# A Comparative Analysis of Vulnerability of Pastoralists and Agro-pastoralists to Climate Change: A Case Study in Yabello *Woreda* of Oromia Region, Ethiopia

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## Abstract

*The article aims at measuring and comparing the relative vulnerability of pastoralists and agro-pastoralists in Yabello Woreda of Borana Zone in Oromia Region. The study used vulnerability indicator method to determine the level of vulnerability of households and social groups. The study showed that half of the sample households are highly vulnerable to impacts of climate change. Among these highly vulnerable households agro-pastoralists comprise the highest proportion (60.5 %) of the highly vulnerable households. .This implies that the pastoral livelihood system is more resilient to climatic shocks and variability compared to that of agro-pastoralism in the study area. Generally, it is pointed out that resort to agro-pastoralism, though forced by local circumstances, seems to be a risky alternative. The problem, therefore, demands further investigation and efforts to create better policy, institution and infrastructure in order to widen opportunities for alternative and supplemental livelihood sources and resources.*

**Keywords**: climate change, vulnerability, pastoralists, agro-pastoralists, Borana, Oromia, Ethiopia

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## Introduction

The issue of climate change has become one of the hottest and debatable agenda for both developed and developing countries. It has been presented as a global issue resulting from an increase in greenhouse gas emissions linked to human activities (O'Brien and Leichenko, 2005). The problem is recognized as one of the most serious global challenges of the 21st century with multiple effects on basic human support systems such as agriculture (crop and livestock production), forests, water resources, and the ecosystem (Aklilu and Alebachew, 2009).

Recent evidence and predictions indicate that climate changes are accelerating and will lead to wide-ranging shifts in climate variables. There will be changes in the mean and variance of rainfall and temperature, extreme weather events, food and agriculture production and prices, water availability and access, nutrition and health status. In line with these, most adverse impacts are predicted in the developing world because of geographic exposure, reliance on climate sensitive sectors, low incomes, and weak adaptive capacity (IPCC, 2007; Heltberg *et al.,* 2009).

The level of vulnerability of different social groups to climate change is determined by both socioeconomic and environmental factors (Temesgen *et al.,* 2008). The widely mentioned socioeconomic factors include the level of technological development, infrastructure, institutions, and political setups (Kelly and Adger, 2000). The environmental attributes mainly include climatic conditions, quality of soil, and availability of water for irrigation (O'Brien *et al.,* 2004). The variations of these socioeconomic and environmental factors across different social groups are responsible for the differences in their levels of vulnerability to climate change.

Though all households in a community are exposed to risks associated with climate change and could potentially be rendered vulnerable, the poorer households are the most at risk. This is because their assets and livelihoods tend to be highly exposed and sensitive to the direct and indirect risk associated with climate change, and because they lack access to formal and informal risk management arrangements. People that depend on agriculture (especially rain-fed), livestock, and fisheries would be at risk. Within households, impacts will sometimes fall disproportionately on vulnerable individuals such as children, women, elderly, and disabled (Heltberg *et al.*, 2009).

Ethiopia is vulnerable to climate change because of its greater reliance on climate sensitive economic sectors: subsistence crop cultivation and livestock production. Low level of socioeconomic development, inadequate infrastructure, lack of institutional capacity and higher dependency on natural resources make the country more vulnerable to climatic factors including climate variability and extreme climate events (NMA, 2007).

Moreover, as Ethiopia is located in the tropics at latitudes of 4° to 15°N and 33° to 48°E, a large part of the country has arid and semiarid climatic condition and hence is highly prone to desertification and drought (NMSA, 2001). It has also fragile highland ecosystems that are currently under stress due to population pressure and associated socioeconomic practices. The country's history is associated, more often than not, with major natural and manmade hazards that have been affecting the population from time to time (NMA, 2007). These hazards have been the main sources of risk and vulnerability in most parts of the country.

Droughts, famine, epidemics and floods are also very common occurrences. In most instances, these disasters are associated with climatic variability and change (Aklilu and Alebachew, 2009). The outcome of these disasters has been loss of crops, destruction of built infrastructure, death of livestock and millions of people, and displacement of people. In general, by weakening the productivity and functioning of livelihood resources, they aggravate the vulnerability of the people that are dependent on these resources.

According to the vulnerability assessment undertaken by the national adaptation program of action (NAPA) team, the most vulnerable sectors to climate variability and change in Ethiopia are agriculture, water, and human health. In terms of livelihood approach, smallholder rain-fed farmers an pastoralists are found to be the most vulnerable. The arid, semiarid and the dry sub-humid parts of the country are highly prone to drought. However, despite such crude explanation, exhaustive research based analysis that measures vulnerability of different sectors and livelihood system at regional, district or household level are not well undertaken.

The aim of this study is, therefore, to measure and compare the relative vulnerability of agro-pastoral and pastoral households in order to hint on the most resilient livelihood strategy that suit the changing conditions of climate. Moreover, the study would assist in the determination of infrastructural and investment activities that increase the adaptive capacity of the communities of the area.

**Conceptual and Methodological Considerations**

Vulnerability is a concept that is widely used in natural hazards, food security and climate change communities. Yet there are diverse definitions and interpretations (Fussel and Klein, 2006; Eriksen and O'Brien, 2007). In general, it refers to the likelihood of injury, death, loss, disruption of livelihoods or other harm as the result of initial shocks, such as floods, earth quakes or other hazards, or economic restructuring. Vulnerability to climate variability and change is closely related to the dynamic social, economic, political, institutional, technological and environmental conditions that characterize a particular context and contribute to negative outcomes (Kelly and Adger, 2000).

Reviews of the interpretations of 'vulnerability' in climate change research have generally identified two different vulnerability concepts: the 'end-point' interpretation and a 'starting-point' interpretation of vulnerability (Fussel, 2007: 163). For the purpose of this study the researchers adopt the 'end-point' interpretation which represents vulnerability as the expected net impacts of a certain level of climate change, taking into account feasible adaptations. This is selected because it is highly relevant in the context of mitigation and compensation policy, and for prioritization of assistance and adaptation techniques (Fussel, 2007: 163) which are the end goals of the study. In line with this, for the purpose of this study the definition given by IPCC is adopted. IPCC defines vulnerability 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* (IPCC, 2001: 995).

To assess vulnerability, researchers from different disciplines have developed many conceptual and methodological approaches to vulnerability analysis. The major conceptual approaches in vulnerability analysis include the socioeconomic, biophysical, and integrated approaches. The socioeconomic approach is mainly concerned with the social, economic, and political aspects of society (Adger, 1999). The biophysical, or impact assessment approach is mainly concerned with the physical impact of climate change on different attributes such as yield and income (Füssel and Klein, 2006). The integrated assessment approach combines both the socioeconomic and the biophysical attributes in vulnerability analysis (Füssel, 2007).

The most commonly used methodological approaches in the climate change literature include the econometric and indicator methods. The econometric method, which has its roots in the poverty and development literature, makes use of household-level socioeconomic survey data to analyze the level of vulnerability of different social groups (Hoddinott and Quisumbing, 2003). The indicator method of quantifying vulnerability is based on selecting some indicators from the whole set of potential indicators and then systematically combining the selected indicators to indicate the levels of vulnerability (Cutter *et al.*, 2003; Temesgen *et al.*, 2008).

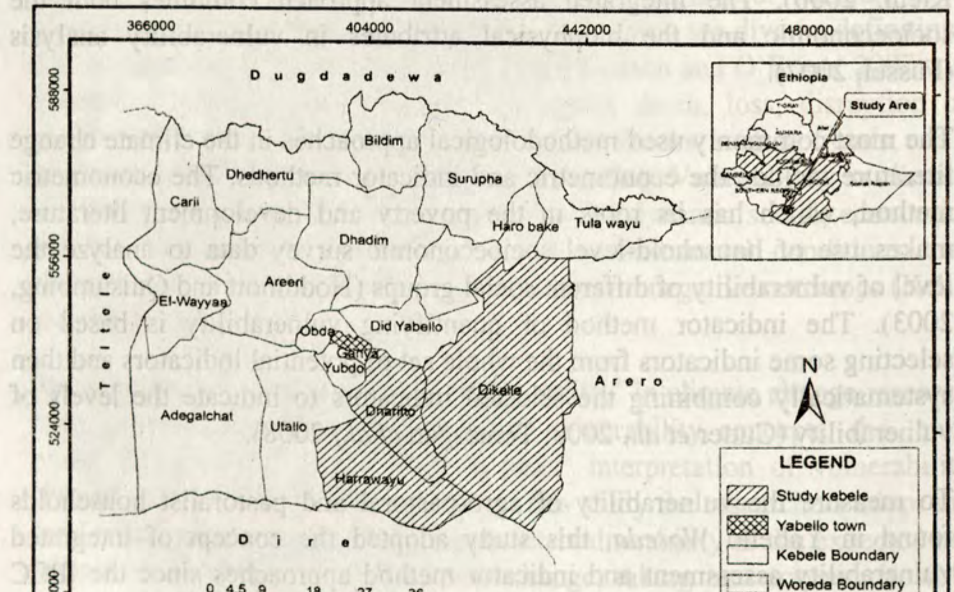
To measure the vulnerability of agro-pastoral and pastoralist households found in Yabello *Woreda*, this study adopted the concept of integrated vulnerability assessment and indicator method approaches since the IPCC definition accommodates both the concept of biophysical and the soconomic indicators in assessing vulnerability (Temesgen *et al.*, 2008).

# Description of the Study Area

## Location

Yabello *Woreda* is located in Borena zone of Oromia Regional State in the southern lowlands of Ethiopia around 565 km from Addis Ababa. It is located at 4°30' N to 5°30'N latitude and 37°45'E to 38°30'E longitudes. The woreda is bounded by Teltele, Arero, Dire and Dugdadawa *woredas* of Borena Zone in the west, east, south and north, respectively. The total land area of the *woreda* is estimated to be 555, 000 km$^2$.

Figure 1. Map of the study area




Source: Authors' own construction, 2010

## Population

According to the 2007 national housing and population census the total population of the *woreda* is 102, 385 (51,537 males and 50,848 females). The *woreda* is sub divided into three urban and 20 rural *kebeles*. From the total population 84,637 settle in rural *kebeles* and 17,748 reside in the urban centers (CSA, 2009). The population density of the study area is around 0.18 persons per $km^2$.

## Climate

The *woreda* is characterized by semi-arid climatic condition and the majority (80%) of the *woreda* belongs to *kola* agro ecological zone (hot semiarid lowland), while the rest 20% belongs to *woina-dega* category (cool and sub-humid highland). The altitude of the *woreda* ranges from 1450 meter to 2250 meter above sea level; it is dominated by plain grass land. It has a biannual rainfall mode with average rainfall of 300mm/year. *Ganna* (March- May) is the main rainfall season. During this period the *woreda* gets from 500 mm up to 600 mm rainfall per year. *Bona* (September-November) is the second rainy season where the *woreda* receives showers that account for 100 mm/year. The average temperature is 28°C where the maximum and the minimum temperature levels are 37°C and 14°C, respectively (YWPDB, 2009).

## Economic Activity

Pastoralism is the predominant livelihood strategy in the *woreda.* For generations it has served as the main source of income and food. The livestock population of the *woreda* is composed of 232,949 cattle, 98,872 goats, 39,073 sheep, 22,972 camels and 3,752 equines. Poultry and bee colony are some other resources that serve as source of food and income in the area. The *worda* has 292,028 hectares of rangeland that serve as grazing land for the livestock population. Ninety percent of the grazing land is owned communally while the remaining 10 percent is owned by individuals and serves as private grazing source (YWPDB, 2009).

Agro-pastoralism is another livelihood strategy that is found in the *woreda.* It has 62,000 hectares of arable land. Crops are produced in the main rainy season using traditional agricultural system. The common crops grown in the area are maize, wheat, haricot bean and *teff.* The average yield per hectare for maize, wheat and haricot bean is about 9 quintals while it is 8 quintals per hectare for *teff* (YWPDB, 2009).

**Climate Variability of the Study Area and Households' Perception**

Exposure to climate change is defined by occurrence of extremes, change or variability of temperature and rainfall from their mean values. To explain the exposure of the sample population both primary and secondary data are used. The secondary sources revealed what has happened in the area at the aggregate level in scientific terms while the primary data is used to capture the perception of households on the issue.

**Drought**

According to the information obtained from the Zonal Disaster Preparedness and Prevention Committee, drought has occurred in the *woreda* 3 times in the past 10 years. With regard to the sample populations' perception on the issue 76.92% of pastoral respondents and 64.38% of agro-pastoral households replied that the occurrence and frequency of drought showed an increasing trend; 34.25% of agro-pastoral households and 23.08% of pastoral household respondents felt a decreasing trend in drought.

**Temperature**

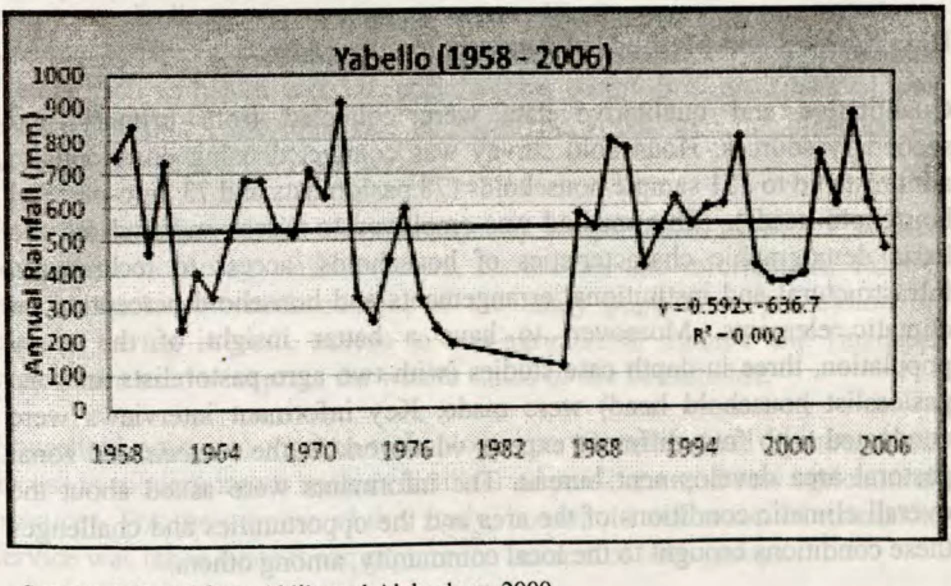
Temperature of the *woreda* is characterized by an increasing trend and high inter-annual variability. The average annual temperature of the *woreda* is about 25.8°C and it has been experiencing an increasing trend of temperature over the past decades (Aklilu and Alebachew, 2009). The great majority of the sample population (93.59% of pastoral households and 80.56% of agro-pastoral respondents) witnessed temperature increment in their area; 6.41% of pastoral and 19.47% of agro-pastoral households perceived a comparative decline of temperature in their surroundings.

**Rainfall**

The study area has a biannual rainfall mode. The main rainy season (*ganna*) receives up to 500 mm per year, and the *bonna* season receives 100 mm averaging 300 mm per year. Figure 2 shows the seasonal rainfall variability of the *woreda.* Assessments of the main rainy season at zonal level between May 2006 and June 2009 revealed that rainfall received during the main season has been very low and scanty. The rainfall was not only below normal but also late by more than two weeks and stopped too early to enhance the normal growth of crops, grasses and herbaceous species in the zone (Aklilu and Alebachew, 2009).

Looking into the perception of the sample population, 65.38% of pastoral households perceived a decreasing pattern. But the majority of the agro-pastoral (i.e. 57.53%) households felt increasing trend. The inconsistency might be a result of the high inter-variability of rainfall in the area. Regarding the starting period, 54.79% of agro-pastoral households and 93.59% of pastoral respondents felt that rainfall usually started late.

Figure 2. Pattern of rainfall for Yabello Woreda (1958-2006)




Source: Adopted from Aklilu and Alebachew, 2009

## Research Design, Data Sources and Methods of Analysis

### Research Design

The study was designed as a cross-sectional survey of households in Yabello *woreda* combining purposive sampling and simple random sampling techniques for the selection of the study *woreda*, *kebeles*, and households. Yabello *Woreda* was purposively selected because the area is highly exposed to impacts of climate change. The co-existence of both the agro-pastoral and pastoral livelihood systems within the same environment also made it a preferable site to meet the objectives of the study.

The *woreda* has 20 rural administrative *kebeles* that are classified into pastoral and agro-pastoral *kebeles*. Then, three *kebeles* were purposively selected taking into consideration access to transportation service and a balanced distribution of infrastructures and facilities in the *kebeles*. Based on these, *Dharitto* (agro-pastoralist), *Harrawayu* (pastoralist), and *Dhikalee* (mix of both social groups) were selected as sample *kebeles* for the study.

### Data Sources and Methods of Analysis

Quantitative and qualitative data were collected from primary and secondary sources. Household survey was conducted using questionnaire administered to 151 sample households (78 pastoralists and 73 agro-pastoral household heads). This method was employed to assess and find out the basic demographic characteristics of households, access to technology, infrastructural and institutional arrangements and household perception on climatic elements. Moreover, to have a better insight of the study population, three in-depth case studies (with two agro-pastoralists and one pastoralist household head) were made. Key informant interviews were conducted with four different experts who work in the *woreda* and zonal pastoral area development bureau. The informants were asked about the overall climatic conditions of the area and the opportunities and challenges these conditions brought to the local community, among others.

Secondary data that are relevant to the research work were gathered from different sources including published books, journals, reports prepared by international, federal and regional institutions, and unpublished materials available at the *woreda* pastoral area development bureau. Different websites from internet were also visited while searching for different literatures.

To analyze the information gathered from different sources, both qualitative and quantitative methods of data analysis were employed. To analyze the quantitative data, household and social group vulnerability index was calculated. In addition to these, descriptive statistics (such as percentage, mean, minimum, maximum, and standard deviation) were employed. The qualitative data collected from the in-depth case study and key informants were contextually analyzed and triangulated with the quantitative results.

**Definition of Model Variables and Expected Signs**

To determine vulnerability of households, the explanatory variables considered were categorized according to the IPCC's definition of vulnerability. Adaptive capacity is 'the ability of a system to adjust to actual or expected climate stresses or to cope with the consequences of those stresses. Adaptive capacity at a household level will be determined by factors such as health and education, access to information, financial and natural resources, the existence of social networks, and the presence or absence of conflicts (Brooks, 2003).

In this paper, household's adaptive capacity is represented by wealth, access to modern technology, infrastructure, institutions and information. Taking into account the wealth context of the study population, possession of camels, saving in cash, access to non-agricultural income and financial support are used to express the wealth status of the households.

Household access to modern technology can be determined by household access to modern inputs such as fertilizer or pesticides and new agricultural practices. For the purpose of this study, household utilization of extension service was taken since it can capture the interest of both groups.

The level of development and availability of institutions and infrastructure plays an important role in adaptation to climate change by facilitating access to resources (Temesgen *et al.,* 2008). Household strategies to maintain good health and achieve education for the children form important elements of securing wellbeing (Eriksen and O'Brien, 2007). Generally, household access to social infrastructure like health clinics, veterinary service, schools, market centers, and financial institutions play important role in enhancing adaptive capacity. To measure adaptive capacity in this study, we assessed household's utilization of such facilities.

Household access to information is the other important factor that contributes to adaptation process of climate change. Households that have access to early warning systems can prepare themselves prior to exposure and hence reduce their sensitivity. Access to information is highly determined by household's social status, i.e., those who have leadership role and membership to various social institutions, and male headed households have better access to information. Possession of radio and literacy contribute for better access and understanding of information provided through public media.

Exposure and sensitivity are almost inseparable properties of a system (or community) and are dependent on the interaction between the characteristics of the system and on the attributes of the climate stimulus (Smit and Wandel, 2006). According to IPCC (2001) 'sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate change stimuli, whereas exposure is the nature and the degree to which a system is exposed to climate variations.'

In this study, sensitivity of households to climate change is represented by its associated impacts, i.e., shortage of food, loss of water sources, and conflicts faced by those households. In the case of exposure, since both social groups are located in the same environment, exposure is almost uniform across the people residing in the area. However, there has been variation in the perception of households in the direction of change of these climatic elements. This would definitely create variation on household's decision in selecting among the different adaptive mechanisms. Therefore, in this study exposure is measured in terms of household perception about temperature and rainfall change patterns, rainfall starting period and occurrence and frequency of drought phenomena.

Table 1. Definition of vulnerability indicators, units of measurements and their hypothesized direction

| Determinants of vulnerability | Vulnerability indicator | Explanatory variables of the indicators | Unit of measurement | Hypothesized functional relationship between indicators and community vulnerability |
|---|---|---|---|---|
| Adaptive capacity | Wealth | Camel ownership | Percentage of total HHs who own or have access | The higher the percentage of total households with asset ownership and access to these income sources, the lesser the vulnerability |
| | | Saving in cash | | |
| | | Non agricultural income | | |
| | | Access to financial support | | |
| | Technology | Access to development workers' support | Percentage of total HHs who use the service | The higher the percentage, the lesser the vulnerability |
| | Infrastructure and institution | Veterinary service | Percentage of total HHs who utilize the services provided by these facilities | The higher the percentage of the users, the lesser the vulnerability |
| | | Health center | | |
| | | Market center | | |
| | | Access to credit | | |
| | | Clean water access | | |
| | Access to information | Radio possession | Total percentage of HHs who are classified into the category | The higher the percentage, the lesser the vulnerability |
| | | HH sex | | |

Table 1 … cont'd

| | | | | |
|---|---|---|---|---|
| | | Literacy | | |
| | | Membership in associations | | |
| Sensitivity | HH level impact of climate change | Food shortage | Percentage of HHs subject to | The higher the percentage, the higher the vulnerability |
| | | Water scarcity | | |
| | | Conflict | | |
| Exposure | HH perception about climate change | Change in temperature | Percentage of HHs that perceive increased temperature | Increasing temperature and decreasing rainfall increase vulnerability |
| | | Change in precipitation | Percentage of HHs that perceive increased RF | |
| | | Change in rainfall timing | Percentage of HHs that perceive more deviation | The higher the variability, the higher the vulnerability |
| | | Frequency and occurrence of drought | Percentage of HHs that perceived increased frequency | The higher the frequency, the higher the vulnerability |

Source: Authors' on construction, 2010

**Vulnerability Index Specification**

To determine the level of vulnerability, the study attempts to analyze vulnerability based on the integrated approach by making the use of vulnerability index. The use of indices is challenged by many ambiguities, some of which are the choices of the right indicators, directions of relationships with vulnerability, weights attached and the optimal scale (Temesgen *et al.,* 2008). The choice of indices was undertaken based on a review of the literature and adjusting to the context of the study population. The direction of relationship in vulnerability indicators (i.e. their sign) was adopted from the procedure followed by (Temesgen *et al.,* 2008) who assigned a negative value to sensitivity and exposure and a positive value to adaptive capacity.

In this research, it is assumed that households with higher adaptive capacity are less sensitive to impacts of climate change keeping the level of exposure constant. Hence, vulnerability is the net effect of adaptive capacity, sensitivity and exposure.

*Vulnerability = Adaptive Capacity +Sensitivity + Exposure* ---------(1)

From this, higher net value indicates a relatively lesser vulnerability of household or social group and vice versa. In this case the values of the indices are only relative values and have no further meaning.

Instead of simply assigning equal or average weight across the variables, a statistical technique, principal component analysis (PCA), is used to determine the weights in the index. PCA is an essential tool for summarizing variability among a set of variables, specially it seeks to describe the variation of a set of variables as a set of linear combinations of the original variables, in which each consecutive linear combination is derived so as to explain as much as possible of the variation in the original data, while being uncorrelated with other linear combinations. PCA as a technique extracts from a set of variables, those few orthogonal linear combinations of the variables that capture the common information most successfully. Intuitively the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information that is common to all the variables (Filmer and Pritchett, 2001; Longyintuo *et al.*, 2005; Temesgen *et al.*, 2008).

**Household Vulnerability Index ($VI_{HH}$)**

Suppose we have a set of K variables ($a^*_{1j}$ to $a^*_{Zj}$) that represents the K-variables (attributes) of each household. PCA starts by specifying each variable normalized by its mean and standard deviation. For instance, $a_{1j} = (a^*_{1j} - a^*_{i})/s^*_{1}$, where $a^*_{1}$ is the mean of $a^*_{1j}$ across regions and $s^*_{1}$ is its standard deviation. The selected variables are expressed as linear combinations of a set of underlying components for each household, j:

$$a_{1j} = V_1 A_{1j} + V_{12} A_{2j} + \text{-----------} + V_{1k} A_{kj}$$

-------- j= 1,…j. -----(2)

$$a_{k1j} = V_{k1} A_{1j} + V_{k2} A_{2j} + \text{------} + V_{kk} A_{kj}$$

Where the A's are the components and the V's are the coefficients on each component for each variable (and don't vary across households). Since only the left hand side of each line is observed, the solution to the problem is indeterminate. Principal component analysis overcomes this indeterminacy by finding the linear combination of the variables with maximum variance, usually the first principal component $A_{1j}$, and then finding a second linear combination of variable orthogonal to the first, with maximal remaining variance and so on. Technically the procedure solves the equations $(\mathbf{R}-\lambda\mathbf{I})v_n = 0$ for $\lambda_n$ and $v_n$ where **R** is the matrix of correlations between the $n^{th}$ component for each variable. Solving the equation yields the characteristic roots of **R**, $\lambda_n$ (also known as eigenvalues) and their associated eigenvectors, $v_n$. The final set of estimates is produced by scaling the $v_n$s so that the sum of their square sums to the total variance, another restriction imposed to achieve determinacy of the problem.

The scoring factors from the model are recovered by inverting the system implied by equation (2). This yields a set of estimates for each of K principal components.

$$A_{1j} = f_{11}\, a_{1j} + f_{12}\, a_{2j} + \text{-------} + f_{1k}\, a_{kj}$$

j= 1,….., j ----------(3)

$$A_{k1j} = f_{k1}\, a_{1j} = f_{k2}\, a_{2j} + \text{----------} + f_{kk}\, a_{kj}$$

The first principal component, expressed in terms of the original (un-normalized) variables, is therefore an index for each household based on the following expression.

$$A_{lj} = f_{11}\,(a^{*}_{1j} - a_{1}^{*}) / (s_{1}^{*}) + \text{------}\, f_{1k}\,(a^{*}_{kj} - a_{k}^{*}) / (s_{k}^{*}) \text{-------} (4)$$

The critical assumption of PCA is that, the undefined 'common information' is in fact determined by the underlining phenomenon that the index is trying to measure (in this case, vulnerability) which unfortunately cannot be statistically verified since it depends on the correct identification of relevant variables of indicators, and is, therefore, largely a matter of judgment. One of the advantages of PCA (apart from the objectivity of the weights) is that it estimates the contribution of each variable to the underlying common phenomenon, and thus enables us to rank the indicators according to their importance in determining the household level of vulnerability

**Social Group Vulnerability Index ($VI_{sg}$)**

An alternative method is developed to calculate the vulnerability of the social group at aggregate level using a simple mathematical approach. In calculating the $VI_{sg}$, the same definition that has been used in constructing $VI_{HH}$ is adopted. With regard to indicator variables, except two variables, the rest are maintained. The dropped variables are sex and household head leadership role. The justification is that at a community level members would not be able to have these entitlements at a time and if they do have, it means no variation and therefore, no need of consideration. The same factor score results that have been generated by the PCA are used to determine the weight of individual indicators' contribution to the overall index.

To start the construction of $VI_{sg}$, first we need to standardize every indicator as a scale free index. This process enables us to overcome the problem of scale of measurement in case the indicator variables are explained through different units of measurement like percentage, ratio, hours, etc. Hahn *et al.* (2009) in their calculation of livelihood vulnerability index (LVI) for two districts of Mozambique used the UNDP's Human Development Index (HDI) approach in standardizing their indices. According to UNDP, life expectancy index is calculated in HDI as a ratio of the difference of the actual life expectancy and a pre selected minimum, and the range of pre determined maximum and minimum life expectancy. In the study, by taking this approach, standardization of the selected variables is made using the equation given below:

$$Index\ P_{sg} = \frac{P_{ac} - P_{\min}}{P_{\max} - P_{\min}} \text{ ----------------- (5)}$$

Where $P_{ac}$ is the actual observation of the social group and $P_{min}$ and $P_{max}$ are the minimum and the maximum values, respectively. In our case since all variables are measured in percentage, the minimum and maximum values are 0 and 100, respectively. As an example for a variable of 'camel ownership' the possible maximum value is 100%, if all respondents have camels; it is 0 if no household owns a camel in that specific social group.

To get the specific contribution of each determinant (adaptive capacity, sensitivity and exposure) to overall index, first we determine the value for these major components using the formula specified below. In the formula, we multiply the standardized value of every indicator variable by its respective weight (derived from the first PCA result). Then, we add the multiples of every indicator variables together and divide the result to the sum of their weights to arrive at the final value of every determinant component.

$$A_{sg} / S_{sg} / E_{sg} = \frac{\sum_i^j f_i P_{sg}}{\sum_i^j f_i} \text{ ---------------- (6)}$$

Where $A_{sg}$, $S_{sg}$, and $E_{sg}$ are adaptive capacity, sensitivity and exposure of the social group, respectively. $P_{sg}$ is the standardized value and $f_i$ is the weight of the indicator variables. To get the final $VI_{sg}$ value, we subtract the sum of $S_{sg}$ and $E_{sg}$ values from $A_{sg}$ value. But, here, instead of assigning equal weights to all the three major components, we allocate a relative weight based on the number of the total variables that constitute these components. Therefore, we can determine the final value of the social vulnerability index using the following equation:

$$VI_{sg} = \frac{K_a A_{sg} - K_s S_{sg} - K_e E_{sg}}{K_a + K_s + K_e} \text{ ---------------- (7)}$$

Where $VI_{sg}$ is the vulnerability index of a social group, $A_{sg}$, $S_{sg}$, and $E_{sg}$ are adaptive capacity, sensitivity and exposure of the social group, respectively. $K_a$, $K_s$, and $K_e$ show the number indicator variables that constitute for adaptive capacity, sensitivity and exposure, respectively. As we stated earlier, vulnerability to be the net effect of adaptive capacity, sensitivity and exposure higher net values show less vulnerability and vice versa.

# Results and Discussions

## Results

To analyze the vulnerability of the study population, PCA was run on 21 selected indicator variables that are given in Table 1. The number of principal components extracted can be defined by the users, and a common method used is to select components where the associated eigenvalues is greater than 1 (Vias and Kumaranayake, 2006). In our case 21 components were extracted, but only the first eight were significant based on the above criterion or Kaiser criterion of an eigenvalues greater than1[1] The eigenvalue (variance) for each principal component indicates the percentage of variation in the total data explained (Vias and Kumaranayake, 2006). In the studies reviewed by the authors, the first principal component accounts for 11.1% (Vias and Kumaranayake, 2006) to 56% (Temesgen *et al.*, 2008) of the total variation.

In our case the first component explained about 10.24% of the total variance in the selected indicators. Based on earlier arguments for the use of PCA in constructing indices, the first principal component was used in calculating the vulnerability indices of households in the study area. The factor scores (weights) from the first PCA are negatively associated with all the indicators identified under exposure and sensitivity, and with the exception of one variable, they are positively associated with indicators identified under adaptive capacity (see Table 2 Column 4). Thus, to construct the vulnerability indices, 20 indicators out of 21 indicators initially were used by dropping the variable that has negative sign in contrast to the initial assumption.

Table 2. Summary statistics of selected variables and the factor score from the first PCA

| Indicator variables | Mean | Standard deviation | Factor score |
|---|---|---|---|
| Camel ownership | 0.3510 | 0.4789 | 0.2125 |
| Non agricultural income | 0.2781 | 0.4496 | 0.2304 |
| Saving in cash | 0.4106 | 0.4936 | 0.3669 |
| Extension service | 0.1258 | 0.3328 | 0.0379 |
| Veterinary service | 0.7947 | 0.4053 | 0.1544 |
| Access to market | 0.4238 | 0.4958 | 0.3280 |
| Micro financial institutions | 0.4636 | 0.5003 | 0.1083 |
| Water sources | 0.3974 | 0.4910 | 0.3681 |
| Health facilities | 0.9272 | 0.2608 | 0.1015 |
| Sex | 0.9272 | 0.2608 | 0.1043 |
| Literacy | 0.0530 | 0.2247 | 0.1250 |
| Radio ownership | 0.4702 | 0.5008 | 0.1501 |
| Leadership role | 0.1921 | 0.3952 | 0.3000 |
| Food shortage | 0.5166 | 0.5014 | -0.1915 |
| Water relief | 0.6755 | 0.4697 | -0.2303 |

Table 2… cont'd

| | | | |
|---|---|---|---|
| Conflicts | 0.5894 | 0.4936 | -0.2283 |
| Perception on temperature increase | 0.1391 | 0.3472 | -0.2388 |
| Perception on rainfall decrease | 0.4570 | 0.4998 | -0.2665 |
| Perception on rainfall variability | 0.2517 | 0.4354 | -0.0287 |
| Perception on frequency of drought | 0.3046 | 0.4898 | -0.2585 |

Source: Household survey, February 2010

**Household Vulnerability Index ($VI_{HH}$)**

Using equation 4 and the factor score, results from the first PCA were used to construct a normalized vulnerability index of a household applying the following formula:

$$VI_{HH} = [f_i\ (a_{ji} - x_i)]/s_i$$

Where $VI_{HH}$ is a standardized vulnerability index of each household;

$f_i$ factor score from the PCA assigned to the indicator variables (K= 20);

$a_{ji}$ the value of each household on the indicator variables;

$x_i$ the sample mean of each selected variables [Column 2 of Table 2];

$s_i$ the standard deviation [Column 3 of Table 2]

Holding exposure and sensitivity constant, a negative index shows the household to have relatively lower adaptive capacity when compared with a household that has a positive index value and vice versa.

Based on this, a total of 151 indices were calculated for the sample population. After sorting these standardized indices ($VI_{HH}$) in ascending order, 3.28 and -2.93 were identified as the maximum and the minimum score of the sample population. The mean score of $VI_{HH}$ for the total population is 0.01. Cutoff values were defined by the researchers to classify households into three different classes of household vulnerability (Table 3). The classifications are: households that scored a negative value as ('highly vulnerable'); households that score from 0 to 2 ('vulnerable'); and, households that score an index value greater than 2 ('less vulnerable').

Table 3. HH classification into different vulnerability classes based on $VI_{HH}$ index score

| Category | Social group | | | | Total | |
|---|---|---|---|---|---|---|
| | AP (N= 73) | | PAS (N= 78) | | N= 151 | |
| | No | % | No | % | No | % |
| Highly vulnerable [$VI_{HH}$ <0 ] | 46 | 63.01 | 30 | 38.47 | 76 | 50.33 |
| Vulnerable [$0 \leq VI_{HH} \leq 2$] | 24 | 32.88 | 36 | 46.15 | 60 | 39.74 |
| Less vulnerable [$VI_{HH}$ > 2] | 3 | 4.11 | 12 | 15.38 | 15 | 9.93 |

Source: Household survey, 2010

Accordingly, 50.33%, 39.74% and 9.93% of the sample population were found to be highly vulnerable, vulnerable and less vulnerable, respectively (Table 3). When we analyze the distribution of $VI_{HH}$ score by households' economic activity, 63.01% of agro-pastoral households and 38.47% pastoral households were found to be highly vulnerable. Higher percentages of pastoral households (46.15%) fall in vulnerable category compared to that (32.88%) of agro-pastoralists. When we compare the mean $VI_{HH}$ score for the two social groups of households, the pastoralists have a relatively higher mean score of $VI_{HH}$ against the agro-pastoral households (0.44 Vs -0.45), indicating that they are generally less vulnerable.

Table 4. Social group vulnerability indicator variables and their respective standardized values (in %)

| Major components | Indicator variables | AP | PAS | Standardized value $P_{sg} = \frac{P_{ac} - P_{min}}{P_{max} - P_{min}}$ | |
|---|---|---|---|---|---|
| | | | | AP | PAS |
| Wealth | HH that own camels | 19.18 | 50.00 | 0.1918 | 0.5000 |
| | HH which save in cash | 36.99 | 45.45 | 0.3699 | 0.4545 |
| | HH that have access to non agricultural income | 23.29 | 31.17 | 0.2329 | 0.3117 |

Table 4… cont'd

| | | | | | |
|---|---|---|---|---|---|
| Technology | HH that use Extension service | 89.04 | 88.31 | 0.8904 | 0.8831 |
| | HH that use vet service | 90.41 | 69.23 | 0.9041 | 0.6923 |
| | HH that have good market access | 42.47 | 41.03 | 0.4247 | 0.4103 |
| Institution and Infrastructures | HH that are member to saving and credit association | 43.84 | 48.72 | 0.4384 | 0.4872 |
| | HH with better access to sustainable water sources | 23.29 | 55.13 | 0.2329 | 0.5513 |
| | HH that use health facilities | 95.89 | 89.74 | 0.9589 | 0.8974 |
| Information source | HH literacy | 5.48 | 5.20 | 0.0548 | 0.0520 |
| | HH that own radio | 46.58 | 47.44 | 0.4658 | 0.4744 |
| Sensitivity | HH that subject to food aid | 52.11 | 50.00 | 0.5211 | 0.5000 |
| | HH that faced conflicts | 40.00 | 44.87 | 0.4000 | 0.4487 |
| | HH that subject to water relief | 82.19 | 53.85 | 0.8219 | 0.5385 |

Table 4… cont'd

| | | | | | |
|---|---|---|---|---|---|
| Exposure | HH that perceive increased temperature | 80.56 | 93.59 | 0.8056 | 0.9359 |
| | HH that perceive decreased rainfall | 42.47 | 65.38 | 0.4247 | 0.6538 |
| | HH that perceive high rainfall variability | 54.79 | 93.59 | 0.5479 | 0.9359 |
| | HH that perceive increased frequency of drought | 65.75 | 76.92 | 0.6575 | 0.7692 |

Source: Household survey, February 2010

## Social Vulnerability Index ($VI_{sg}$)

To calculate the $VI_{sg}$ first we need to standardize the indicator values into scale-free measurements. The standardized values for the study subjects are given in Table 4.

Using these standardized values, the $VI_{sg}$ is calculated based on equation 7. The summarized results of the $VI_{sg}$ of the study subjects are presented in Table 5. As we can see from the table, the standardized social vulnerability index score for pastoralist is 0.035 while the agro-pastoralist vulnerability index equals 0.003.

Table 5. Results of $VI_{sg}$ calculation for pastoral and agro-pastoral social groups

| Determinants of vulnerability | Agro-pastoralist | Pastoralist |
|---|---|---|
| Adaptive capacity | 4.283 | 5.262 |
| Sensitivity | -1.755 | -1.487 |
| Exposure | -2.479 | -3.147 |
| $VI_{sg}$ | 0.003 | 0.035 |

Source: Household survey, February 2010

Based on our earlier assumption, higher net values indicate a relatively lesser vulnerability of the social group. Accordingly, agro-pastoralist group is found to be more vulnerable than the pastoralists (Table 5).

In general, the findings of the study reveal higher vulnerability of agro-pastoralist households in the study area. The $VI_{HH}$ which gives the vulnerability score of household shows that from the total sampled population, half of them are 'highly vulnerable'. Among the 'highly vulnerable' sample households, the agro-pastoralists account for about 61%. In the case of $VI_{sg}$ score, the agro-pastoralists have a relatively lower index value which implies a relatively higher vulnerability of the group.

## Discussion of the Findings

To explain the higher vulnerability of agro-pastoralists it is very important to look into the historical and actual practice of farming activity in the area. Historically, farming practices (crop production) was started in the area as an economic diversification strategy by destitute households that have lost their asset through the recurrent droughts (Oba, 1998). From this statement we can learn that the economic status of agro-pastoral households is lower, i.e., they are either destitute or have lost their assets. Since wealth and adaptive capacity are correlated positively, the lower economic status of these households implies their lower adaptive capacity. Given this low adaptive capacity, when these households are exposed to climatic shocks, their sensitivity is relatively high. In addition, higher rainfall variability and recurrent droughts have contributed towards shortening of recovery period. Due to these facts, these households were not able to come out of the trap yet, and hence, their vulnerability has been increasing.

Looking into the current agricultural practice of the study population, the sampled agro-pastoral households cultivate an average 1.5 hectare of land using oxen power. Though, the *woreda* has a biannual rainfall mode, farming practices usually take place in the longer rainy season only. Modern input utilization of these households is very poor. According to the information gathered from the in-depth case studies with the members of the social group and the key informants, there is no consistent supply of agricultural inputs like fertilizer, improved seed, and pesticides and herbicides in the *woreda.* According to the household survey, all the sampled households do not have access to fertilizer. About 45% of households indicated that they use improved seed whenever it is provided to them by the NGOs or in the form of aid; otherwise, there is no regular supply of the input in the sampled *kebeles.*

In the sampled *kebeles* there are no irrigation schemes. Therefore all households practice rain-fed agriculture. But as mentioned previously, the rainfall condition of the *woreda* is not in favor of these households. High rainfall variability, decreasing of rainy days, and increased temperature conditions have induced reduction of productivity; and when these are accompanied by extremes like droughts the result is a complete loss of production. In our case, 95.89% of the agro-pastoral households stated that they suffer from a complete loss of their harvest during such periods. Hence, these situations cause the dwindling of households' income and food self-sufficiency both in the short and in the long run, increasing their vulnerability.

In their assessment of impacts of drought on agriculture in two villages of Borena, Fassil *et al.* (2001) have identified the problems that are related with farming activities in the area. According to the response of households interviewed by the researchers, the households often sow seeds at the beginning of the rainy season and when rainfall is inadequate they lose both the seeds and the yield. Sometimes the impact goes beyond this and forces some households to sell animals to buy inputs for agricultural production. Moreover, the households indicated that crop production is not a sustainable venture in the rangelands; it may, in fact, increase their dependency on food aid. In spite of this, they keep on trying to produce crops, but without success most of the times (Fassil *et al.,* 2001). Thus, sensitivity of the agro-pastoral households to climatic variability and change is relatively higher.

Selection of appropriate adaptive mechanisms prior to actual exposure to hazards have important impact in reducing sensitivity and hence aggregate vulnerability. Household's perception has also important role in selecting adaptive strategies even when households are exposed to similar situation. In our study, in comparative terms, higher percentage of pastoral households have a better understanding of the changes of climatic conditions that coincide with the scientific or meteorological data. The researchers believe that this has its own contribution to the higher vulnerability of agro-pastoral households in the study area. A good case that supports this argument is, despite increasing trend of short rainy days in the area, the majority (99%) of agro-pastoral households in the area sow maize which requires a longer maturity period, demonstrating that agro-pastoralists lack knowledge about appropriate crop production management and technologies.

The other critical advantage of pastoral households over the agro-pastoralist is mobility. Based on the information collected from key informants from zonal office, though, the degree of movement has shown a decreasing trend in general terms, the pastorals still use the approach as a coping mechanism at times of climatic shocks. From our survey, 78% of pastoral households indicated sending their livestock elsewhere when the climatic conditions get worse in their vicinity. Although the agro-pastoralists also adopt this mobility strategy for their livestock, it is not possible for them to escape from the impacts that are associated with loss of harvest.

## Conclusions

As discussed above, pastoral households and agro-pastoralists depend heavily on natural resources for their livelihoods entailing mainly livestock-keeping and crop cultivation, which are sensitive to changes of climatic conditions. Though the two social groups are equally exposed to extreme drought and climatic shocks, the effects are not identical across these groups. The level of their vulnerability to climate change and their capacity to adapt have been shaped by initial wealth status, natural resource base and choice of appropriate adaptive strategies.

Pastoral households own relatively more asset/livestock and maintain their mode of mobility in space and time. In contrast, agro-pastoral households have little asset or are dropouts taking up opportunistic crop cultivation or combining it with livestock-keeping with limited or no mobility. The pastoralists have better initial wealth status and continue with long-established viable strategy (mobility) rendering them better capacity and advantage to cope with climate-induced effects. Alternatively, the agro-pastoralists with lower wealth status have adopted cultivation, which is more sensitive to climate change, and practice little or no mobility, rendering them very vulnerable to consequences of climate change. Consequently, the agro-pastoralists with limited mobility are more vulnerable to climate change and variability than are nomadic pastoralists in the study area.

Therefore, it can be concluded that rain-fed farming is less resilient in the face of mounting climatic shocks in the study area. It has increasingly become unviable livelihood strategy under the changes of climatic conditions. This suggests that farming is a very risky business in the pastoral lowlands. And, hence, pressing on sedentarization and crop cultivation cannot be an option for all pastoral systems, as producers shift between herding and cultivation depending on the economic and ecological conditions in space and time. This indicates that investments and interventions to increase local adaptive strategies should consider the dynamic conditions of pastoral production systems in specific context and conditions.

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## Endnote

[1] The eigenvalue is a measure of standardized variance with a mean of 0 and standard deviation of 1. Each standardized variable (i.e. each of 21 indicators in this case) contributes at least the variance of 1 to the principal component extraction. The Kaiser criterion states that unless a principal component extracts at least as much as one of the original variables (i.e. has a standardized variance equal to or greater than 1), it should be dropped from further analysis (Filmer and Pritchett, 2001 cited in Longyintou *et al.*, 2005).