

Farmers' Livelihoods Vulnerability to Climate Variability and Change in Didesa Basin Southern Part of Abay Basin, Ethiopia

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1 Introduction

Climate related evidences shows that there is an increase in frequency of extreme events such as drought, floods and different crop and animal pests in relation to climate changes where, historical records show an increase in global temperature since the late 19th century. Intergovernmental Panel on Climate Change (IPCC) predicts an increase in temperatures between 0.3 and 0.7 °C over the next two decades and an increase of 0.3–4.8 °C by the end of the 21st century, depending upon emission scenarios (Collins et al. 2013; Kirtman et al. 2013). The changes were with different manifestation like an increase in temperatures, frequency of cold days, cold nights, and decreased in coolness, while frequency of hot days, increased hot nights, and heat waves (Kirtman et al. 2013).

Africa is one of the most vulnerable continents to climate variability and change due to high reliance on climate sensitive sector (e.g. agriculture) and low adaptive capacity (Boko et al. 2007; Adger et al. 2007) result from poverty. By the 2050s, 350–600 million Africans will be at risk of water stress, extensive floods, drought,

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famine, and loss of life specifically, sub-Saharan Africa (Arnell 2004; IPCC 2007; Lobell et al. 2011).

In relation to the changes, IPCC (2007) reported that, rain fed crop yields will decline by 10–20% by 2050 and crop revenues could fall by 90% by 2100. Ethiopia, with an estimated 96 million people live on less than \$1.25 a day (Belay et al. 2013) where, agriculture is a major economic sector employing 85% of the labor force and contributing 40% to the countries' national GDP considered the most vulnerable due to climate related hazard and risks (Belay et al. 2013; Boko et al. 2007; Conway and Schipper 2011; Cooper et al. 2008; Thomas et al. 2007).

Von Braun (2007), for instance, identified that a 10% decrease in seasonal rainfall from the long-term average generally translates into a 4.4% decrease in the Ethiopian food production. Study by World Bank (2010), projects that unless steps to build resilience are effective, climate change will reduce Ethiopia's GDP growth by 2–6% by 2015, and up to 10% by 2045 between 0.5 and 2.5% and between 0.5 and 2.5% per year (EPA 2011). Such impacts would be greatest in SSA and Ethiopia for many reasons (Patt et al. 2009; Deressa et al. 2009). First, high reliance on climate sensitive sectors (agriculture). Second, due to unsustainable patterns of land use practices this could exacerbate climate change. Third, lack the necessary capital to invest in adaptation as well as maintain stability in society when physical harm occurs (Patt et al. 2009; IPCC 2007).

According to Simane et al. (2014) due to high projection of significant future climate change in Ethiopia in the coming decades; aggregate national vulnerability result does not capture the complexity of vulnerability at agro ecological level leads agricultural productivity remains challenged. This is particularly true in the Didessa basin where the soil and terrain, diverse topography, socio-economic, prevalence of climate variability, environmental conditions and sensitivity of agriculture and ecosystem exhibited in land, water resources degradation and biodiversity loss.

Different studies have developed an index to determine the level vulnerability on farmers to climate extremes using the “vulnerability as expected poverty” approach (Deressa et al. 2009; Swain and 2011). Using Livelihoods Vulnerability Index (LVI) and LVI-IPCC (Hahn et al. 2009; Entwire et al. 2013; Can et al. 2013; Simane et al. 2014). They used several variables into major components to capture the level of exposure, adaptive capacity and sensitivity to climate change impacts.

The present study used Agro Ecological Zones (AEZ) as unit of analysis to examine farmer's livelihoods vulnerability to climate variability and change considering the effect of agriculture relevant climate factors, sensitivity and adaptive capacity in the Didessa basin of the Blue Nile River. Livelihood Vulnerability Index (LVI) framed within the Livelihood Vulnerability Index—Intergovernmental Panel for Climate Change(LVI-IPCC) categorization (Hahn et al. 2009; Simane et al. 2014) and Sustainable Livelihood Approach (SLA) (Birkmann 2006) used in the context of the study area.

2 Materials and Methods

2.1 Descriptions of Study Area

This study was conducted in the Didessa basin of the Blue Nile basin located in the southern most part in 2015 on 450 farm households in Ethiopia. Astronomically it is located 36° 02' and 36° 46' east longitude and between 7°43' and 8° 13' north latitude. Mean annual rain fall 1586 mm having only one summer rainy season. The mean max-min temperature is 30 and 11.45 °C. respectively (NMSA 2015) Altitude ranges between 1720 to 2088 m a.s.l excluding mountains of greater than 3500 m a.s.l (Buzuneh 2011) (Fig. 1).

2.2 Study Design, Data Source, Sampling Techniques, Procedure and Size

The study was applied a cross-sectional quantitative study design, supplemented by qualitative study, to assess the level of farmers vulnerability to climate variability across agro ecological zones of Didessa basin. The study was agro ecological zone based conducted in the western Ethiopia. Consequently four districts were selected in such a way that each class in the sample proportion for each AEZ in the entire basin. Eighteen (18) villages representing AEZ were selected and systematic random sampling was then used in selecting twenty five (25) households from each AEZ totaled 450 respondents.

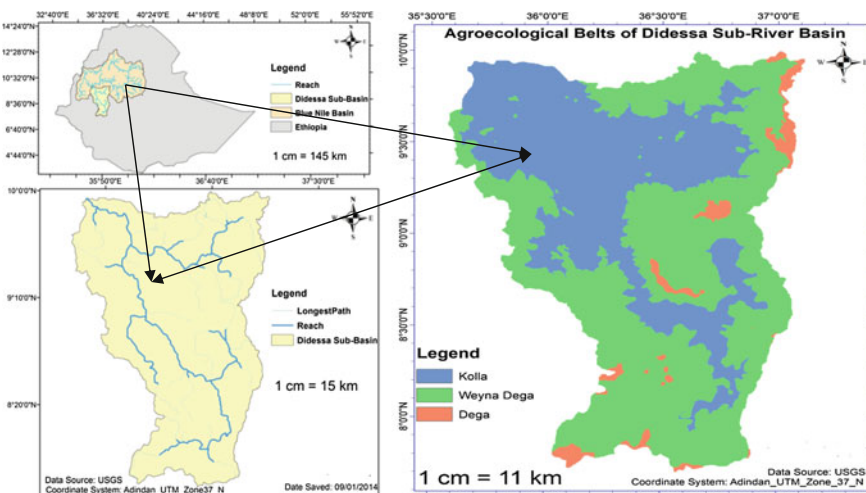


Fig. 1 Map of Didessa basin, boundary, agro-ecological setting. *Source* United State Geological Survey, 2014

The data for this research was collected using standard questionnaires prepared for the survey in May 2015. The collected data includes the ten major components in the livelihoods vulnerability index (LVI) analysis namely: socio demographic profiles of the households, ecosystem, infrastructure, health, wealth, social network and institution, livelihoods and other relevant information. Besides, exposure data were obtained from national meteorological service agency proxy station. To verify the quantitative data, qualitative data were collected through focused group discussion (FGD). Finally, two sets of analysis were undertaken: calculation of a balanced weighted average LVI and calculation of a LVI based on the IPCC framework (IPCC 2007).

2.3 Calculating the LVI: Composite Index Approach (Model)

Drawing up on the SLA and the LVI-IPCC approach (Hahn et al. 2009; Simane et al. 2014) the study apply a balanced weighted average approach (Sullivan et al. 2002). Each subcomponent contributes equally to the overall index even though each major component includes a different number of sub-components. In LVI analysis, first transform the raw data into appropriate measurement unit such as percentage, ratio and indices. Second, standardizing the sub components measured on different scale using Eq. (1). To standardize a main component, the quotient of the difference between the actual score and the minimum value and the difference between the maximum and minimum values obtained from the total sample was calculated.

$$\text{Index } I_{vi} = \frac{S_r - S_{min}}{S_{max} - S_{min}} \quad (1)$$

where I_{vi} is the standardized value for the indicator, S_r is the observed (average) sub-component indicator for agro-ecology of r , and S_{min} and S_{max} are the minimum and maximum values, for the indicator across all the AEZ respectively. Third, standardizing, the sub-component indicators are averaged using Eq. (2) to obtain the index of each major component:

$$M_r = \frac{\sum I_{vi}}{N} \quad (2)$$

where M_r is one of the ten major components for agro-ecology r (Table 1); index I_{vi} represents the sub components, indexed by i , that make up each major component and “ N ” is the number of sub-components in each major component. Fourth, combines the weighted averages of all the major components to generate the LVI score. The number of indicators of which it is compressed to determines the weights of each major component (W_{mi}). Values for each of the ten major components for an agro-ecology are calculated and averaged using Eq. (3) to obtain the AEZ-level LVI:

Table 1 Vulnerability Index Components: key components used to generate the vulnerability index across the agro ecological zone

LVI-IPCC	Capitals	Major components	Sub-component (Indicator)	Hypothesis
Exposure	<i>Climate</i>	Change in temp, and RF	Change in temperature Change in precipitation Occurrence of extreme events (drought, floods)	Increase in temperature and decrease in precipitation increase vulnerability
Sensitivity	<i>Natural Capital</i>	Ecosystem	Land use system, Land cover change, Land suitability, Land management (SWC) Irrigation potential	The more forest cover and suitable land and access to irrigation the less sensitive
		Agriculture	Annual total production (inverse) changes in productivity, diversity of crop species, agricultural diversity index	The more productivity, diversification the less sensitive
Adaptive capacity	Financial capital	Wealth	Farm size of the HHs (inverse), Number of livestock(inverse), saving at HH level, loans, non-agricultural income	The more the wealthy status the more the adaptive capacity
	Physical capital	Technology	Insecticide and pesticide supply, fertilizer supply, improved seeds supply, irrigation potential	The more access to technology the more the adaptive capacity
		Infrastructure	Access to all-weather roads, schools, veterinary services, market, saving and credit, electricity and telephone	The more access to infrastructure the more the adaptive capacity
	Human capital	Community	Sex of HH heads, education level, health services, radio ownership availability of extension skill/training	The more the information the more the adaptive capacity

(continued)

Table 1 (continued)

LVI-IPCC	Capitals	Major components	Sub-component (Indicator)	Hypothesis
		Livelihood strategy	Average agric. livelihood diversity [1/(no. of agric. activities + 1)], Percent of HHs dependent on agric as major source of income, Percent of HHs dependent on non-farm activities as source of income	The higher the agricultural livelihoods diversity the lesser the vulnerability
	Social capital	Social network	Availability of bylaws, number of no-working days/month, tradition of working together	The more farmers are members with less no-working days and the more the tradition of working together the better
		Socio demographic	Dependency ratio, female headed household, average family members in the households	The higher the dependence ratio the higher, the vulnerability

Source Hahn et al. (2009), Simane et al. (2014) and profiles indicators tailored to the study area

$$LVI_r = \frac{\sum_{P=1}^{10} WM_i M_{ri}}{\sum_{P=1}^{10} WM_{ri}} \tag{3}$$

where, LVI_r is the Livelihood Vulnerability Index for AEZ_r. Following Eqs. (1)–(3), Hahn et al. (2009) calculated the major components of LVI based on the LVI-IPCC vulnerability categorization (Exposure (E), Sensitivity(S) and Adaptation (A)) using the following equation:

$$CF_{r=} \frac{\sum_{P=1}^f WM_i M_{ri}}{\sum_{p=1}^f WM_{ri}} \tag{4}$$

where, CF_r is the LVI-IPCC defined contributing factors for agro-ecology of r, M_{ri} are the major components for the agro-ecology of r, indexed by i, W_i, the weights of each major components, f is the number of the profiles associated contributing factors

and p is indexed to the profiles associated with the CF. Finally, the researchers developed the LVI-IPCC vulnerability categorization (see Table 1) using Eq. 5

$$\text{LVI-IPCC}_r = (e_r - a_r) * S_r \quad (5)$$

where, LVI-IPCC_r is the LVI for agro-ecology r expressed using the IPCC vulnerability framework, e_r is the calculated exposure score for agro-ecology r , a_r is the calculated adaptation capacity score for agro-ecology r and s_r is the calculated sensitivity score for agro-ecology r . We scaled the LVI-IPCC from -1 (least vulnerable) to 1 (most vulnerable) and is best understood as an estimate of the relative vulnerability of compared populations in agro-ecology.

3 Results

3.1 Livelihoods Vulnerability Index Components in the Didessa River Basin

In this section we provide an analysis of the key profiles used to generate the vulnerability index, highlighting the key profiles and where they differ between agro-ecological zones. The study participants' backgrounds are shown in Table 2. A total of 450 farm households participated in the study and of those studied 86.88% were male and 13.12% were female. In terms of age category, the majority of respondents 81% are within the active working age group (31–65), while 32 respondents 4% are above 65 years of age. About, 396 (88%) were married and the remainder were single, divorced, or widowed. Education levels are low with many of the respondents 30.22% being illiterate, approximately 16%, were attended adult education, and about 42.66% attended primary cycle of schooling (1–4 level).

Table 2 Demographic characteristics of the study population ($n = 450$)

Characteristics	Category	Highland	Midland	Lowland
Gender	Male headed household	90	80	94
	Female headed household	10	20	6
Marital status	Married	95	82	91.33
	Not married	1	3.5	3.33
	Divorced	1	3	4.66
	Widowed	3	11.5	0.666
Education	No education/illiterate	26	26.5	38
	Adult education (reading and writing)	34	12	9.33
	Primary school	30	51.5	39.33
	Secondary school and above	10	10	13.33

Source Survey result, 2015

*All values in the table presented in percent (%) in a given AEZ

3.1.1 Exposure Profile: Natural Disaster and Climate Variability

The exposure analysis result shows high score of climate variability and change in the lowland with 0.501 followed by 0.423 and 0.414 in highland and midland respectively. When the main components were reviewed by sub-components (i.e. indicators), lowland agro ecology was most vulnerable in terms of exposure to climate variability (0.501). Farmer perceptions toward climate variables in the basin indicated that temperature is increasing and rainfall decreasing though slight variation across agro ecological zone. People living in different agro-ecological system socio economic, cultural, farming system and soil are believed to perceive climate change differently (Simane et al. 2012; Gutu et al. 2012; Sewagegn 2011). The exposure profiles includes undulating and steeply sloping farmlands, low soil fertility level due to frequent degradation, soil erosion, below average rain and mounting temperature (Table 3). As a result, agricultural productions decreased and threaten the lives and livelihoods of farmers in the basin. Similar studies identified such indicators as the measurement of exposure (Deressa et al. 2009; Fussel 2010; Gutu et al. 2012).

3.1.2 Sensitivity Profiles: Ecosystems and Agriculture

Ecosystem

The dominant farming systems in the Didessa basin are shaded coffee/livestock farming system and cereal/livestock mixed farming system. The sensitivity of the agro ecologies in the basin ranges from 0.302 to 0.28. The highland agro-ecology shows, high sensitivity score (0.31) for ecosystem than the midland (0.256) and lowland (0.2) agro-ecology. This is due to failure to take care of natural resources (e.g. soil and water), shortage of land, inadequate livelihoods option, population pressure, fuel demand (socio economic) and low level of awareness on natural re-sources management. Natural capital and vulnerability to climate change are tightly linked (Bankoff et al. 2004). The greater the level of dependence of a household on the ecosystems 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

Table 3 Annual average monthly temperature and precipitation in the surveyed AEZ

AEZ	Altitude (a. s.l)	Area coverage (%)	Temperature		Av. Monthly precipitation	Average annual precipitation (mm)
			Maximum	Minimum		
Kola	1000–1450	47.2	31.27	13.92	133.00	900–1500
WD	1500–2450	45.8	30.6	10	136.77	1500–1850
Dega	2229–2870	7	23.74	8.66	167.25	1850–2750

Source Authors calculation from NMA (2015)

livelihoods. However, the key informant from the Didessa basin stated that the rate of ongoing forest distraction is higher than the previous periods due to increased population pressure people to occupying the forest lands without restriction.

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. In this regards, water source, the average time taken to reach is found to be highest in the lowland. The highland and Lowland agro-ecology reported the highest percentage (32.3 and 31) of households that do not have a consistent water supply. These households become even more vulnerable during the dry season when most natural water sources tend to dry up. Households in the highland reported storing water as compared to those in the midland and lowland agro-ecology. Inverse household water letter per day indicated (0.016) in highland (0.024) in the midland and (0.047) in the lowland. Besides, in terms of irrigation use the highland agro-ecology better off with 17% and the soil and water conservation practice is high in the highland (73%) than midland and the lowland.

Agriculture: Farm Land size

The average land holdings were 1.86 ha although the farm land size differs across agro-ecology of the Didessa basin. In the highland 1.39 ha, in lowland 2.39 and in the midland 1.79 ha which is above the national average household farm size 1.22 ha (CSAa 2012). However, about 41.21, 32.37, 31.38% of farm households in the highland, midland and lowland households respectively owning less than one hectare. The vulnerability level of household in the study area shows that households who owned a better size of land were less vulnerable to climate change (inverse average farm size LVI score HL (0.089), ML (0.066) and LL (0.047). This is because the bigger the size of land, the higher the diversity of crops that are grown, the better their access to improved technology, and the better their access to financial services and extension services. Accordingly, the score value those households with more farm sizes will have high adaptive capacity and less vulnerable to climate impacts as compared to those with less sized farms. This is similar with the finding of Gutu et al. (2012) on a time series analysis of climate variability and its impacts on food production in north Shewa zone in Ethiopia.

Moreover, according to the information from the agronomist of the study area, the number of plots a farmer operates at different locations play vital role in reducing vulnerability because of differences in climate variability across agro ecological zones, within the same agro ecological zones and even differences exhibited for those households with more number of farm plots are less vulnerable as compared to those with single or fewer plots.

3.1.3 Adaptive Capacity

Infrastructure

Access to major indicators of infrastructure are comparable to national average figures and do not vary significantly across agro-ecological zone (Table 4). It is worth noting that 70.83% of the households have access to agricultural extension services and about 72.07% of household's access to health services within 5 km of their homes a figure that does not vary significantly across agro-ecological zone.

Technology

The percentage of farmers who have access to different farm technology (irrigation, insect side and pest sides, fertilizers use and improved seeds) were 65 and 11% in highland, midland and lowland agro-ecology. The differences in technology profiles between AEZ were attributed primarily to differences in the agro-ecology, soil and terrain, farming system and use of chemical fertilizer, improved seed as well as irrigation potential. Farmers who have better tropical livestock unit (TLU) will have better access to farm technologies. But the application of these inputs was limited even among farms in a better wealth status due to sky rockets of the farm technologies prices. In addition, the total amount of chemical fertilizer applied is low, even among farmers that report using some fertilizer. The use irrigation on their land in the agro-ecology has not statistically significant due to low experience and low access to irrigation technology which still goes with purchasing power. The improved seed use is different among the agro ecology where the highland and midland farmers do use more improved seeds on average compared to lowland. The improved varieties use rate is high in the midland agro-ecological zone than in the

Table 4 Access to basic services and indicators of infrastructure within 5 km of the home, as reported in household surveys in the Didessa basin

Indicators	Proportion of farmers with access (%)		
	Highland	Midland	Lowland
Road (access to all weather roads)	100	99.5	94
Primary school	96	94	82.66
Veterinary services	88	98	93
Access to market (km)	100	99.5	98
Access to health services	74	81.3	60.9
Access to credit	97	98.5	92.6
Access to institutions	95	91	91
Access to electricity	10.10	12.06	33.55
Access to telephone	54.73	32.5	41.37

Source Survey result, 2015

highlands due to the favorable topography and climatic variables for the intensive crop production.

Wealth profile: Access to credit

The wealth profile score showed that access to credit was a significant determinant of vulnerability level. In terms of access to credit, there is no significant difference in the three agro ecological zone. Farmers in the category of high access to credit have high probability to reduce vulnerability as compared to those who do not have access within that category. However farmers claimed the bureaucracy for access to cash for purchase of agricultural inputs, which resort farmers to borrowing from local lenders at exorbitantly high interest rates. This is similar to Shewmake's (2008) finding that households with poor access to credit are more vulnerable.

Land Holding and Livestock Ownership

The average land holding is 1.86 ha, with 93.06% of the farmers owning their land. Of this, 80.88% got land ownership certification (Table 5). Among respondents, 83, 49.74 and 47.65% reported that their land holding size has decreased over the past 20 years in highland, midland and lowland respectively, due to land degradation and loss of soil fertility, while 6, 9.23 and 16.78% of the households in the three agro-ecology highland, midland and lowland have reported an increase in agriculturally useable land holdings as a result of clearing forest lands and grazing areas and redistribution of land. Lowland agro-ecology statistically significant larger average land holding size (2.39 ha) compared to the highland and midland due to possibility to expand to communal land and absence of land ownership certificate especially in the northern part of the basin.

In terms of livestock ownership, the highland agro ecological zone has a higher level of livestock ownership than the mid highland and lowland zones. The inverse average No of live stock unit (TLU) of LVI score shows highland was less vulnerable (LVI score = 0.0097) compared to lowland and midland 0.0182 and 0.013)

Table 5 Land and livestock holdings size in the Didessa basin across agro ecological zone

Description	Highland	Midland	Lowland
Land ownership	100	93	52
Average land holding size (ha)	1.39	1.79	2.39
Changes in farmland size over the last 20 years	6	9. 23	16.78
• Increase	83	49. 74	47.65
• Decrease	11	41. 03	35.57
• No change			
Possession of livestock in tropical livestock unit (TLU)	6.7	4.77	3.57

Source Survey result, 2015

* All figures are in % within the given AEZ, except for average land holding size and TLU

due to better number of livestock with verities. This is due to the facts that a farm land in the midland and lowland are better for agricultural production and the highland suitable for livestock grazing land due to its mountainous and not conducive for cultivation and favorable in terms of access to livestock health service.

3.1.4 Community Profile

Agricultural Experiences

The result revealed that in the lowland farmer's agricultural experience were less than mid and highland farmers with an average year of experience around 21.77 years, 23 years and 24.88 years, respectively. Many years of experience have shown a lower level of vulnerability to climate impact as compared to those households with very few years of experience. Hence, experienced farming households have an increase likelihood of choosing change planting date, planting different crops and varieties, apply various farm management practices and techniques that can be used in the face of anticipated climate change which confirm the findings of (Nhemachena and Hassan 2007; Gutu et al. 2012).

Education and Access to Farm Extension Training

Farmers in the Didessa agro-ecological basin had access to extension training with 89.7, 68.3 and 54.5% in highland, midland and lowland agro-ecology respectively. Farm households with an access to formal education greatly contribute to climate change adaptation and reduce vulnerability in the basin. Extension services have the potential to influence farmers' decision to change their farming practices in response to climate change (Nhemachena and Hassan 2007; Maddison 2007).

Health

In highland only 12.1%, the least households reported ill health as a result of better livelihood options and government and private health facilities. The agro-ecological zone with most households reported ill health was lowland zone (26%), because of lack of health facilities and distance from the health centers. As a result, family member had to miss school or work in the past 6 month due to illness was high in lowland (18.5%) which result low participation of family members in agricultural activity, decline of the agricultural production and affect adaptive capacity of farmers in the agro-ecology. Average malaria exposure prevention index was high in the lowland (0.485) than the highland (0.159) and midlands (0.314). Lowland households reported as being more vulnerable to malaria exposure due to less access health services (60.9%) to get bed net and high mounting temperature relative to the highland and mid lands (74 and 81.3%) respectively.

Livelihoods Strategy

The livelihood strategies of the households in the Didessa basin of Blue Nile basin were diverse which were different across agro-ecology due to difference in their knowledge and experience to disaster exposure. The common livelihoods strategies employed in the basin includes growing crops, raising animals, collecting natural resources and family member or members go to other areas for work. Almost all the agro ecological zone households relying solely on agriculture for income the result indicated that about 95, 93 and 87% of households in HH, ML and lowland respectively. Although, the Lowland had higher vulnerability scores for two of the Livelihood Strategies indicators, Lowland agro-ecological zone households are better in traveling outside the community to work 0.15 as livelihoods strategy compared to 0.067 and 0.09 in highland and midland agro ecology.

Average agricultural livelihood Div. Index which was calculated as the inverse of (the number of agricultural livelihood activities +1) reported by a household the highland and mid land basically relay on crop and animal raring where as the lowland agro ecology relay on hunting and forests products in addition to the crop animal raring. Consequently the lowland agro ecology was less vulnerable (with LVI score of 0.25) compared to the highland and midland (score, 0.33). However, But when the three sub-components were averaged, the overall livelihood strategies index was lowest in lowland (0.42) and highest in midland (0.45) and highlands (0.449). This is because of its relative favorable environmental situation such as health, infrastructure, schools and access to market to work in the highland and mid highland and relatively better options of livelihood activities and agricultural diversification option. Consequently, the lowland agro-ecology was relatively more vulnerable than the rest agro-ecology due to limited livelihoods strategy.

Socio Demographic and Social Network Profile

The issue and the role of population growth and family size in development, in general, and climate change adaptation and vulnerability in particular is largely unresolved. The family size of the households in the study area differs across different agro-ecology due to differences in access to infrastructure such as health center, education and extension services. As a result, about 54, 26.5 and 30.66% of farm households have family size of greater than 6 members in highland, midland and lowland agro-ecology respectively. Large family size was assumed to be the source of labor, skills and strong social capital to adapt to changing climate situation (Deressa et al. 2011) and enable a household to accomplish various agricultural tasks especially at the peak seasons.

However, large family sizes have negative impacts on the households in the Didessa basin. This is because the available livelihoods opportunities 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 children, women and large sized families are affected mostly by the climate change events (Abate 2009). Therefore, households with large family size are highly vulnerable to climate change induced risks which is true in the highland area of the basin where access to land and livelihoods option is limited compared to the two agro ecological zones.

Social capital measures varied little between agro-ecology. Households reported borrowing money more frequently and receiving more in-kind assistance from family and friends relative to the number of times they lent money or provided assistance in the past month is higher in highland than the midland and lowland households (borrow: lend ratio: 0.02, 0.06, 0.16; receive: give ratio: 0.2, 0.247, 0.27) respectively. Generally, social bonds in the basin is great due to the cultural and tradition showing decreased compared to the past two three decades. 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 (Hahn et al. 2009). Overall, the lowland (0.44) households were more vulnerable than the highland and midland in social networks profile score (0.44) and (0.40) respectively.

4 Discussion

4.1 *Livelihood Vulnerability Index: Practical Implications in the Didessa Basin*

The standardized values of all the ten major contributing profiles are presented in spider diagram (Fig. 2). The spider diagram ranges between 0 (least) and 0.9 (highest). Index value should be interpreted as a relative value to be compared with the study sample only. Lowland agro-ecology is most vulnerable in terms of socio-demographic profile (0.268), social network (0.44) and technology (0.11). The highland agro-ecology is most sensitive in terms ecosystem (Land use system, Land cover change, Land suitability land management (SWC), irrigation,) (0.313) while the lowland agro-ecology is most sensitive in terms of agriculture (0.517) followed by highland (0.43). In terms of percent of technology access the midland and highland were superior to the lowland (65, 58 and 11%). Overall, the LVI score for highland, midland and lowland are (0.43, 0.422 and 0.392) respectively

4.2 *IPCC-LVI Contributing Factors in the Didessa Basin*

The LVI-IPCC is computed by grouping the ten major profiles into three factors, namely exposure (made up of one major component), sensitivity (two major

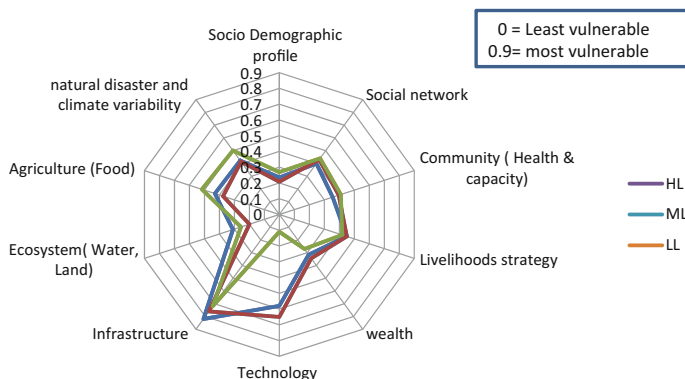


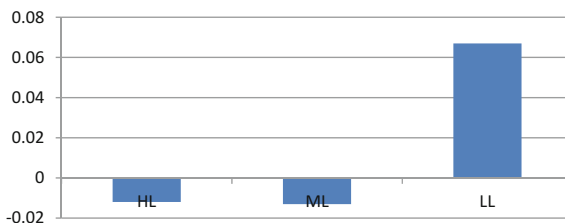
Fig. 2 Spider Diagram of the Major livelihoods vulnerability contributing profiles for Didessa basin across agro-ecology. *Source* computed from Survey, 2015

Table 6 Calculated indices for contributing factors and the Livelihood Vulnerability Index under the LVI-IPCC framework

AEZ	Exposure	Sensitivity	Adaptive capacity	LVI-IPCC
Highland	0.423	0.36	0.461	-0.012
Midland	0.414	0.28	0.462	-0.013
Lowland	0.501	0.374	0.434	0.067
Average	0.446	0.318	0.453	0.014
Max	0.501	0.374	0.463	0.067
Min	0.414	0.28	0.434	-0.013
SD	0.4784	0.04917	0.01646	

Source Survey result, 2015

Fig. 3 LVI of the different agro ecologies in the Didessa basin, Blue Nile basin Ethiopia. *Source* Survey result, 2015



components) and adaptation capacity (seven major components). Calculating indices for the three factors are represented in Table 6. Index values are interpreted as relative values to be compared within the study sample only. The LVI-IPCC is on a scale from -1 (least vulnerable) to 1 (most vulnerable) (Fig. 3).

The calculated LVI-IPCC indices ranged from 0.067 to -0.013 (Table 6). Lowland is more exposed (0.501) to climate change impacts than HL (0.423) and ML (0.414). Based on socio demographic, livelihoods, and social networks, wealth, infrastructure, technology, and community profile, midland and highland ecosystem showed a higher adaptive capacity (0.462 and 0.461) relative to the lowland (0.374). However, considering for the ecosystem (water,) and agriculture (food) lowland (0.374) and highland (0.302) may be more sensitive to climate change impacts than midland (0.28). The overall LVI-IPCC scores indicate that lowland households are more vulnerable than highland and midland households (0.067 versus -0.012 , -0.134 , respectively). This study result, is similar with Simane et al. (2014) where 62% of the total land mass (lowland, valley fragmented AES 1 and the mountainous highland AES 5) is categorized as having high relative vulnerability in Choke Mountain ecosystem.

5 Conclusions and Recommendation

The LVI and LVI-IPCC offers a framework to evaluate and understand relative climate variability and changes vulnerability at household to community level in Didessa river basin. This chapter presented the LVI-IPCC as alternative methods for assessing vulnerability of farmers in different AEZs to climate variability and change. The LVI method provides a detailed depiction of factors driving household livelihood vulnerability in a particular study area. The LVI-IPCC result indicated that the lowland agro-ecology is most vulnerable to climate change due to high level of exposure and relatively low level of adaptive capacity compared to midland. The finding of the study will have important policy relevance that could enable smallholder farmers in lowland agro-ecology to better adapt to the effects of climate change and variability and to develop programs to strengthen the most vulnerable sectors.

The study recommends that increasing adaptive capacity to climate variability and change to the range of climate extremes that they experience (drought, floods wheatear related shocks). The study also recommends the flexible application of LVI-IPCC as tools for the climate related analysis and impact assessment by substituting the value of the indicator that is expected to change and recalculating the overall vulnerability index. The study LVI might be used to project future vulnerability, for example under simple climate change scenarios.

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