Factors affecting vulnerability level of farming households to climate change in developing countries: evidence from Eritrea

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Abstract. Most research conducted on vulnerability assessment considers grossly at regions, countries and population groups on an aggregation of the communities. Few if any have critically assessed vulnerability at the individual household level in developing countries. In this research, an assessment of factors that determine the vulnerability level at the farming household in developing countries focused in Eritrea has been conducted. Based on the data from the baseline survey of the Ministry of Agriculture Eritrea, an econometric analysis was conducted to assess the factors affecting vulnerability levels to climate change. A logistic regression model was used and result indicates that various socioeconomic, biophysical and environmental factors influenced vulnerability levels of households differently. Important factors including level of education, profession, location, gender, income diversity, poverty level, access to credit and market, poverty level, dependency ratio and access to clean water were found to affect significantly the vulnerability level to climate change of farming households. It is recommended that development policy targets on key points that promote resilience and adaptive capacity of farming household, including education, gender equality, income generation, access to credit and market.

1. Introduction
The term “vulnerability” has no universally accepted definition, largely because different disciplines use the term differently to explain their areas of concern. Studies on life sciences define vulnerability as the degree to which an exposed unit is susceptible to being harmed by exposure to stress, in conjunction with its ability to cope, recover or adapt [1]. In contrast, poverty and development literature, which focuses on social, economic and political conditions, defines vulnerability as an aggregate measure of human welfare that integrates environmental, social, economic, and political exposure to a range of harmful perturbations. IPCC defines vulnerability as the inability to withstand the adverse impact of exposure to stresses or shocks associated with environmental and social change, and the absence of the capacity to adapt to the impact [1], [2]. Adger and Kelly define social vulnerability as the exposure of groups or individuals to stress as a result of social and environmental change, where “stress” refers to unexpected changes and disruptions to livelihoods [4]. The Intergovernmental Panel on Climate Change (IPCC) (2007) defines vulnerability to climate change as the degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes, and vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity [3].

The adverse effect of climate change and variability has become an environmental and socioeconomic problem causing vulnerability at the global, regional, community or household level.
Reports show that in Sub-Saharan Africa, many vulnerable regions are likely to be adversely affected by climate change [5]. These include the mixed arid-semiarid systems in the Sahel, arid-semiarid rangeland systems in parts of Eastern Africa, the systems in the Great Lakes region of Eastern Africa, the Coastal regions of Eastern Africa and many of the drier zones in Southern Africa [6]. According to [7] households that rely on rain-fed agriculture are more vulnerable to climate change. Poor and landless households, children, women and large-sized families are mostly affected by climatic shocks. Social and ecological conditions that influence poor people’s lives and make people vulnerable to climate change include lack of access to basic social services, loss of employment opportunities, lack of empowerment to participate in political processes, violence and insecurity as well as environmental degradation and lack of access to important natural resources [8].

According to [9] many factors contribute to vulnerability, and these factors act to undermine the capacity for self-protection, blocks or diminish access to social protection, delays recovery or expose some groups to greater or more frequent hazards than other groups. The factors that contribute to vulnerability include rapid population growth, poverty and hunger, poor health, low levels of education, gender inequality, fragile and hazardous location, and lack of access to resources and services, including knowledge and technological means and disintegration of social patterns [10]. It was further reported that other causes of vulnerability include lack of access to information and knowledge, lack of public awareness, limited access to political power and representation [9].

Vulnerability levels of countries, regions, and population groups on an aggregation of the communities as a whole have been discussed in the literature. Few if any have critically assessed vulnerability levels at the individual household level. Although studies conducted on an aggregation can give an important clue on the overall vulnerability of a country, region or population group, it undermines the individual vulnerability that each household faces in the given community. The assessment of factors that determine vulnerability level at the farming household in developing countries focused on Eritrea is, therefore, the main theme of this study.

2. Country background

Eritrea is located at the northern part of the Horn of Africa, between latitudes 12° 40' and 18° 02” North of equator and longitudes 36° 30” and 430 20” east of Greenwich [11]. It has a landmass area of, about 125,700 km² inclusive of the islands, and a coastline spanning some 1,900 kilometres. It borders Sudan in the north and west, Ethiopia in the south, Djibouti in the southeast and the Red Sea in the east (figure 1). Eritrea’s physical features are characterized by central and northern highlands extending for about 350 km north to south; flat coastal plains of the eastern lowlands; and flat plains of western lowlands interspersed with hills [12]. The altitude across the country varies considerably, from 1,500 to 2,400 meters above sea level in the highland areas; from 0 to 500 meters in the eastern lowland areas; and from about 700 to 1,400 meters in the western lowlands [13].

Figure 1. Map showing the location of Eritrea in Africa. Source: Google. https://www.freeworldmaps.net/africa/eritrea/eritrea-physical- map.jpg.
Influenced by the expanding Sahel-Saharan desert, and its proximity to the Red Sea and the land’s physical features, Eritrea has a highly variable climate. Altitude and topography are major determinant factors of the climate in general and temperature in particular in Eritrea [11]. For each 200-meter rise in elevation there is a 1°C decline in mean annual temperature. Average temperatures vary considerably, with the eastern lowland having an annual mean of 31 °C reaching as high as 48 °C; while in the highland areas the annual mean is 21 °C with a maximum of 25 °C. In the western lowland areas, the annual mean is 29 °C with a maximum of 36 °C [11].

Eritrea has a dominantly arid climate with about 70% of its land area classified as hot and arid and receiving average annual rainfall of less than 350 mm. The main rainy season in most parts of the country is from mid-June to mid-September. There is also a short rainy season covering a small part of highland areas which occurs between March and May. The eastern coastal areas and parts of the adjacent escarpment receive a winter rain between December and February [10, 12, 13]. The eastern lowland is much drier with average annual rainfall between 50 and 200 mm. Given that the northern areas of the eastern lowlands fall within the eastern limit of Sahelian Africa, it receives less than 200 mm/year of rain [15]. The Southern areas experience average annual precipitation of 600 mm, with the central highland areas receiving about 400-500 mm per year. Eritrea faces environmental issues such as continued deforestation, desertification, soil erosion and overgrazing. Climatic risks pose a serious challenge to Eritrea’s emerging development prioritise for agricultural development, livestock raising, forestry conservation, water resource management, coastal and marine environmental protection and safeguarding public health [11, 12].

The economy of Eritrea is mainly dependent on traditional farming, livestock husbandry and mining, rendering them vulnerable to the negative impact of climate variability and its consequent results. Households that regard themselves as pastoralists, agro-pastoralists and crop farmers are vulnerable communities to climate variability and its consequences. Over the years, the communities have evolved a production system that adapts to the fluctuations in climate variability and erratic rainfall [14]. Despite the majority of the population in Eritrea being involved in agriculture and related activities (about 80%), the contribution of the agricultural sector to GDP is minimum limited to only 11.7% [16]. The contribution of industry and service sectors to GDP is 29.6% and 58.7% respectively. Given the erratic rainfall and low input low output production system in Eritrea, harvests generally cannot meet the food needs of the country without supplemental grain purchases [11].

3. Methodology

3.1. Data collection
The ‘Baseline Survey of Agricultural Households’ conducted in 2016 by the Ministry of Agriculture; Eritrea was used as a source of data for this analysis. This dataset provides a household-level cross-sectional data on demographic and socio-economic characteristics and indicators to vulnerability, resilience and coping mechanisms. Furthermore, secondary data was also collected from relevant stakeholders and documents to support the primary data. Focus groups discussion on key informant (men, women and youth groups), were also conducted using the Participatory Rural Appraisal (PRA) method. For this purpose, unstructured questionnaires were prepared. More data on climate variability and natural disasters were obtained from Google website. Interviews with 656 individual household heads were carried out to gather information relevant to factors influencing climate related vulnerabilities by trained enumerators who could speak the local language.

3.2. Methods of analysis and model specification
Vulnerability Livelihood Index (VLI) analysis was carried out to determine the level of vulnerability of farming households in Eritrea. Using SPSS version 20, an ordered logistic regression was applied to understand the determinant factors of the level of vulnerability to climate change. Ordered logit model was selected because the values of (LVI) were ordered from less vulnerable to vulnerable to highly vulnerable level. An ordered logistic regression and ordinal logit model are interchangeably used here
for the same purpose. It is specifically developed to handle ordinal scale variables such as less vulnerable, vulnerable and highly vulnerable [17]. The ordered logit model estimates not only the coefficients of the independent variables but also the threshold parameters. But the slope coefficients of the regressors are the same in each category; it is only that their intercepts (threshold) differ [18]. The threshold is the cut-off point where the values of the ordered dependent variables change from one category to another, that is the shift from less vulnerable level to vulnerable to highly vulnerable [17]. The method of estimation, as in all multinomial regression models, is by the method of maximum likelihood [19]. The underlying estimation principle we want to estimate according to Gujarati, is given as follows [17]:

\[ P(Y_i \leq j) = P(\beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + \mu_i \leq a_i) \]  

(1)

Where \( Y_i \) is an ordered response variable with \( j \) categories, \( P \) is the probability of occurring an event of the response variable, \( X_i \) represents explanatory variables, \( \beta_i \) coefficients, \( \mu_i \) the error term and \( a_i \) the intercept (the cut-off point or threshold).

Equation 1 gives the (cumulative) probability that \( Y_i \) falls in a category \( j \) and below (i.e. in category 1, 2 ... or \( j \)). In order to compute the probability that a random variable takes a value equal to or less than a given number, we use the cumulative distribution function (CDF) of probability distribution, the ordered logit model [20]. Now to compute such probabilities, we use:

\[ \frac{\exp(a_i \beta X)}{1 + \exp(a_i \beta X)} \]  

(2)

which is the CDF of the logistic probability distribution. Note that \( \beta X \) stands for \( \sum_k \beta_k X_k \).

Now the effect of a regressor on the ordered dependent variable is nonlinear, as it gets channelled through a nonlinear CDF (logit in this case). To make the interpretation easier, we can make use of the odds ratio defined by the following formula [17, 19]:

\[ \frac{\Pr[Y_i \leq j/X]}{\Pr[Y_i > j/X]} = \frac{\Pr[Y_i \leq j/X]}{\Pr[1 - \Pr[Y_i \leq j/X]]} \]  

(3)

where

\[ \Pr[Y \leq j/X] = \sum_{m=1}^{j} \Pr[Y = m/X]. \]

which denotes the cumulative probability that the outcome is less than or equal to \( j \). Now if we use the logistic CDF given in (Eq. 2) to compute the odds ratio in (Eq. 3) and take the log of this odds ratio (i.e. logit), then, we obtain, after simplification, the following formula, [17,19]:

\[ \ln \frac{\Pr[Y_i \leq j]}{1 - \Pr[Y_i \leq j]} = a_i \cdot \sum_{n=1}^{k} \beta_n X_{ni} \quad j = 1, 2, \ldots (j-1) \]  

(4)

Thus Eq. (4) gives a sequence of logits (or log odds; three such logits in this case as not vulnerable, vulnerable and highly vulnerable), which all have the same regressors and the same (slope) coefficients but different intercepts [16, 17].

4. Results and Discussions

4.1. Vulnerability levels of households

Vulnerability level of households was analysed by applying the seven major vulnerability components to each household. These include: (i) socio-demographic profile (SDP), (ii) livelihood strategies (LS), (iii) social networks (SN), (iv) food (F), (v) health (H), (vi) water (W), and (vii) natural disasters and climate variability (NDCV) [21]. The vulnerability level is scaled from least vulnerable with low vulnerability value to most vulnerable with the highest vulnerability value [22]. Accordingly, only 12% of the respondents were found to be “less vulnerable” to climate change due to their strong
adaptive capacity and low sensitivity. The rest 63% and 25% were vulnerable and highly vulnerable respectively (figure 2).

But why are some households less vulnerable while others highly vulnerable? Indeed, households differ in many aspects of their socioeconomic, demographic, and environmental and many other factors. To understand which specific variable influence the level of vulnerability a deep scrutiny of the nature of the household is required. An empirical analysis using quantitative data supported by qualitative analysis is one method used to categorize households into relatively distinctive groups of vulnerability level. It is, therefore, important to analyse factors that determine vulnerability level to climate change in order to have a clear understanding of the causes so that appropriate policy measures can be recommended. The socioeconomic and demographic and environmental factors supposed to determine vulnerability levels are listed as follows (Table 1):

| Variables                        | Explanation                      | Code   | Reference category        | N   | Percentage |
|----------------------------------|----------------------------------|--------|---------------------------|-----|------------|
| Level of vulnerability (VulLev)  | less Vulnerable                  | 0      | Highly Vulnerable          | 78  | 11.9       |
|                                  | Vulnerable                       | 1      |                           | 414 | 63.1       |
|                                  | Highly Vulnerable                | 2      |                           | 164 | 25.0       |
| Zone (Zoba)                      | NRS                              | 1      | SRS                       | 96  | 14.6       |
|                                  | SRS                              | 2      |                           | 47  | 7.2        |
|                                  | Anseba                           | 3      |                           | 96  | 14.6       |
|                                  | Gash-Barka                       | 4      |                           | 89  | 13.6       |
|                                  | Maekel                           | 5      |                           | 78  | 11.9       |
|                                  | Debub                            | 6      |                           | 250 | 38.1       |
| Dependency Ratio (DR)            | ratio ratio                      | ratio  | ratio                     | 100 |            |
| Gender (Gen)                     | Female                           | 0      | Female                    | 130 | 19.8       |
|                                  | Male                             | 1      |                           | 526 | 80.2       |
| Level of Education (Edu)         | No education                     | 0      | Higher than secondary     | 259 | 39.5       |
|                                  | Primary level                    | 1      |                           | 247 | 37.7       |
|                                  | Secondary level                  | 2      |                           | 116 | 17.7       |
|                                  | Higher than secondary            | 3      |                           | 34  | 5.2        |
| Marital status (Marit)           | Single                           | 1      | Widowed                   | 20  | 3.0        |
|                                  | Married                          | 2      |                           | 565 | 86.1       |
|                                  | Divorces                         | 3      |                           | 21  | 3.2        |
|                                  | Widowed                          | 4      |                           | 50  | 7.6        |
| Main Stay of HHH (Prof)          | Agro-pastoralist                 | 1      | Crop Farmer               | 251 | 38.3       |
|                                  | Pastoralist                      | 2      |                           | 45  | 6.9        |
|                                  | Crop Farmer                      | 3      |                           | 360 | 54.9       |
| Income Diversity level (InDiv)   | Not diversified                  | 0      | Highly diversified        | 205 | 31.2       |
|                                  | Slightly diversified             | 1      |                           | 112 | 17.1       |
|                                  | Moderately diversified           | 2      |                           | 234 | 35.7       |
| Poverty level (PoLe)                  | Highly diversified | 3  | 105 | 16.0 |
|-------------------------------------|--------------------|----|-----|------|
| Extreme low income                  | 0                  |    | 164 | 25.0 |
| Low income                          | 1                  |    | 164 | 25.0 |
| Moderate income                     | 2                  |    | 164 | 25.0 |
| High income                         | 3                  |    | 164 | 25.0 |

| Access to credit (AccCr)            |                    |    |     |      |
|-------------------------------------|--------------------|----|-----|------|
| No                                  | 0                  |    | 282 | 43.0 |
| Yes                                 | 1                  |    | 374 | 57.0 |

| Access to Market (AccMa)            |                    |    |     |      |
|-------------------------------------|--------------------|----|-----|------|
| No                                  | 0                  |    | 218 | 33.2 |
| Yes                                 | 1                  |    | 438 | 66.8 |

| Access to Electricity (AccEl)       |                    |    |     |      |
|-------------------------------------|--------------------|----|-----|------|
| No                                  | 0                  |    | 476 | 72.6 |
| Yes                                 | 1                  |    | 180 | 27.4 |

| Access to Clean water (AccWtr)      |                    |    |     |      |
|-------------------------------------|--------------------|----|-----|------|
| No                                  | 0                  |    | 523 | 79.7 |
| Yes                                 | 1                  |    | 133 | 20.3 |

| Access to Cooperatives (AccCo)      |                    |    |     |      |
|-------------------------------------|--------------------|----|-----|------|
| No                                  | 0                  |    | 581 | 88.6 |
| Yes                                 | 1                  |    | 75  | 11.4 |

| Access to Extension service (AccExt)|                 |    |     |      |
|-------------------------------------|------------------|----|-----|------|
| No                                  | 0                |    | 403 | 61.4 |
| Yes                                 | 1                |    | 253 | 38.6 |

| Participation in forest closure (ParCls) |     |     |      |
|-----------------------------------------------|----|-----|------|
| No                                            | 0  | 399 | 60.8 |
| Yes                                           | 1  | 257 | 39.2 |

| Participation in tree planting (ParTre)      |     |     |      |
|-----------------------------------------------|----|-----|------|
| No                                            | 0  | 264 | 40.2 |
| Yes                                           | 1  | 392 | 59.8 |

| Participation in soil and water conservation (ParSoil) |     |     |      |
|--------------------------------------------------------|----|-----|------|
| No                                                      | 0  | 190 | 29.0 |
| Yes                                                     | 1  | 466 | 71.0 |

| Total                                              | 656 |     |      |

In order to see whether these hypothesised variables determine the level of vulnerability of households, an empirical test is required. Therefore, it is hypothesised that the above variables don’t have any effect on the level of vulnerability of households due to climate change. Thus the null hypothesis is stated as “all coefficients are equal to zero”. Alternatively, we can hypothesise that at least one of the variables affects the vulnerability level of households due to climate change. That is the alternative hypothesis is as “at least one of the coefficient of the regressors is not equal to zero”. Accordingly, an ordered logit regression is carried out to test the null hypothesis.

4.2. Descriptive statistics and econometric result

By applying the Livelihood Vulnerability Index (LVI), households were categorized into three distinctive vulnerability levels such as less vulnerable (0), vulnerable (1) and highly vulnerable (2). In order to understand what determines households to be more vulnerable or not, socioeconomic and biophysical factors (variables) were regressed against the (LVI) scores. Accordingly, the regression results are given on (Table 2).

From the regression, a high level of Chi-Square (479.7) with (Probability > $\chi^2 = 0.0$) was found indicating that the model as a whole was significant at 95% level of significance (Table 2). The Pseudo R-Square score were Cox and Snell = 0.519, Nagelkerke = 0.624, McFadden = 0.411, with a Logit function. So collectively all the explanatory variables have strong influence on the choice probability.

In the ordinal regression, the analysis is made in a probability or the likely that an event in a given variable occurs to be highly vulnerable as compared to the reference category. Accordingly, many socioeconomic variables were found to be significantly determining the level of vulnerability of farming households due to climate change. In the following analysis, only statistically significant variables are presented. All of the estimates of the coefficients ($\beta$) are given in log-odds ratio in table 2 column 2. To make the interpretation easier, the estimated log-odds ratio coefficients are converted...
to their respective odds ratio values, as given on column 7, by simply converting them into their respective exponential forms. But most important is the sign of the coefficients showing the relationship of the explanatory variable with the dependent variable, in this case the vulnerability level (Table 2).

Table 2. The Ordinal Logit Model estimation and the odds ratio of the level of vulnerability.

|               | Estimate (β) | Std. Error | Wald df | Sig. | Exp(β) (odds ratio) | 95% Confidence Interval |
|---------------|--------------|------------|---------|------|---------------------|-------------------------|
| VulLev = 1    | .563         | .948       | .353    | 1    | 1.76                | -.129 - 2.422           |
| VulLev = 2    | 6.693***     | 1.028      | 42.352  | 1    | 806.74              | 4.677 - 8.709           |
| DR            | -1.103**     | .104       | 112.632 | 1    | .33                 | -1.306 - .899           |
| Zoba=Anseba   | 1.865**      | .528       | 12.481  | 1    | 6.46                | .830 - 2.900            |
| Zoba=Debub    | 2.376**      | .550       | 18.675  | 1    | 10.76               | 1.298 - 3.454           |
| Zoba=Gash-Bar | 2.271**      | .545       | 17.391  | 1    | 9.69                | 1.203 - 3.338           |
| Zoba=Mackel   | 2.162**      | .600       | 12.961  | 1    | 8.69                | 6.46 - 3.338            |
| Zoba=NR       | 1.826**      | .554       | 10.867  | 1    | 8.69                | 6.46 - 3.338            |
| Zoba=SR       | 0            |            |         |      |                     |                         |
| Gen=0         | 2.490**      | .329       | 57.211  | 1    | 12.06               | 1.845 - 3.135           |
| Gen=1         | 0            |            |         |      |                     |                         |
| Edu=0         | 1.654**      | .537       | 9.481   | 1    | 5.23                | .601 - 2.707            |
| Edu=1         | .839         | .503       | 2.787   | 1    | 2.31                | -.146 - 1.824           |
| Edu=2         | .387         | .514       | .566    | 1    | 1.47                | -.620 - 1.394           |
| Edu=3         | 0            |            |         |      |                     |                         |
| Prof=1        | -.241        | .253       | .913    | 1    | 0.79                | -.736 - .254            |
| Prof=2        | -1.178**     | .442       | 7.101   | 1    | 0.31                | -.204 - .312            |
| Prof=3        | 0            |            |         |      |                     |                         |
| InDiv=0       | 1.645**      | .443       | 13.786  | 1    | 5.18                | .777 - 2.514            |
| InDiv=1       | .851*        | .425       | 3.999   | 1    | 2.34                | .017 - 1.685            |
| InDiv=2       | .649         | .335       | 3.748   | 1    | 1.91                | -.008 - 1.306           |
| InDiv=3       | 0            |            |         |      |                     |                         |
| PoLe=0        | 1.539**      | .400       | 14.782  | 1    | 4.66                | .755 - 2.324            |
| PoLe=1        | 2.328**      | .350       | 44.208  | 1    | 10.26               | 1.642 - 3.015           |
| PoLe=2        | 1.838**      | .322       | 32.633  | 1    | 6.28                | 1.207 - 2.469           |
| PoLe=3        | 0            |            |         |      |                     |                         |
| AccCr=0       | 1.287**      | .263       | 23.906  | 1    | 3.62                | .771 - 1.803            |
| AccCr=1       | 0            |            |         |      |                     |                         |
| AccMa=0       | .919**       | .265       | 12.039  | 1    | 2.51                | .400 - 1.439            |
| AccMa=1       | 0            |            |         |      |                     |                         |
| AccWtr=0      | -.772**      | .273       | 7.967   | 1    | 0.46                | -.1308 - .236           |
| AccWtr=1      | 0            |            |         |      |                     |                         |
| Parsoil=0     | 1.266**      | .282       | 20.218  | 1    | 3.55                | .714 - 1.818            |
| Parsoil=1     | 0            |            |         |      |                     |                         |

** = significant at 1%; * = significant at 5%.
a. This parameter is set to zero because it is redundant (reference category).

Some explanatory variables including dependency ratio, profession, and access to clean water were found to have a negative relationship with the vulnerability level. This indicates that vulnerability is highly likely to occur as these variables decrease. It is a normal phenomenon that households with no access to clean water in any standard to be more vulnerable than otherwise. It seems absurd that vulnerability level decreases with increasing dependency ration. In this analysis age limit (less than 18
or greater than 65) was used as a defining factor for dependency ratio. Nevertheless, as in many developing countries, in Eritrea, children and old age people are actively involved in income generating activities so that their contribution to reduce vulnerability could be acknowledged. Therefore, the negative relationship between vulnerability level and dependency ratio could be attributed to the involvement of both child and old ages in the economic activity. On the other hand explanatory variables including gender (female), lower level of education, low income diversity, poverty level, less access to credit and market were found to have a positive relationship with higher level of vulnerability. Location was also found to have a significant effect on vulnerability. Each of these will be discussed independently below.

Levels of vulnerability by Location: There is a difference in the level of vulnerability as seen from locational perspective. Although in all of the zones (zobas) the proportion of moderately vulnerable are more or less similar, the proportion of highly vulnerable households were more in zoba Gash-Barka (45%) followed by Anseba (32%), and Maekel (30%). The number of highly vulnerable households was relatively less in SRS (8.5%) than all of the other zones, followed by NRS (19%) and Debub (23%) (figure 3).

![Figure 3. Percentage of levels of vulnerability by Zone.](image)

When the vulnerability level was tested empirically using ordered logit, taking a location or zone as a factor, the econometric result shows that all zones were found to be highly likely to be vulnerable than not relative to the reference category. This implies that vulnerability to climate change is highly pervasive in all regions irrespective of the location, altitude, farming system and differences in microclimate.

Levels of Vulnerability by educational level of Households: Education, be it formal or informal, is an important factor in resilience building to vulnerability. In this regard, resilience building on households and community level helps reducing vulnerabilities in advance. It is an important part of any disaster risk mitigation strategy [23]. In this particular study the level of education was roughly classified into four categories as “No education”, “primary level”, “secondary level” and “above secondary level”. The analysis indicates that vulnerability is inversely correlated with high level of education. The percentage of less vulnerable households decreases as the level of education decreases from higher to lower level and vice versa. By simply taking the two extreme vulnerability levels the less vulnerable and highly vulnerable households, the percentage of highly vulnerable households decreases as the level of education increases from no education to primary or secondary or beyond. Conversely, the percentage of low vulnerable households declines as the level of education goes down from higher level of education to high school or primary or no education and vice versa (figure 4a). Households with a relatively lower level of education and particularly female-headed households were found to be more vulnerable than otherwise. Households with no education or lower than primary level were 7.6% more vulnerable than households with a higher level of education, and female-headed households were 25% more vulnerable than male-headed.
From empirical test point of view, households with no education were highly likely to be positively related with high vulnerability, indicating that illiterate households tend to be more likely to be highly vulnerable. However, the empirical analysis indicated that once a household head is out of illiteracy level, there is no clear distinction of the level of vulnerability between the primary and secondary levels of education. Only an insignificant difference is observed in the level of vulnerability when household heads attain a higher level of education out of the illiteracy level.

Vulnerability versus gender: Gender also matters to determine vulnerability. Gender related vulnerability is important because it is a key issue in social protection and poverty reduction. The worsening effects of climate change affect women severely when gender differentiated attitudes of the people in the society exists [24]. Gender differentiated attitudes creates gender inequality between men and women and constraints women to own her rights in the society. Moreover, socially constructed role and responsibility leads women to be much more susceptible than men to poverty [25]. Gender also intersects with other social categories. For example, women in rural areas of developing countries depend on natural resources, such as water, and agricultural and forest products, for their livelihood, making them particularly vulnerable to changes in availability and access. Climate change is widely anticipated to affect women’s life adversely [22, 23].

In this particular report female headed households were found to be positively correlated with vulnerability. The percentage of female headed households increases as we go from less vulnerable to highly vulnerable levels (figure 4b). The econometric result also confirms that the probability of being highly vulnerable increase if the household head is female and vice versa.

Access to credit versus vulnerability: Access to credit and other institutions helps households develop resilience to vulnerability. In the absence of well-functioning credit and insurance markets households are exposed to adverse events and make them highly vulnerable. This can affect not only
destitute households whose power of resilience are deprived of but also non-poor households who can fall back potentially into poverty [28]. In this survey the percentage of highly vulnerable households was more when they don’t get credit indicating that credit influences the level of vulnerability. The econometric result shows that households are highly likely to be more vulnerable when access to credit is zero and vice versa. The percentage of highly vulnerable households increases from less than 10 % to over 40% when they are deprived of access to credit (figure 5a).

Vulnerability and access to market: Unlike the commercial farm households, small scale farming households in most developing countries are only partially integrated into incomplete markets [29]. Hence their level of vulnerability is partially predetermined by whether a particular household has an access to market or not. In this particular study about 89% of the households who didn’t have access to market were moderately to highly vulnerable. The ordered logit regression analysis indicates that households with no access to market were more likely to be highly vulnerable. When households were deprived of an access to the market, the percentage of highly vulnerable households increased from less than 10 % to over 40% (figure 5b).

Vulnerability and profession: Although, farming households are involved in diverse activities, the respondent in the survey identified themselves into one of the three mainstay professions: i) pastoralist, ii) agro-pastoralist and iii) crop farming. It was found that 85% of the pastoralist, 84% of the agro-pastoralist and 91% of the crop farmers were moderately to highly vulnerable. Households who regard themselves as agro-pastoralists were more likely to be less vulnerable as compared to crop farmers or purely pastoralists. This is in agreement with the decreasing of vulnerability as diversity increases. Vulnerability was, nevertheless, an overwhelming phenomenon in all types of profession irrespective of their location and farming system.

![Figure 6a. Trend from not diversified to highly diversified versus vulnerability level.](image1)

Income diversity and vulnerability: Although farm or income diversification by itself should not be considered as a goal for farming households, diversification helps to increase household income [30]. If it contributes to better nutrition, then the probable that a household with diversified income becomes vulnerable reduces. In this study we can observe that the percentage of households to be highly vulnerable reduces with the percentage increase in income diversity and vice versa (figure 15a). Seasonality and risk are some of the major reasons for income diversity. The degree to which it becomes necessary to diversify for seasonality and risk reasons varies according to the underlying livelihoods of farming households, the degree to which cash income is released from diversification, and the ability of markets to provide food supplies at reasonable prices [31]. This indicates that farming households develop resilience to vulnerability by diversifying their income and livelihood.

The empirical analysis indicates that households with low income diversification are more likely to be highly vulnerable than those with diversified income (figure 6a). But there is no significant difference between the moderately and highly diversified income groups in their vulnerability level (Table 1).
Poverty versus vulnerability: Poverty is a crucial element of the notion of vulnerability [32]. Vulnerability can be seen as a cause of poverty, as a reason why the poor remain poor, or as an effect of poverty [29, [31]], poverty is not only being measured as income poverty but seen within a larger framework of “well-being”, which tries to take a comprehensive view of the livelihood of the people [33]. Vulnerability and poverty are closely connected and influence each other very deeply, while they are at the same time clearly distinct from each other. Thus, poor households are more vulnerable than the well to do. In this particular study, it is found that the extremely poor are by far highly likely to be vulnerable than the poor, the moderate-income and the well to do. The percentage of highly vulnerable group of households displays a sharp decline as income increases, whereas the percentage of less vulnerable increases (figure 6b).

5. Conclusion
The findings of the study reveal that various socioeconomic, biophysical and environmental factors influenced vulnerability levels due to climate change. Some variables including dependency ratio, profession, and access to clean water were found to have a negative relationship with the vulnerability level indicating that the vulnerability is highly likely to occur as these variables decrease. On the other hand variables including gender (female), low level of education and income diversity, poverty level, low access to credit and market were found to have a positive relationship with the high level of vulnerability. Differences in socio-demographic factors of households such as level of education, gender and profession exhibited different levels of vulnerability. Households with a relatively lower level of education and particularly female-headed households were found to be more vulnerable than otherwise. Households with no education or lower than primary level were 7.6% more vulnerable than households with a higher level of education, and female-headed households were 25% more vulnerable than male-headed. Income diversity and level of poverty were also significantly determining the level of vulnerability in farming households. Location was also a factor in determining the level of vulnerability as the different zones indicate significant variability to the degree of vulnerability.

Development programs need to target the factors that develop resilience and adaptive capacity of households including education, income generation, promotion of gender equality, and access to credit and market. Further research is recommended in this area and these findings can be used as a benchmark study to be compared with future, more extensive studies.

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Competing interests
The author(s) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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