
Prob > $F = 0$				Prob > $F = 0.0769$		
R-squared = 0.3041				R-squared = 0.0437		
Root MSE = 0.33456				Root MSE = 0.1633		

***, ** and * significant at the 1, 5, and 10% probability levels, respectively

consumption and sale, in so doing determining its contribution to household's future food consumption expenditures. The results of our model suggest that, a unit increase in cultivated land would increase the expected food consumption expenditure by 24.33%. A similar relationship is also reported by Schröder-Butterfill and Marianti (2006) who indicate that cultivated land is positively related with household food security.

Furthermore, our results of analysis show that, the use of improved seeds was positively and significantly influencing the expected food consumption expenditure ($P < 0.01$). For a discrete change in the use of improved seeds from 0 to 1, the household's future food consumption expenditure would increase by 12.92%. Again, this relationship was expected, because the use of improved seed potentially contributes to increase in productivity and reduce downward fluctuation in production due to the potential characteristics of improved seeds in resisting pests and diseases, as well as their ability to tolerate adverse weather conditions. The high productivity and production from use of improved seeds would in turn reduce the household's VFI. Jaleta et al. (2018) report a similar relationship: they found access to improved seeds to be significantly associated with household's food consumption in Ethiopia.

As expected, the adoption of SWC practices influenced the expected PCFCE positively ($P < 0.01$). This is consistent with Bogale (2012)'s findings, which indicate a positive relationship between adoption of SWC practices and household future food consumption expenditure in Ethiopia. Using SWC practices tends to reduce soil erosion, while maintaining the fertility status and moisture content of a farm land, thus improving farm productivity and allowing production of a fast maturing crop. In addition, SWC practices may reduce the impact of crop loss caused by flooding and land degradation, in so doing reducing the household's VFI. Our results suggest that the adoption of SWC practices would boost the expected food consumption expenditure of a household by 9.96%.

The results of analysis also reveal that the expected PCFCE decreased with the age of household head ($P < 0.1$). The model coefficient suggests that a unit increase in age of the household head would result in a decrease of expected PCFCE by 0.28%. We further infer this to the inverse relationship between age and productivity of farmers: as the age of farmers increases, their productivity decreases. Consequently, the decrease in productivity would result in reduced income and diminution of expected PCFCE.

Our results further show that the expected food consumption expenditure increased with access to credits ($P < 0.1$). The model coefficient suggests that a unit increase in access to credits would increase the expected food consumption expenditure of a household by 9.39%. This also implies that households receiving credits were less likely to be VFI than their counterpart households who did not receive credits. This can be attributed to the fact that access to credit enables farmers to make timely purchase of agricultural inputs, such as fertilizer, pesticides, herbicides, and improved seeds, which in turn enhances farm productivity and increases future food availability and consumption expenditure. A similar relationship is reported by Iftikhar and Mahmood (2017) in their study of relationship of agricultural credit with food security.

It is a common approach to estimate vulnerability to food insecurity using vulnerability as expected poverty, which is very often expressed as a function of expected mean and variance of household consumption. In our study, we estimated the *ex-ante* probability distribution for each household to suffer from food insecurity using the expected mean and variance of household consumption (Gonçalves and Machado 2014).

We then determined the VFI status of each household using a 0.5 vulnerability score as the threshold level (Pritchett et al. 2000). Accordingly, a household was inferred as having low VFI, when the vulnerability score was less than 0.5 and was considered highly VFI when the score was greater than or equal to 0.5. The current food insecurity status of a household was determined using the yardstick of food poverty line. In this regard, a household was considered as food insecure when the PCFCE was less than the threshold level; otherwise the household was inferred as food secure. By considering both the vulnerability status of household and its current food insecurity status, we extended our analysis into several food insecurity and vulnerability categories as shown in Table 3.

The results indicate that about 45.6% of the sample households had stable food security levels. These households were food secure and had low probabilities of being food insecure in the near future (less VFI). On the other hand, about 24% of the total households were categorized as food insecure for an extended period of time and were considered as suffering from chronic food insecurity. They had PCFCE values which were below the threshold level with probabilities of being food insecure being greater than

Table 3 Classification and decomposition by vulnerability and food security status. Source: computed from the survey data

	Food security status				χ^2-value	Total	
	Secure		Insecure				
	No.	Percent	No.	Percent		No.	Percent
Vulnerability status							
Low vulnerable	186	45.588	48	11.765	57.317***	234	57.353
High vulnerable	75	18.382	99	24.265		174	42.647
Total	261	63.971	147	36.029		408	100.00

***, ** and * significant at the 1, 5 and 10% probability levels, respectively

0.5. These were considered as being highly VFI having little chance of escaping from food insecurity in the near future. According to FAO (2008), these households may need a special attention in terms of direct food assistance and access to productive resources which will enable them to improve their productive capacity and help them escape from food insecurity in the near future.

About 11.8% of the total households were considered as suffering from transient food insecurity, which means that even if they had current PCFCE values of less than the value of food poverty line, they were less likely to fall into food insecurity in the near future and could utterly escape from food insecurity. Moreover, about 18.38% of the total households were grouped under the transient food security category, meaning that these households may face a sudden drop in their ability to access adequate and sufficient food, hence fail to maintain good nutritional status in the near future. Those households had access to adequate food but were highly VFI. This implies that they were more likely to become food insecure in the future. About 30% of the total households (11.765 + 18.382%) were categorized as having an unstable food insecurity status. Overall, these findings imply that households were recurrently moving into and out of the state of being food insecure which has a particular policy implication, that is, vulnerability to food insecurity should be viewed in a broader manner as not only entailing VFI farmers who are chronically food insecure, but also those who are currently food insecure but less likely to be VFI as well as those who are currently food secure but highly likely to be VFI in the near future. In our study, these households constituted about 54% of the total households in the study area.

5 Conclusions

Access to adequate and sufficient food in many developing countries, such as Ethiopia, is unstable. This means that the status of food insecurity of many households in these countries varies over time and is inherently dynamic in nature. This, in turn, implies that food security policies and initiatives should above all be based on a though understanding of the existing categories of VFI. It is important to understand both the groups of households who are currently food insecure as well as those who are expected to be food insecure in the near future. In this paper, we analyze vulnerability of farming households to food insecurity in East Hararghe using the VEP approach. The results indicate that 36.03% and 42.64% of the total households suffered from current and future food

insecurity, respectively. When considering both the current and future food insecurity, we found that about 24.26% suffered from chronic food insecurity, 11.765% from transient food insecurity, and 18.38% suffered from transient food security. Furthermore, we found that the age of household head, family size, access to credit, size of cultivated land, adoption of SWC practices, and access to improved seeds were the key factors that influenced VFI. We recommend that any initiative, policies and strategies to combat VFI should be informed by a thorough understanding of the existing categories of VFI. Equally important is the establishment and strengthening of tailor-made service providers, including institutions that provide agricultural extension and credit services, and supply of affordable inputs to smallholder farmers. It is important to support the introduction and implementation of SWC practices which aim to enhance productivity and sustainable use of land water resource base.

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The first author handled the data analysis and discussion of results. Other authors supervised the writing of the manuscript, proofread to ensure quality of the research as well as contributed to the revision of the study for publication. All authors read and approved the final manuscript.

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The data that support the findings of this study can be obtained from the authors based on the request.

Competing interests
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