ORIGINAL ARTICLE

SOCIAL VULNERABILITY TO CLIMATE CHANGE IN THE ABBAY BASIN, UPPER BLUE NILE OF ETHIOPIA

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ABSTRACT

This paper assesses the social vulnerability to climate change in the valley of the Abbay-Beshilo, Upper Blue Nile Basin of Ethiopia. Data were collected using a survey of households and focus group discussions as well as from the global weather data for soil and water assessment tool, office documents and research reports. Climatic elements were analyzed using simple regression and standardized precipitation index, while social vulnerability index was used to calculate vulnerability scores for social capital indicators. The study found different social vulnerability scores for different indicators. Households were highly dissatisfied with the services given by local leaders. However, households were less vulnerable to climate change by policy-related indicators though discussants complain of the little or no benefits gained from the policy interventions. This study is the first assessment of relative levels of social vulnerability to climate change in the Abbay-Beshilo Valley of Ethiopia. Since social capital is so vital in reducing climate change risks during and after every disaster, it is essential to consider it when designing adaptation measures.

Keywords: Abbay Basin, climate change, Ethiopia, social vulnerability, standardized precipitation index

INTRODUCTION

Climate change is the greatest environmental challenge that current human generations face (Ajibade, 2013; Vincent, 2004). It is differently defined in almost every knowledge domain (IPCC, 2007; Kabote, et al., 2014). The most cited definition of climate change is that of the IPCC (2007), which defines it as a long-term change in rainfall, temperature and extreme weather episodes. Temporal and/or spatial variations of the mean state climate beyond individual weather events is also termed as climate variability (IPCC, 2007). These phenomena have potential impacts on water, food and nutrition, agriculture, human health, ecosystem, and infrastructure (IPCC, 2013; Kabote, et al., 2014). The impacts are differentiated by location, gender and wealth status. Fragile areas like the Abbay gorge are more vulnerable to climatic risks mainly due to unfavourable environment and over dependency on climate sensitive agricultural sector (Kabote, et al., 2014). In this regard, the work of Vincent (2004) also highlighted that future climate change will have potential spatial differentiation of impacts.

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Traditionally studies have concentrated on projections of climate change using models based on past analogues of climate variability and then making suggestions on how such changes affect human populations through changing patterns of weather and coastal flooding. However, such top-down approaches fail to take into account the vulnerabilities of human populations in terms of social indicators (Hahn et al., 2009; Houghton, 2009; Vincent, 2004). Assessing the likely impact of climate change is interlinked with the social dimension of vulnerability. Therefore, understanding how different societies socially tied to adapt to climate change is a key element of research (Hahn et al., 2009; Vincent, 2004). As a result, the field of vulnerability study has emerged to see the way in which human populations mediate the adverse impact of climate change through their social networks, relationships, organizational affiliations and institutions. This area of research marks one of the emerging research areas of society-nature relationships with key policy and practical applications. The index of social vulnerability has many applications in contributing to the growing field of vulnerability assessment; enhancing the ongoing debates on the notions of vulnerability and helping to interpret the conceptual framework of vulnerability assessment (Vincent, 2004).

Studies were conducted in Ethiopia on climate change and related issues. Some studies tend to focus on the different shocks in relation to growth and/ or consumption (Dercon, 2004; Dercon et al., 2005). Others examine the relationship between rainfall and crop production at the zonal, regional and national levels (Segele & Lamb, 2005; Woldeamlak, 2009). Some others analyze yield or monetary impact of climate change and adaptation measures using climate models (NMA, 2001; Temesgen, 2007; Yosuf et al., 2008; You and Ringler, 2010). A few other scholars also examine climate induced-hazards, impacts, responses and local innovations to climate change adaptation, restricted to the pastoral lowlands (Aklilu and Alebachew, 2009; Yohannes and Mebratu, 2009). Additionally, studies were carried out on perception and adaptation without integrating vulnerability (Conway & Schipper, 2010; Temesgen et al., 2009). Only Temesgen (2010) analyzed the vulnerability of agriculture dependent farmers using the integrated vulnerability assessment framework aggregated at regional level covering a wider geographical area having diverse biophysical and socio-economic contexts.

Reviewing these previous studies, it is found that there are no research works that treated social vulnerability to climate change in Ethiopia in any spatial scale using social vulnerability index, except blaming the recurrent drought, severe land degradation and misdeeds of the previous regimes. In this regard, scholars of climate-change contend that without understanding social vulnerability it is difficult to acquire a better knowledge of human adaptation to climate change (Adger, 1999; Kelly & Adger, 2000; Vincent, 2004; Wisner et al., 2004). This situation inspired the author to examine the local level social vulnerability to climate change by integrating different indicators in the Gorge of the Abbay-Beshilo, upper Blue Nile of Ethiopia. By developing an index, this can add social vulnerability to the existing knowledge domains of biophysical vulnerability to climate change at the local level.

VULNERABILITY ASSESSMENT

Concepts of vulnerability

The most contested term for various scholarly communities is 'vulnerability', which refers to the degree to which a system is likely to experience harm due to exposure to a hazard usually associated with floods, droughts and poverty (Fusel & Klein, 2005; Turner II et al., 2003). Vulnerability has its origins in the natural hazards and food security literature (Cutter, 1996). The term vulnerability is now a central concept in the livelihood, food security, sustainability science, land-use change, natural hazards, disaster risks management, public health and global environment and it is increasingly used in climate change research (Fussel, 2006; Schroter et al., 2004).

Vulnerability is commonly considered to be the ability to anticipate, resist, cope with and respond to a hazard (Wisner et al., 2004). However, vulnerability definitions reveal a distinction in the literature between the two main epistemological approaches. The natural hazards school of thought arises out of a positivist vein and, hence, focuses on the objective studying of hazards. Under this approach, emphasis is placed on a particular environmental stress and vulnerability refers to the risk of exposure of an ecosystem to a natural hazard. In contrast, the human ecology and political economy schools of thought have arisen out of interpretive social science paradigms based on relativist and constructivist ontology In these cases, vulnerability refers to a particular group or social unit of exposure and especially to the structures and institutions–economic, political and social–that govern human lives (Vincent, 2004).

One of the heavily relied upon definitions of vulnerability in the context of climate change studies is from IPCC (2001, 2007). IPPC defines vulnerability as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. The same institution provides two more definitions that are not specified as natural, or social vulnerability, but fit into the separate climate research streams. From the natural standpoint, the IPCC defines vulnerability as "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, p. 995). From a social point of view, it describes vulnerability as the degree to which a system is susceptible to injury, damage or harm. Along the same line, Houghton and Khandker (2009) explain vulnerability as a risk of falling into poverty in the future, even if the person is not necessarily poor in the present; it is often associated with the effects of shocks such as drought and floods with a drop in farm production. Thus, social vulnerability is typically broken into three overlapping components: exposure, sensitivity and adaptive capacity (Turner II et al., 2003).

Exposure is the magnitude, frequency, intensity, and duration of climate-related hazards such as hurricanes, droughts, floods and storms, changing distribution of temperature and rainfall, which expose farmers' livelihood assets (IPCC, 2007). Sensitivity is the degree to which the rural household is adversely affected by the exposure to the changing climatic variables. Sensitivity can be measured by the proportion of people who have been facing food shortage, water scarcity, number of months in food shortage, and level of access to different services. Adaptive capacity on the other hand refers to people's ability to adapt and recover from climate exposure by facilitating access to livelihood resources for adaptation. Sensitivity and adaptive capacity largely depend on the main livelihood activities practiced by a farmer and the specific livelihood resources needed to carry out these activities (IPCC, 2007; Luers et al., 2003; Turner II et al., 2003).

In this line of argument, Schroter et al. (2004) noted that agricultural vulnerability to climate change in terms not only of exposure to higher temperatures, but also crops yield sensitivity to high temperatures and farmers' ability to adapt to the effects of that sensitivity by planting more heat -resistant cultivars or different crops. Thus, one can conclude that exposure, sensitivity and adaptive capacity are inherently intertwined (Gallopin, 2006). For example, greater amounts of exposure will lead to greater sensitivity, while adaptive capacity can reduce the system's sensitivity. In practice, these steps do not happen chronologically, but instead play a continuous role in enhancing or diminishing each other. Consequently, many studies combine sensitivity with exposure or combine sensitivity with adaptive capacity depending upon the indicator under consideration.

Theoretical frameworks of vulnerability assessment

There are three major theoretical frameworks used to explain vulnerability: the biophysical vulnerability, the social/socio-economic vulnerability and the integrated vulnerability. The biophysical vulnerability assessment framework tries to assess the risks and levels of damage to certain exposed units that arise from exposure to the hazards of a particular type and magnitude (Fussel, 2006; Schroter et al., 2004). This approach uses quantitative models to measure exposure and sensitivity of biophysical and socio-economic systems to the given environmental risk based on forecasts or estimates of climate prediction models, or by creating indicators of sensitivity for real or potential hazards, including their frequency. A key aspect of the biophysical approach is the clear distinction between two factors: one, the hazard characterized by its site, intensity, frequency and probability (Benson & Twigg, 2007) and, the other, the vulnerability of the degree of damage caused by a hazard. Therefore, it is mostly considered as the outcomes' endpoint of vulnerability (Fussel, 2006).

This approach has invited criticism assuming that humans are passive recipients of global environmental change and thus failing to capture their dynamic ability to mediate such hazards, either through resisting an event or coping with it. The reason is attributed to the fact that it has failed to consider the role of social structures and institutions that shape differential exposure and consequences (Turner II et al., 2003). The second limitation raised by scholars is that studies relying on climate scenario projections from general circulation models (GCMs) suffer from uncertainty. In addition, methods relying on advanced climate projections and multiple international and national databases may be impractical for development planners working at the community level (Hahn et al., 2009). Therefore, this approach was not applied in this study.

The second vulnerability assessment framework is social/socioeconomic vulnerability, which is regarded as a priori condition of a household or a community conditioned by socio-economic and political contexts (Adger & Kelly, 1999; Fussel & Klein, 2005; Wisner et al., 2004). While some authors termed this approach ‘socio-economic vulnerability’ (Adger et al., 2004; Brooks, 2003), others chose the term ‘social vulnerability’ (Adger, 1999; Kelly & Adger, 1999; Vincent, 2004), and still a few others explained it as ‘contextual vulnerability’ (O'Brien et al., 2007).

The second-generation vulnerability studies apply this approach focusing on the local scale to enhance local capacity in the face of climate change. The theoretical approach focuses exclusively on people, asking who is the most vulnerable, how susceptible they are and why (Fussel, 2006). This approach assesses vulnerability based on variations in socio-economic dynamics, institutional characteristics, political status of people and social groups in the community in order to measure adaptive capacity (Fussel & Klein, 2005).

There are many works that explain vulnerability in the socio-economic vulnerability approach (Adger, 1999; Adger & Kelly, 1999; Vincent, 2004; Wisner et al., 2004). Wisner et al. (2004) point-out various socio-economic factors that can lead the system to vulnerability situations. These factors include economic imbalances, power disparity among social groups, knowledge dissemination, and discrimination in welfare and social protection. However, it is contended that violent conflict and illness can lead to a greater loss of life than the natural and human-induced hazards such as earthquake, drought, flood and famine.

This approach has also attributed vulnerability of the society to socio-economic and political factors. Studies argue that in reality environmental factors are creating variation in society (Cutter et al., 2003; Temesgen, 2010). For example, two or more groups found in similar social conditions, but characterized by different environmental attributes can have different levels of vulnerability to climatic stresses. Thus, Fogera, Dembia and Dera *woreda*s of the Amhara region of Ethiopia are more vulnerable to floods than Chilga and other *woreda*s because of geographic exposure keeping other social factors equal. The second limitation of this approach is its failure to consider variation in natural resource endowments to counteract the negative impact of environmental shocks. Although resource-rich households experience greater losses than the resource-poor, they can recover more quickly from a climatic stress.

Various lines of investigation show the inadequacies of biophysical and socioeconomic vulnerability frameworks. This recognition has led to the emergence of integrated vulnerability assessment framework, which draws a range of physical, biological and social science disciplines using a range of methods (Fussel & Klein, 2005; Houghton, 2009). Integrated approach brings together critical insights from political-economy perspectives with the awareness of physical-human systems interaction (Adger et al., 2004; Brooks, 2003; Houghton, 2009). The two systems interconnect in all the ways. Natural elements are not isolated from the social and economic environment. Hence the latter cannot be interpreted in terms of their impact on people without taking into account social and economic conditions (Luk, 2011). Accordingly, this study used integrated vulnerability assessment approach guided with the sustainable livelihood framework as it integrated social capital indicators and climate variables.

STUDY AREA

The study was conducted in the Abbay Basin of Simada *woreda* (district), which is located in South Gondar Zone of the Amhara Region, about 774 km north of Addis Ababa and 209 km southeast of Bahir Dar city (Woreda Office of Agriculture, 2011). Simada lies between latitudes 11.00° and 11.5° N latitude and 38.10° and 38.40° E longitudes. Although the altitude of Simada *woreda* ranges from 1196 to 3250 m above sea level (asl) the studied *kebele*s are found in the *kola* climatic zone of Abbay-Beshilo Gorge with altitudes ranging from 854 to 1500 m asl (See Fig. 1).

The *woreda* is bordered in the southeast by the Beshilo River, which bounds it with South Wollo Administrative Zone, on the southwest by the Abbay River, which separates it from East Gojjam Zone, in the northwest by the Wanka River, a tributary of the Abbay, which bounds it with Estie *woreda*, and in the north and northeast by Lay Gaynt and Tach Gaynt *woreda*s respectively. This indicates that the *woreda* is almost totally inclusive in the Abbay River basin. Shrubs and thorny trees scattered or clustered in some areas characterize the vegetation cover. Most parts of the *woreda* have bare soils especially during dry seasons. Vegetation is mainly natural including woodlands and grasslands.

The *woreda* has three climatic zones: *kola* (60%), *woyna-dega* (30%) and *dega* (10%) (Tibebe, 2008). Meteorology data indicate that the mean annual temperature is 23° C. For the period 1979 to 2010 the overall rainfall amount and distribution varied throughout the time and was erratic (Refer to Section 4.1). Much lower total annual rainfall (554 to 847 mm) with the average annual rainfall of 687 mm was detected in the Abbay-Beshilo Gorge. The main rainy season extends from Mid-June to the beginning of September. July and August are the wettest months, while December, January and February are very dry months. This means that the area has high rainfall for the two summer months in the year with less or no rainfall during the other months of the year.

According to the Office of Agriculture, Simada has an estimated total population of 228,271, which means an increase of 22% from the 1994

Population and Housing Census data. This is an average of 4.2 persons per household. The population density of 102 persons per km^2 is less than the South Gondar Administrative Zone average of 145 people per km^2.

Almost all the population living in the *woreda* is dependent on rain-fed mixed farming (cultivation of crops and rearing of animals), as elsewhere in sedentary farming areas of Ethiopia. The major crops grown are sorghum, haricot bean, maize and *teff*. The main livestock are cattle, goats, sheep and equines. The majority of the households reported decreasing food crop and livestock production, that they could not cover their household expenses. Most of the poverty stricken areas have suffered from chronic food insecurity resulting from erratic distribution of rainfall, snowfalls, degraded farmlands, small landholdings, pests and various diseases infestations, livestock disease, malaria and other diseases affecting human beings. This has left the population dependent on food-aid for over the past thirty years. Agricultural

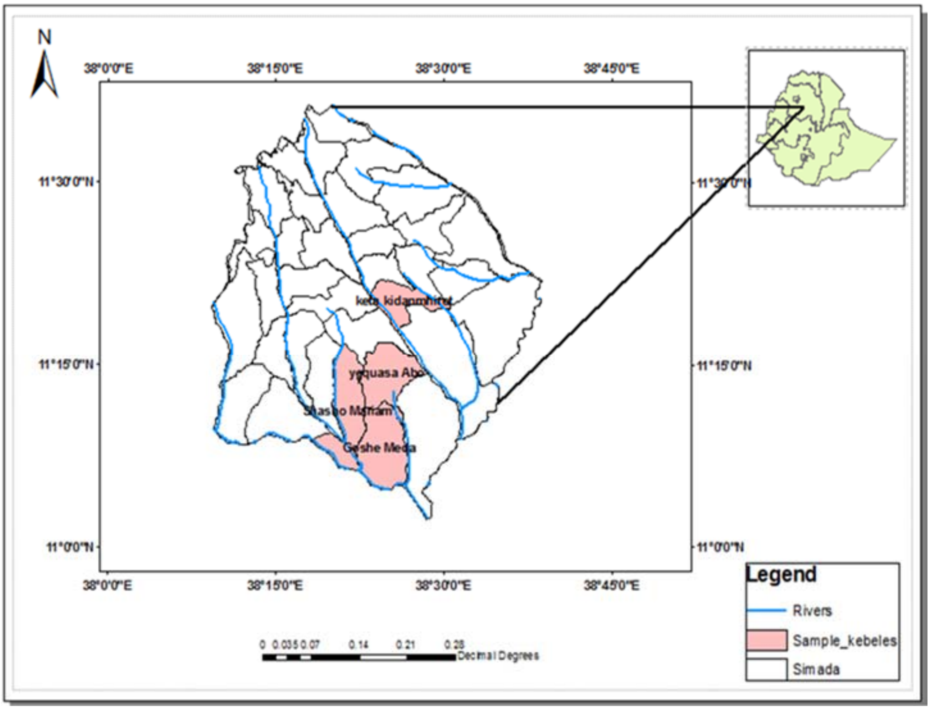

Figure 1: *Location of the study area*
Source: Own computation from Ethio GIS Database.

wage labor along with sesame weeding and harvesting opportunities in Metemma, Humera, and Quara are important income sources for the poor and the very poor and for many people who are dependent on PSNP and firewood sales to meet their food needs as well.

Poor health and nutrition status of the community was the primary general problem of the people in the *woreda* as identified during the focus group discussion forums held with the local community. Low health service, which is the result of the insufficiency of health institutions as compared to the *woreda* population, inaccessibility to health services, limited supply of drugs, malnutrition and weak immunization coverage are among the most prioritized problems of the area. Different health indicators such as prevalence of different diseases, child and maternal morbidity and mortality, low status of personal and environmental sanitation, inadequate immunization coverage and poor health facilitation are the signs that point out the existence of the poor health status of the *woreda* communities.

The cultivated land-use dominates the study area. The human-occupied areas can be divided into: (1) cultivated areas that can be categorized as dominantly and moderately cultivated land use units with cereal crops, and some open grassland; (2) shrubby grassland, bush, open shrubby grassland and rock out crop; (3) nursery sites, plantation areas and open wooded land; and (4) small towns and other settlements. The cultivated areas cover generally the areas having from flat to gentle slopes, whereas moderately cultivated areas cover the area with moderately steep slopes. Shrubby grassland with scattered cultivation and open wooded land with bush cover the southern part of the study area and it is not suitable for cultivation due to the presence of deep river gorges (Tibebe, 2008).

METHODS

The study used integrated vulnerability framework approach, which assesses vulnerability based on social dynamics, institutional characteristics, political status of people and social groups in the community to measure adaptive capacity (Fussel & Klein, 2005) and climatic elements to measure exposure levels of the community to climate change risks. The proponents of this framework consider social vulnerability as the 'starting point', which is linked to the context and the human security. The assumption is that social factors can worsen or reduce the impact of climatic shocks by increasing or decreasing the sensitivity of the system comprising individuals, groups, communities, countries, sectors, etc. From the biophysical factors rainfall and temperature conditions were integrated with the socio-economic indicators to measure the exposure of the community to climate change.

Two research designs (cross-sectional and longitudinal designs) and two data sources (primary and secondary sources) were employed to generate data for this study. Cross-sectional designs were followed to gather data from farming households using a questionnaire survey at a point in time in order to examine the current situations of rural households. Longitudinal designs were used to record monthly climatic values from Global Weather data for soil and water assessment tool (SWAT; http://globalweather.tamu.edu/) and other government offices.

Data collection and analysis took place in two stages. Household survey preceded focus group discussions (FGDs). Thus, the first stage informed the second stage. The results from the two stages were integrated in order to expand the scope and improve the quality of the results. This approach is known as sequential cross-sectional research design. The study used a household for the cross-sectional data as a unit of analysis during the survey because of its responsibility in decision-making on resource use. For the time -series climate data, the unit of analysis was the community because there was no possibility of getting climate data at the household level.

Household survey

Four *kebele* administrations (KAs) were selected using simple random sampling technique. Because of time and resource constraints only four *kola* KAs from the Abbay Gorge were selected. Further stratification of households in terms of annual income, household size and gender was not done because it was assumed that systematic random sampling can accommodate households having these different criteria in obtaining representative sample population. Sample size determination was carried out to obtain reliable data for the study. Yemane's (1967) sample size determination formula referred by Israel (1992) was checked within the determination of the sample household size for a better representation of the study population.

The formula provided 263 sample populations. Then, the 263 households were distributed to each *kebele* using probability proportional to size (PPS) method in order to ensure equal representation of households as there are different household sizes in each KA. The PPS method provided larger number of household heads for Yequasa Abbo (96), distantly followed by Shasho Mariam (69), Goshmeda (54) and Keta Kidanemihret (44) (See Table 1).

Sampling frames were obtained for each *kebele* by taking the list of all household heads from the *kebele* administrative offices. The sample households were drawn from each *kebele* using systematic random sampling method from the list of names after a certain sampling interval (K) that was determined by dividing the total number of households in the *kebele* by the predetermined sample size of each *kebele*. Next, a number was selected between one and the sampling interval (K) using lottery method, which is called the random start and was used as the first number included in the sample. Then, every Kth household head after that first random start was

Table 1: *Determined sample size by* kebele *administration*

Sample *kebeles*	No. of households	Sample size
Keta Kidanemihret	863	44
Goshmeda	1011	54
Yequsa Abbo	1857	96
Shasho Mariam	1302	69
Total	5033	263

Source: Woreda Administration Offices, 2012.

taken until reaching the desired sample size for each *kebele*. Systematic sampling is to be applied only if the given population is logically homogeneous within the respective strata (*kebele* administration in this case), because systematic sample units are uniformly distributed over the population (Feige & Marr, 2012). In this case, sampling units are rural households who are uniformly distributed in the respective *kebele* administrations.

A structured questionnaire was administered to 263 randomly selected respondents drawn using systematic random sampling technique. Ten respondents at Yequasa Abbo *kebele* participated during pre-testing of the questionnaire to ensure validity and reliability of the data. Interviews to fill the questionnaires were done at respondents' homes and either the household head or spouse was contacted depending on availability. The questions asked were close-ended to capture social indicators, which explained vulnerability levels of surveyed households reside in the Abbay Basin.

Focus group discussions

Focus group discussions (FGDs) involved farming household heads. The study involved four FGDs, encompassing forty participants. The plan was to have six to fifteen members per FGD for effective participation and good quality of data; hence participants ranged from eight to twelve across the four *kebele*s. This aimed at enabling participants to take part in the analysis of the issues of social assets and extreme weather events. It has also the purpose of obtaining in-depth information on perceptions and ideas of the groups on social vulnerability to climate change. That is, this method addressed the cooperation culture of the society and the occurrence of extreme weather events as compared to the past. This method helped to triangulate the household survey and meteorological data. The uses of this data gathering method is recognized by Creswell (2012) by stating that qualitative inquirers triangulate among different data sources to enhance the accuracy of a study. Triangulation is the process of corroborating evidence from different individuals, types of data, or methods of data collection in descriptions and themes in qualitative research. Discussions were recorded in a notebook. Grass-root level extension officers, land administration experts and *kebele* leaders were consulted for clarification on certain issues.

Data analysis

Analyses of climate change indicators demand various quantitative and qualitative methods. The quantitative methods include simple regression (SR), standardized precipitation index (SPI) and social vulnerability index (SVI) complemented with descriptive statistics like mean, percentage, maximum and minimum values. Illustrations such as line graphs, bar graphs and spider diagrams made clear the results of the study on social vulnerability and exposure trends.

SR was used for analyzing temperature and rainfall trends. When we examine the relationship between quantitative outcome and single quantitative explanatory variable, simple linear regression is the most commonly used method in order to detect and characterize the long-term trend and variability of temperature and rainfall values at annual time scale. The parametric test considers the SR of the random variable Y on time X. The regression coefficient is the interpolated regression line slope coefficient computed from the data as used by Mongi et al. (2010) is:

$$Y = \beta x^{\cdot} + c \ [1]$$

where, Y = Physical factor (changes in rainfall and temperature) during the period; β = slope of the regression equation; x = number of years from 1979 to 2010; c = regression constant.

The standardized precipitation index (SPI) was used to identify the duration, magnitude and intensity of droughts during 1979 to 2010 using annual rainfall data. The SPI is a statistical measure indicating how unusual an event is, making it possible to determine how often droughts of certain strength are likely to occur. The practical implication of SPI-defined drought, the deviation from the normal amount of precipitation, would vary from one year to another. It can be calculated as:

$$SPI = \frac{x - \bar{x}}{\sigma} \ [2]$$

SPI refers to rainfall anomaly (rainfall variance, irregularity and deficit) on multiple time scales; X represents annual rainfall in the year t; X is the long-term mean rainfall; and σ represents the standard deviation over the period of observation (McKee et al.,1993, cited in Woldeamlak, 2009). Hence, the drought severity classes are:

Extreme drought (SPI<-1.65);
Moderate drought (-0.84 > S > -1.28),
Severe drought (-1.28 > S > -1.65);
No drought (S > -0.84).

Having quantified the SPI values, drought duration, magnitude, and intensity were analyzed. Drought duration is the period between drought-starts and drought-ends expressed in months or years. Drought magnitude (DM) is the sum of the negative SPI values for all the months or years within the period of drought (McKee et al., 1993). Mathematically it can be expressed as:

$$DM = \sum_{j=1}^{x} -(SPI\ ij) \ [3]$$

where, j starts with the first month/year of a drought and continues to increase until the end of the drought (x) for any of the i time scales.

Drought intensity (DI) is the ratio of the drought magnitude of the duration event, which can be expressed as Mi/Li, where Mi is drought magnitude and Li is the drought duration calculated from the SPI. Although most drought analysis used the monthly time scale, the yearly scale was selected for the purpose of this study. If the monthly scale had been used, the presentation would have been complicated and would have made the results and discussion bulky.

Social vulnerability index

Assessment of the vulnerability levels of the farmers was done using the social vulnerability index (SVI) based on the household survey data considering functional relationships of indicators with vulnerability. As the creation of social vulnerability index has several applications, it contributes to the growing field of vulnerability assessment, adds to the ongoing debates about notions of vulnerability and helps to define the conceptual framework of vulnerability assessment (Vincent, 2004).

The SVI were constructed using equal weighting approach to measure households' access to a set of social assets and climate change exposures (Hahn et al., 2009). On the basis of the conceptual framework, indicators were selected for four components of social capital and climatic factors such as temperature, rainfall distribution and extreme weather events using expert judgment, observation and previous studies. The indicators were changed into standardized index using the following equation (ICRISAT, 2006; Sudarshan, 1981; Sullivan et al., 2002; UNDP, 2010):

$$\text{Social vulnerability index (SVI)} = \frac{\text{Observed values} - \text{Minimum values}}{\text{Maximum values} - \text{Minimum values}} \quad (3)$$

This method of normalization takes the functional relationship between the predictor variable and vulnerability levels of households. International Crops Research Institute for the Semi-arid Tropics/ICRISAT (2006) identified a type of relationship: vulnerability increases with the increase (decrease) in the value of the indicator. In this type of relationship, the higher the value of the indicators, the more is the vulnerability. For example, the larger the change in temperature, rainfall, and distance indicators, the more will be the vulnerability of the place or the community to climate change. In this case, the variables have a positive functional relationship with vulnerability and hence the normalization was done using equation 3. For these types of variables, the average values are taken as observed values. For variables that measure frequencies of events, the minimum value is set at 0 and the maximum at 100. For indicators, which assumed to have an inverse relationship (adaptive capacity indicators) with vulnerability, the inverse scoring technique was used in the standardization of values for each social indicator by equation 4 based on ICRISAT (2006) and NMA (2007).

$$\text{Inversed Social vulnerability index (ISVI)} = \frac{\text{Maximum values} - \text{Observed (average) values}}{\text{Maximum values} - \text{Minimum values}} \quad (4)$$

In this case, let us consider the number of relatives in a village of households, a high value of this variable implies better off households in the study site. So the rural households will have more capacity to cope with the impact of climate change. Put it differently, the vulnerability levels will be lower and the number of relatives in a village has an inverse functional relationship with vulnerability.

According to equation 4, an indicator with the least value will have the highest standardized value. By taking the inverse of the value of the indicator, one can create a number that assigns higher values to households with a lower number of livelihood activities and vice-versa. Normalizing vulnerability indices for each indicator on a scale of 0 to 1 allows calculating mean scores for each major component using equation 5 (Hahn et al., 2009):

$$\text{Average social vulnerability index (SVI)} = \frac{\sum_{i=1}^{n} \text{Index}}{n} \quad (5)$$

where, SVI is one of the four main components for social capital such as networks and relationships (NR), organizational affiliations (OA), policy (P) and leadership and service delivery (LSD); Index refers to the sub-components, represented by i, which make up each principal component, and n is the number of sub-components in each major component. For example, the average index of the networks and relationship (NR) component can be calculated as:

$$\frac{NR_1 + NR_2 + NR_3 \ldots .. + NR_n}{N} \quad (6)$$

By applying the same procedure, composite indices were computed for other sub-components and then for the overall vulnerability levels of households residing in the Abbay Basin. Once the index values for each component were calculated, the composite index was computed using the weighted average with the following equation to obtain the social vulnerability level (SVI) (Hahn et al., 2009):

$$SVI = \frac{\sum_{i=1}^{7} Ni\ NCi}{\sum_{i=1}^{4} Ni} \quad (7)$$

where, SVI is social vulnerability index equals the weighted average of the four important components; the weights of each main component, Ni is the number of indicators in sub-components that make up each major component (NCi).

The quantitative analysis was complemented with qualitative methods. The collected qualitative text or word information through in-depth interview and writing field notes during observations were analyzed. Before directly getting into analysis, collected data were converted into word processing documents and field notes were read to begin the process of analysis.

RESULTS AND DISCUSSION

Temperature and rainfall changes

The temperature is a critical determinant of plant growth and animal survival. Therefore, the analysis of temperature can be important in many situations where crops, livestock, stored products, pests and diseases are affected by its variability. The meteorological data showed that annual temperature in the study area had been in increasing trend for the last three decades.

Figure 2 presents the maximum (Tmax), minimum (Tmin) and mean temperature (Tmean) trends of the studied area over the period of 1979 to 2010. The estimated trend line for average annual temperature is y = 0.052+18.49. The trend line has a positive slope indicating that the average temperature has increased by 1.61° C over the past 32 years. On decadal time scales, it rose by 0.50° C. This indicates that there was faster rate of temperature increase in the studied site. The rate of increase in the studied site was also faster than the national level increase (0.23° C-25° C/decade), which was observed over the past fifty five years.

The Abbay-Beshilo Gorge area is drought affected. Drought is a natural hazard, which can be marked, by precipitation deficiency that threatens the livelihood resources and overall development efforts of nations or specific places by exacerbating water shortage. Therefore, analysis of drought frequency (pattern), duration, magnitude and severity is highly demanded in order to design appropriate actions.

Figure 3 shows the standardized precipitation index for the study site (1979 –

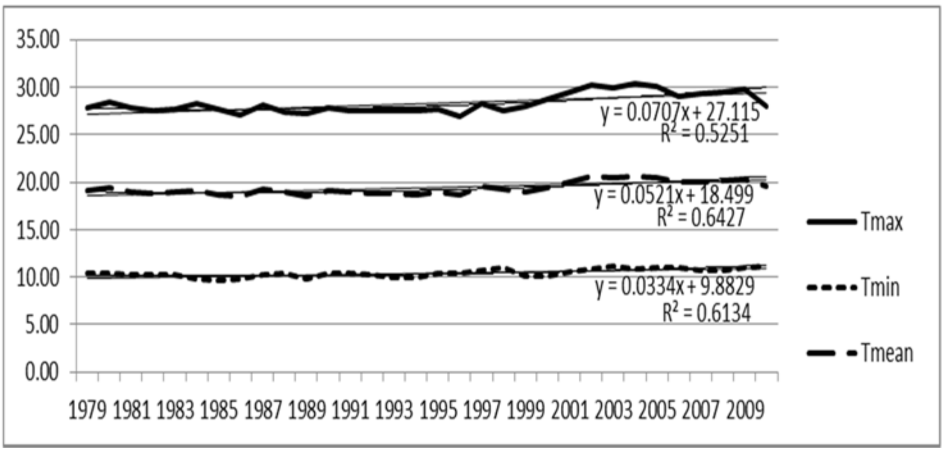

Figure 2: *Temperature trends in the studied site*
Note: Tmax – maximum temperature Tmin – minimum temperature Tmean-mean temperature.
Source: Computed from NMA and Global Weather Data [http:// Globalweather.tamu. edu/].

2010). It is clear from the figure that rainfall is characterized by periodic fluctuation of wet and dry years. Out of thirty two years of observation, fifteen years (46.88%) recorded below the long-term average annual rainfall and the rest fifteen years recorded above the long-term average. Only one year received nearly normal rainfall in the period. Before 1983, the rainfall was above the long-term average whilst from 1983 to 1995, it was below the long-term annual rainfall. Again, in 1986 positive SPI value was detected in spite of its failure in 1987. Likewise, a positive trend was identified from 1988 to 1990, but drier conditions were experienced in 1991. Once more, a slight recovery was observed from 1992 to 1993 with alternate rise and fall until 1998. Most of the negative anomalies occurred after 1998. The amount of rainfall in the years 1984, 1987, 1997, 1999, 2002 and 2008 were the lowest on record in the observation period, marking the worst drought years. Then, the rainfall indicated a recovery in 2006 from the low values of 1999 to 2005, but went down in the next three years, marking a large decline in 2008 and 2009. Again, the rainfall showed significant recovery in 2010. Five flood years were identified with high SPI values in 1980, 1986, 1989, 1994 and 1998 with SPI values of 1.5, 1.95, 1.35, 2.26 and 1.56 respectively.

Having quantified drought-based SPI values, the drought duration, magnitude, and intensity were analyzed. Although most drought analysis used the monthly time scale, the yearly scale was selected for the purpose of this study to reduce complications of the results. The result indicates that 13.53 drought magnitude and 1.04 intensity were computed in fifteen years of duration.

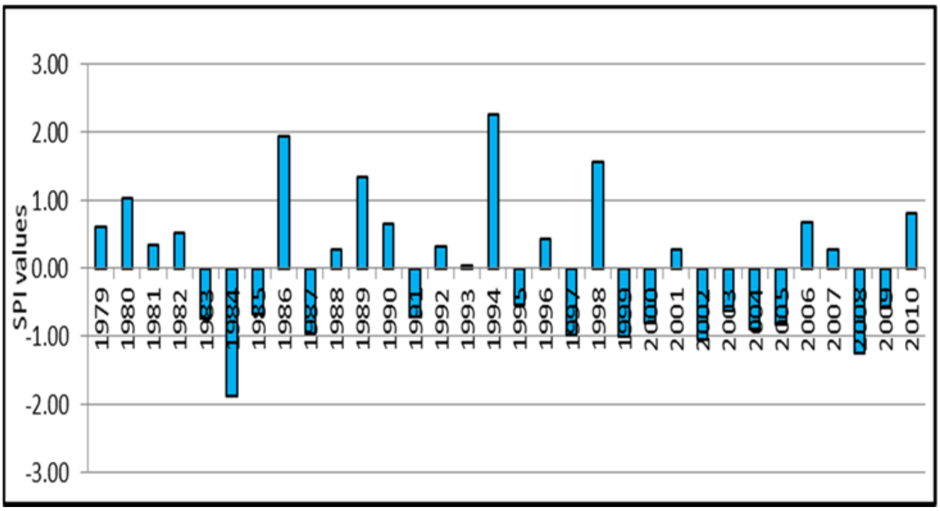

Figure 3: *Standardized precipitation index (SPI) for the study area*
Source: Computed from NMA and Global Weather Data [http://Globalweather.tamu.edu/].

Social vulnerability to climate change

Vulnerability is associated with social capital, which can facilitate coordination and cooperation in times of crisis for material gain or even resolve disputes (Barungi & Maonga, 2011; Nyangena & Sterner, 2008). In this study, the households' social capital was assessed by using components such as networks and relationships, organizational affiliations, policies and strategies, as well as decision-making and service delivery. See results in Table 3 for each indicator and Figure 5 for a summary of the sub-components of social capital.

Networks and relationships

The forms of social networks and relationships examined in the study area were the number of relatives in a village (kinship), degree of attachment with relatives and neighbors (friendship), farmer-to-farmer extension, helps received from relatives or neighbors, and borrowings from and lendings to relatives. The survey results indicate that many of the respondents were involved in several social activities and networking with relatives and non-relatives involving resource, work and information sharing. However, the surveyed households were not free from being vulnerable to these indicators.

By the number of relatives in a village, the households had a social vulnerability score of 0.94, indicating very high degree of vulnerability to climatic risks. The reason is that the average number of relatives in a *got* (village) was 8.79. However, number of relatives in a village may not be sufficient condition to measure the vulnerability levels of the households without supporting it with degree of attachment, because a person having a large number of relatives may be in conflict with them as opposed to a person who has strong attachments to his/her limited number of relatives and non-relatives. Thus, the latter may have better adaptive capacity than the former who is with higher vulnerability level. The results on the degree of attachments of households with relatives and neighbors provided 0.62 social vulnerability score (Table 3). This means households having weak ties with their relatives and neighbors were detected there, indicating limited capacity against the impact of climate change. From this, we can infer that poor attachment of households with their relatives and neighbors has strong association with natural resource depletion and high poverty level.

Concerning the cooperative tradition of the society, households have very limited capacity. Over 74% of the households reported that the cooperative tradition of the society has been in a decreasing or worsening condition from time to time. Although better access to livelihood assets and people's good attachment with relatives and neighbors have positive influences, inverse relation is obtained in the more vulnerable sites. The results also showed that by borrowing money from relatives and non-relatives, the households were highly vulnerable by 0.81 score. Again, the households were more vulnerable with regard to lending money to relatives and non-relatives having 0.85 score (Table 2).

Table 2: *Normalized vulnerability indices for major components and indicators*

Social vulnerability indicators	Measured values and indices				
	Unit	Observed	Maximum	Minimum	LVI
Networks and relationships indicators					
Average number of relatives in a village	No.	8.79	150	0	0.94
HHs who have loose ties to relatives/ neighbors	%	62.4	100	0	0.62
Societies' cooperation/support culture	%	73.7	100	0	0.74
HHs who do not get farmer-to-farmer extension/ month	%	42.4	100	0	0.42
HHs who do not get help from relatives/neighbors/6 month	%	35.0	100	0	0.35
HHs who do not get loan from relatives/neigh/6 months	%	81.4	100	0	0.81
HHs who do not lend money in the past 6 months	%	85.2	100	0	0.85
Average networks and relationships vulnerability					0.68
Organizational affiliation indicators					
HHs who are not members of farmers' cooperatives	%	74.9	100	0	0.75
HHs who are not members of credit and saving group	%	90.9	100	0	0.91
HHs who are not members of religious groups	%	37.3	100	0	0.37
HHs who are not members of other organizations (*Edir*)	%	98.5	100	0	0.99
HHs who have no relative holding position in *kebele* administration	%	67.7	100	0	0.68
Average organizational affiliation vulnerability					0.74
HHs who feel unsecured on their farmland	%	21.3	100	0	0.21
HHs who are not encouraged by land certificate	%	13.3	100	0	0.13
HHs who have no information on government policies	%	36.1	100	0	0.36
HHs who are dissatisfied with government policy	%	33.8	100	0	0.34
HHs who are dissatisfied with NGOs role in development	%	33.8	100	0	0.34
Average policy related issues index					0.28
Leadership and service delivery					
HHs who are unhappy by their local leaders' decisions	%	75.3	100	0	0.75
HHs who are not participated in their local leaders election	%	21.7	100	0	0.22
Frequency of visits to HHs by DAs in a cropping season	Freq	1.0	10	0	0.91
HHs who are not visited by DAs in a cropping season	%	45.6	100	0	0.46
Average Leadership and service delivery index					0.58

Source: Household Survey, March to September, 2012.

Different forms of supports the households have gained, from relatives and non-relatives, provided relatively little contribution for the households' social vulnerability index value in the study area with LVI score of 0.35. Although the cooperative and support culture of the society was reported to be on a decreasing situation, the respondents involved on some social and economic activities especially in farming, harvesting, threshing, keeping livestock, marketing, taking sick family members to health institutions, house construction and sharing useful information, to mention a few (e.g. Figure 4).

Figure 4 illustrates rural people's cooperation in harvesting teff during untimely rain in November 2012. The results from group discussion that those give-and-take types of co-operations are still working to some extent, but sharing crops, some amount of money, and animals for different agricultural and marketing purposes have been greatly decreasing with negative implications on the adaptive capacity of the studied households.

In the aggregated social vulnerability indices, the households scored 0.68 by the networks and relationships component of social capital (Table 3). By almost all the indicators, the households had limited capacity in terms of networks and relationships to undertake adaptation/coping with activities against the impact of climate change. This may result from the very high level of vulnerability of households in terms of other livelihood resources in the study area. From this, one can infer that there is strong network and relationship among people in the places where there is relatively better access to different livelihood resources while the reverse is true in the areas where there is limited or no access to such resources. As Temesgen (2010) argued, in the vulnerability and adaptation studies as well as networks and relationships can play a significant role in information exchange and in facilitating help and support with the people during the climatic hazards and, thereby, in reducing vulnerability to climate change impact. Other studies noted that networks and relationships are assets, which exist in the networked relationships to cope up with the impacts of climate change and related issues (Adger, 2003; Luk, 2011). Wisner et al. (2004) also argue that households that have access to social networks are less vulnerable to natural

Figure 4: *Farmers cooperation in agricultural activities, November, 2012*
Source: Own field Photo, November 2012.

hazards. These represent social safety nets and a form of informal grass-roots insurance available to the household during climate-related crisis (Vincent, 2007).

Organizational affiliations

Farming household's organizational affiliation in this study was examined based on membership status of households in farmers' cooperatives, saving and credit groups, religious groups, traditional help associations (*edir* and *equib*), and relatives holding positions in *kebele* administration. The survey results indicated that the households had highly limited membership status in different help associations because about 99% of them had no membership status in traditional help associations. In terms of membership status in saving and credit groups, 91% of the households were found to be not attached to saving and credit associations. Similarly, 75% of the households were found without membership status in farmers' cooperatives, both implying limited access in securing useful information, agricultural inputs and financial resources necessary for adaptation to climate change. Nearly, 68% of the respondent households had no relative holding position in the *kebele* administration. About 63% of the households had no membership status in religious groups indicating higher degree of vulnerability of the households at the times of climate change induced risks (See Table 3).

Overall, households' level of social vulnerability scored 0.74 by organizational affiliations, indicating limited capacity and in turn greater vulnerability level of households to climate change-induced risks (Table 2). Other studies argue that as vulnerability and adaptation are dynamic social processes, the ability of societies to adapt is determined, in part, by the ability to act collectively. Being members of any association or group is crucial for reducing vulnerability by enhancing adaptive capacity of farming households through information exchange, experience sharing and material and financial support in times of climatic disasters (Adger, 2003; Luk, 2011). In the light of this argument, other scholars also argue that associations can build trust, confidence and moral values, and provide information that will help the households to adapt to climate change (Nyangena & Sterner, 2008).

Policy issues

Policy processes are important determinants of vulnerability and adaptation to climate change. Accordingly, land tenure security, land certification, flow of policy information, and the benefits the households acquire from the current policies were examined under this issue. The results indicated that households had an aggregated vulnerable score of 0.28 by policy issues. When we see indicator wise, equal vulnerability score (0.34) was obtained by policy deliverables and by the NGOs' role in supporting local development efforts for reducing socio-economic and environmental problems. Limited numbers of NGOs have focused on relief provision and safety net programs in the study area. The households reported that there is no significant improvement in their living standard by both the government and NGOs' interventions. The surveyed households had a social vulnerability score of 0.36 by access level to current policy information (Table 2). Due to its isolated and inaccessible nature and its difficult terrain arrangement the Abbay-Beshilo Gorge is one of the least preferred areas for the government's and the NGOs intervention. This has in turn led to gain limited or no benefits from these kinds of intervention. In addition to being the least preferred area for development interventions, the inaccessible topographic setting has made the households more vulnerable in terms of information flow on potential hazards, new technology options and actual implementations of policies and strategies.

Leadership and service delivery

Different levels of government institutions play a crucial role in helping communities by enhancing their adaptive capacity against climate change. All levels of government, such as federal, regional, zonal, *woreda* and *kebele* are involved in administering the community and in initiating other development activities. In this context, households' level of satisfaction with the decisions and/or services provided by their local leaders, households' participation in their leaders' election processes, number of households who have been visited by development agents in the past cropping season and frequencies of visits per cropping season were taken as indicators to assess the vulnerability levels of rural households to climate change impact. The results indicated that the households had a social vulnerability of 0.58 by leadership and service delivery indicator. Consequently, in terms of levels of satisfaction from the services and decisions provided by local leaders, the score was 0.75, indicating the highest vulnerability to climate change risks (See Table 3). This may be attributed to the fact that again the inaccessible nature of the area has posed difficulties for the zonal and *woreda* officials to undertake continuous monitoring on the grass-root-level decision-makers and service providers so that focus group discussants reported some kind of bias and discriminations in getting some benefits.

Another important indicator considered in social vulnerability analysis was

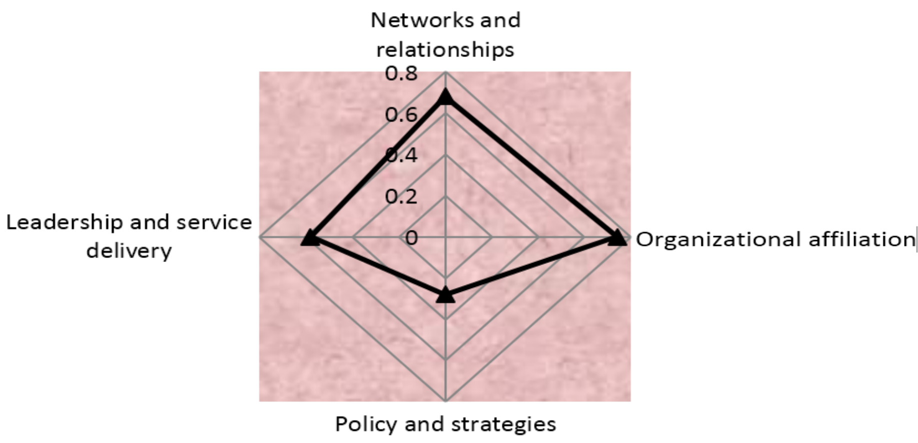

Figure 5: *Vulnerability of households measured by social capital components*
Note: index value of 0 means no or very low vulnerability and vulnerability increases as SVI values increase in the radar diagram outwards from the center.
Source: Household survey, March to September 2012.

access to extension services (whether the households accessed extension services or not and how often). The inverse scoring technique depicted in Equations 4 indicated that by the development agents' (DAs) frequency of visits to households in the past cropping season, the households had 0.91 score, indicating very limited extension services provided to the rural households. Even 46% of the surveyed households reported that they had never received any visit from DAs in the season considered (Table 2). From this, we can infer that neither extension visits nor visits and trainings have brought significant capacity increment in terms of skill, knowledge and attitudinal changes in adopting new adaptation technologies. In fact, development agents remain at the edge, never reaching the farmer and service packages may not fit the Abbay-Beshilo Gorge.

Figure 5 presented the average vulnerability score for the sub-components of social capital. It is clear from the spider diagram that in terms of organizational affiliations, households were found to be highly vulnerable (0.74) implying very limited affiliations of households to different formal and informal organizations. Again, in terms of networks and relationships, they were more vulnerable by 0.68 score and in terms of leadership and service delivery the scored was 0.58. Despite the challenges to identify the indicators that reflect the local social assets, including them in climate vulnerability assessment is essential as many adaptation behaviors rely on collective insurance mechanisms such as religious groups, agricultural cooperatives, credit groups, and traditional help associations. In terms of policy directions, it seems that the households are less vulnerable to climate change impact.
However, the data gathered from the household surveys in the study area does not show what farmers have experienced. Such a lack of congruence between the survey data and what people actually experienced is understandable. In the discussion sessions, people complained of little and/ or no benefits obtained from the policy interventions though the government has declared double-digit economic growth over the last eleven years.

CONCLUSIONS

Climate change is a very real fact that will inevitably affect human populations in the coming decades. In this paper, an empirical index was created to assess the rural households' relative social vulnerability to climate change in the Abbay-Beshilo Gorge of Ethiopia. A theory-driven aggregate index of social vulnerability was formed through the equal weighting approach of four composite sub-indices: networks and relationships, organizational affiliations, policy strength, and leadership/service delivery. Vulnerability assessment provides a framework for identifying and measuring these very important components of social capital, which may create differential vulnerability situations of the studied community.

The outcome of the current vulnerability study in terms of social capital puts the rural households of the study area in the most vulnerable position to climate change impact. Whilst the studied households were found to be the most vulnerable social groups to climate change by organizational affiliations

(0.74), networks and relationships (0.68) and leadership and service delivery (0.58), they were the least vulnerable in terms of policy deliverables (0.28). It is important to remember, however, that this is a relative scale and it should not imply that the latter social vulnerability component is entirely resilient.

Despite the fact that better access to livelihood assets and people's good attachment with relatives and neighbors have positive influences, inverse relation is obtained in the studied area. The indices are grounded in existing literature on vulnerability and use the most important local level data sets. Thus, this study marks the first robust assessment of relative levels of social vulnerability of rural households to climate change in the Abbay-Beshilo Gorge. Since social capital is so vital in reducing climate change risks during and after disaster, it is required to consider the same when adopting adaptation and mitigation policy measures. Thus, the government should try to maintain intact the social networks and make the best use of the existing social networks in the development processes.

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REFERENCES

Adger, W. N. (1999). Social Vulnerability to Climate Change and Extremes in Coastal Vietnam. *World Development, 27(*2), 249-269.

Adger, W. N. (2003). Social Capital, Collective Action, and Adaptation to Climate Change. *Economic Geography, 79*(4), 387-404.

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to Climate Chnage in the Developing World. *Progress in Development Studies 3*(3), 179-195.

Adger, W. N., Brooks, N., Bentham, G., Angew, M., & Eriksen, S. (2004). *New Indicators of Vulnerability and Adaptive Capacity.* Norwich, East Anglia: Tyndall Center for Climate Change Research.

Ajibade, I. (2013). *Climate change and human rights: A case study of vulnerability and adaptation in coastal communities in Legos, Nigeria* (doctoral dissertation, Universty of Westtern Ontario London, Canada).

Benson, C., & Twigg, J. (2007). *Tools for Mainstreaming Disaster Risk Reduction: A Sustainable Livelihoods Approaches. Guidance Notes for Development Organizations.* Geneva, Switzerland: International Federation of Red Cross and Red Crescent Societies/ProVention Consortium.

Brooks, N. (2003). *Vulnerability, Risk and Adaptation: A Conceptual Framework* (Tyndall Centre Working Paper 38). Retrieved from http:// tyndall.ac.uk

Creswell, J. W. (2012). *Educational Ressearch: Planning, Conduction and Evaluating Quantitative and Qualitative Research.* New York, NY: Pearsons Educational Inc.

Cutter, S. L. (1996). Vulnerability to Environmental Hazards. *Progress in Human Geography, 20*(4), 529-539.

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly, 84*(2), 242-262.

Dercon, S. (2004). Growth and shocks: evidence from rural Ethiopia. *Journal of Development Economics, 74,* 309– 329.

Dercon, S., Hoddinott, J., & Woldehanna, T. (2005). *Shocks and consumption in 15 Ethiopian Villages, 1999-2004.* Washington DC.: International Food Policy Research Institute.

Feige, S., & Marr, M. A. (2012). *Sampling Manual: A Guide to Sampling under the CDM with Special Focus to POAs* (1st ed.). Frankfurt: KfW.

Fussel, H. M. (2006). *Vulnerability: A Generally Applicable Conceptual Framework for Climate Change Research.* Stanford, CA: Global Environmental Change.

Fussel, H. M., & Klein, R. J. T. (2006). Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. *Climatic Change, 75 (*3), 301-329. Retrieved from http://link.springer.com/article/10.1007%2Fs10584-006-0329-3

Gallopin, G. C. (2006). Linkages between Vulnerability, Resilience, and Adaptive Capacity. *Global Environmental Change, 16,* 293–303.

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change–A case study in Mozambique. *Global Environmental Change, 19*(1), 74-88. doi: 10.1016/j.gloenvcha.2008.11.002

Houghton, J. (2009). *Global Warming: The Complete Briefing (4th ed.). Cambridge:* Cambridge University Press.

ICRISAT/International Crops Research Institute for the Semi-Arid Tropics. (2006, March). Retrieved January 12, 2013, from www.icrisat.org/what-we-do/

IPCC/Intergovernmental Panel on Climate Change. (2001). *Impacts, Adaptation and Vulnerability.* Cambridge: Cambridge University Press.

IPPC/Intergovernmental Panel on Climate Change. (2007). *Adaptation to Climate Change in the Context of Sustainable Development, Background Paper.* Bonn: UNFCCC Secretariat. Retrieved from http://www.teriin.org/events/docs/adapt.pdf

IPCC/International Panel on Climate Change. (2013). *Climate Change 2013: The Physical Science Basis.* Retrieved from http://www.ipcc.ch/report/ar5/wg1/

Israel, G. G. (1992). *Determing sample size* (University of Florida/IFAS Extension, PEOD6). Retrieved from https://edis.ifas.ufl.edu/pd006

Iyengar, N. S, & Sudarshan, P. (1982). A Method of Classifying Regions from Multivariate Data. *Economic and Political Weekly, 17*(51), 2047+2049-2052. Retrieved from http:// www.jstor.org/stable/4371674

Kabote, S. J., Mamiro, D. P., Synnevag, G., Urassa, J. K., Mattee, A. Z., Chingonikaya, E. E., … Masolwa, L. M. (2014). Rain-Fed Farming System at a Crossroads in Semi-Arid Areas of Tanzania: What Roles do Climate Variability and Change Play?. *Journal of Environment and Earth Science, 4(*16), 85-101. Retrieved from http://www.iiste.org/Journals/index.php/JEES/article/view/15154/15731

Kelly, P. M., & Adger, W. N. (2000). Theory and Practices in Assessing Vulnerability to Climate Change and Facilitating Adaptation. *Climatic Change, 47,* 325–352.

Luers, A. L., Lobella, D. B., Sklard, L. S., Addams, C. L., & Matson, P. A. (2003). A Method for quantifying vulnerability, applied to the agricultural system of the Yaqui Valley, Mexico. *Global Environmental Change, 13*(4), 255–267. doi:10.1016/S0959-3780(03)00054-2

Luk, K. Y. (2011). *Vulnerability Assessment of Rural Communities in Southern Saskatchewan* (Master's thesis, University of Waterloo, Ontario). Retrieved from https://uwspace.uwaterloo.ca/bitstream/handle/10012/6305/Luk_Ka_Yan.pdf?sequence=1

McKee, T. B., Doesken, N. J., & Kleist, J. 1993. The Relationship of Drought Frequency and Duration to Time Scales. In *Eighth Conference on Applied Climatology (Jan 17-23, 1993, Anaheim California). Conference Proceedings* (pp. 179-184). Anaheim, CA: Colorado State University. Retrieved from http://ccc.atmos.colostate.edu/relationshipofdroughtfrequency. pdf

Mongi, H., Majule, A. E., & Lyimo, J. (2010). Vulnerability and adaptation of rain fed agriculture to climate change and variability in semi-arid Tanzania. *African Journal of Environmental Science and Technology, 4,* 371-381.

Moss, R. H., Brenkert, A. L., & Malone, E. L. (2001). *Vulnerability to Climate Chnage: A Quantitative Approach.* Washington DC.: The U.S. Department of Energy.

National Centers for Environmental Prediction. (2010). *Global weather data for SWAT (1979-2010, January).* Retrieved March 6, 2013, from http://globalweather.tamu.edu/

NMA/National Meteorological Agency. (2001). *Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC).* Addis Ababa, Ethiopia: National Meteorological Services Agency under the GEF supported.

NMA/National Meteorological Agency. (2007). *Climate Change National Adaptation Program of Action (NAPA) of Ethiopia.* Addis Ababa: NMA.

Nyangena, W., & Sterner, T. (2008). *Social Capital and Institutions in Rural Kenya: Is Machakos Unique?* (Resources for the Future Discussion Papers).

O'Bbrien, K., Eriksen, S., Nygaard, L. P., & Schjolden, A. (2007). Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy, 7*(1), 73–88. doi: 10.1080/14693062.2007.9685639

Schröter, D., Polsky, C., & Patt, A. G. (2004). Assessing Vulnerabilities to the Effects of Global Change: an eight step approach. *Journal of Mitigation Strategies for Global Change, 10,* 573–596. Retrieved from http://download.springer.com/s

Segele, Z. T., & Lamb, P. J. (2005). Characterization and variability of Kiremt rainy season over Ethiopia. *Meteorology and Atmospheric Physics, 89,* 153-180. doi: 10.1007/s00703-005-0127-x

Sullivan, C. A., Meigh, D. J., & Fediw, M. T. (2002). *Derivation and Testing of the Water Poverty Index Phase 1. Final Report May 2002 Vol.1 Overview.* Wallingford and London: Center for Ecology and Hydroology, Natural Environment Research Council.

Temesgen Tadesse Deressa. (2007). *Measuring the Economic Impact of Climate Change on Ethiopian Agriculture: Ricardian Approach* (Policy Research Working Papers 4342). Washington DC: World Bank. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/7290/wps4342.pdf?sequence=1

Temesgen Tadesse Deressa. (2010). *Assessment of the Vulnerability of Ethiopian Agriculture to Climate Change and Farmers Adaptation Strategies* (doctoral dissertation, University of Pretoria). Retrieved from http://repository.up.ac.za/bitstream/handle/2263/28969/ thesis.pdf?sequence=1

Temesgen Tadesse Deressa, Hassan, R. M., Tekie Alemu, Mahmud Yesuf & Ringler, C. (2008). *Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia* (IFPRI Discussion Paper 00798). Washington DC.: Environment and Production Technology Division. Retrieved from http:// www.ifpri.org/sites/default/files/publications/ifpridp00798.pdf

Temesgen Tadesse Deressa, Hassan, R. M., Ringler, C., Tekie Alemu & Mahmud Yesuf (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change, 19*(2), 248–255. doi: 10.1016/j.gloenvcha.2009.01.002

Tibebe, B. (2008). *Water Resources Potential Assessment of Simada Woreda with Particular Reference to Groundwater: A Case Study of Bijena-Muge River Catchments, South Gondar Ethiopia* (Master's thesis, Arbaminch University).

Turner II, B. L., Kasperson, R. E., Matsone, P. A., McCarthy, J. J., Corellg, R. W., Christensene, L. … Schillerb, A. (2003). A framework for Vulnerability Analysis in Sustainability Science. *Proceedings of the National Academy of Sciences of the United States of America, 100*(14), 8074–8079. doi: 10.1073/pnas.1231335100

UNDP/United Nations Development Program. (2010). *Human Development Index Trends, 1980-2010, Table 2, Statistical Annex 151.* New York: UNDP. Retrieved from http://hdr. undp.org/en/countries

Vincent, C. (2004). *Creating an Index of Social Vulnerability to Climate Change for Africa* (Tyndall Center for Climate Change Research, Working Paper 56). Norwich, East Anglia

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). *At Risk: Natural Hazards, People's Vulnerability and Disasters.* London: Routledge, Francis Group.

Woldeamlak Bewket. (2009). Rainfall variability and crop production in Ethiopia: Case study in Amhara Region. In S. Ege, H. Aspen, Birhanu Teferra & Shiferaw Bekele (Eds.), *Proceedings of the 16th International Conference of Ethiopian Studies* (pp. 823-836). Trondheim: Harrassowitz.

Retrieved from http://hpccc.gov.in/PDF/Agriculture/ Rainfall%20Variability%20and%20Crop%20production%20in%20Ethiopia%20Case%20study%20in%20the%20Amhara%20Region.pdf

Yohannes Aberra. (2012). Perceptions of climate change among members of the House of Peoples' Representatives, Ethiopia. *Journal of Risk Research, 15*(7), 771-785. doi:10.1080/13669877.2012.657219

You, G. J.-Y., & Ringler, C. (2010). *Hydro-Economic Modeling of Climate Change Impacts in Ethiopia* (IFPRI Discussion Paper 00 960). Washington DC., Addis Ababa, New Delhi: IFPRI. Retrieved from http://www.ifpri.org/sites/default/files/publications/ifpridp00960.pdf