Rural Households' Vulnerability to Food Insecurity in Boset District, Central Ethiopia

Getachew Moreda[1], Degefa Tolossa[2], and Negussie Sime[3]

Abstract

Rural households in Ethiopia are vulnerable to food insecurity due to the unprecedented climate variability and the incidence of poverty. This study examines the levels of vulnerability to food insecurity in Boset District of East Shewa Zone, Central Ethiopia. Food insecurity is recurrent in this area and the social vulnerability aspect of the society has received little attention from researchers. The study was conducted by adopting the mixed methods approach, in which 397 household were surveyed, key informants were interviewed, focus group discussions were held, and observations were made. The levels of vulnerability were measured through the Integrated Vulnerability Assessment Approach and weights were applied for each of the indicator variables via a Principal Component Analysis (PCA). More than half (52.6%) of the total respondents were found to be highly vulnerable, i.e., with negative potential impact, followed by 28.5% being vulnerable, and 18.9% less vulnerable. The results also showed a statistically significant difference ($p<1\%$) in levels of vulnerability to food insecurity across the sample *kebeles*. Hence, to lessen the resulting potential impact of exposure and sensitivity, interventions should focus on enhancing the adaptive capacities of households, and need to prioritize those *kebeles* with high levels of vulnerability. Furthermore, results of the study suggest that future research should take into account the time dimension of vulnerability to food insecurity.

Keywords: adaptive capacity; climate variability; exposure; food insecurity; integrated vulnerability assessment; sensitivity

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1. Introduction

Reducing food insecurity continues to be a major public policy challenge in developing countries (Babatunde and Qaim 2010). Food insecurity has been threatening millions of Ethiopians who live in the rural areas (CSA and WFP 2014; Diriba *et al*. 2017; Malla *et al*. 2017; Zewdie *et al*. 2017). In Ethiopia, 7–8 million people are routinely protected every year through the mainly donor funded Productive Safety Nets Program (PSNP) (Devereux *et al*. 2008). The country constitutes one of the seven African countries that account for half of the food insecure population in Sub-Saharan Africa (Mesfin, 2014); and it receives between 20% - 30% of all food aid to sub-Saharan Africa (Sosina and Holden, 2008).

Quite a large number of food security related studies have been conducted in Ethiopia. A closer analysis of those studies show that they have focused on understanding the current situation (Diriba *et al*. 2017; Malla *et al*. 2017; Zewdie *et al*. 2017) and they may not necessarily be investigating future prospects. Likewise, studies have also documented that food insecurity varies spatially (Zewdie *et al*. 2017).

Studies showed that food insecurity was precarious in Ethiopia (van der Veen and Tagel 2011; Adugna and Wagayehu 2012; Mesfin 2014). Consequently, there is a need to address this problem and assess food insecurity with respect to vulnerability. This is because reducing vulnerability is one of the prerequisites for addressing food security targets (Lovendal and Knowles 2006). There is a growing recognition that the causes of food crises and other disasters are not so much natural as social, political, and economic (Burg 2008). This can be substantiated by the argument forwarded by Kelman *et al*. (2016) that development decisions creating and perpetuating vulnerability are the root causes of disasters, not environmental phenomena, which sometimes become hazardous. The authors added that, from this vulnerability view point, disasters were not 'natural', neither in the sense of being from nature nor in the sense of being normal and acceptable. Lastly, identification of the characteristics of households likely to be vulnerable to food insecurity can allow for targeted food security strategies (Ndobo and Sekhampu 2013).

Furthermore, understanding food insecurity by focusing on the situational vulnerability of households has added advantages. Scholars have justified that vulnerability assessment could address the issue of future incidents of food insecurity (Scaramozzino 2006). Similarly, Riely (2000) mentioned that it could help to be more forward-looking and dynamic by incorporating the elements of risk and coping capacity into the assessment. Capaldo *et al*. (2010) on their part have stressed that understanding the trend that many households frequently move in and out of a state of undernutrition suggests the notion of food insecurity to be best thought of in a dynamic sense. Likewise, Ionescu *et al*. (2009) demonstrated that vulnerability referred to a potential event (e.g., of being harmed) and not to the realization of this event and so it concerned a judgment that referred to a possible future.

The vulnerability aspect of food insecurity in Ethiopia has been given minimal attention (Lautze and Maxwell 2007; Workneh *et al*. 2011; Lemma and Wondimagegn 2014; and, Sandstrom and Juhola 2017). For instance, a review of documents that dealt with the food crises in Ethiopia during 1999–2000 and 2002–2003 revealed the lack of a coherent, post-crisis strategy to reduce the embedded vulnerabilities that characterized a wide range of Ethiopian livelihoods systems (Lautze and Maxwell 2007). The same authors also observed that even in the Poverty Reduction Strategy Paper (PRSP) of Ethiopia, there was a failure to acknowledge the fact that Ethiopia's disasters mainly happened due to the country's ecological, economic, political, and social systems (Lautze and Maxwell 2007).

Likewise, Sandstrom and Juhola (2017) in their recent study on Ethiopia concluded that the 'drought narrative' was predominant, while the 'vulnerability narrative' was much less visible, especially in the appeal documents that were used to raise funding for relief. To the contrary of the position held by the Ethiopian authorities, however, many scholars contend that "an inability to tackle chronic food insecurity indicates a number of institutional, economic and political problems" (Ericksen *et al*. 2010). Furthermore, authors have argued this could be partly because "the economic and political factors that contribute to vulnerability and risk are intractable and these issues can shake the politically ruling power" (Armas and Gavris 2016: 139). Therefore, these authors pointed out that the ruling bodies tended to focus on the physical or engineering aspects of a hazard, thus avoiding 'explosive' problems such as social vulnerability (Armas and Gavris 2016).

Naturally, disasters like drought may worsen food insecurity and malnutrition (Tesfamicheal *et al*. 2016). Especially, if these disasters are more frequent, they affect not only food security levels, but could also lead people to make use of a destructive and depletive response by selling assets at prices below their real value, leading to potential poverty traps (Dercon and Christiaensen, 2011). However, it has been suggested that "lessening the effects of disasters would involve reducing vulnerability through socio-economic interventions, rather than solely attempting to diminish the impact of hazards through technological or engineering feats" (Burg 2008: 610).

Assessing the vulnerability of households to food insecurity is required because of the relatively few empirical studies found in the literature in general (Babatunde *et al*. 2008), and particularly within Ethiopia (Workneh *et al*. 2011; Lemma and Wondimagegn 2014). There is a need for more research to identify the highly vulnerable micro-environments and associated households in order to provide agronomic and economic coping strategies for the affected populations (IPCC 2007). In addition, place-based studies are both necessary and essential for understanding the dynamics of vulnerability (Ford and Furgal 2009).

This study differs from previously conducted research works in that we have adopted the Integrated Vulnerability Assessment Approach to see the vulnerability levels of households to food insecurity. The objective of this study is, therefore, to examine the levels of vulnerability to food insecurity in Boset district of East Shewa Zone by employing this approach. The authors believe that the work adds to the growing literature on food security; helps to reorient the thinking and action of decision makers; and reinforces the importance of incorporating the aspect of vulnerability whenever food insecurity assessments are made.

2. Theoretical Framework

2.1. Conceptualization of vulnerability

The concept of vulnerability, the susceptibility to food insecurity or not being able to meet food needs, has become an important part of food security analyses since the 1980s (Burg 2008). However, vulnerability is not a straightforward concept, and there is no consensus as to its precise meaning, the term is used to mean different things to different authors (Adger *et al*. 2004; Fussel and Klein 2006; Fussel 2007; Babatunde *et al*. 2008; Burg 2008; Thabane 2015).

The Food and Agricultural Organization of the United Nations (FAO) defines vulnerability as "the presence of factors that place people at risk of becoming food insecure or malnourished" (FAO 1999: 11). Similarly, Andrews and Flores (2008) defined vulnerability as "the full range of factors that place people at risk of becoming food insecure, including those factors that affect their ability to cope" (p. 2). In addition, vulnerability is defined as "a relative measure, for a given population or region, of the underlying factors that influence exposure to famine and predisposition to the consequences of famine" (Downing 1990: 9). Thus, vulnerability can be considered as comprised of risks (or a chain of risky events) that people confront in pursuit of their livelihoods, the sensitivity of the livelihood to these risks, the risk response or the options that people have for managing these risks and finally the outcomes that describe the loss in wellbeing (Turner *et al*. 2003). In this study, vulnerability is treated as a concept determined by the exposure, physical setting and sensitivity, and by the ability and opportunity of households to adapt to change (Adger 2006).

2.2. Approaches to vulnerability assessment

No single indicator or single theory of vulnerability will be helpful or credible for the purpose of understanding and lessening the vulnerability of a specific place or system (Patt *et al*. 2009). Given that vulnerability is a relative measure (Fussel and Klein 2006; Patt *et al*. 2009), its assessment is affected by the disciplinary biases of individuals involved (Adger *et al*. 2004). Therefore, empirical studies suggest the assessment can be categorized into three basic approaches: the natural hazards and disaster approach (biophysical), the social vulnerability approach, and the integrated approach (Yamin *et al*. 2005; Fussel 2007).

Scholars observe that the biophysical approach focuses on hazards, the dose-exposure of affected communities to identified impacts, and hazard-related vulnerabilities (Yamin *et al*. 2005; Brooks 2003). The implication is that factors such as the frequency, intensity and nature of the physical hazard and the exposure of communities to such hazards are key components of vulnerability (Yamin *et al*. 2005). On the other hand, the social vulnerability approach of assessing vulnerability is referred to as ‘‘the state of individuals, groups or communities in terms of their ability to cope with and adapt to any external stress placed on their livelihoods and well-being” (Fussel 2007). In this case vulnerability is determined by the availability of resources and, crucially, by the entitlement of individuals and groups to call on these resources (Fussel 2007). Vulnerability is something that exists within systems independently of external hazards (Brooks 2003). For many human systems, Brooks (2003), citing different authors, views vulnerability as an inherent property of a system and that it arises from the internal characteristics of that system, and thus it may be termed “social vulnerability”. The third approach, i.e., the integrated approach, combines the ‘internal’ factors of a vulnerable system with its exposure to ‘external’ hazards (Fussel 2007). Again, this approach is known to be determined by conditions such as the physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impacts of hazards (Yamin *et al*. 2005).

Among the three approaches discussed so far, the integrated vulnerability assessment approach is adopted to inform this particular study. This is because the approach links the two views that vulnerability depends on both biophysical and human factors (Ribot 2010), offsets the limitations raised against each of the previous two approaches (Figure 1).

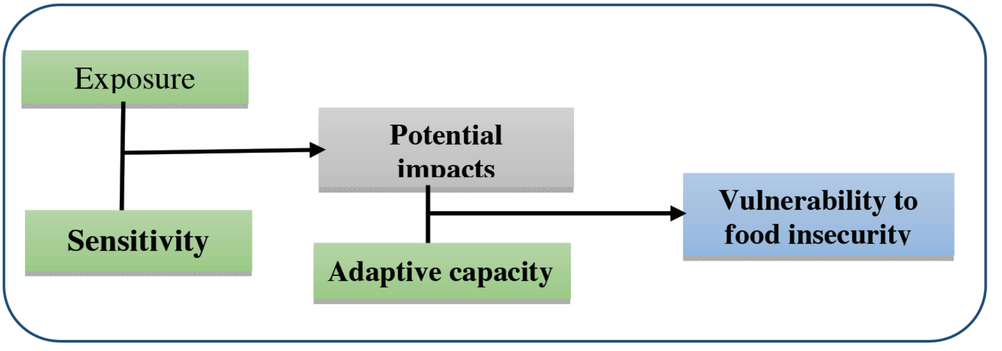

Figure 1. A framework of vulnerability to food insecurity as a function of exposure, sensitivity, and adaptive capacity

Source: Adapted from Ionescu *et al*. (2009) and Geronimo *et al*. (2013)

It can be observed from the framework that vulnerability is a hierarchical aggregation of the three components: exposure, sensitivity and adaptive capacity (Smit and Wandel 2006). In this analytical framework the analysis of the vulnerability to food insecurity begins with examination of the exposure and sensitivity components, which are inseparable properties of a system. Thus, exposure and sensitivity linked together affect potential impact (Gbetibouo *et al*. 2010). The framework shows the exposure is related to climate variability since the units of analysis are rural households who earn their living mainly from agriculture. It has been arguedthat the role played by climate variability and change in affecting the dimensions of food (in)security is so crucial that the impact of climate variability on increased vulnerability to food insecurity is quite significant (Karfakis *et al*. 2011).

Sensitivity and exposure togethercould contribute to food insecurity which arise primarily out of climatic variability and extreme precipitation events that occur more frequently as a result of climate change (Westerhoff and Smit 2009). As the livelihood of the rural people is heavily dependent on agriculture which is sensitive to occurrence of extreme climate events, some potential impacts (like water scarcity, crop failure, conflict over resources) may result. However, these potential impacts will not result directly into food insecurity, but rather adaptive capacities of the households will come into play to moderate the adverse effects. Hence, based on the access to resources to assist the households in coping with the potential impacts, the levels of vulnerability could be determined. Here we used the term vulnerability to food insecurity because it was mentioned by scholars like Burg (2008) thatpeople and places are not simply vulnerable: they are vulnerable to something, in this case food insecurity.

3. Materials and Methods

3.1. Setting of Boset District

Boset district extends between $8^{0}24'$- $8^{0}51'$ North latitude, and $39^{0}16'$- $39^{0}50'$ East longitude. It is located in the northeast part of East Shewa zone, Oromia National Regional State (Boset District Finance and Economic Development Office 2012). The data from Central Statistical Agency (CSA, 2013) showed that the total population of Boset district for the year 2017 was projected to be 189,795, out of which 42,793 (22.5%) would be urban inhabitants and 147,002 (77.5%) rural population. In terms of agro-climate zone, most parts of the district (89%) belong to tropical (kolla) zone and the remaining small section (11%) is sub-tropical (woina dega). The average annual temperature in the district varies between 25 – 30^{0}C for the tropical (kolla) and 15 – 20^{0}C for the subtropical (woina dega). The rainfall pattern is weakly bi-modal with spring (a small rainy season) during the months of April and May while summer is (a long rainy season) during the months of July - September. The mean annual rainfall ranges between 700 – 800 mm with high intensity and variability.

3.2. Research design and sampling

This study was conducted on the basis of cross-sectional survey using mixed methods research approach. The choice of mixed approach was dictated by the research problem under investigation and in view of benefiting from the merits of using this research approach (Johnson and Onwuegbuzie, 2004; Creswell 2009, 2012; Creswell and Clark 2011).

The primary data inputs for the research were generated by employing household survey, Key informant Interviews, Focus Group Discussions and observations. Questionnaire survey was administered by 12 Development Agents (DAs). Key informant interviews were also held with heads of offices and focal persons from health, women’s and children’s affairs, water resources, irrigation, crop production, livestock production, natural resources management, disaster preparedness and prevention, World Vision Ethiopia - Boset Area Development Program, and community elderly.

Similarly, focus group discussions consisting of six men's and four women's groups were conducted separately with members, each comprising 6–10 individuals. The criteria for inclusion in the group discussion were household heads who have lived in the *kebele* for more than five years and who had some knowledge of food insecurity issues. Lastly, personal observations were also employed to generate primary qualitative data. Secondary data were drawn from multiple published and unpublished documents.

To have a full picture of the district, out of 33 rural *kebeles*, a total of 6 *kebeles* located at different places were selected. Food insecurity status, access to irrigation facilities, and participation in the Productive Safety Net Program (PSNP) were used as criteria for selecting the sample *kebeles*.

A list of households living in each of the selected *kebeles* was taken as a sampling frame, then respondents were selected using a systematic random sampling technique proportionate to the size of households in each *kebele*. The systematic random sampling technique was employed because it is a probability sampling method and is easy to manipulate during the selection of the sample households (Babbie 2008; Bryman 2012). Using the formula developed by Yamane (1967) as cited in Israel (2013), the sample size was calculated and resulted in a total of 397 participants (48 female- and 349 male-headed households). In the determination of the sample size, a 95% confidence level and a **p**-value of 0.05 were assumed for maximum variability. Mathematically, the formula is presented as:

$$n = \frac{N}{1 + N(e)^2}$$

Where n stands for the sample size, N signifies the total number of households in all the *kebeles*, e designates maximum variability which is 5% (0.05).

3.3. Methods of data analysis

The examination of vulnerability to food insecurity undertaken in this study was conducted through the Integrated Vulnerability Assessment Approach. The approach allows to explore the three components of vulnerability: the exposure, sensitivity, and adaptive capacity of the households concerned.

Vulnerability is not a directly observable phenomenon (Ellis 2003; Luers *et al*. 2003). Thus we adopt the most common method of quantifying vulnerability by using a composite of proxy indicators. The reason for using indicators is that they seem to be useful media because they synthesize complex state-of-affairs, such as the vulnerability of households, into a single number that can then be easily used (Hinkel, 2011). Thus, the respective indicators chosen were made to represent the biophysical and socio-economic conditions of the rural households.

However, it must be noted that this approach has certain limitations in that indices are limited in their application by considerable subjectivity in the selection of variables and their relative weights, by the availability of data at various scales, and by the difficulty of testing or validating the different metrics (Luers *et al*. 2003).

The model specification is given as:

Vulnerability = (Adaptive Capacity) – (Sensitivity + Exposure) (1)

As can be seen from Eq. 1 a negative value is attached to both exposure and sensitivity and a positive value for adaptive capacity following the works of Temesgen *et al*. (2008), Workneh *et al*. (2011), Gutu *et al*. (2012), and Opiyo *et al*. (2014). When the adaptive capacity of the household exceeds that of its sensitivity and exposure, the household becomes less vulnerable to the impacts and the reverse is also true (Opiyo *et al*. 2014). In other words, areas which are highly exposed to climate shocks are more sensitive to damage, assuming constant adaptive capacity (Gutu *et al*. 2012; Opiyo *et al*. 2014). Therefore, a higher net positive value implies lesser vulnerability to food insecurity and vice versa.

The vulnerability indicators measured, however, need first to be normalized as the ratio of the difference between the actual value and pre-selected minimum, and the range of maximum and minimum values of indicators (Hahn *et al*. 2009) so as to overcome problems of scale of measurement (Workneh *et al*. 2011; Menberu, 2016). The normalization process is done to the range of values in the data set by applying the following general formula:

$$Index\ value = \frac{(Actual\ values - Minimum\ values)}{(Maximum\ values - Minimum\ values)} \quad (2)$$

Next to normalization of the selected indicators comes attaching weight for them. To this end, after reviewing different literatures Gbetibouo *et al*. (2010) summarized that there are three methods which are used to assign weights to indicators: (1) expert judgment; (2) arbitrary choice of equal weight; and (3) statistical methods such as principal component analysis or actor analysis. However, due to the inherent shortcomings of the first two methods, such as indicators not equally affect vulnerability, possibility of expert's judgment to be subjective, and even due to lack of the appropriate experts in the area (Gbetibouo *et al*. 2010), in this study the use of Principal Component Analysis (PCA) is opted to generate weights for the indicators.

PCA is frequently used in research that constructs indices for which there are no well-defined weights (Temesgen *et al*. 2008; Gutu *et al*. 2012); the PCA generated the weights, based on the assumption that there is a common factor that explains the variance in the vulnerability (Gutu *et al*. 2012). The generation of weights through PCA was performed using standard statistical software, i.e. STATA (Version 12.0).

The construction of the vulnerability index, relied on the following model specification:

$$V_i = \left(A_1X_{1j} + A_2X_{2j} + \cdots + A_nX_{nj}\right) - \left(A_{n+1}Y_{1j} + A_2Y_{2j} + \cdots + A_{n+n}Y_{nj}\right) (3)$$

where Vi is vulnerability index, while Xs are elements of adaptive capacity, andYsareexposure and sensitivity. The values of X and Y are obtained by normalization using their mean and standard deviation. For instance, $X_{1j} = (X_{1j} - X_1^*)/S_1^*$, where X_1^* is the mean X_{1j} across the different households, S_1^* is its standard deviation.

A_1 is the principal component result of factors. In this regard, the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information common to all the variables (Vyas and Kumaranayake, 2006; Temesgen *et al*. 2008; Workneh *et al*. 2011; Gutu *et al*. 2012; Opiyo *et al*. 2014).

It follows that the whole matrix of X_{1j} appears as:

$$X_{ij}/Y_{ij} = \begin{cases} (X_{11} + X_{12} + \cdots + X_{1n}) - (Y_{11} + Y_{12} + \cdots + Y_{1n}) \\ \vdots \\ (X_{m1} + X_{m2} + \cdots + X_{mn}) - (Y_{m1} + Y_{m2} + \cdots + Y_{mn}) \end{cases} \tag{4}$$

The I and j in the foregoing notation imply the number of rows (in this case is the 397 individual households) and the number of columns (17 variables of adaptive capacity, exposure andsensitivity), respectively.

In **Eq. 3**, the *As*, are the first component score of each variable computed using PCA. Finally, the vulnerability index of each household is obtained using **Eq. 5** as follows:

$$V_i = \begin{pmatrix} A_1 \\ A_2 \\ \vdots \\ A_{n+n} \end{pmatrix} \times \begin{cases} (X_{11} + X_{12} + \cdots + X_{1n}) - (Y_{11} + Y_{12} + \cdots + Y_{1n}) \\ \vdots \\ (X_{m1} + X_{m2} + \cdots + X_{mn}) - (Y_{m1} + Y_{m2} + \cdots + Y_{mn}) \end{cases} \tag{5}$$

Finally, based on the results obtained from **Eq. 5** the households are classified into three categories, i.e. highly vulnerable, vulnerable and less vulnerable. However, it should be notedthat the value of the index computed is not an absolute value (Opiyo *et al*. 2014).

Hence, based on the final output of the finding, those households with a vulnerability index value of less than 0 are highly vulnerable, those with an index value between 0 and 1 are vulnerable, and those with an index value above 1 are categorized as less vulnerable.

3.4. Indicators of vulnerability to food insecurity

The proposed indicators of vulnerability to food insecurity are identified from various empirical findings cited frequently in the literature, being informed with relevant theories, and based on availability of data. The exposure is determined by the frequency and the severity of natural and man-made hazards (WFP 2009). Accordingly, perception on increased temperature and rainfall adequacy, and perception on frequency of drought and flood occurrence were the indicators used to be measured. The assumption here is that increased temperature and inadequate rainfall, and farming households exposed to higher frequency of droughts or floods are more vulnerable (Temesgen *et al*. 2008; Gbetibouo *et al*. 2010; Workneh *et al*. 2011; Gutu *et al*. 2012; Opiyo *et al*. 2014).

Sensitivity, on the other hand, is considered to reflect the responsiveness of the household to climatic influences and is shaped by both socio-economic and environmental conditions (SEI 2004 cited in Gbetibouo *et al*. 2010). It was assumed, those areas with higher frequencies of climate extremes (e.g., drought and flood) were subjected to higher sensitivity due to loss in yield and thus loss of livelihood, given that the main source of livelihood in rural Ethiopia is agriculture (Temesgen *et al*. 2008). Thus, decline in farmland holding and crop production, food shortage, water scarcity, and incidence of conflict were the identified indicators (see also Swift 2006; Workneh *et al*. 2011; Opiyo *et al*. 2014; Dabalen and Paul 2014; Awal *et al*. 2016).

The adaptive capacity component of the vulnerability is taken as "the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change" (IPCC 2007). This component mainly constitutes the asset portfolio of the households concerned (Gbetibouo *et al*. 2010). It was argued that "the more assets people have, the less vulnerable they are; conversely, the greater the erosion of people's assets, the greater their insecurity" (Moser 1998). Accordingly, the following are indicators of adaptive capacity for this study, namely: gender, literacy level, access to non-farm income, total farmland size, access to communal resources, access to irrigated land, gross household annual income, availability of assistance by *kebele*, equality of women on resource ownership, access to agricultural extension service, access to health extension support, access to credit service, and availability of formal supporting organizations (see also Temesgen *et al*. 2008; Workneh *et al*. 2011; Notenbaert *et al*. 2013; Gutu *et al*. 2012; Opiyo *et al*. 2014; Tesfahun *et al*. 2015).

Table 1. Components of vulnerability, units of measurement, and hypothesized functional relationship with vulnerability

Components of vulnerability	Units of measurement	Hypothesized functional relationship with vulnerability
Adaptive capacity		
Male headed households	%	The higher the percentage of the rural households with asset ownership, and have access tothe different services available, the lesser the vulnerability.
Households with formal education	%	
Access to non-farm income	%	
Total farmland size	Hec.	
Access to communal resources	%	
Access to irrigated land	%	
Gross household annual income	Birr*	
Access to weather forecast	%	
Availability of farm equipment	%	
Availability of assistance by *kebele*	%	
Equality of women on resource ownership	%	
Access to DA service	%	
Access to health extension support	%	
Access to credit service	%	
Availability of formal supporting organizations	%	
Sensitivity		
Decline in crop production	%	The higher the percentage of households affected by extreme weather events and incidence of conflict, the higher their vulnerability.
Food shortage	%	
Water scarcity	%	
Unsafe waste disposal	%	
Incidence of conflict	%	
Exposure		
Perception on temperature increase	%	Increasing incidence of drought and frequency coupled with increased temperature and inadequate rainfall, increase the vulnerability.
Perceived frequent drought	%	
Perceived frequent flood	%	
Perception on inadequacy of rain	%	

*Birr is the currency for Ethiopia, where about 27 Ethiopian Birr was equivalent to 1 USD in 2017.

4. Results

4.1 The characteristics of households in the study area

The household heads included in the study were comprised of 349 (87.9%) male- and 48 (12.1%) female-headed households. The household size ranged between 2 and 14 members, with an average of six people per household. About 50.6% of the respondents claimed to have observed an increase in the size of household members, while the remaining 39% and 10.4% observed either a decrease or no change, respectively. The age of household heads ranged from 21 to 86 years, with an average of 44 years. Out of the total respondents selected, 90 (22.7%) were illiterate, 78 (19.6%) could only read and write, 164 (41.3%) attended elementary school (1–6 grades), 52 (13.1%) attended junior (7–8 grades) school, and 13 (3.3%) of them reached high school levels. In fact, there was disparity between male-headed and female-headed households, with the former having received a more formal education with a statistical significance level of 10%.

Only 15.1% of the total respondents were engaged in non-farm activities to gain additional income. The non-farm activities in the study area constituted selling local drinks, petty trading, making handicrafts, and selling forest products (charcoal and firewood). Ownership of farmland size ranged from 0.25 to 6 hectares, with an average of 1.6 hectares, and about 60.7% of the total respondents owned less than or equal to 1.5 hectares. Similarly, with respect to the trend of land holding, 45.6%, 31.2%, and 23.2% of the respondents experienced decreased, not changed, and increased land holdings, respectively. The gender dimension of owning farmland depicted the existence of a statistically significant difference ($p<0.01$): male-headed households owned more farmland than their female counterparts. As indicated, owning greater farmland could help in reducing the level of vulnerability, which implied that the male household heads would be in a better position in this regard.

As far as level of crop production over the last 5-10 years is concerned, about 61.7% (n=245) were confronted with decline in their crop production. The others, which constituted 22.4% (n=89) and 15.9% (n=63), reported no change and increased production, respectively, in their production level over the stated period. For those who mentioned decline in crop production, some of their reasons included lack of access to modern inputs, recurrence of drought, land degradation, and inability to purchase modern inputs. It was only 40% (n=159) of the respondents that reported to have access to communal resources. In addition, only 33.5% (n=133) of the respondents had access to irrigable land, in which the male household heads had better access than their female counterparts ($p<0.05$).

4.2 Results from the Vulnerability Index

The PCA was run on the indicators identified in Table 1, and the result revealed nine components with Eigen values greater than one for the data set on vulnerability indicators. These nine components explained 58.6% of the total variation in the data set. As per the argument made in the methods of data analysis section above for the use of PCA in constructing indices, the first principal component was considered for the computation, which explained the majority of the variation in the data set. The results of the factor scores on the first PCA (Table 2) show positive association with 11 out of the 15 indicators of the adaptive capacity; and negative association with 6 of the 9 indicators of sensitivity and exposure.

The vulnerability indices were, therefore, constructed for the indicators of adaptive capacity that had a positive association with the first PCA, and for those indicators of sensitivity and exposure that had a negative association. This is because adaptive capacity is considered to be positively contributing to the reduction of vulnerability, while exposure and sensitivity negatively contribute to vulnerability reduction (Opiyo *et al*. 2014). Thereby, those indicators selected were the ones which were in line with our hypothesized relationship vis-à-vis vulnerability (see Equation 3.1). Thus, out of the 24 indicators we initially considered, only 17 of them were employed in constructing the Vulnerability Index.

Using the factor scores obtained from the PCA and the standard score of each indicator, the vulnerability index of each household was computed, which resulted in 397 indices for the sample population with a minimum value of -2.96209 and a maximum value of 3.84875. As there are no universally accepted cut-off points, following the works of scholars (Workneh *et al*. 2011; Karfakis *et al*. 2011) households were classified into three categories. Here it should be noted that vulnerability is thought as a continuum (Lovendal and Knowles 2006; Babatunde *et al*.008). Accordingly, it was found that 52.6% (n=209) of the total respondents were highly vulnerable to food insecurity. The remaining 28.5% (n=113) and 18.9% (n=75) were vulnerable and less vulnerable, respectively.

Table 1. Normalized values and factor scores of the first Principal Component.

Indicators	Unit	Actual	Normalized score	Factor score
Adaptive Capacity				
Male headed households	%	87.9	0.12	-0.1656
Households with formal education	%	57.7	0.42	-0.1071
Access to non-farm income	%	15.1	0.85	0.2208
Total farmland size	Hec.	1.6	0.76	0.2712
Access to communal resources	%	40.0	0.60	-0.1660
Access to irrigated land	%	33.5	0.66	-0.2464
Gross household annual income	Birr	13527.36	0.76	0.0844
Access to weather forecast	%	91.7	0.08	0.1641
Availability of farm equipment	%	37.5	0.63	0.2000
Availability of assistance by *kebele*	%	22.4	0.78	0.0911
Equality of women on resource ownership	%	71.5	0.28	0.1819
Access to DA service	%	80.4	0.20	0.1238
Access to health extension support	%	73.3	0.27	0.2878
Access to credit service	%	28.2	0.72	0.1417
Availability of formal supporting organizations	%	57.2	0.43	0.2798
Sensitivity				
Decline in crop production	%	61.7	0.62	0.0744
Food shortage	%	91.7	0.92	-0.2353
Water scarcity	%	56.9	0.57	-0.2350
Unsafe waste disposal	%	36.0	0.36	0.3983
Incidence of conflict	%	19.9	0.20	-0.1629
Exposure				
Perception on temperature increase	%	79.6	0.80	-0.0086
Perceived frequent drought	%	88.9	0.89	-0.2999
Perceived frequent flood	%	24.7	0.25	0.0260
Perception on inadequacy of rain	%	94.2	0.94	-0.2157

Based on the computation made to construct the vulnerability index of households, levels of vulnerability were also examined across the sample *kebeles*. Results are presented in Table 3.

Table 2. Levels of vulnerability to food insecurity across *kebeles*

Kebele	Levels of vulnerability						Total	
	Highly vulnerable		Vulnerable		Less vulnerable			
	n	%	n	%	n	%	n	%
Buta Wagare	3	14.3	3	14.3	15	71.4	21	100.0
Digalu Wanga	8	26.7	7	23.3	15	50.0	30	100.0
Q/H/ Mirqasa	138	86.2	19	11.9	3	1.9	160	100.0
Sara Areda	15	28.8	22	42.4	15	28.8	52	100.0
Sifa Batte	35	32.4	50	46.3	23	21.3	108	100.0
Tiri Birreti	10	38.5	12	46.1	4	15.4	26	100.0
Total	209	52.6	113	28.5	75	18.9	397	100.0

Pearson $chi^2(10) = 168.4835$ Pr = 0.000

Results from Table 3 showed that there was significant difference (p<1%) in vulnerability to food insecurity across the sample *kebeles*. Accordingly, the finding revealed about 86.2% of the households in Q/H/Mirqasa *kebele* were highly vulnerable to food insecurity, followed by Tiri Biretti and Sifa Batte with 38.5% and 32.5% of the respondents falling in the same category, respectively. Such a large percentage of households were highly vulnerable in Q/H/Mirqasa *kebele* partly because the soil in this locality was mainly stony which made it less favorable for crop production and due to its distance from the center (Wolanchity town) basic infrastructures were critically lacking there. In contrast, respondents from Buta Wagare (71.4%) and Digalu Wanga (50%) were found to be less vulnerable to food insecurity.

The finding from Table 3 was somewhat in line with what was initially indicated by the district level experts when selecting the sample *kebeles*. By that time, the experts had identified Buta Wagare, Digalu Wanga, and Tiri Biretti *kebeles* to be better off in their status of food security. In contrast, Q/H/Mirqasa, Sifa Batte, and Sara Areda were selected to represent those *kebeles* which were highly food insecure. The findings would imply that the local authorities and other stakeholders working on food insecurity should undertake interventions based on the levels of vulnerability to be effective in their endeavor. To have a better grasp of the levels of vulnerability to food insecurity, the study finding is also presented according to gender in Fig. 2.

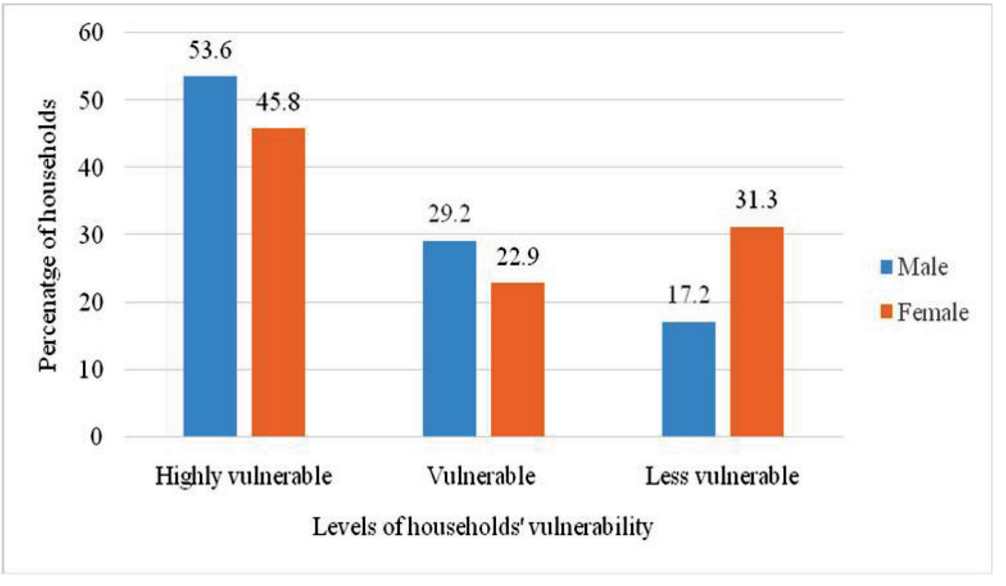

Figure 2. Levels of vulnerability to food insecurity according to gender

Figure 2 reveals that female-headed households were better in their levels of vulnerability to food insecurity, in all the three categories of vulnerability, when compared to their male-headed counterparts ($p<0.1$). This relative better position could be because female-headed households had better access to credit ($p<5\%$) and they engaged more in non-farm activities ($p<5\%$).

5. Discussion

The levels of vulnerability to food insecurity measures showed that more than half of the total respondents were highly vulnerable, which could be attributed to different reasons. To begin with, the findings showed that only 15.1% of the respondents diversified their source of income into non-farm activities. In fact, when households diversify their income sources, it can serve as a buffer to minimize the risk of becoming food insecure. It was shown that a heavy reliance on limited income sources had severe consequences when some shock (like drought) was encountered. For example, an agricultural dependence suggests that the income effects of a decline in agricultural productivity (all else being equal) could be significant (Burke and Lobell 2010), which may end up raising the level of vulnerability.

Total farmland size was the other variable found to have a positive contribution towards minimizing the level of vulnerability in the study area. This is because more farmland may allow crop diversification, which serves as an insurance against the adverse effects of unusual climate variability. Similarly, Abebaw and Ayalneh (2007) found that among rural households in Dire Dawa, the incidence of food insecurity was inversely related to the farm size of the household. On top of this, asset holdings (which can be expressed in terms of availability of farm equipment in our case) have considerable effects on reducing the vulnerability levels of farming households. Of course, a study conducted in Nicaragua (Karfakis *et al*. 2011) and another study in Ethiopia (Tesfahun *et al*. 2015) obtained similar findings, which confirmed the positive contribution of asset holdings in reducing vulnerability.

An increase in gross annual income was also found to have a positive contribution in minimizing the levels of vulnerability. It can be argued that households with more income can purchase modern inputs, introduce new technologies, and invest in diverse livelihood sources to boost their productivity and protect themselves against any odds of climate variability. Our findings again corroborate with a study finding that was obtained from Eastern Ethiopia (Lemma and Wondimagegn 2014). Somewhat related to increased income was access to credit services, in which only 28.2% of the total respondents had access. The survey finding was also confirmed by focus group discussants and key informants of the study. The problem related to such limited access is that households are forced to accept high interest loans from private money lenders, which may make them gradually get caught up in a debt spiral. Furthermore, due to the limited access to credit services, the rural households are denied the benefits they could receive, such as using new technology packages, investment in diversification, and others.

The finding on levels of vulnerability according to gender revealed that female-headed households were better relative to their male counterparts. This may suggest that the vulnerability of some households to food insecurity could be reduced meaningfully by focusing on providing more access to non-farm income, availing farm equipment, improving access to credit, and providing well targeted assistance by formal institutions. Likewise, a lower incidence of food insecurity in the female headed households than that of the male-headed ones was found by Abebaw and Ayalneh (2007). Contrary to our finding, a study conducted in Nigeria by Babatunde *et al*. (2008) found that female headed households were more vulnerable to food insecurity than male headed households, due to differential access to assets.

It can be observed from the final output of the vulnerability index that the combined effects of sensitivity and exposure exceeded the adaptive capacity of households for more than half of the total respondents who participated in the survey. This can be evidenced with the significantly large number of respondents who witnessed the occurrence of extreme weather events and the concomitant problems manifested in terms of food and water shortage. In similar terms, it was observed by Karfakis *et al*. (2011) that even small variations in temperature had heavy effects on the farmers' future ability to access sufficient food. Likewise, households are more vulnerable over time owing to insufficient rebuilding of assets after each successive shock (Ellis *et al*. 2009). Indeed, it can be deduced that the future prospect of food security for those who were highly vulnerable is worrisome. It must be implied that more work is needed in terms of lessening the sensitivity of households and building their adaptive capacity. To this end, it was succinctly elaborated that building the owned assets and broadening the livelihood options could enhance a households' flexibility, which would enable them to flourish in good times, sustain through stress, and rebuild after some shocks (Ribot 2010).

6. Conclusion and Recommendation

This paper looked at the levels of vulnerability to food insecurity among rural households. On the basis of Integrated Vulnerability Assessment

Approach, the households' levels of vulnerability were measured. It was found that more than half of the studied households were highly vulnerable to food insecurity. This would imply that the overwhelming majority of rural households in the study area either did not have access to the required livelihood assets to minimize their vulnerability or that their asset endowments were already depleted. In addition, it was also obtained across the sample *kebeles* that a statistically significant variation existed in terms of vulnerability levels ($p<1\%$). The fact that the large proportion of households have been identified to be highly vulnerable could be because of the strong influence of the exposure indicators (increased temperature, frequent drought, and inadequate overall rainfall) and the concomitant problems that were expressed in terms of sensitivity (food shortage, water scarcity, and incidence of conflict over resources).

Therefore, in order to reduce the likely adverse effects, the local authorities and non-governmental organizations operating in the area must concentrate on augmenting the adaptive capacity of households. This is because these stakeholders can have a relatively meaningful influence over the indicators of this component. Furthermore, for the sake of the efficient use of the meager resources, local authorities and non-government actors operating in the area may need to prioritize their interventions according to the levels of vulnerability. Finally, for practical applications and a wider impact, our study suggests the need to consider the time dimension of vulnerability when conducting future research. Consideration of time dimension is recommended because levels of vulnerability could vary over time even within a single year.

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