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Farm Household Vulnerability to Climate Change and Its Determinants: The Case of *Ada'a Berga* District of West *Shewa*, Ethiopia

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Authors' contribution

This work was carried out in collaboration between the authors. Author DAT designed the study, framed the objectives, managed the analyses of the study, collected the relevant literature and wrote the protocol and first draft of the manuscript. Author DGD suggested the necessary modifications. Both authors read and approved the final manuscript.

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ABSTRACT

The main objective of this study was to analyse the vulnerability of households to the impacts of climate change and factors that influence houses to be vulnerable in Ada'a Berga districts of western Shewa zone. To achieve the objective, study area and sample households' were selected by using multi-stage sampling procedure. Descriptive statistical analysis, Principal Component Analysis (PCA) and Ordinal Logit Model were applied to a set of primary data collected from 421 randomly sampled farmers with the aid of semi-structured questionnaire in six purposively selected kebeles'. The analytical results of descriptive statistics indicates that households that are headed with above 65 years of age, illiterate, less experienced in farming, with more number of dependent family members, and tenants who are not frequently visited with extension workers, lack of access to climate information, depend only on rain fed farming, no own land, no access to credit at all, no

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other option of income, no market in their nearby, private infertile land, experienced increase in temperature and change in the pattern of rainfall were vulnerable in the community. Besides, based on the vulnerability index results of PCA, households of the study area were categorised into three (42%, 38% & 20%) moderately vulnerable, highly vulnerable and less vulnerable to their own percent. Empirical result of Ordinal Logit Model showed that vulnerability of a household was determined by several explanatory variables, i.e., social, economic and biophysical. Therefore, policy measures and development efforts are focused towards improving the adaptive capacity of the farm households, while working to reduce those factors, i.e., both biophysical and socio-economic that significantly contributes to the exposure and sensitivity of the houses in the locality. The most vulnerable families should be the primary target of any future interventions.

Keywords: Climate change; determinant; PCA; vulnerability.

1. INTRODUCTION

Currently, our planet is facing a great challenge of climate change due to its impact on environment, social and economic aspects of the human living. This is because warming of the climate system is unequivocal, since the 1950s, many of the observed changes are unprecedented over decades to millennia, i.e., the atmosphere and ocean have warmed, the amounts of snow and ice have diminished through melting, and sea level has risen. These were due to average surface temperature has increased by more than 1.4°F (0.8°C) over the past 100 years. Relative to this global surface, temperature change for the end of the 21st century (2081–2100) is projected to likely exceed 1.5°C under high confidence [1]. Consequently, the effect of projected increase in temperature will leads to heat waves that will occur more often and last longer, the ocean will continue to warm and acidify, global mean sea level to rise and extreme precipitation, and resultant extreme events like drought and flood will become more intense and frequent in many regions [2].

Similarly, the temperature across Africa continent is predicted to rise by 2-6°C over the next 100 years, and rainfall variability is predicted to increase, resulting in frequent flooding and drought [3]. On the other hand, the mean annual temperature of Ethiopia was increased by 1.3°C with average rate of 0.28°C per decade between 1960 and 2006, and it is also projected to increase by 1.1 to 3.1°C by the 2060s, and 1.5 to 5.1°C by the 2090s. However, the change in climate regarding the increase in temperature and variability in precipitation (both regarding quantity and pattern) is correspondingly expected across the globe, but the resultant impacts of climate change are not evenly borne across countries, communities and households [4]. Because, the extent of climate change impacts on the community not only depends on the magnitude of impact but also on systems expositive or sensitivity characteristics and on the ability of people and ecosystems to deal with the effects, adaptive capacities [5].

Thus, vulnerability to climate change is commonly defined as a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity and adaptive capacity [6]. Exposure is the nature and degree to which a system (environmental and human) is exposed to significant climatic variations. Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Here the effect may be direct (e.g., a change in crop yield in response to a change in temperature) or indirect (e.g., loss of livestock caused by an increase in the frequency of drought). On the other hand, adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to cope with or to adopt the consequences [7]. Therefore, the system is vulnerable if it is exposed and sensitive to the effects of climate change and at the same time has the only limited capacity to cope or live with. In contrast, a system is less vulnerable if it is less exposed, less sensitive or has a robust adaptive ability [8].

In this regard, the global poor, particularly in developing countries are adversely impacted by climate change since they live in heavily influenced countries and locations within those countries; and depend on natural resource-based livelihoods that are disproportionately affected by climate change [9]. This is mainly due to a dependence of the poor on rain-fed agriculture for their living in all aspect (including for their social and economic wellbeing) which is significantly affected and the most vulnerable sectors to climate change [6,10]. This is why [11] noticed as the vulnerability is a state of well-being and is not the same for deferent populations living under deferent environmental conditions or faced with complex interactions of social norms, political institutions and resource endowments, technologies and inequalities. Therefore, vulnerability to climate change is conceived from contextual vulnerability which assesses the degree to which biophysical and socioeconomic systems are susceptible to and unable to cope with adverse impacts of climate change [12].

By considering this, the present study was emphasised on both the biophysical that is genuinely external and socioeconomic which is internal factors to the system by using the indicators of two elements of vulnerability to climate change impacts at the household level. Since understanding the vulnerability of farming community at the household level to climate change and variability is an important starting point in addressing the negative impacts of climate change. [13] analysis of vulnerability to climate change at any level that would enable policymakers to tackle climate change problems with precision since it helps to have an anticipatory plan for and adapting to a changing climate that individuals and societies can take advantage of opportunities and reduce risks. Therefore, the objectives of this study were to (1) analyse the households' vulnerability to climate change and variability; (2) investigate the levels of household vulnerability towards the impact of climate change, and (3) identify determinants of household vulnerability to the effects of climate change in the study area.

2. METHODOLOGY

2.1 The Study Area

The study was conducted in *Adalberto* district of West *Shewa* zone of *Oromia*, Ethiopia. *Adalberto* district lies between 9°12" to 9°37"N and 38°17" to 38°36"E with area covers 798.35 sq. Km and located about 109km northeast of zonal town *Ambo* and 64km away to the west of Addis Ababa, the capital city of Ethiopia [14]. The district is comprised from 53% of lowland, 26% of Midland and 21% of highland. Its annual average precipitation is 1290mm, and the minimum and maximum average yearly temperature lie between 12 and 25°C [15].

Based on the population projections of the area, 2017, the current total population of the district is estimated as 158,917 of which 79,061 are males, and 79,856 are females [16]. Of this majority, 97% (n=133,181) of the district is the rural population i.e., 66,765 are males and 66,416 are females. Mixed crop and animal husbandry is a mainstay of livelihood. Accordingly, the main crops grown include cereals (barley, wheat and *teff*), pulses (horse bean, chickpea, and lentil), oil crops (rapeseed, Niger seed and linseed), fruits and vegetables (papaya, mango, and banana; cabbage, kale, onion). In the regards to livestock cattle, donkey, mule and horse are commonly reared [17].

2.2 Sampling Techniques, Sources and Methods of Data Collection

The data for the research was obtained from a survey of 421 households in six *kebeles'* of the district in 2017. The study *kebele* within the districts were selected based on a multi-stage sampling procedure. Consequently, six *kebeles'* were selected from the lowland strata purposively and the survey households were selected randomly using the rule of proportion to the total population size of the sampled *kebeles'*. Both primary and secondary sources of data were used to achieve the objective of this study. A survey was made to collect primary data from household using a semi-structured questionnaire after it was tested by 10 percent of total sample households in each *kebele*. Besides of survey data focus group discussion and key informant interview was conducted through using discussion or interview guiding checklist to triangulate the data and emphasis on the specific issue related with vulnerability to climate change and on the trends of climate change impacts in the study area, respectively.

Secondary data pertinent for this study was obtained from zonal and district level agriculture and disaster prevention and preparedness office and Central Statistical Authority (CSA). Tools for analysis were done using statistical packages for social science (SPSS) v.20.0 and STATA v.12.0 software.

2.3 Conceptual Framework of Vulnerability and Its Analytical Tools

According to [6] vulnerability to climate change is defined as the degree to which geophysical, biological and socio-economic systems are susceptible to and unable to cope with, adverse impacts of climate change, and is a function of three factors: the types and magnitude of exposure to climate change impacts; sensitivity of the target system to a given amount of exposure and the adaptive capacity of the target system. Consequently, there are various approaches developed to assess vulnerability at the different level of climate change. Of these, the first approach is socioeconomic vulnerability assessment, which mainly focuses on the socioeconomic and political status of individuals or social groups [18]. Individuals in a community often vary regarding education, gender, wealth, health status, access to credit, access to information and technology, formal and informal capital, political power, and so on [19]. These variations are also responsible for the differences in vulnerability levels. In this case, vulnerability is considered to be a starting point or a state (i.e., a variable describing the internal state of a system) that exists within order before it encounters a hazard event [20,21]. Thus, vulnerability is considered to be constructed by society as a result of institutional and economic changes [11].

In general, the socioeconomic approach focuses on identifying the adaptive capacity of individuals or communities based on their internal characteristics. A study by [11] is an example of this approach. In that study, the environmental factor in a district to coastal lowlands of Vietnam was taken as given, and vulnerability was analysed based only on variations in socioeconomic attributes of individuals and social groups. But the main limitation of the socioeconomic approach is that it focuses only on variations within society (i.e., differences among individuals or social groups) based on the internal capacity. In reality, organisations vary not only due to sociopolitical factors but also to environmental factors. For instance, two households having similar socioeconomic characteristics but different ecological qualities can have different levels of vulnerability and vice versa. In general, this method overlooks other causes of weakness which is external like environmental shocks, such as drought and flood. It also does not account for the availability of natural resource bases to potentially counteract the negative impacts of those shocks; for example, areas with easily accessible underground water can better cope with drought by utilising this resource.

The second approach is the biophysical approach which emphasis on assessing the level of damage that a given environmental stress causes on both social and biological systems. [18] identified this approach as a risk-hazard approach. Besides, [21] referred to the biophysical approach as an end-point analysis responding to research questions such as, “What is the extent of the climate change problem?” and “Do the costs of climate change exceed the costs of GHG mitigation?". Even if it is very informative, the approach has its limitations. The primary limitation of this approach emanates from the ignorance of social capacity and its specific focus on physical damages, such as soil fertility, yield, income, and so on.

The third is integrated assessment approach. This combines both socioeconomic and biophysical methods to determine vulnerability. The approach emphasis both on the internal and external vulnerability to climate change. Even though the approach corrects the weaknesses of the above two approaches but still there is the limitation, lack of the standard method to combine both biophysical and socioeconomic indicators. Since, it uses different data sets, ranging from socioeconomic data sets (e.g., race and age structures of households) to biophysical factors (e.g., frequencies of earthquakes); these datasets certainly have different and yet unknown weights. Despite its weaknesses, however, this approach has much to offer regarding policy decisions [19]. Accordingly, limited numbers of scholars applied this method in order to assess the vulnerability to climate change from local to regional levels, such as [19] in measuring Ethiopian farmers’ vulnerability to climate change across regional states, [22] such as in analyzing spatial vulnerability of rural households to climate change in Nigeria, [23] in analyzing vulnerability and resilience to climate change induced shocks in north *Shewa*, Ethiopia and [24] also used in measuring household vulnerability to climate induced stresses in pastoral rangelands of Kenya. Therefore, the present study also found it appropriate and adapted to analyse the vulnerability of farmers' of *Ada’a Berga* district to climate change by making use of vulnerability index.

But the approach was challenged with the use of indices such as choices of the right indicators, directions of relationships with vulnerability, weights attached, and the optimal scale. The opportunities of indices were undertaken based on a review of the literature [22,23] and adjusted to the context of the study area. To solve the problem of giving measurable weight to the indicators, researchers recommend some tools to use. The two most common weighting methods used to combine symbols are equal and unequal weighting technique. The former method assigns equal weight to each symbol. The latter method assigns different weights to various indicators using: (i) expert judgment [25,26]; (ii) arbitrary choice of equal weight [27,28]; and (iii) statistical methods such as Principal Component Analysis (PCA) or factor analysis [29,30]. Of these, the most advanced method is PCA; therefore, this study also used it to generate the weights. Because, it is a technique for extracting common information from a set of variables which are statistically independent linear combinations [19].

Besides, the vulnerability index development is given as developed by [31] that vulnerability is seen as the net effect of adaptive capacity (socio-economic) and sensitivity/exposure (biophysical):

Vulnerability = (adaptive capacity) – (sensitivity + exposure) .... (1)

In this linear equation, the higher net value indicates lesser vulnerability and vice versa. This implies that if the adaptive capacity of the household exceeds that of its sensitivity and exposure, the household becomes less vulnerable to climate change impacts and the reverse is also true. The model specification further looks like:

$$V_1 = [(A_1X_{1j} + A_2X_{2j} +\text{----}+A_nX_{nj}) - (A_{n+1}Y_{1j} + A_{n+2}Y_{2j} +\text{----} A_{n+n}Y_{nj})] \quad \ldots \quad (2)$$

Where $\boldsymbol{V_1}$ is the vulnerability index, while $\boldsymbol{Xn}$ are elements of adaptive capacity, and $\boldsymbol{Yn}$ are elements of exposure and sensitivity. The values of **X** and ***Y*** are obtained by normalisation using their mean and standard errors. For instance; $X_{1j} = (X_{1j} - X_1^*)/S_1^*$, Where X_1^* is the mean of X_{1j} across the different households, S_1^* is its standard deviation. $\mathbf{X_1}$ 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 capture the largest amount of information common to all the variables. The whole matrix of X_{1j} appears as follows:

$$Xij/Yij = \begin{Bmatrix} (X11 + X12 + \cdots + X2n) - (Y11 + Y12 + \cdots + Y1n) \\ (Xm1 + Xm2 + \cdots + Xmn) - (Ym1 + Ym2 + \cdots Ymn) \end{Bmatrix} \ldots (3)$$

The ***I*** and ***j*** in the above notation implies the number of rows (in this case individual households) and the number of columns (in this case variables of adaptive capacity, exposure and sensitivity) respectively. In Eq. 4, the $\boldsymbol{A_1}$ is the first component score of each variable computed using PCA in **STATA**. Finally, the vulnerability index of each household will be obtained using Eq. 4 as follow:

$$Vi = \begin{bmatrix} A1 \\ A2 \\ . \\ . \\ An+n \end{bmatrix} \times \begin{Bmatrix} (X11 + \cdots + X1n) - (Y11 + \cdots + Y1n) \\ . \\ (Xm1 + \cdots + Xmn) - (Ym1 + \cdots Ymn) \end{Bmatrix} \quad (4)$$

In calculating the direction of relationship in vulnerability indicators following [26], a negative value was assigned to both sensitivity and exposure. The reason is that households which are highly exposed to climate change are more sensitive to its adverse impact, assuming the adaptive capacity is constant. This implies that a higher net value indicates lesser vulnerability and vice versa. Establishing the scale of analysis is important when using the indices. Accordingly, since vulnerability analysis ranges from local or household [11,23] level to the global level [25]. The choice of scale is governed by the set objectives, methodologies, and data availability. This study was focused on household level or local scale with the enthusiasm to analysis the farm household vulnerability to climate change and their strategies. Then the households were classified in to three categories (i.e. highly vulnerable, vulnerable and less vulnerable) based on the value of their vulnerability index [24]. Accordingly, the index computed shows the relative measure of vulnerability, representing the households' own experience of deal with in the past compared to other households than indicating thresholds or an absolute status of the household.

2.4 Econometric Model to Analysis Factors Influencing Household Vulnerability

Various factors ranges from socio-economic to biophysical were suggested in different research as the major contributor to the vulnerability of households' to climate change in the rural area [19,23,24]. Accordingly, this research also analyzed factors that determining the vulnerability of households in the study area using ordinal logistic regression model. Because the ordinal logit model always used when, the outcome variable is categorized in an ordinal scale. In this case, since where vulnerability is ordered as **(1)** highly vulnerable, which implies households for whom the difference between adaptive capacity and sensitivity/exposure is significantly negative; **(2)** moderately vulnerable, which indicates that households for whom the difference between adaptive capacity and sensitivity/exposure is nearly zero; and **(3)** less vulnerable, which infers that the difference between adaptive capacity and exposure/sensitivity is significantly positive. In this study, sensitivity of households to climate change is represented by its associated impacts, i.e., shortage of food, loss of water and pasture resources faced by given households. Regards to exposure, was analyzed assuming all households are located in the same environment, thus exposure is almost uniform across the respondents residing in the study area. Consequently, this model is particularly useful in that it can show movement between vulnerability groups, explaining who moves in and out of vulnerability. Following [32], the reduced form of the ordinal logit model is given as:

$$Y = X_j^I \beta + UIj \tag{5}$$

Where **Y** is the level of vulnerability and involves ordered outcome, that is, **Y=1** was given to households that have a high level of vulnerability as observed by the negative value of adaptive capacity minus sensitivity/exposure; **Y=2** was given to households having adaptive capacity nearly equal to their sensitivity/exposure; and **Y=3** was given to households having their adaptive capacity exceeding their sensitivity and exposure. $\mathbf{Y^*}$ is the given state of vulnerability. The $\mathbf{X_{ij}}$ are the explanatory variables determining vulnerability level of the households'. The independent variables included in the model were sex, age of the household head, experience in the study area, household size, education level of the household head, dependency, marital status, social linkages, visits by extension officers, access to early warning information, non-farm income, herd size, herd structure, access to markets, property regimes, access to remittances, employment, coping strategies, herd diversity, credit access, herd mobility, climate change, experience in increased temperature, drought, floods, and wind, and natural hazards encountered in 5 years. $\mathbf{\beta_S}$ are parameters estimated, and $\mathbf{U_{ij}}$ is the disturbance term. **Y*** is unobserved, but what was observed in this study is:

- ✓ $Y = 1$ if $Y^* \leq \mu 2$
- ✓ $Y = 2$ if $\mu 2 < Y^* \leq \mu 3$
- ✓ $Y = 3$ if $\mu 3 < Y^*$

Given the cumulative normal function **Φ (β' x),** the probabilities can be shown, thus,

- ✓ Prob [y=1 or highly vulnerable]= $\Phi(-\beta' x)$,
- ✓ Prob [y = 2 or neutral level of vulnerability] = $\Phi(\mu_2-\beta' x)-\Phi(\mu_3-\beta' x)$
- ✓ Prob [y=3 or less vulnerable]=$1-\Phi(\mu 3-\beta' x)$

3. RESULTS AND DISCUSSION

3.1 Measuring Socioeconomic and Biophysical Vulnerability

The trans-boundary nature of climate change makes its impact global in its concern. However, vulnerability to climate change is different from region to region, community to community and from one specific household to the other within the same city or village. Exposure or sensitivity nature of the system (i.e., social, economic and biophysical system) and their adaptive capacity to the impacts of climate change is the primary reason for the marked variation to the vulnerability of individual household or community.

3.1.1 Social vulnerability

Social vulnerability is the one which is internal to the households or community. The households' vulnerability to climate change is mainly due to weaknesses in social capital or vulnerability. The analysis results in Table 1 indicates that 67% of respondent have dependent family member and due to having this much number of dependent family member the respondents reported that they have been facing challenge, particularly during climate fluctuation. This is because the more dependents a household, the more likely for it to be vulnerable since a more significant proportion of household resources are directed to dependents who cannot contribute much toward household welfare [24]. The problem is also severe in the households which are relatively weak in comparison to resource endowed. On the other hand majority of respondents, 43%

were reported as they are illiterate and even not able to read and write their name as well. This implies that farmers in the area were lack of ability to analyse early warning information given on the future effects of climate change and the action to tackle (prevention) or to reduce (preparedness) the extent of its impact on their living. This is in line with the study conducted in North *Gonder* [33]. The founder states that lack of education is among the variable that put farm households to be vulnerable in the area. Since well-educated people are in better position to manage risks related to climate change and its impact [34].

In the regards to extension service, about 62% of farmers were reported as they were not continuously visited with development agent thought there was minimums of two extension workers were assigned to serve the community. Government policy and strategies were addressed to the city, and various developmental activities carried out within the grass root level have been mainly through using this channel. But due to the ineffectiveness of this and weakness in early warning system channel, 91% of farm households in the area noticed as they were not well informed ahead of climate change impact that experienced in their communities. This boldly suggests that it is the major contributing factors for the vulnerability of the population. Because rural households who have better access to education, livelihood strategy, social network and early warning system to extreme climate risks have a better adaptive capacity and lesser vulnerability to climate change impacts [33].

3.1.2 Economic vulnerability

This is among the variables which are internal to the households and ability to determine their vulnerability. The analysis output in Table 1 shows that about the total interviewed (100%) of homes noticed that agriculture is their primary income sources and of which majority, about 82% is depended solely on rain-fed, and only 18% is supported with small-scale irrigation, which is mainly home garden. Similarly, of the interviewed around 70% of the farmers mentioned as they do farming to cover only the consumption need of their households.

On the other hand, 93% of the interviewed were reported as they have no other means of income source than farming. But the rest only 7% experienced diversifying income from other sources. This was mainly from non-farm income sources that practised primarily in the off-season in the forms of wage labourer in the nearby town, in cement factors exist in their community like *Muger*, *Dangote*, Capital, *Bedrock* and *Habesha*, and by moving to a distant area in search of temporary work. This is in line with a study conducted by [23] in the North *Shewa.* It indicated that household operates on less diversified livelihoods, low access to credit and market, small landholding, the small area under irrigation are under the high level of economic vulnerability. In contrast, a household with diversified income sources and developed institutional structures is better able to manage risks and prevent biophysical impacts from translating into human impacts [34].

Concerning to rural finance, about 36% of the farmers were noted as they have no access to credit. On the other hand, agricultural technology, chemical fertilisers and improved seeds are scarce and extremely priced now. Therefore, most smallholder farmers cannot afford them [34]. This means their intention to widen and mechanise their agricultural activities was insufficient. As a result, the chance of households vulnerability was increasing given their dependence on subsistence farming.

3.1.3 Biophysical vulnerability

A biophysical vulnerability is purely external and mostly not controllable factors of vulnerability irrespective of the scale. Table 1 indicates that 100% of farmers were reported as a temperature of the area is increased and mention this as the primary reason for the susceptibility of their livelihood. This is because an increase in temperature of the city is mostly associated with reduction or complete loss in their crop yields and seriously challenging the households with the lack of feed and water, and frequent occurrences of disease for their livestock.

Concerning precipitation, about 36%, 25%, 20% and the rest 19% of the interviewed were reported as the amount of rainfall were decreased, increased, changed in the time of raining and increase in the frequency of drought in the area, respectively. Here not the other even increase in precipitation has also negative consequence in their living because such increase in rainfall after prolonged drought leads to flood with which they were suffering regarding damage in their property, environment and livelihood.

Similarly, about 83% of interviewed households also reported the prevalence of such extreme events in the area and their experience of a devastating impact on their livelihood. The significant effects that tenants mentioned due to such extreme events include the reduction in crop yield, complete loss of their crop, lack of water and pasture for their animal, prevalence in animal disease and failure of their livestock due to such extreme event in their community. In addition to this, 95% of informants were reported as they were also profoundly challenged with less fertility of their land and associated low productivity in their farming. This is in convergence with reports of [24] who indicated that steeply sloping farmlands coupled with low fertility level due to various degradation to soil erosion, below average rain and mounting temperature and its effect have the significant contribution to the vulnerability level of farmers. This is also what majority of interviewed households confirm as one of the first constraints that increase their susceptibility to the occurrence even miner abnormality in the climate of the area.

Table 1. Social, economic and environmental indicators and their effect on vulnerability level of household

Variables	Character	%
Social variables		
Sex of HH head: female-headed HH	Male	83
	Female	17
Age of HH head: above 65 years	Below 30	6
	30-65	84
	Above 65	10
Family size: more with dependent family group	HH with less than five members	25
	HH with more than five members	75
	HH with more than 5 & which is dependent	67
Educational level: HH with no primary education	Illiterate	43
	Read & Write	17
	Primary	40
Health: access to health service	Yes	80
	No	20
Experiences: farmers with having less than ten years' experience	Short	11
	Medium	60
	High	29
Extension service:	Yes	37
	No	63
Road: local road network	Yes	79
	No	21
Access to climate information or access to an early warning system	Yes	91
	No	9
Marital status	Married	95
	Divorced/separated	5
Economic variables		
Wealth status of the HH	Rich	7
	Medium	67
	Poor	26
Source of income	Cattle	1
	Crop	9
	Mixed	90
Land ownership	Yes	92
	No	8
Types of agriculture	Rainfed	82
	Mixed (rainfed & irrigation)	18

Variables	Character	%
Reason for farming	HH consumption	70
	Profit making	12
	Mixed purpose	18
Access to input	Yes	96
	No	4
Use of input: improved seed & fertiliser	Yes	97
	No	3
Credit access: having no access to credit at all	Yes	64
	No	36
Non-farm income: HH with no nonfarm income	Yes	7
	No	93
Distance to markets: more than 10 km away	Yes	79
	No	21
Environmental variables		
Temperature: experiencing the increase	Increase	100
Changes in the pattern of precipitation	Increase	25
	Decrease	36
	Change in time of raining	20
	Increase in freq. of drought	19
Sloppy	Plain	2
	Medium	78
	Seep	20
Soil fertility	Infertile	2
	Less fertile	95
	Fertile	3
Hazard experience	Yes	83

Sources: Computed from HH survey of 2017 and Districts report.

3.2 Measuring Household Level Vulnerability

The household level vulnerability of the study area was analysed by employing different indicators of vulnerability using PCA. Accordingly, the variables under social and economic aspect measure adaptive capacity while the variables under the section of environment aspect measure the sensitivity and exposure to climate change impacts (Table 2). During the computation of PCA in STATA software, the indicators which revealed two components with the eigenvalue more significant than 1 and explained 75.9% of the variation in the dataset. Of these two components, the first principal component explained 47.6 and the second primary component explained 28.3%. By considering the level of variation explained, the first principal component was taken, which told the majority of change in the dataset.

In the Table 2 majority of factor score of the first PCA was negatively associated with several indicators under social and economic, and environmental aspect which identified as adaptive capacity, and sensitivity and exposure, respectively. Here the sign and magnitude of each principal component score play a significant role because it implies two things. An indicator with the negative index indicates that the household has relatively lower adaptive capacity in comparison to a home with a positive index value and vice versa, keeping exposure and sensitivity constant. The reason is that adaptive capacity is considered as positively contributing to the reduction of vulnerability, while exposure and sensitivity are negatively contributing to vulnerability reduction since they are external. Based on these, households were categorised into the different level of vulnerability thereby to understand susceptibility of each home in the community better. This is necessary step to devise ways that can contribute to increasing their adaptive capacity at the same time helps to reduce their driving factors. Out of 25 indicators used in the analysis about 16 are negatively associated with vulnerability, i.e., 12 are under adaptive capacity, and four are under sensitivity and exposure.

Table 2. Factor score for the first principal component analysis

Variables	Primary component score
Social vulnerability variables	
Sex of HH head: female-headed HH	+0.008
Age of HH head: above 65 years	-0.105
Family size: more with dependent family group	-0.028
Educational level: HH with no primary education	-0.396
Health: access to health service	+0.954
Experiences: farmers with having less than ten years' experience	-0.124
Extension service: farmers who do not frequently get visit per year	-0.043
Road: local road network	+0.958
Access to climate information: no knowledge to use	-0.112
Economic variables	
Wealth status of the HH: poor households	+0.288
Source of income: income from rain-fed farming	-0.568
Land ownership: farmers who have no own land	-0.073
Types of agriculture: rainfed agriculture	-0.027
Reason for agriculture: for personal consumption	-0.083
Access to input: who have no access to get input	+0.912
Use of information: farmers who are not using improved seed & fertiliser	+0.974
Credit access: HH who have no access to credit at all	-0.026
Non-farm income: HH with no other option of income than farming	-0.004
Distance to markets: HH who have no market in their nearby	-0.073
Environmental variables	
Temperature: HH who experienced the increase in temperature	−0.182
Precipitation: HH who change the pattern of rainfall	-0.008
Sloppy: HH who farm in steep slope	+0.875
Soil fertility: HH who own in a fertile land	-0.221
Hazard experience: HH who didn’t experience extreme events	-0.061

Sources: STATA output of principal component analysis from data of 2017 HH survey.

The computation of vulnerability index of each household in the study area is carried out using Eq.4 that discussed in the previous section. Accordingly, via Eq.4, the vulnerability index is calculated using the indicators listed under adaptive capacities, which are positively associated with the first PCA, and signs of sensitivity and exposure, which are negatively associated with the first PCA, were used in this calculation. Consequently, the variables considered in this equation are including sex, access to health service, availability of local road network, wealth status, access to input and use of information from the adaptive capacity side and change in temperature, change in the pattern of precipitation, soil fertility of the land owned by the household and hazard experienced by the family from the indicators mentioned under sensitivity and exposure.

As result households in the study area were classified into three categories using the vulnerability index (Fig. 1). Accordingly, under the first category, the finding reveals that majority, 42% of the households identified as under the category of moderately vulnerable, their principal component index (PCI) lay between in the range of -1 to +1. This implies that households need urgent but temporary assistance in case of shock and stresses. Second, about 38% of households are under the category of highly vulnerable, for which PCI lay between in the range of -1.1 to -3. This indicates that those households are in the sever situation, mean as they are almost at a point of no return. Third, the outcome illustrates about 20% of the farm households are under the category of less vulnerable. This is because the computed PCI lay between the ranges of +1.1 to +3. This shows that houses are in a sensitive situation but can still cope with the moderate level of climate-induced shocks.

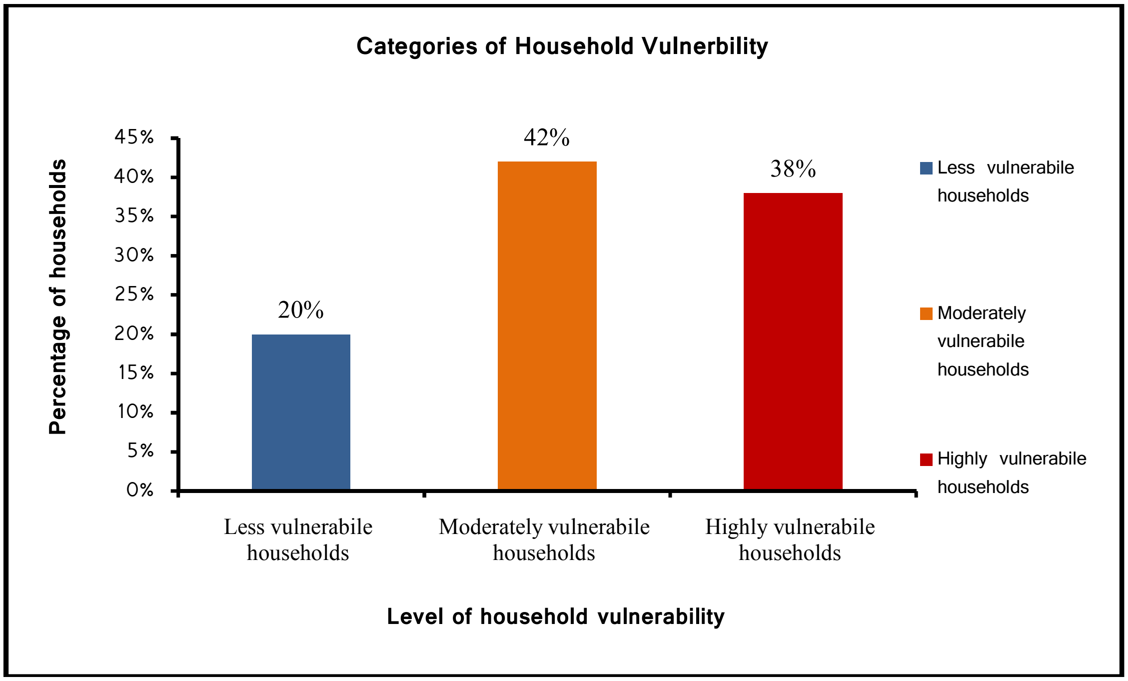

Fig. 1. Household's vulnerability to climate change impacts in *Adalber*to district

3.3 Determinants of Household Vulnerability

The econometric result that summarised in Table 3 shows among the 25 hypothesised factors on the vulnerability of households to climate change; ten variables were found to have significant influence at a different level. Of these significant variables, eight variables were found negative, and the rest two are positively associated with the vulnerability of the households. The variables that are significant and associated positively with the vulnerability level of the house shows the decisive role in the reduction of household vulnerability. In contrast, variables which were found significant and negatively related to the weakness of households imply negative contribution of the variables to the susceptibility of the families. Accordingly, variables which were found significant are discussed in detail below.

Sex of the household head: the result reveals that female-headed households are negatively associated with the vulnerability of houses at the $P<0.05$ level. This implies that, of those highly vulnerable households, female-headed households are the one. The possible explanation here is that families with female-headed are in such a situation probably because women may be disadvantaged from getting valuable information related to forecasted hazardous climate. This finding is in line with [35] conducted in southwest Nigeria. The outer indicates that female-headed households are more vulnerable to the effects of climate change than their male counterpart. The main reason for this is that female-headed households are more poverty prone than male-headed farming households [36].

Family size: is negatively associated with the vulnerability of the households to the impacts of climate change. The inverse odds ratio of $11.54E^{-4}$ of the odds ratio of $8.667E^{-6}$ indicates that households with more number of the dependent family member are by $11.54E^{-4}$ times highly vulnerable to changes in climate at $P<0.05$ level. This implies that a home with an additional amount of dependent family member is susceptible to the effect of climate change. This may be due to households face the challenge to feed a number of dependent family members during the livelihood of the house badly hit by the impact of climate change. In contrary to the present study [37,38] found that households who have significant family size are not vulnerable than the counterpart. Their reason is that large family size is anticipated to enable tenants to take up labour-intensive adaptation measures and to reduce the vulnerability of that specific household. Similarly, [39] notice that households with a large family size are not vulnerable because the large family might be forced to divert part of its labour force into non-farm activities to generate more income and reduce consumption demands.

Farm experience: is one of the determinant factors to the rural household in the face of climate change. Accordingly, farmers with having less than ten years' experience are negatively related to the vulnerability of households. Moreover, the computed inverse odds ratio of $2.99E^{-6}$ of the odds ratio of $3.3472E^{-5}$ indicates that a farmer with the short period of farm experience is by $2.99E^{-6}$ times highly vulnerable to the disastrous impact of climate change compared to farmers with the long period of experience in farming at P<0.1 level. This indicates that households headed with the short period of farming experience moderately vulnerable to the climate change. [40] found that improved knowledge and farming experience is positively influenced farmers' decisions to take up measures that able them to reduce their vulnerability. Similarly, the finding of [41] indicates that experienced farmers are expected to have more knowledge and information about climate change, and agronomic practices that they can use in response to climate stimuli and that helps them to reduce their vulnerability in the area.

Access to climate information: households who have no access to climate information are negatively related to the vulnerability of the houses in a strongly significant manner. The computed inverse odds ratio of $1.397E^{10}$ of the odds ratio of $7.160E^{-9}$ indicates that households who have access to climate information are by $1.397E^{10}$ times highly vulnerable to the stress of climate change and this is significant at P<0.01 level. This implies that households who have no access to climate information are highly vulnerable to the adverse effect of climate change in the area. The likely explanation for this is that, if the household didn’t get essential information early, the families might be at the state of risk and vice versa. Thus, in the face of climate fluctuation households who get new climate information and who don't get it is not equally vulnerable to the impact of climate change. Because families who notice and are aware of changes in climate and its effects would take up any appropriate measures that help them to reduce losses associated with these changes [40]. Similarly, [41] found that households' awareness of changes in climate attributes is essential for preventive decision making. Since, access to information has mixtures of impacts on the decision-making ability of farm households [37].

Wealth status of the households: is negatively associated with the vulnerability due to climate change. The computed inverse odds ratio of $10.00E^{2}$ of the odds ratio of 0.001 indicates that the houses in the community by $10.00E^{2}$ times highly vulnerable due to their resource base at the significance level of P<0.1. This infers that households in the study area are highly sensitive to the impacts of climate change due to their low wealth status or limited resource endowments. The possible suggestion for the significant level of vulnerability of the households due to their wealth status is strongly associated with the poorhouse, who have limited resource base to invest in various activities which helps them to reduce their vulnerability to extreme events. Correspondingly, multiple researchers also support the idea that poor people are highly vulnerable due to their poverty level, wealth status and they have less money to spend on preventative measures, emergency supplies, and recovery efforts [42,43,44].

Source of income: is the variable which positively associated with the vulnerability of the households in the area. The computed inverse odds ratio of $10.84E^{13}$ of the odds ratio of $9.222E^{15}$ implies that families in the community are not vulnerable to the impact of climate change by $10.84E^{13}$ times due to their income source at the significance level of P<0.01. This shows that some of the households in the community are not vulnerable because of the income source. The probable suggestion for this is maybe houses who have income from various sources in comparison to homes who get their income source only from agriculture, i.e., from a fixed resource like a tree, crop production and livestock rearing. [45] indicates that farm households with higher income sources are less vulnerable to impacts of climate change because have options to take preparedness measures. On the other hand, a unit increase in farm income increases the probability of reducing the vulnerability of households to the impact of climate change [19].

Reason for farming: is the variable negatively related to the vulnerability of households to the impacts of climate change. The inverse odds ratio of $10.00E^{2}$ of the odds ratio of 0.001 indicates that families with the aim of farming for household consumption are vulnerable by

$10.00E^2$ times to the fluctuation in a climate of the area in comparison to households who practice farming for additional income sources of a house. This infers that a home that practices subsistence farming in contrast to dwellings who make farming to both purposes are highly vulnerable to the impacts of climate change. The probable reason is that if a single unexpected weather extreme occurs, may lead to a complete loss of field, which is the only livelihood of this households thereby lead to face a severe challenge of life in contrast to farm households who practice farming with additional aim. Similar studies conducted by [46] reported that poor or rural families who depend primarily on agriculture for their economic or livelihood sustenance are the most vulnerable population group because the impact of climate change mostly leads them to a general deterioration in households' welfare. The reason here is the effects of climate change, or climate variability is not evenly spread among the different socio-economic household groups [41].

Table 3. Ordinal logistic regression model analysis regarding the effects of various factors that influence households to be vulnerable to climate change and variability

Determinants variables	Estimation	Stand error	Odds ratio	z	P-value
Sex of HH head: female-headed HH	-7.822	0.0378	0.000	3.939	0.003**
Age of HH head: above 60 years	-0.201	0.040	0.818	0.002	0.098
Family size: more with dependent family group	-11.66	0.196	8.667E-6	0.000	0.000***
Educational level: HH with no primary education	-2.727	0.092	0.065	2.482	0.208
Health: access for health service	12.89	0.040	3.975E5	0.620	0.380
Experiences: farmers with having less than 10 years' experience	-10.268	0.060	3.3472E-5	3.821	0.032*
Extension service	-6.226	0.050	0.002	3.639	0.101
Road: local road network	-10.067	0.040	4.247E-5	0.375	0.192
Access to climate information	-18.755	0.168	7.160E-9	5.282	0.000***
Wealth status of the HH	-6.524	2.056	0.001	2.056	0.046*
Source of income	36.760	0.035	9.222E15	0.000	0.000***
Land ownership	2.939	0.027	18.893	0.524	0.426
Types of agriculture	-2.570	0.077	0.077	1.724	0.163
Reason for farming	-7.267	0.078	0.001	3.120	0.000***
Access to input	-26.690	0.020	2.56E-12	0.001	0.016**
Use of input: improved seed & fertilizer	-6.206	0.017	0.002	3.293	0.070
Credit access: having no access to credit at all	-0.044	0.48	0.957	0.000	0.986
Non-farm income: HH with no farm income	61.759	0.026	6.631E26	0.001	0.000***
Distance to markets: more than 10 km away	-0.761	0.041	0.467	0.002	0.959
Climate change: experiencing change	2.687	0.038	14.691	0.505	0.000***
Temperature: experiencing increase	7.485	0.054	1.781E3	0.000	0.363
Changes in the pattern of precipitation	-1.426	0.140	0.240	0.000	0.255
Sloppy	-2.729	0.044	0.065	0.739	0.686
Soil fertility	5.264	5.805	1.9329E2	0.822	0.364
Hazard experience	2.687	3.781	14.691	0.505	0.477

, ** & * Significant at $p<0.1$, $p<0.05$ & $p<0.01$ respectively*

Access to input: households who have no access to information are negatively related to the vulnerability to climate change. The computed inverse odds ratio of $3.91E^{11}$ of the odds ratio of $2.56E^{-12}$ indicates that households who have no access to agricultural input are by $3.91E^{11}$ times highly vulnerable to the impacts of climate change at $P<0.01$ level. This suggests that families who have no access to agricultural information are highly sensitive to the adverse effect of climate change in the area. Currently, lack of access to agricultural input is mainly related to the capacity to buy it because it is becoming costly. Due to this, the productivity of crop production is reduced thereby vulnerability of the households to the impact of climate change is increased in the area. Similarly, farmers in Nigeria were also challenged with the scarcity of agricultural input mainly because of the high cost of farm inputs beyond the reach of the farmers' capacity to buy [47]. Lack of access to data due to various reasons like finance, credit facilities and information for the action to take because of climate change stresses are the significant challenges of farmers of southern Africa [48].

Non-farm income: HH with additional non-farm income is significantly and positively associated with vulnerability to climate change. The inverse odds ratio of $15.1E^{24}$ of the odds ratio of $6.631E^{26}$ indicates that households who involve in non-farm income are not vulnerable by $15.1E^{24}$ times to average change in climate contrary to his counterparts. The probable suggestion is that houses who have experience in involving in non-farm income in addition to farm income may have one more chance to invest in preparedness action. In line to this [49] found that households who have opportunities to be involved in non-farm income have an alternative source of income and that can be invested in various appropriate measures when the household stick by shock. On the other hand, a study conducted in West-Arsi by [50] indicates that households who are not flexible for multiple income sources during climatic variability are highly vulnerable.

4. CONCLUSIONS AND POLICY IMPLICATION

Understanding the vulnerability level of the human or biophysical system is a paramount stage in the face of climate change. The action is worth particularly in a community where rain-fed agriculture is the only means of living coupled with the current climate reality. Here the vulnerability of a given city or individual households to the impacts of climate change is emanated either due to having low adaptive capacity because of their weak socio-economic characteristics or due to high exposure and sensitivity of the households as well as the community. In the view of this, analysing the farm households' vulnerability towards climate change and its determinate factors was the prime aim of this study. Hence, the analysis result of this study shows that the levels of households' vulnerability within the district were different from one *kebele* or community to the other and from households to household even within the same neighborhood.

The finding indicates that households characterized with weak socio-economic capital, i.e., houses that owned more numbers of dependent family member, who are headed with illiterate, didn't get frequent visit from extension worker, who are solely depends on rain-fed agriculture, no more chance to support household income and no access to credit service were more vulnerable to the adverse effects of climate change. Similarly, households that were exposed to all or some of the biophysical vulnerability like an increase in temperature, change in the pattern of precipitation, practice on sloppy land, and less fertile soil are showed as they were relatively vulnerable to the impact of climate change. But households with some capacity of socio-economic and biophysical characteristics are in the relative level of vulnerability. As result of this, some of them are almost at a point of no return, need urgent but temporary assistance, and in a vulnerable situation but can still cope-up with aa moderate level of climate-induced shocks.

This level of vulnerability of individual households indicates that the existence of low adaptive capacity and high exposure and sensitivity. This implies as which families are currently vulnerable and which are not. Consequently, homes that are not presently vulnerable means are not to mean they are not will be susceptible even in the near future because vulnerability is dynamic with time and conditions. Thus, a local level planner can quickly identify the vulnerable households in the community and can readjust their work by providing spatial emphasis to those at risk currently.

Therefore, it calls for policies and strategies that able to reduce both current and future vulnerability of the households and communities under broader sphere of sustainable development agenda. Pertinent policy can take urgent action in the intent to reduce the underlying vulnerability of the individual households through working to strengthen adaptive capacity of the households while reducing their exposure and sensitivity. Solid policy can achieve this through developing context-based strategies by which the local and national interventionist practitioners can exert their unreserved efforts through strengthening the social, economic and environmental capacity of the households which determines their vulnerability to the impact of climate change.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. IPCC (Intergovernmental Panel on Climate Change). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the *Fifth Assessment Report* of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA; 2013.
2. IPCC (Intergovernmental Panel on Climate Change). Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of Working Group II to the fifth assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA; 2014.
3. Hulme M, Doherty RM, Ngara T, Lister MG. African climate change: 1900-2100, Climate Research. 2001;17:145-168.
4. Linkd Environmental Services, 2012. Methodology: Climate Change Risk and Vulnerability Assessment for Rural Human Settlements. Prepared by Link*d* for the Department of Rural Development and Land Reform: Spatial Planning and Facilitation Directorate. Model 2012.
5. Lingaraj GJ, Upadhyay H, Ghosh S, Balakrishnan S, Mishra A, Bhadwal S, Nair S. Review of vulnerability assessments in India; Regional context for Vulnerability Assessment; Policy Framework in India to Address Climate Change and Development of Methodology for Climate Change Vulnerability Assessment; 2014.
6. IPCC (Intergovernmental Panel on Climate Change). Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK; 2007. ISSN: 1520-5509.
7. IPCC (Intergovernmental Panel on Climate Change). Climate change 2001: Impacts, Adaptation and Vulnerability, Summary for Policymakers, WMO; 2001.
8. Smit B, Wandel J. Adaptation, adaptive capacity and vulnerablity. Global Environmental Change. 2006;16:228–292.
9. Heltberg R, Osmolovskiy MB. Mapping vulnerability to climate change. World Bank, 1818 H Street, Washington, DC, USA; 2010.
10. IFPRI (International Food Policy Research Institute). Agriculture And climate change: An Agenda for negotiation in Copenhagen. 2020 focus 16; 2009.
11. Adger WN. Social vulnerability to climate change and extremes in Coastal Vietnam. World Development. 1999;27(2):249-269.
12. Hinkel J. Indicators of vulnerability and adaptive capacity: Towards a clarification of the science-policy interface. Global Environmental Change. 2011;21:191–208.
13. USAID (United State Agency for International Development). Adapting To Climate Variability and Change: A Guidance Manual for Development Planning, Washington, DC, USAID; 2007.
14. Challa A, Abdelkadir A, Mengistu T. Effects of graded stone bunds on selected soil properties in the central highlands of Ethiopia. International Journal of Natural Resource Ecology and Management. 2016;1(2):42-50.
15. Fikre G, Multi A. Method approach to study landslide hazard. A case study in Ada BergaWoreda, Western Showa Zone, Oromiya Region, Ethiopia. MSc Thesis, Addis Ababa University; 2010.
16. CSA (Central Statistics Authority). The Federal Democratic Republic of Ethiopia Statistical abstract. Addis Ababa, Ethiopia; 2013.
17. Fekadu B, Mequanent M. Determinants of food security among rural households of Central Ethiopia: An empirical analysis. Quarterly Journal of International Agriculture. 2010;49(4):299-318.

18. Füssel H. Vulnerability: A generally applicable conceptual framework for CC research. Global Environmental Change. 2007;17:155–167.
19. Deressa T, Hassan RM, Alemu T, Yesuf M, Ringler C. Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the nile basin of Ethiopia. IFPRI Discussion Paper; 2008.
20. Allen K. Vulnerability reduction and the community-based approach: A Philippines study. In Natural Disasters and Development in a Globalizing World, Ed. M. Pelling. 2003;170–184.
21. Kelly PM, Adger WN. Theory and practice in assessing vulnerability to climate change and facilitation adaptation. Climatic Change. 2000;47(4):925–1352.
22. Madu AI. Spatial vulnerability assessments of rural households to climate change in Nigeria: Towards evidence-based adaptation policies; 2012.
23. Tesso G, Emana B, Ketema M. Analysis of vulnerability and resilience to climate change induced shocks in North Shewa, Ethiopia. Agricultural Sciences. 2012;3(6): 871-888.
24. Opiyo FO, Wasonga OV, Nyangito MM. Measuring household vulnerability to climate-induced stresses in pastoral rangelands of Kenya: Implications for resilience Programming; 2014.
25. Brooks N, Adger WN, Kelly PM. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environmental Change. 2005;15:151-163.
26. Moss R, Brenkert A, Malone E. Vulnerability to climate change, a quantitative approach; 2001.
27. Lucas HB, Hilderink M. The vulnerability concept and its application to food security P.L. RIVM report 550015004/2004.
28. Patnaik U, Narayanan K. Vulnerability and Climate Change: An Analysis of the Eastern Coastal Districts of India. Paper was presented in an international workshop on "Human Security and Climate Change" at Holmen Fjord Hotel, Asker, near Oslo, on 21–23 June 2005, Organized by the Centre for the Study of Civil War, International Peace Research Institute, Oslo (PRIO) & Centre for International Environmental and Climate Research at the University of Oslo (CICERO) for the Global Environmental Change and Human Security Program (GECHS); 2005.
29. Cutter SL, Boruff BJ, Shirley WL. Social vulnerability to environmental hazards. Social Sciences Quarterly. 2003;84(2): 243–261.
30. Thornton PK, Boone RB, Galvin KA, Burn SB, Waithaka MM, Kuyiah J, Karanja S, Gonzalez-Estrada E, Herrero M. Coping strategies in livestock-dependent households in East and southern Africa. Human Ecology. 2007;35(4):461–476.
31. IPCC 2012. Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups i and ii of the intergovernmental panel on climate change, Cambridge University Press, Cambridge and New York.
32. Green WH. Econometric Analysis, 4th ed. Prentice-Hall, Upper Saddle River, NJ; 2000.
33. Sisay T. Vulnerability of smallholder farmers to climate change at Dabat and West Belesa Districts, North Gondar, Ethiopia. J Earth Sci Clim Change. 2016;7: 365.
34. Heltberg R, Osmolovskiy MB. Mapping vulnerability to climate change. World Bank, 1818 H Street, Washington, DC, USA; 2010.
35. Amusa TA, Okoye CU, Enete AA. Gender-based vulnerability and contributions to climate change. Adaptation decisions among farm households in Southwest Nigeria. American-Eurasian J. Agric. & Environ. Sci. 2015;15(9):1779-1789. ISSN: 1818-6769.
36. Olorunsanya EO, Omotesho OA. A gender analysis of poverty profile of rural farming households in North Central, Nigeria. Int. J. Agric. Econs and Rural Dev. 2011;4(2):11-26.
37. Dolisca F, Carter RD, McDaniel JM, Shannon DA, Jolly CM. Factors influencing farmers' participation in forestry management programs: A case study from Haiti. Forest Ecology and Management. 2006;236:324-31.
38. Anley Y, Bogale A, Haile-Gabriel A. Adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers in Dedo district, Western Ethiopia. Land Degradation and Development. 2007;18: 289–302.

39. Tizale CY. The dynamics of soil degradation and incentives for optimal management in the Central Highlands of Ethiopia. PhD thesis, Department of Agricultural Economics, Extension and Rural Development, Faculty of Natural and Agricultural Sciences, University of Pretoria; 2007.
40. Hassan R, Nhemachena C. Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. AfJARE. 2008;2(1).
41. Maddison D. The perception of and adaptation to climate change in Africa. CEEPA Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa, University of Pretoria; 2006.
42. Long AP. Poverty is the new prostitution: race, poverty, and public housing in post-Katrina New Orleans. J. American History. 2007;94:795-803.
43. Cutter SL, Emrich CT, Webb JJ, Morath D. Social vulnerability to climate variability hazards: A review of the literature. Hazards and Vulnerability Research Institute, Department of Geography, University of South Carolina, Columbia, SC 29208; 2009.
44. Fothergill A, Peek L. Poverty and disasters in the United States: A review of recent sociological findings. Natural Hazards. 2004;32(1):89-110.
45. Tessema SA, Yibekal AY, Chanyalew, Endris GS. Understanding the process of adaptation to climate change by small-holder farmers: the case of east Hararghe Zone, Ethiopia. Agricultural and Food Economics; 2013. Available:http://www.agrifoodecon.com/content/1/1/134
46. Juana JS, Makepe PM, Mangadi KT. Empirical analysis of the impact of drought on the Botswana economy, Presented at the AERC/UNU-WIDER Climate Change Workshop, Helsinki, 25-29 September, 2012.
47. Ozor N. Understanding climate change. Implications for Nigerian Agriculture, policy and Extension.Paper presented at the National conference on climate change and the Nigeria Environment. Organized by the Department of Geography, University of Nigeria, Sukka; 29 June-2nd July, 2009.
48. Nhemachena C, Hassan R. Micro-level analysis of farmers' adaptations to climate change in Southern Africa. IFPRI, Environment and Production Technology Division. Washington, DC: International Food Policy Research Institute; 2007.
49. Obayelu AO, Adepoju AO, Idowu T. Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria. Journal of Agriculture and Environment for International Development-JAEID. 2014;108(1):3-16. DOI: 10.12895/jaeid.20141.140
50. Abate FS. Climate change impact on livelihood, vulnerability and coping mechanisms: A case study of West-Arsi Zone, Ethiopia. LUCSUS, Lund University SE-22644, Lund, Sweden; 2009.

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