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Measuring Livelihood Vulnerability to Climate Extremes: Households Adjacent to Humbo CDM Project Site, Southern Ethiopia

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ABSTRACT

In Ethiopia, Humbo carbon sequestration afforestation and restoration clean development mechanism (A/R CDM) project has managed to restore degraded forest (2728 ha) through strategic replanting and protection and thereby managed to generate revenues from carbon sale. However, the study fulfil research gap in terms of the impact of the intervention on the resilience of households against climate variability. Hence, the study was conducted at Humbo district households adjacent to A/R CDM project area to measure the household livelihood vulnerability to climate variability. Both quantitative and qualitative approaches were employed for the study. The livelihood vulnerability index framed with LVI-IPCC framework was applied through cross-sectional household survey conducted on 139 households that were randomly selected from three representative kebeles. The results indicated that major income sources for the households were categorized into livestock production (29.1%), crop (42.9%), off-farm (17%) and non-farm (42.6%) such as petty trade, and labour. The overall LVI-IPCC showed that 16% of households were highly vulnerable to climate extremes while 54% and 30% of households were categorized as less and moderately vulnerable, respectively. Substantial variation across the kebeles was observed in components, sub-components and three dimensions (adaptive capacity, sensitivity and exposure) of vulnerability. The LVI-IPCC estimated that households in the Abela Longena kebele were highly vulnerable (0.000) to climate variability and change compared to Habicha Bade (-0.035) and Bosa Wanche (-0.046). Therefore, integrating rural development schemes aimed at increasing adaptive capacity and designing site-specific intervention strategies to reduce vulnerability of the communities to climate variability and change is recommended to the range of climate extremes that they experience.

Keywords: *CDM; Climate variability; Humbo; Livelihood strategies; Vulnerability index*

INTRODUCTION

In Ethiopia, forest resources play a significant role in the country's economy, particularly in the livelihood of rural people, as important sources of energy, food, employment, medicine, fodder and income [1,2,3].

Apart from depending on forests and woodlands for domestic energy, studies [1,4] undertaken in various parts of the country indicated that rural households engage in commercial supply of wood, charcoal, and other timber and non-timber forest products to urban areas to generate cash income thereby to support their livelihood. Besides the significant role forests play as livelihood assets to rural people, currently their importance is further emphasized due to their key role in controlling and maintaining the stability, functioning, and sustainability of global ecosystems [5, 6] in the face of frighteningly changing global climate. Forests serve as the world's most important terrestrial storehouses of carbon. However, in order to serve this function, the mature forests should be left intact [5].Most of the developed countries' governments have now committed to increased funding for carbon sequestration and protection of forest biodiversity in order to reduce emissions of greenhouse gases [6]. Particularly, under Clean Development Mechanism (CDM) of Kyoto protocol on Green House Gas emission, investing in land and forest resources of developing countries has received the attention of industrialized countries. Having twin objectives of reducing greenhouse gasses and promoting sustainable development in host countries, the CDM projects are being implemented in non-industrialized countries since 2005 [5,7]. In line with this, in 2006, carbon sequestration Afforestation and Reforestation (A/R CDM) project has started its implementation in Humbo district of Southern Ethiopia [8,9]. Initiated by World Vision Australia and World Vision Ethiopia, the initiative introduced a farmer-managed natural regeneration technique to restore the degraded natural forest and thereby to generate carbon credits. Consequently, the forestland that had long been an open access resource has become enclosed and protected [3]. Since the time of its introduction, the project managed to restore 2,728 hectare of degraded forest and thereby contributed to the reduction of greenhouse gases from the atmosphere [9, 10].

In spite of the widespread debate over the potential of CDM projects to achieve their sustainable development goals, as CDM pipeline shows, the number of A/R CDM project is rapidly increasing. The available scanty study on potential benefit of A/R CDM projects in Africa [11] indicates that, in short run, the projects are less likely to benefit local communities and may even harm them by restricting access to natural resources and competing for scarce groundwater. In Ethiopia, the available published study [9] indicated that Humbo carbon sequestration A/R CDM project has managed to restore degraded forest through strategic replanting and protection and thereby managed to generate revenues from carbon sale. However, it did not touch the impact of the intervention on the livelihoods of households.

In a midterm evaluation report of the Humbo carbon sequestration A/R CDM project, World Vision Australia reported protection and enhancement of biodiversity, reduced water and wind erosion, increased water supply, and returning of wild animals as major outcomes of the project [12].The report claims the establishment of local cooperatives, securing of user rights to cooperatives, and financial inflows from the sale of carbon stocks as social and economic benefits of the regeneration and protection of the degraded forest. However, the midterm evaluation report did not disclose how the surrounding communities cope with the loss of forest products caused by the sudden restrictions imposed by the project. It neither did assess the impacts of the benefits claimed to be associated with the project on the livelihood assets of the households nor on communities participating in it. The study by Aynalem [3] comprehensively revealed various factors influencing local people's access to the forest products and their bargaining power over the carbon revenue. However, the costs incurred or the benefits enjoyed by a given community in turn significantly influences the way that community views and manages the natural resource under consideration. Therefore, this study was conducted to measure household livelihood vulnerability to climate extremes.

Materials and Methods

Study Site Description

This study was conducted in Humbo Tabala district of southern Ethiopia which is located 397 km southwest of the capital city Addis Ababa [13]. The Humbo town, capital of the district geographically located in approximate coordinates of 6°46'48.47" to 6°41'04.28"N latitude and 37°48'35.44" to 37°55'14.51"E longitude (Figure 1). Agro ecologically, 11% of the district falls under highland ('Dega'), 27% falls under mid-highland ('Woina-Dega') and the remaining 61% falls under lowland ('Kolla'). Mean annual temperature of the district is 22ºC and mean annual rainfall is 1123mm with altitudinal range of 1100 to 2335m.a.s.l [13]. The vegetation can be classified as the dry woodland forest type. It had been covered by dense broad-leaved vegetation types and montane forests before they were cleared around fifty years ago. Besides, Fabaceae and Combretaceae and Oleaceae were found to be the most species rich families in the area [14].

Research Design and Sampling

This research has employed both quantitative and qualitative approaches obtained by household survey, key informant interview, focus group discussion, and review of secondary sources. This study was also employed a cross-sectional research design in order to get in-depth insight of the issues under consideration including quantitative and qualitative approaches of data collection [16, 13].

The sampling frame for survey included those households that are legally organized as forest development cooperatives to manage the forest of interest. A two stage sampling procedures was employed to select the sample households in the study area [15]. In the first stage, three representative cooperatives, out of seven, were purposively selected on the basis of their accessibility and representativeness: Abela Longena, Hobicha Bada and Bosa Wanche. In the second stage, proportional sampling technique was applied to draw samples from the population. Thus, 10% of the households from each cooperative were included in the sample i.e. 51, 46 and 42 household heads were selected, respectively, from each cooperatives using systematic random sampling technique.

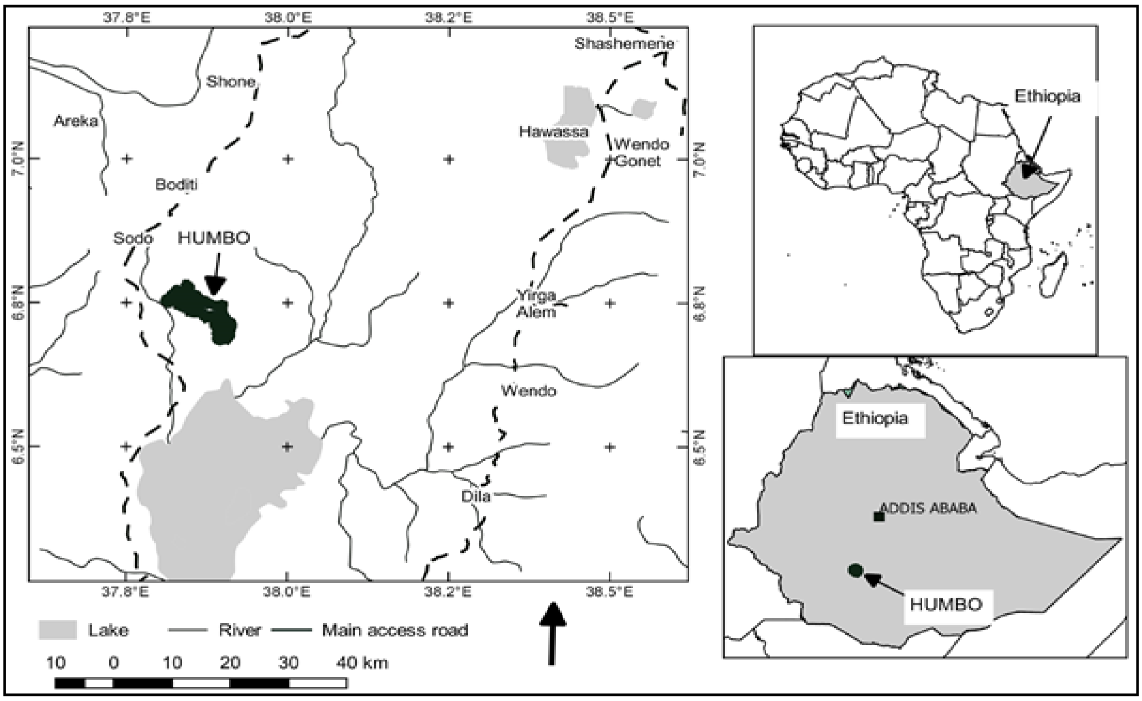

Figure1. *Map of Humbo district in southern Ethiopia [15].*

Livelihood Vulnerability Analysis

The livelihood vulnerability index (LVI) was utilized based on modified version of [17] Hahn et al. (2009). The LVI developed contains nine major components and the sub-components comprised thirty-eight indicators (Table 1). The computation of each indicator value followed the process of standardization adopted from the computation of the life expectancy index of the Human Development Index [17] as in Equation 1:

$$\text{Index } S_b = \frac{S_b - S_{min}}{S_{max} - S_{min}} \qquad (1)$$

In the index, S_b is the original subcomponent of the block b, Smin and Smax are the minimum, and maximum values for each subcomponent determined using data from the three blocks (i.e. three kebeles) of the district. After each was standardized, the subcomponent was averaged using Equation 2 to calculate the value of each major component:

$$M_b = \frac{\sum \text{Index } S_{bi}}{n} \qquad (2)$$

Where: M_b equals one of the major components for the block b, index S_b represents the subcomponents, indexed by i, that makes up each major component and n is the number of subcomponents in each component. Once values for each of the eight major components for a block were calculated, it was averaged using Equation 3 to obtain the LVI at block level:

$$LVI_b = \frac{\sum W_{Mi} M_b}{\sum W_{Mi}} \qquad (3)$$

Where: LVI_b is the livelihood vulnerability index for the block b, and the weight age of the eight major components, W_{Mi} determined by the number of subcomponents that make up each major component, contribute equally to the overall LVI [5, 17]. In this study, the LVI is scaled from zero (least vulnerable) to one (most vulnerable).

On the other hand, the LVI-IPCC approaches utilize household level primary data to measure the subcomponents. The major contributing factors of LVI-IPCC are exposure, sensitivity, and adaptive capacity to measure the influence of the climate change and variability on the households' vulnerability and resilience. All three major components were combined [17] as in Equation 4.

$$CF_b = \frac{\sum W_{Mi} M_{bi}}{\sum M_{bi}} \qquad (4)$$

Where: CF^b is an IPCC-defined contributing factor (exposure, sensitivity or adaptive capacity) for the block b, M_{bi} is the major components for the block b, indexed by i, M_{bi} is the weightage of each major component, and n is the number of major components in each contributing factor. Once exposure, sensitivity and adaptive capacity were calculated, the three contributing factors were combined using Equation 5.

$$LVI\,IPCC_{db} = (E_b - AC_b) * S_b \qquad (5)$$

Where $LVI\text{-}IPCC_{db}$ is the LVI for the district d and block b expressed using the IPCC vulnerability framework, E is the calculated exposure score for the block, AC is the calculated adaptive capacity score for the block, and S is the calculated sensitivity score for the block [17]. Then, the LVI-IPCC is scaled from -1 (least vulnerable) to 1 (most vulnerable).

Table1. *Major and sub-components comprising the LVI developed for the study area*

LVI-IPCC	Major components	Descriptions of sub-components	Hypothesized function
Adaptive capacity	Demographic profile	Household dependency level	The higher the dependence ratio, the higher the vulnerability
		Age of Household head	The higher the age, the higher the vulnerability
		Sex of Household head (Male/Female)	The more the information, the more the adaptive capacity
		Education level Household head	
		Percentage of literates in the Households	
		Household size (Persons/HH)	The larger households tend to have more economically inactive dependents which in turn increases vulnerability
	Livelihood strategies	Total household income (Amount of Birr/HH)	The more the wealthy status, more the adaptive capacity
		Income from crop (Amount of Birr/HH)	
		Income from livestock (Amount of Birr/HH)	
		Number of livestock (TLU/HH)	
		Off-farm income (Amount of Birr/HH)	
		Land size (Ha/HH)	
		Number of crops (diversity) in the system	The more diversification of crop species, the more the adaptive capacity
	Social network and Infrastructure	Membership in farmers' association (Yes/No)	The more in membership in social network, the more the adaptive capacity
		Membership in "*Ikub*"/"*Idir*" (Yes/No)	
		Access to schools (Walking distance in km)	The more access to infrastructure, the more the adaptive capacity
		Access to nearby market (Walking distance in km)	
		Percentage of HHs using saving and credit	
		Percentage of HHs accessing electricity	
		Percentage of HHs using telephone	
		Social safety-net program (Yes/No)	
	Technologies	Percentage of HHs applying fertilizer	The more access to technology, the more the adaptive capacity
		Percentage of HHs using improved seed	
		Percentage of HHs who have radio/TV set	
Sensitivity	Health	Access to health care (in km)	The more access to infrastructure, the less the sensitivity
		Privet toilet facility (Yes/No)	
	Water resources	Access to clean drinking (in km)	The more access to infrastructure (the shorter this time), the less the sensitivity
		Availability of consistent water supply (Yes/No)	
	Ecosystem	Distance from forest to household (in km)	The more access to forest resources, the less the sensitivity
		Number of forest products utilized before A/R project	
		Improved access to firewood (Yes/No)	
		Improved access to fodder (Yes/No)	

		Assistances in tree planting in farms (Yes/No)	The higher practice of planting tress the less the sensitivity
Exposure	Natural disasters	Average number of natural disasters in the past two decades	More reflects higher exposure
	Climate variability	Average number of factors triggered climate change in the past two decades	More reflects higher exposure
		Average number of climate effects on livelihoods in the past two decades	Increase in climate effects on livelihoods, increase vulnerability
		No. of response measures to halt shocks of climate variability in the past two decades	More reflects and response measures to shocks, the lower exposure
		Perception on change in climate in past three decades (Yes/No)	The higher perception on climate variability, the less exposure

'HHs' stands for the 'households'. The table is customized from Hahn [17].

Results And Discussion

Demographic and Socio-Economic Characteristics of Households

The results showed that the majority of the sampled households (92.6%) were male-headed, while the rest were female-headed. This indicates that male-headed households highly dominated the female-headed households in the surveyed area. The age distribution showed that the age of respondents ranged from 25-86. More than half (52.5%) of the respondents falling in the age category of less than 18 years, 19.9% in the age range of 19-29 years, 17.3% in the age range of 30-40 years and the remaining 10.2% were 41 and above. This shows that there is large age gap among the respondent household heads. However, on average respondents are in the productive age group. On the other hand, mean family size of the surveyed households was 7.2 with minimum and maximum of 2 and 16, respectively. The results showed that household heads have better penetration of formal education system. More than 35.8%, 38.8% and 11.9% of household heads in the studied community have access to attend the primary, secondary and tertiary level of education, respectively. The rest (13.4%) of interviewed household heads were not attended formal education.

The mean land holding size of the household was 0.89 hectare of land. This indicates that there is a severe shortage of agricultural land in the area even though the majority of the respondents reported that their main livelihood activity is farming. On the other hand, the results indicated that major livelihood strategies include sole crop farming (21.5%); mixed agriculture (34.1%); crop, livestock and fuel (23.7%); labour (6.7%) and the others (12.5%) in the studied community. The farmers grew diversity of cereal and perennial crops on their farmlands mainly maize, sorghum, teff, horicon beans, pigeon pea, coffee, inset and other root crops. Cattle, goat, sheep, and donkey were the major livestock species in the study areas. The results indicated that the mean livestock holding of the households was about 1.93 TLU[1.]

However, due to severe soil erosion, fragmented land size, and erratic rainfall, crop production has been negatively affected [8; 19; 3]. Livestock (e.g. cattle, sheep, goat, poultry, and donkey) has also important place next to crop production in the economy of the inhabitants of the district. Furthermore, other economic activities like handcraft industry, trade and others also play important role in the livelihood of the inhabitants of the district [19;13].

Pattern of Household Vulnerability

Adaptive Capacity

Demographic Characteristics

The index analysis indicated that demographic profile component scored 0.301, 0.375 and 0.341 for the Bosa Wanche, Hobicha Bade and Abela Longena, respectively (Table 2). The results indicated that Hobicha Bade was more vulnerable and has less adaptive capacity to prevailing climate impact compared to the rest two sites. This could be due to higher household dependency ratio, increased family size, and relatively poor education level of household heads that triggered the community being vulnerable to climate variability in the area. For instance, 28.9% individuals in the households in the Hobicha Bade community were considered to be dependent on family resources to run the day to day life styles. According to Dechassa [20], large family sizes have negative impacts on the households in the Didessa basin. This is because the available livelihoods opportunities

[1] *TLU is Tropical Livestock Unit as defined in [18].*

to family members are very much limited and only one or two of a household member usually engage in productive livelihood activities that can support the family plus members of the households whose ages are less than 14 and greater than 65 age categories are also not active participants. Similar study confirmed that in west Arsi zone of Ethiopia that children, women and large sized families are affected mostly by the climate change events [21].

Livelihood Strategies

The vulnerability index analysis indicated that livelihood strategies component scored 0.658, 0.693 and 0.651 for the Bosa Wanche, Hobicha Bade and Abela Longena, respectively (Table 2). This shows that households in Hobicha Bade was more vulnerable to climate change mainly due to lower income level from crop and livestock production and off-farm activities, and shortage of farming land that was highly contributed for the low adaptive capacity of the communities to climate extremes. In general, this implies that increasing total income of the households by enhancing the revenue generated from crop production through planting improved crop varieties, increasing livestock productivity through practice of good performing breeds, and alternative means regarding off-farm activities is crucial improving livelihood strategy of the households and in turn, better adaptive capacity against climate variability.

Social Network and Infrastructure

The vulnerability index analysis indicated that social network and infrastructure component scored 0.266, 0.286 and 0.178 for the Bosa Wanche, Hobicha Bade and Abela Longena, respectively (Table 2).

The results show that households in Hobicha Bade community were relatively more vulnerable to prevailing climate impacts mainly due to insufficient electricity coverage, limitations related with saving and credit services, and poor access to safety net program in the study area. For instance, the results indicated that 71.1% and 67.4% of the sampled households in Hobicha Bade community were lack electricity coverage and access to saving and credit service in their area, respectively. Borrowing and lending money indicate the financial assistance households receive in cash and kind from their social network and households that borrow money more than they lend are more vulnerable [17].In other hands, more than 61.9% of the sampled households have no access support from the safety net program in study area. In contrast, the result indicated significant portion of the community have better access to basic infrastructure such as primary school (99.2%), market information (99.2%), and all weather roads (87.8%) in the study area. This implies the household vulnerability level was determined by balanced investment in terms of infrastructure development across the study area and emphasis should be given. Moreover, formal education tends to improve the ability of smallholder farmers to better comprehend issues affecting them and therefore look for possible solutions at the appropriate places. On the other hand, illiteracy limits smallholder farmer's access to information especially from written sources, thereby increasingly their susceptibility to climatic stresses [22]. Other studies indicate that farm households with an access to formal education greatly contribute to climate change adaptation and reduce vulnerability. Extension services have the potential to influence farmers' decision to change their farming practices in response to climate change [23, 24].

Technologies

Regarding the technologies, the vulnerability index analysis indicated that the component scored 0.333, 0.391 and 0.261 for the Bosa Wanche, Hobicha Bade and Abela Longena, respectively (Table 2). The result considered use of agricultural fertilizers, supply and use of improved seed varieties, and having of radio/TV set showed that households in Hobicha Bade community were relatively vulnerable and low adaptive capacity to climate change impacts compared to the others. For instance, 78.3% of the households in the Hobicha Bade community have no access to either radio/TV set as means of information. Key informant interview and focus group discussion also revealed majorities of households in the study area have no radio/TV set mainly due to lack of awareness and problems related with electricity. In contrast, results indicated that 90% and 87.5% of the sampled households use organic fertilizer and improved seed varieties in their farm lands in general.

SENSITIVITY

Health

The vulnerability index analysis indicated that health component scored 0.184, 0.089 and 0.172

for the Bosa Wanche, Hobicha Bade and Abela Longena, respectively (Table 2). This shows that households in Bosa Wanche community were highly sensitive and in turn, more vulnerable to climate change mainly due to insufficient access to healthcare centre relatively compared to other communities. The results indicated that 62.6% of the sampled households in the Bosa Wanche community do not have better access to health care centre. In contrast, majorities of sampled households (99.2%) have private toilet in the study area.

Water Resources

The vulnerability index analysis indicated that water resource component scored 0.230, 0.098 and 0.091 for the Bosa Wanche, Hobicha Bade and Abela Longena, respectively (Table 2). This shows that households in Bosa Wanche were highly sensitive and in turn, more vulnerable to climate change impacts mainly due to insufficient availability of sustainable water supply (including streams and rivers) and clean drinking water in the area. Although the area have relatively better water resources, the results indicated that 24% and 20% of households in Bosa Wanche community do not access clean drinking water and lacks sustainable water supply, respectively. In other hands, key informants and information from focus group discussion revealed that water sources was increased due to restoration of the forest area and investment carried out through carbon sequestration A/R CDM project. Even though the even distribution of the drinking water sources built by the carbon sequestration A/R CDM project should be managed, the actions made to improve the access to clean drinking waters across the community was encouraging that needs to be continued in collaboration with local government administration according to interviewed key informants. On the other hand, utilization of a natural water source is likely to lead to an increase in a household's vulnerability to water borne diseases and water scarcity due to inadequate rainfall. Furthermore, water is usually sourced by women and young girls hence distant water sources increases the time burden of household chores and affects time for care in the case of women, and school attendance in the case of the girl child [22, 20].

Ecosystem

The vulnerability index analysis indicated that ecosystem component scored 0.675, 0.691 and 0.567 for the Bosa Wanche, Hobicha Bade and Abela Longena, respectively (Table 2). This shows that households in Hobicha Bade community were sensitive and in turn, more vulnerable to climate change impacts compared to others. This is mainly due to restriction on forests resource such as firewood for household consumption and fodder for the livestock populations.

The results indicated that majorities (86%) of respondents perceived complete restriction on firewood and fodder collection from the forest as introduction of the A/R project In contrast, 43.7% of the sampled households in study area confirmed that carbon sequestration A/R CDM projects provided assistance to plant trees on their farm lands. According to interviewed key informants, the restriction on forest resources triggered the communities to establish own woodlots and encouraged to plant trees in the farm lands so that it improved the microclimate compared to last two decades. Natural capital and vulnerability to climate change are tightly linked [25].

The greater the level of dependence of a household and the greater sensitivity of natural resources, such as farming, forestry, the higher their vulnerability to climate change and vulnerability level varies depending on the contribution of natural resources to their livelihoods [20].

Exposure

Natural Disaster

The vulnerability index analysis indicated that natural disaster component scored 0.155, 0.234 and 0.304 for the Bosa Wanche, Hobicha Bade and Abela Longena, respectively (Table 2). This shows that households in Abela Longena community were more vulnerable and exposed to climate change impacts compared to the rest two mainly due to increasing encounter of natural disasters such as drought, and flooding. The results also indicated that 76.1% of sampled households perceived the climate related natural disasters were increased in alarming rate in past three decades in the area.

In addition, key informants also indicated that natural disasters like prolonged drought resulted decline in agricultural productivity and exposing the community to climate extremes so that planting trees with sustainable watershed management should be prioritized. Similar studies identified such indicators as the measurement of exposure [26, 27].

Climate Variability

The vulnerability index analysis indicated that climate variability component scored 0.346, 0.403 and 0.411 for the Bosa Wanche, Hobicha Bade and Abela Longena, respectively (Table 2). This shows that households in Abela Longena community were more vulnerable and exposed to climate change impacts mainly due to increased number of factors contributed to climate change, insufficient response mechanisms to halt the shocks, and increased climate effect on the livelihoods in the communities. In contrast, 99.3% of the households have perceived significant changes on climatic parameters such as temperature and precipitation in the area in past three decades. This implies that increasing the response mechanism of households in the communities to climate shocks should be given emphasis so as to minimize the level of exposure to climate variability.

In general, the vulnerability diagram of the major components of the LVI showed in figure 2 below.

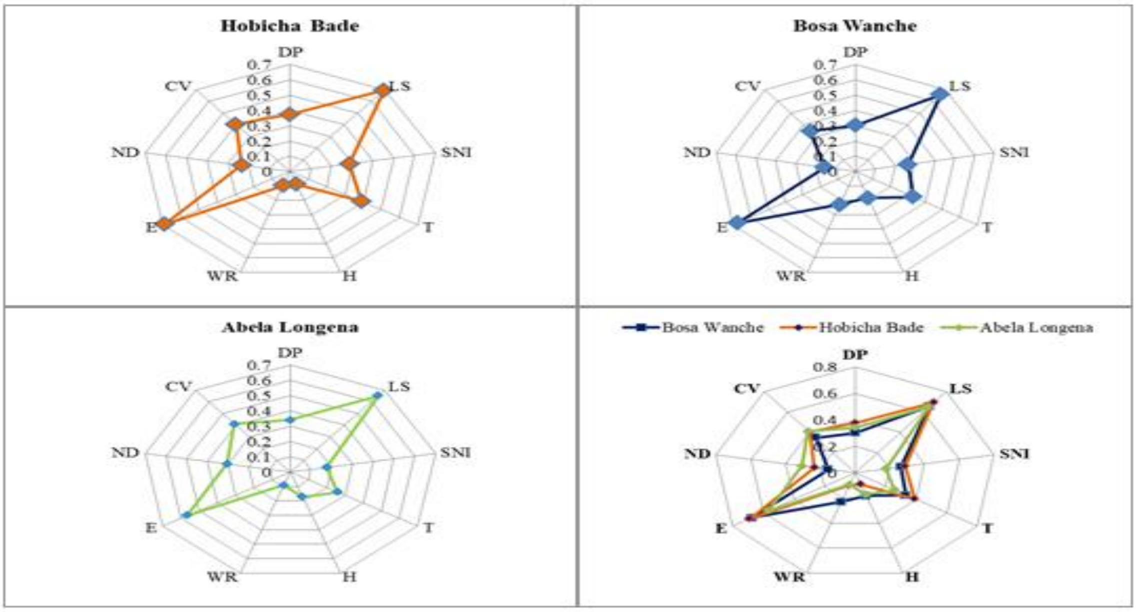

Figure2. *Vulnerability spider diagram of major components of LVI*

Where: DP, demographic profile; LS, livelihood strategies; SNI, social network and infrastructure; T, technology; H, health; WR, water resources; E, ecosystem; ND, natural disaster; CV, climate variability. The scale represents 0 for least vulnerable and 0.8 for most vulnerable.

Overall Vulnerability Score

Based on final weighted average score, the household vulnerability index ranged from -0.373 to 0.402. The overall LVI-IPCC scores indicate that households in Bosa Wanche are comparatively less vulnerable to climate extremes compared to others because of better adaptive capacity (0.390) and less exposure (0.263). In other terms (Table 2), the calculation of LVI-IPCC showed that the households in Abela Longena kebele are more vulnerable to climate change compared to Habicha Bade (-0.035) and Bosa Wanche (-0.046).

Table2. *Indexed major components LVI-IPCC for the sampled kebeles*

Contributing factors	Major components	No of sub-components	Sampled kebeles (LVI)			Overall sample
			Bosa Wanche	Hobicha Bade	Abela Longena	
Adaptive capacity	Demographic profile	6	0.301	0.375	0.341	0.341
	Livelihood strategies	9	0.658	0.693	0.651	0.667
	Technologies	3	0.333	0.391	0.261	0.326
	Social networks and Infrastructure	7	0.266	0.286	0.178	0.240
	Mean score		0.390	0.436	0.358	0.394
Sensitivity	Health	2	0.184	0.089	0.172	0.147
	Water resources	2	0.230	0.098	0.091	0.135
	Ecosystem	5	0.675	0.691	0.567	0.640

	Mean score		0.363	0.293	0.288	0.311
Exposure	Natural disasters	1	0.155	0.234	0.304	0.239
	Climate variability	4	0.346	0.403	0.411	0.390
	Mean score		0.263	0.318	0.358	0.317
LVI-IPCC			-0.046	-0.035	0.000	-0.024

The calculation of overall lvi-ipcc indicated that 16.1% of the households in the communities were highly vulnerable to climate change and variability that need urgent intervention. On other hands, 54% and 29.9% of the households in the communities were categorized as less and moderately vulnerable to climate extremes, respectively. In this regard, 25.5% of the households in abela longena were highly vulnerable to climate change and variability that need urgent intervention. The rest, 29.4% and 45.1% of the households were less and moderately vulnerable to climate extremes. on other side, the results indicated that 10.9% of the households in hobicha bada were highly vulnerable to climate extremes. In this regard, 65.2% and 23.9% of the sampled households were categorized into less and moderate level of vulnerability to climate variability. unlike other communities, only 4% of households in bosa wanche were highly vulnerable in addition to 72.5% and 17.5% of the sampled households were less and moderately vulnerable to climate change respectively.Regarding the impact of contributing factors, on average the adaptive capacity component has contributed 38.5% followed by exposure 31% and sensitivity 30.5% to overall household vulnerability index. The analysis indicated that adaptive capacity score contributed 41.7% to household vulnerability index in habicha bade community resulted household with lowest adaptive capacity and in turn, higher vulnerable to climate extremes compared to bosa wanche and abela longena. On other hands, sensitivity score contributed 35.7% to household vulnerability index in bosa wanche community resulted household with most sensitive and vulnerable to climate extremes compared to hobicha bade and abela longena. The findings also indicated that exposure score contributed 35.7% to household vulnerability index in abela longena community resulting household highest exposure to climate extremes compared to bosa wanche and hobicha bade (figure 3)

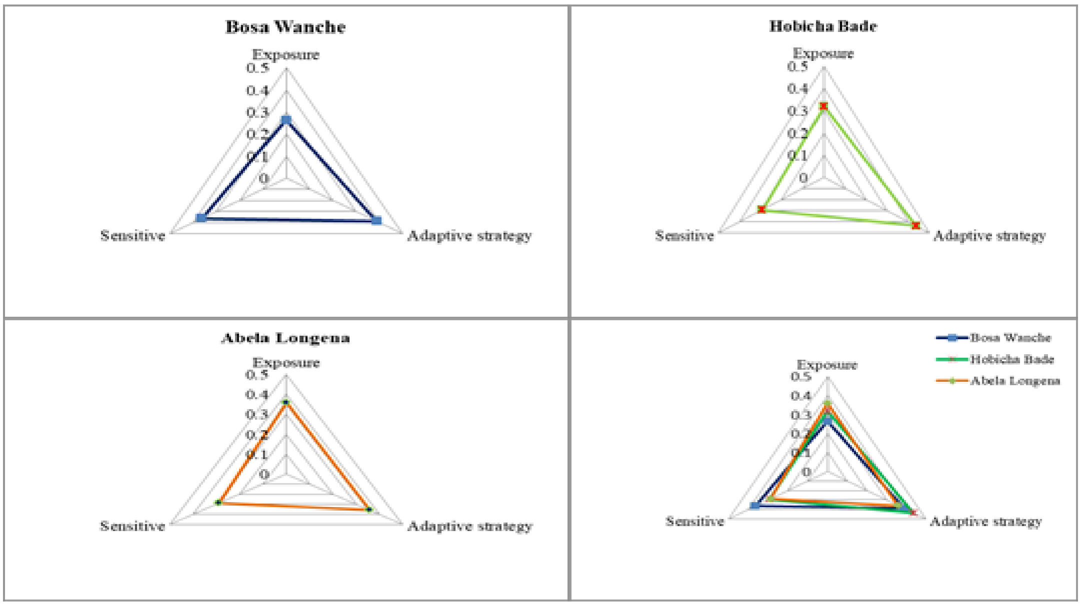

Figure3. *Vulnerability triangle diagram of contributing factors of LVI-IPCC*

CONCLUSION

The researcher presented the LVI and LVI-IPCC as alternative methods for assessing vulnerability of farmers to climate variability and change. The sub-components used to construct the LVI in this study were based on the current conditions of our study sites, available data from household survey and focus group discussions. Hence, the LVI-IPCC indicated that 16% of the households in the communities were highly vulnerable to climate change and variability. On other hands, 54% and 29.9% of the households in the communities were categorized as less and moderately vulnerable to climate extremes, respectively. The results also showed that the households in Abela Longena site are more vulnerable to climate change compared to Habicha Bade and Bosa Wanche. The improvement in the condition of ecosystem, health and water helps to reduce sensitivity whereas strengthening demographic profile, social network and infrastructure, technologies and diversification of livelihood activities enhance adaptive capacity of the communities. The findings of this study provide insight to devise coping strategies for indigenous communities and incorporate them in the climate change policies. Overall, it is hoped that the LVI will provide a useful tool for development planners to evaluate livelihood vulnerability to climate change impacts in the communities in which they work and to develop programs to strengthen the most vulnerable sectors. Therefore, integrating rural development schemes aimed at increasing adaptive capacity to climate variability and change is recommended to the range of climate extremes that they experience.

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