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Assessing determinants of livelihood vulnerability to climate change impact in rural communities context in arsi and east shewa zones of oromia region, Ethiopia

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Abstract

Livelihoods vulnerability is compounded effect of socio-economic and environmental factors that interact under a set of social systems that can be managed with proper strategic measures. Accordingly, Ethiopia has already adopted various responsive measures to maintain sustainable livelihoods. However, studies reveal that most of the strategies have been designed without adequate information on the vulnerability level and determining factors. This study identified the livelihoods vulnerability status and determinants in context of climate change impacts. Farmers' perceived vulnerability, ranking technique and IPCC-LVI model were employed to a wide-ranging of primary data collected from 410 farmers sampled randomly from four districts of Arsi and East Shewa zones of Oromia region. The results revealed that the climate structures have been significantly changing over time imposing challenges on livelihoods sustainability, while government has introduced various response measures. In this regard, community level livelihoods vulnerability rating score was 49% and 66.7% in highland and lowland, respectively, indicating more adverse situation under lowland community, relative to highland areas. Additionally, the perceived sensitivity rating score was 45% in highland community and 74% in context of lowland community, while the corresponding perceived community exposure are 54.5% and 77.3% in highland and lowland community. Contrarily, adaptive capacity rating score indicate about average level with slightly small difference that is 53% and 52% for highland and lowland agro-ecology respectively showing moderate level adaptive capacity of the study community to manage prevailing climate change impacts associated risks. These results demonstrate a need to strengthen adequate information on community level livelihoods vulnerability, exposure, sensitivity and adaptive capacity. Therefore, policy makers should redesign appropriate regional policy, strategy and extension approaches based on well identified community vulnerability. This ensures environmentally suitable rural development in smallholders farming system.

Keywords: Climate, change, Impacts, Livelihoods, Vulnerability, Smallholder and Farmers

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INTRODUCTION

The developing countries have been already vulnerable to climate change impacts which commonly manifested through extreme weather events (IPCC, 2007). In the context, developing countries are most vulnerable to frequent climate change impacts as the result of scarcity of capital to promote adaptation measures and high possibility of exposure to disasters (World Bank 2009). According to various findings, weather risks which commonly influence livelihood vulnerability are the most pressing consequences of climate change at global and community level. In this regard, with a 0.6°C global temperature change, 2-3% increase in rainfall was projected in tropical and 3% decrease in subtropical latitudes; were observed in the end of 20th century, while an increase of 1.4°C and 5.8°C global temperature projected by the end of the 21st century inducing vulnerability (Udin, 2014).

Under Ethiopian circumstance, climate change related impacts are apparent through increased frequency of droughts and floods which required adequate research prior to promotion of adaptation strategies (Asfaw and Lipper, 2011, Howden; 2007 and Morton, 2007). As a result, Ethiopia has been identified among the utmost vulnerable countries to direct impacts of climate change and indirect negative effects on environmental sustainability (The World Bank Group, 2011). Apparently, in Ethiopia, more than 83% of the population entirely depends on rain-fed agriculture and thus, any small change in seasonal rainfall patterns and temperature has a direct impact on agricultural productivity (MoANR, 2017) which entirely increase the livelihoods vulnerability to climate change.

In a more detail, vulnerability is a resultant effect of three major factors: namely exposure, sensitivity and adaptive capacity as well as their relationship in the system that can be described as a set of factors that categorize certain individuals/groups as "vulnerable" to certain natural disasters. Vulnerability is also defined as the degree to what extent a particular system is prone to adverse impacts of natural disasters (Arega, 2013 and Adger, 2006). Generally, understanding vulnerability with its components helps to evaluate the nature and magnitude of climate change impact, identify sources of vulnerability and to design climate smart adaptation responses (Marshall et al, 2009).

In Ethiopia, a range of improved technologies and practices have been developed and disseminated to the broader farming communities to manage vulnerability to climate change impacts (Rosegrant, et al., 2008). Consequently, this study has been designed to generate adequate information on livelihoods vulnerability at community level and provides the proper recommendation for policy level and technical managers in respective of Oromia Region's rural community in general and study community in particular. Additionally, households' food self-sufficiency in rural communities and national food security are significantly subjective to normal performance of seasonal rainfall reliant farming systems which is naturally sensitive to climate change and weather variability in Ethiopia in general and the study areas in particular. However, the extent studies, like Muluneh (2015), indicate that Ethiopian Central Rift Valley (CRV) which embraces the study areas is under continuous threat due to frequent environmental degradation, leading to structural changes in climatic condition in the form of recurrent drought and seasonal weather variability.

On the other hand, except some few areas, location specific studies on estimating the overall impacts of climate change in context of introduced strategies are inadequate. According to studies, for instance, Mulatu et al., 2016 and FAO,2016, this is a notable gap that is yet to be sufficiently researched in the country. This research is significant because it will identify the location specific factors that are responsible for the livelihoods vulnerability in comparison between highland and lowland agro-ecologies emphasizing on four districts and twelve Villages of East Shewa and Arsi zones of Oromia region. Consequently, this study has been designed to generate adequate information on livelihoods vulnerability at community level and provides the proper recommendation for policy level and technical managers in respective of Oromia Region's rural community in general and study community in particular.

METHODS AND MATERIALS

General Context of the Areas Selected for the Study

The Areas selected for this study are situated in Oromia Regional State along the Great Central Rift Valley (CRV), where risks associated with climate change and weather variability are common and affecting livelihoods of the community. Commonly, mixed farming and agro-pastoral farming system are regularly conducted in each of highland, mid and lowlands. In this context, four districts, of which Bosat and Dudga districts were selected from East Shewa, while Hetossa and Tiyo districts were selected from the Arsi Zone. Most of the villages in the districts are situated along the Awash river catchment, where recurrent adverse impacts of climate change are severe as the result of frequent drought (Figure 1).

Generally, an altitude of the study areas ranged from 500-3500 meters above sea level (masl). More specifically, the study has been conducted in the east shewa zone representing the low land areas and Arsi Zone, representing the highland parts. The highland (2300 to 3200 masl) with cold climate, while the midland (1500 to 2300 masl), experiencing warm climate and the lowlands (500 to 1500 masl) having hot with arid land areas (Tamirat,2019 and Tamirat 2018). Despite the persistent drought in the lowlands, there are three distinct seasons; with two rainy seasons and one dry season (World Bank Group, 2011).

East Shewa zone covers a total of 971,159.21ha land area with twelve administrative districts (10 rural and 2 urban) in the central lowland of Oromia Region. Agro-ecologically, the zone constitutes 18.7% highland, 27.5% midland and 53.8% lowland with rainfall 1150mm (Asfaw, et al., 2020). As to this author, of total land size, about 12.6% is arable land, of which arable land 47.31% is currently under cultivation practices in every year. Similarly, Arsi the largest Zone of the region is situated in central Oromia Regional State covering an area of 19,825.22 km^2 and consist of 25 administrative districts (WIKIPEDIA, 2023). Generally, due to diverse set of agro-ecological zonation, Arsi zone is predominantly characterized by moderately cool (40%) followed by cool (34%) annual temperature (Addisu, et al., 2020).

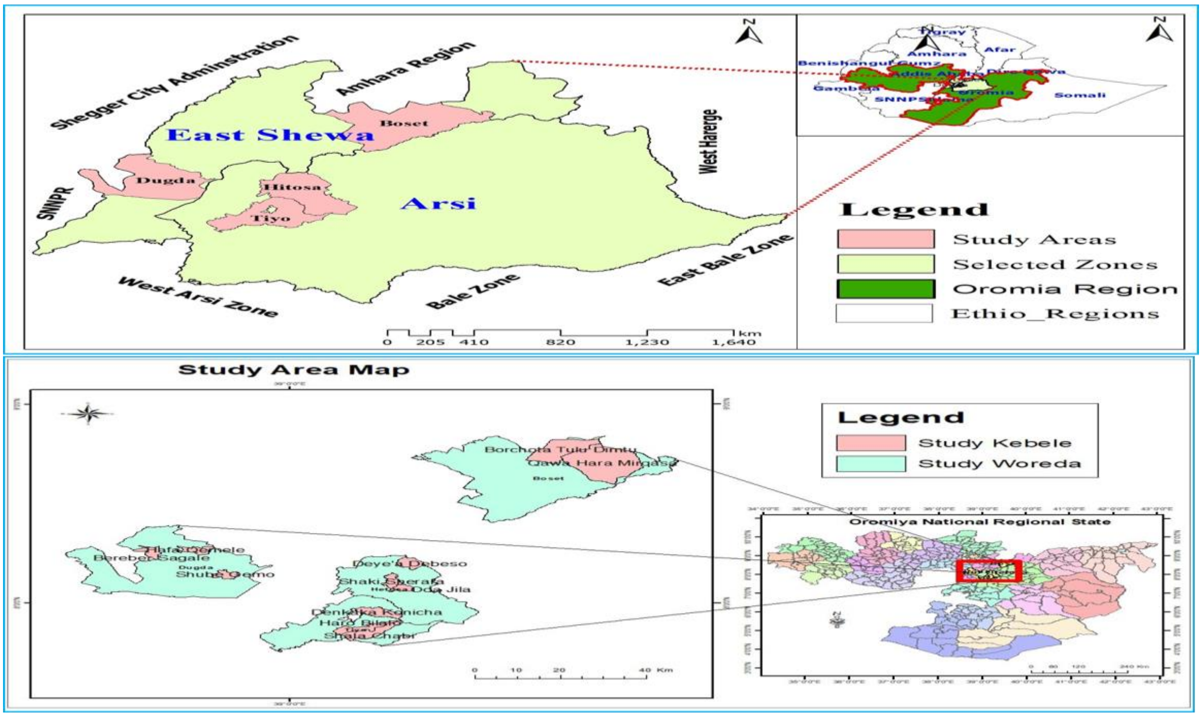

Figure 1. Study area map and location (**Source**: Developed based on google File)

Data collection

A total of 410 farm households were sampled through structured questionnaire interviews across the two agro-ecology of the farming systems in the two zones. To attain the required standard and good quality data, the structured interview questionnaires, formats for secondary data collection and checklist (interview guide) for guiding the discussion process have been developed thus enabling relevant data collection from primary (individual farmers through enumerators managed interviews) and secondary sources (published source documents) for the analytical and crosschecking of the information. Based on the experience of Abate (2009) and Thornton (2010), who listed multi-dimensional vulnerability determinant variables, essential data were identified, where the selected indicators included in the data collection checklist.

The primary data such as socio-demographic (educational level, age, sex, marital status, social networks, farming experience, etc) economic and resources (landholding, livestock holding, crops and cropping systems, seasonal incomes, source of incomes, water availability, sources of livelihoods etc) were collected. Furthermore, infrastructures and services (extension services, public facilities, access to markets, credit and mass media services) and natural disasters (emphasized on drought frequency and weather variability) and strategies (adaptation and coping strategies related data) were collected. The whole spectrum of data were analyzed using Statistical Package for Social Sciences (SPSS) sub-program. Furthermore, participatory discussions and direct observations procedures are intensely synchronized with other data collection techniques with the intention to triangulate the collected information including the study findings. Based on the nature of the data, appropriate analytical techniques were selected and specified against study variables and objective, where descriptive statistical techniques were employed.

On the other hand, livelihoods vulnerability indicators and components were identified to define the required data and relevant information. To delineate the livelihoods vulnerability indicators and components, adequate literature review was conducted. In this regard, the selected exposure impact indicators include; frequency of climate variability, water resource availability, shortage of irrigation water sources, increased drought frequency, increased major agricultural disease and pest occurrence. For adaptive capacity six indicators were used i.e. agricultural livelihoods diversification, non-farm income diversification, wealth and yearly income, use of improved agricultural technology, technical capacity to manage climate change, exposure to technical and Technological supports. Again, sensitivity component indicators include, Seasonal productive crop Land decrease (abandoned land), Crops productivity and production decrease over time, Significant loss of crops varieties over time, decline of livestock number, productivity and production over years and food sufficiency reduced (below yearly 1.8 Qt/person) and increased climate change impact associated Risks.

Data analysis

Descriptive analysis

The identified and collected data were analyzed using descriptive statistics; which includes frequency, percentage and mean emphasizing on the aspect of the data that helps to compare results with ground reality and some other study evidences. In this regard, primary data that are related to perceived impact of climate change were analyzed using descriptive statistical tools across the selected two agro-ecologies based on some selected vulnerability criterion, where the processed data were summarized and presented in tabular formats.

Indexing and Inferential Methods

Index Model for Vulnerability Components Analysis

This section highlights the approaches that were adopted to compute the vulnerability major components (sensitivity, exposure and adaptive capacity) separately before the aggregated vulnerability analyses. In this context, the collected data were analyzed based on the index formula suggested by Nasir et al. (2014), which was employed to determine the adaptation of introduced strategies and innovations in the study community. The model specification is a composite of the summarized components and variables shown below (Formula 1):

$$ASI = ASn \times 0 + \text{Asl} \times +\text{Asm} \times 2 + \text{Ash} \times 3 \quad (1)$$

Where, ASI = Aggregated Adaptation Strategy Index

Asn = Frequency of farmers rating the strategy as having none ……………….…. (0)

Asl = Frequency of farmers rating the strategy as having low level ….………….. (1)

Asm = Frequency of farmers rating the strategy as having medium level …..…… (2)

Ash = Frequency of farmers rating the strategy as having high level …..…..……. (3)

The respondents have been managed to rate present-day status comparing with previous times situation, to generate information over time and they were expected to assign a scoring value on a four-point scale for each indicator in respective of each major component and strategy in viewpoint of ranking. The four-point scales represent as high, moderate, low and negligible in which these ranking levels were represented by 3,2,1 and 0 numerical values, respectively. The acquired data were assessed quantitatively to produces a description related to major vulnerability components from the viewpoint of the respondents which can be presented for each respondent and in aggregate form. The collected data were properly coded and analyzed quantitatively and the results interpreted to draw relevant conclusion that enable the investigator to generate the reliable evidence to encompass the policy recommendations. In this aspect, the score of each variable rating level were summarized and finally aggregated from which the percentage was calculated considering the assumed highest score if all respondents (farmers) rate a particular indicator three (3 point) which is simply 600 for highland and 630 points for lowland agro-ecology, respectively for strategies and variables ranking.

Index Model for Livelihoods' Vulnerability Analysis

In several contexts, climate impact vulnerability is an important aspect of climate change studies which stimulated the selection of Vulnerability analytical model for current study. Based on Adu (2013), IPCC Livelihood Vulnerability Index (IPCC-LVI) technique was used to determine the overall livelihoods vulnerability to climate change impacts. The below (formula 2) is a working equation which indicates the function of the major components:

Vulnerability = f(Exposure, Sensitivity, Adaptive Capacity) **(2)**

The frequently employed procedure to assess vulnerability is the vulnerability index grounded on specifically defined combinations of indicators (Adu, 2013). Accordingly, each of the vulnerability's major component (exposure, sensitivity, and adaptive capacity) usually have sub-components and these components were standardized where average weight of the components were used. To analyze the index of each indicator, it is required to standardize the measurements of each indicator (making unit free), where the following model has been selected and employed to execute the standardization of particular measurement (equation 3).

$$Index_{shi} = \frac{S_h - S_{min}}{S_{Max} - S_{min}} \quad (3)$$

Where S_h is an observed sub-component of particular indicator for *I* household and S_{min} and S_{max} are identified minimum and maximum values of indicators, respectively for specific sub-component. After each indicator has been standardized, the sub-component indicators were averaged using below equation (formula 4).

$$M_h = \sum_{k=0}^{n} \frac{\text{Index}xshi}{n} \quad (4)$$

where M_h is one of the eight major components of vulnerability [Livelihood Strategies (LS), Socio-Demographic Profile (SDP), Health (H), Social Network (SN), Water (W), Food (F) and Natural Disaster (ND), or Climate Variability (CV)] for household and the $index_{shi}$ were assumed to characterize sub-components which is commonly indexed by i, that makes up each major component, and n is the number of sub-components in each major component (Hahn, 2008). Then, the working equation to estimate the livelihoods vulnerability based on the IPCC framework is:

LVI-IPCC= (Exposure-Adaptive capacity) * Sensitivity ***(5)***

Generally, livelihoods vulnerability components (major and sub-components) and indexing procedures for each component were adapted from IPCC framework. Commonly, several researchers converge to common components and indexing approach adopted from IPCC, where eight major components with 35 sub-components were identified for the study of livelihoods vulnerability. Specifically, Thi et al. (2024), Tran, et al. (2023) and Septri et al. (2024) approaches were adopted as the reference in this particular study to determine overall livelihoods' vulnerability in the study community.

Tobit Regression Model to Assess Determinants of Livelihood Vulnerability

The determinants of livelihood vulnerability to climate change impacts were analyzed using the Tobit regression model. In this regard, Weather-related variables (average, standard deviation, and coefficient of variation for rainfall and maximum temperature) were used directly in the Tobit regression analysis. Due to multicollinearity effect that was observed among the variables, minimum temperature variable was excluded from the model, while the indexed value was used for model estimation. The Tobit model was adopted from Bierens (2004) and the selected model can be expressed as:

$$LVI_i = \alpha + \sum_{j=1}^{3} \beta_j S_{ij} + \sum_{j=1}^{4} \gamma_j C_{ij} + \sum_{j=1}^{2} \delta_j I_{ij} + \sum_{j=1}^{9} \epsilon_j E_{ij} + v_i \quad (6)$$

Where LVI_i is a latent variable denoting the vulnerability of i^{th} household to climate change. In addition, j is the number of variables in each variable category. S_i, C_i, I_i and E_i are the independent variables for social, economic, institutional, and environmental variables, respectively, with β_j, γ_j, δ_j, and ϵ_j as the estimated parameters. The model's error term (v_i) usually assumed to be the independent $N(0; \sigma^2)$ distributed conditionally on independent variables.

RESULTS AND DISCUSSION

Perceived level of Livelihoods vulnerability to climate change impacts

Table 1 below illuminates that majority of respondents perceived the level of climate change impact vulnerability as moderate level in both highland and lowland agro-ecology. However, comparatively the proportion of respondents that indicates the moderate level of vulnerability for highland agro-ecology is slightly higher (63.5%) than lowland (59%) agro-ecology, while in the case of lowland areas, the second majority (33.8%) perceived high level of community vulnerability as compared to only negligible proportion of the respondent from highland agro-ecology indicating that serious situation in the lowland farming system of the study community.

Table 1. Perceived level of vulnerability to climate change impact in the study Community

No	Perceived level of Vulnerability	Highland		Lowland		Total	
		Actual	%	Actual	%	Actual	%
1	Highly Vulnerable	2	1.0	71	33.8	73	17.8
2	Moderately Vulnerable	127	63.5	124	59.0	251	61.2
3	Less vulnerable	58	29.0	15	7.2	73	17.8
4	Negligibly vulnerable	13	6.5	-	-	13	3.2
	Total	**200**	**100.0**	**210**	**100**	**410**	**100.0**

In addition to perceived level of vulnerability analysis, three vulnerabilities components were separately analyzed using respective indicators where the results presented in below four Tables (Table 2, 3, 4 and 5) including the perceived level of vulnerability. Among these, Table 2 was established based on IPCC-LVI sensitivity indicators which show the aggregated score below average (45%) for highland and above average (74.1%) for lowland agro-ecology which clearly indicates highest degree of sensitivity at lowland area compared with highland farming system. Specifically, the declining trend of livestock productivity appeared the highest (78.7%) score, which followed by the decline of productive farm land used for seasonal crops that rated the next top score (78.3%) in the lowland block.

Table 2. Perceived sensitivity of farm livelihood in context of climate change impact

Category of the effect indicators	Highland Agro-ecology					Lowland Agro-ecology				
	3	2	1	Total	%	3	2	1	Total	%
Productive crop Land decrease	81	168	18	267	44.5	336	126	31	493	78.3
Crops production decrease over time	51	144	41	236	39.3	207	196	39	442	70.2
Loss of crops varieties over time	90	174	31	293	48.8	222	224	19	465	73.8
Livestock number decrease over years	66	170	60	296	49.3	234	210	24	468	74.3
Livestock productivity declined	78	92	59	229	38.2	312	156	26	496	78.7
Livestock production decrease	75	186	45	306	51.0	219	224	19	462	73.3
Declining of biodiversity	30	154	80	264	44.0	192	216	34	442	70.2
Average				**270**	**45.0**				**467**	**74.1**

On the other hand, the highest score which explains declining trend of livestock production in the highland area is about the average (51%) indicating the larger disparity between the highest score of the lowland (73.3%) and highland agro-ecology. Generally, the sensitivity indicators rating scores shows that the lowland farming business is operating within the sensitive situation which is alarming situation for policy makers and producers to look for better adaptation and mitigation strategies. Table presented below (Table 3) was established based on IPCC-LVI Exposure indicators with an intention to show the degree to what extent the community is exposed to bad climate condition and weather variability in the past ten years which ultimately leads to climate change impacts and related risks. According to analyzed and interpreted survey data, among the selected seven indicators, frequent weather variability and change found to be highest (84%) in rating score in the lowland areas, while the increased agricultural pest incidence indicator scored highest (65.8%) within the highland agro-ecology.

Table 3. Exposure indicators and rating in respective of study community

Categories of effect indicator	Highland Agro-ecology					Lowland Agro-ecology				
	3	2	1	Total	%	3	2	1	Total	%
Frequency of weather variability increased	21	262	52	335	55.8	357	162	10	529	84.0
Water availability and supply declining	171	158	54	383	63.8	234	226	19	479	76.0
shortage of irrigation water source	261	64	49	374	62.3	237	158	42	437	69.4
Drought frequency increased in10 years	15	140	45	200	33.3	330	162	18	510	81.0
Rain shortage frequency increasing	27	124	83	234	39.0	324	164	19	507	80.5
Agricultural pest incidence increased	204	138	53	395	65.8	342	146	22	510	81.0
Family Natural resource reduced	168	146	55	369	61.5	159	246	34	439	69.7
Average				**327**	**54.5**				**487**	**77.3**

An aggregated score of exposure indicators for highland agro-ecology is about average level (54.5%) when compared with the highest score (77.3%) of the lowland agro-ecology situation indicating harmful situation which necessitates new strategies and approaches to divert the negative consequence of climate changes impacts and related threats in context of lowland community and ecosystem. Furthermore, the result summarized in Table 4 was handled based on the IPCC framework vulnerability indicators with the intention to show the perceived degree to what extent a particular community is susceptible to resultant effect of climate change expressed in context of seasonal weather variability in past cropping seasons which eventually leads to social in security and disorder in the exposed community. Among the selected eleven vulnerability indicators, the danger related to agricultural production found to be the highest rated indicators (87.3%) in lowland block compared with the score of the same indicators rated relatevly low (56 %) in context of highland agro-ecology.

Table 4. Livelihoods Vulnerability indicators and rating

Vulnerability Indicators	Highland Agro-ecology					Lowland Agro-ecology				
	3	2	1	Total	%	3	2	1	Total	%
Agricultural production in danger	126	190	20	336	56.0	372	138	14	524	87.3
Lack of weather early warning	60	168	51	279	46.5	150	248	27	425	70.8
Frequent change of crops choice	144	166	51	361	60.2	96	284	30	410	68.3
Shortage of potable water	132	128	37	297	49.5	234	202	18	454	75.7
Shortage of Irrigation & facilities	261	86	53	400	66.7	270	138	40	448	74.7
Small farm landholding	39	132	73	244	40.7	153	150	49	352	58.7
Poor access to extension services	45	116	119	280	46.7	213	168	36	417	69.5
Dependency on outsider	75	120	52	247	41.2	93	154	69	316	52.7
Inadequate access to credit service	48	102	106	256	42.7	84	200	52	336	56.0
Inadequate access to CC training	24	152	101	277	46.2	96	212	58	366	61.0
Lack of private land for family	90	122	73	285	47.5	93	190	69	352	58.7
Average				**297**	**49.0**				**400**	**66.7**

The aggregated vulnerability score found to be about average (49%) from bottom line for highland agro-ecology, while the lowland score (66.7%) is relatively higher and above average when compared with highland agro-ecology score. On the other hand, climate change and weather variability do affect the social, economic and natural environments of the community which in real sense depend upon the adaptive capacity of the individuals and the community.

Practically, the adaptive capacity of the community is the function of livelihoods, resources and technical dimensions of the community and service delivery system to influence the impact of climate change in a positive manner. In context of this study, IPCC-LVI adaptive capacity indicators adopted and employed to determine the most impacting factors in context of study community and Table 5 shows the summary of the results against each indicator and disaggregated results based on the respondents' rating score which indicates overall adaptive capacity of the community and to identify the most leading determinant factors. The data presented below in Table 5, shows that for highland agro-ecology exposure to extension service is the most important variable which better scored

(63.5%) followed by Technical capacity of the community to manage the adaptation and mitigation strategies and agricultural livelihood diversification with 58.7% and 58.5%, respectively. However, the majority (62.5%) of the selected adaptive capacity components rated within the range of the average level score (about 50%) by the respondents indicating that the moderate level adaptive capacity of the community and the systems to withstand the climate change related shocks and associated risks.

Table 5. Community Level Adaptive Capacity to Manage Climate Change Impacts

Category of the indicators	Highland Agro-ecology					Lowland Agro-ecology				
	3	2	1	Total	%	3	2	1	Total	%
Agriculture livelihood Diversification	102	172	77	351	58.5	99	260	44	403	64.0
Non-farm income diversification	15	76	84	175	29.2	39	190	60	289	45.9
Family wealth (Assets)	63	134	95	292	48.7	30	142	71	243	38.6
Family level yearly income	54	200	69	323	53.8	30	216	75	321	51.0
Improved agricultural technology	105	152	80	337	56.2	69	170	102	341	54.1
Technical capacity to manage adaptation	99	194	59	352	58.7	54	178	84	316	50.2
Exposure to techniques and technology	108	126	91	325	54.2	60	194	85	339	53.8
Exposure to extension service	129	202	50	381	63.5	63	242	59	364	57.8
Average				**317**	**52.8**				**327**	**51.9**

Similarly, the most important component for the lowland agro-ecology found to be agricultural livelihood diversification (64%), while the exposure to extension service (57.8%) and use of improved agricultural technology (54.1%) rated 2nd and 3rd level respectively in the lowland blocks of the study community. Likewise, the majority of the adaptive capacity components (62.5%) rated average level by survey respondents which shows similar trend with highland agro-ecology indicating the moderate level adaptive capacity of the community in the lowland study area and community. In these selected two agro-ecology, the overall and aggregated rating score found to be within the average range with slightly small difference, that is about 53% and 52% for highland and lowland agro-ecology, respectively, showing moderate level adaptive capacity of the study community and overall system. Therefore, the ability of the study community to adjust to climate change including weather variability and extreme to moderate the potential damage or to cope with consequences of climate change seems to be about average which needs strategies to improve the adaptive capacity to higher level so that the system remains sustainable in all aspects against climate change impacts and associated consequences.

Livelihoods Vulnerability and Determinants

Under this sub-section, Livelihood vulnerability indexing was based on the measurement of eight major components and thirty-five sub components which ultimately contributes to the indexed value of three (exposure, Sensitivity and adaptive capacity) vulnerability components where accordingly the results summarized in the below Table 6 and presented in respective of the two study agro-ecologies. From Table 6, the aggregated LVI values were found to be 0.459 and 0.556 for highland and lowland agro-ecology, respectively, indicating a bottom level moderate vulnerability to the impact of climate change for highland areas and above moderate level vulnerability of lowland livelihoods vulnerability to the impact of climate change associated risks.

Table 6. Livelihood Vulnerability situation in the study survey community

Indicators	Number of Major components	Number of sub components	Major component index value	
			Highland	Lowland
Adaptive capacity	3	12	0.444	0.525
Sensitivity	3	15	0.485	0.542
Exposure	2	8	0.448	0.601
Total	8	35	1.377	1.668
Livelihood Vulnerability Index (LVI)			0.459	0.556
IPCC -LVI (e-a)*S			**0.002**	**0.041**

The three contributing factors, that are adaptive capacity, sensitivity and exposure to natural disasters contributes relatively closer impacts for highland agro-ecology vulnerability, while the variation among the contributing factors are larger for lowland agro-ecology area as compared to the highland community situation. According to the findings, lowland livelihoods are highly vulnerable to climate change as identified by high index value of exposure (0.601) and relatively low (0.525) adaptive capacity. The sensitivity index for the lowlands is 0.542, while 0.485 for the highlands. For the highlands, adaptive capacity is 0.444 indicating below average level. In this regard, Ebrahim, et.al.(2022) identified that comparatively the Kolla (lowland area) as the most vulnerable (0.18) as the result of its highest exposure (0.74) and sensitivity (0.71) and lowest adaptive capacity (0.49), while Daga (highland area) is least vulnerable (0.08) because of its lowest exposure (0.61) and sensitivity (0.42); but the majority of findings mentioned in this study indicate highest vulnerability as compared to our finding in context of livelihoods vulnerability.

Relative to our findings, Getnet et.al.(2022) identified slightly highest vulnerability score (0.64) for households residing in lowland, followed by those of households in the highland (0.61) and midland (0.54) agro-ecologies in context of the same scenario which all of these findings (0.601) are slightly higher than the result of current findings. According to these authors, these findings are explained by the average score of the exposure index value of 0.46, 0.44, and 0.38 for the lowland, highland, and midland agro-ecological zones, respectively, suggesting a greater exposure of lowland communities to climatic risk than highland and midland community. In this regard, in the study conducted in Ethiopia, Dendir and Simane (2019), asserted relatively higher overall livelihoods vulnerability score for Sodo lowland (0.39) as compared to Cheha midland (0.356) and Ezha highland (0.379), indicating relatively moderate vulnerability of the locality to climate change. Furthermore, Javeed (2022) conducted the LVI analysis in context of two study areas in India without referring the agro-ecology, where he observed the index score of 0.413 in Doda and 0.408 for Bhaderwah with overall vulnerability index score of 0.411, indicating moderate vulnerability i.e. closely similar with findings of this study.

In generalized scenario, farming in the study communities is mainly dependent on rainfall amount and distribution that fit the requirement of crops to mature and livestock production. The rainfall variability, especially deficit rainfall as well as poor distribution increase the vulnerability of the livelihoods in the study community resulting from poor productivity and low production from per-unit of land. As the result, the highest value of exposure (0.601) for lowland agro-ecology indicates the degree of burden that the local community is confronting along the process of daily livelihoods making. On the other hand, the analyzed data results related to determinants of vulnerability to climate change impact are presented in the below figure (Figure 2 presents aggregated results for highland and lowland agro-ecologies in perspective of eight components) with intention to show the most contributing, moderate and least contributing factors in respective of each indicator and ultimately to overall livelihood vulnerability.

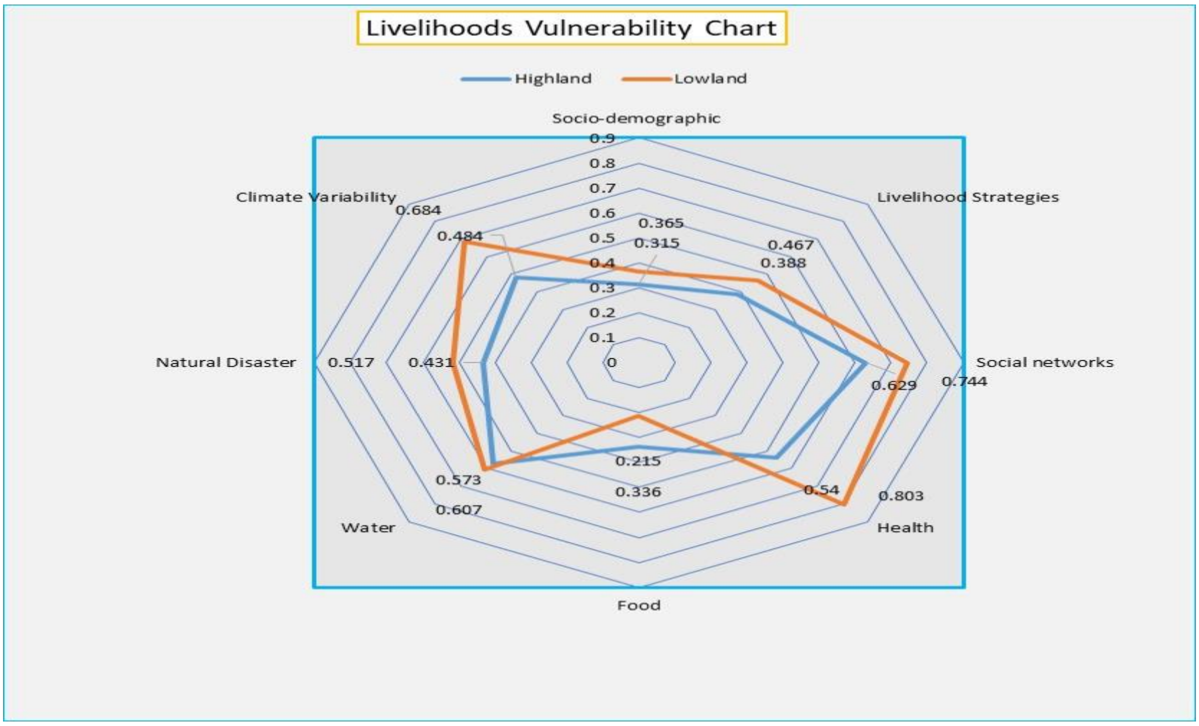

Figure 2. Vulnerability Contributing Variables

Based on extent studies and IPCC frameworks, there are eight major components and thirty-five sub-components which contribute to respective major components were selected in this study where all specified sub-components were indexed and the summarized results were presented and discussed under below section based on the Figure 2 Above which indicates the value of each component.

Socio-demographic component:- According to IPCC framework, socio-demographic component is among the components significantly contributing to adaptive capacity of the households and ultimately the community's vulnerability. In this aspect, the sub-components of this major component are dependence ratio, female headed households, head of household with no formal education, which each of them indexed based on respective measurement and major component value summarized from these indices. From Figure 2, the overall major component value for socio-demographic variable was found within the values considered as lower for both highland and lowland agro-ecology with the vulnerability score of 0.315 and 0.365, respectively, with insignificant difference between the two agro-ecologies. This study identified slightly lower vulnerability as compared to the finding of Ebrahim, Miheretu and Alemayehu (2022), who revealed Kolla (Lowland) as most vulnerable (0.47) followed by the highland (0.39), and intermediate highland (0.38) in the context of study community. In comparison, Javeed (2022) asserted vulnerability index value of 0.365 (36.5%) in Doda (India); indicating moderate vulnerability whereas 0.363 (36.3%) in Bhaderwah which means vulnerability is just approaching moderate level. Furthermore, Dendir and Simane (2019), also asserted vulnerability value closer to Ezha with a weighted average of 0.35 point, that followed by 0.3-point score in Cheha and similar 0.3-point score in Sodo, which are representatives of the highland, midland and lowland parts of the locality, respectively; the result of which is similar with current finding.

Livelihood strategies:- In context of Livelihoods strategies, the findings of this study show that the livelihood strategies as the major component contributes moderate level (0.467) to climate change impact vulnerability for lowland area which is slightly higher than the highland contribution value (0.388) showing highly significance of this major component in the climate change impact vulnerability in the lowlands, compared with highland farming system. In this regard, Javeed (2022), further revealed the vulnerability index score of 0.290 (29%) for Doda and 0.273 (27.3%) for Bhaderwah block indicating low vulnerability level in both blocks which are by far less vulnerable as compared to the current study findings. Similar study by Dendir and Simane (2019) summarized aggregated average score for livelihood strategies indicator, where both Cheha (midland) and Sodo (lowland) districts showed greater vulnerability of 0.43 and 0.41, respectively.

Social network:- The indices and the summary of the result show extremely higher (0.744) in context of lowland farm households and also slightly higher than the value (0.629) reported for the highland. Justifiably, the contribution of this component for highland agro-ecology is the highest of all other remaining components within the same agro-ecology and the second highest when compared with the score of other components within the agro-ecology of lowland area. Generally, this finding indicated relatively stronger social network score in lowland agro-ecology, as compare to findings of Ebrahim, Miheretu and Alemayehu (2022), who noted index value score of 0.61, 0.53 and 0.63 for lowland, intermediate highland and highland respectively for social networks component. However, the findings of these authors in context of the social network was closely similar with findings reported concerning highland community in current study. Again, according to Getnet, Menberu and Linger (2022), the social capital components have the highest index value in the midland (0.35), followed by highland (0.34) and lowland (0.33) agro-ecosystems, where the lowest level of index value in terms of social network support in lowland agro-ecology is due to farmers' lack of credit access, which may impede the adoption of improved agricultural technologies and farm inputs. Furthermore, in terms of social network component, Dendir and Simane (2019), reported the more index value in Ezha highland (0.49) as compared to Sodo (0.45) and Cheha (0.42) scores which in real scenario significantly lower as compared to the findings reported in context of highland and lowland community in the current study.

Health:- The finding of this study reveals the highest contribution (0.803) at lowland, while moderate effect (0.540) at highland agro-ecology for the sensitivity indicator that manifested in context of health. Similarly, Javeed (2022) reported vulnerability index score of 0.497 (49.7%) for Doda and 0.487 (48.7%) Bhaderwah study sites without specifying the nature of agro-ecology. Furthermore, Dendir and Simane (2019) found more index score of Ezha highland with a weighted contiribution score of 0.33, while Cheha midland (0.23) showed less contribution to vulnerability; the results of which were significantly lower.

Food:- Generally, the indexed value of this major component is lower at both (highland and lowland) areas of the study. Specifically, the lowest (0.215) score for lowland agro-ecology indicates the insignificant contribution of this particular component to its vulnerability component. However, relatively higher index score (0.336) observed at highland which illustrate significant contribution of this component in context of highlanders compared with lowland situation. Overall, the lower score identified in both cases (highland and lowland) in context of this component are not a granting condition for farm households which adversely affecting the whole system of community like change of life style, migration within and outside the country deepening the instability of social system and livelihoods ultimately leading to chronic vulnerability of the community. Furthermore, Ebrahim, Miheretu and Alemayehu (2022) conducted and summarized study results which divulged Kolla (0.42) is more vulnerable while *Woina-Dega (midland)* is less vulnerable (0.34) and Daga (highland) is moderate (0.38) in terms of food major component indicators. Similarly, the study conducted by Dendir and Simane (2019) in Ethiopia, revealed that Sodo lowland was found to be more vulnerable in context of food component (0.47) as compared to the vulnerability score of Cheha (0.35) and Ezha (0.33) districts.

Water:- Water aspect as major component of sensitivity consists of five sub components, namely conflict over the water resources, sustainability of water supply for household consumption and time taken to access water sources in the community. An indices summary of this major component indicates above average score which is an indication of testing situation in highland and lowland agro-ecology. However, an indexed score of the highland (0.573) is closer to moderate relative to the lowland score (0.607), which require the adequate attention and emphasis to maintain sustainable life and livelihoods of the community. With regard to this, Getnet, Menberu and Linger (2022), reported extremely highest vulnerability index score of the water resources (0.97) for the lowland; indicating relatively more vulnerability of lowland community as compare to highland (0.91) and midland (0.70) agro-ecology. Again, according to Dendir and Simane (2019), the LVI score showed below average score for Sodo lowland district but revealed more vulnerability of this area (0.46) than Ezha (0.37) and Cheha (0.33) districts which are representatives of midland and highland, respectively.

Natural disasters:- The overall vulnerability contribution score of highland agro-ecology seems within the bottom range of moderate (0.431) in context of water showing relatively moderate vulnerability, while aggregated score of lowland area illustrates the upper level moderate (0.517) which is closer to unsafe range when considered climate change vulnerability categories. In comparison, Javeed (2022), found 0.206 (20.6%) vulnerability index score for Doda and 0.28 (28%) in Bhaderwah study area indicating low vulnerability level in both study area as compare to current study findings in context of natural disasters scenario.

Climate change associated Risks:- The result of analysis shows that bottom range moderate (0.464) for highland agro-ecology and as expected the highest score (0.684) was obtained for lowland agro-ecology. The finding of this component is lower when compared with the findings of Ebrahim, Miheretu and Alemayehu (2022), who indicated vulnerability index score of 0.98 in Kolla (lowland), 0.98 in Woyina Daga (midland) and 0.9 in Daga (highland) which are extremely higher as compare to the score of current study findings.

Assessments of Livelihood Vulnerability Determinants using Tobit Regression

The aggregated data (merged highland and lowland agro-ecology data) were used to analyze the determinants of livelihoods vulnerability using Tobit model. The indexed value of vulnerability component indicators scores have been taken as a dependent variable, while socio-economic, technological variables and weather related parameters presented in the below Table 7, are considered as independent variables.

In this regard, vulnerability indicator components (exposure, sensitivity and adaptive capacity) scores were indexed using the Principal Component Analysis (PCA) and indexed value of those variables has been taken as dependent variables in Tobit regression analysis. Similarly, CSA practices rates of adoption and minimum temperature parameters were indexed using the same technique (PCA) in order to reduce the dimension of variables score to a single variable, where the indexed values were used as independent variables in the selected model. In this regard, rainfall and maximum temperature parameters were used directly in Tobit regression analysis, while based on the multicollinearity effect observed in the process of data analysis and management, minimum temperature parameters were indexed using PCA technique.

Table 7. Tobit Regression Analysis to determine Determinant of livelihoods Vulnerability

Explanatory variables	Inferential statistics			
	Coefficient	**Std. Err**	**t-value**	**p>/t/**
Agro-ecology	-3.830	4.662	-0.820	0.412
Age of the Respondents	-0.067	0.015	-4.460	0.000***
Education level of Households head	0.164	0.120	1.360	0.175
Family size of Households	0.175	0.056	3.140	0.002**
Crop diversification	-0.003	0.102	0.030	0.979
Alternative income source	-0.935	0.297	3.150	0.002**
Livelihood diversification	-0.330	0.129	2.570	0.011**
Drought frequency	0.419	0.106	3.970	0.000***
Farm size of Households	-0.032	0.090	-0.360	0.720
Extension Support	-0.105	0.182	0.580	0.565
Credit Support	0.882	0.255	3.450	0.001***
Rainfall mean	-0.018	0.010	-1.830	0.068*
Rainfall standard deviation	0.173	0.166	1.040	0.300
Rainfall coefficient of variation (CV)	100.380	84.628	-1.190	0.236
Maximum Temperature Mean	0.449	0.640	0.700	0.483
Max Temp Coefficient of Variation (CV)	121.207	136.916	-0.890	0.377
Minimum Temperature Index	-0.027	0.299	-0.090	0.929
CSA Practices adoption Index	-0.057	0.124	-0.460	0.647
Constant	**0.725**	**18.067**	**0.040**	**0.968**
Log Likelihood --------------------------------- 910.078				
LR chi-square (X^2) ---------------------------- 133.030				
Prob>chi-Square (X^2) -----------------------------0.000				
Pseudo R^2 --0.068				

Among the effect of socio-economic indicators emphasized in the study, only the effect of family size and education level of households on livelihoods vulnerability was found to have positive influence indicating that as these particular variables increase in respective measurement scale, the resultant effect tends to increase households' livelihood vulnerability in context of climate change impact. In this regard, a unit increases in the scale of family size in particular household, tends to increase the vulnerability of the households by a factor of

0.175 which is statistically significant at 1% significance level. On the ather hand, the age of households heads found negative indicating that a unit increase in the measurement of households' head age tends to reduce the households' vulnerability to climate change impacts by a factor of 0.067 which is statistically significant at 1% significance level. These findings are somewhat consistent with other research findings, like Arega (2013), who asserted that an increase in family size of household heads tends to increase the odds of a household being vulnerable in the circumstance of climate change and weather variability. As presented in Table 7, among the two institutional supports included in this analysis (extension and credit), dummy credit accessibility and supports was found positive association with climate change related livelihoods vulnerability, indicating that respondents with adequate accessibility to credit had a higher likelihood of increasing the vulnerability to climate change by about factor of 0.88 point, which is statistically significant at 1% significance level, while the effect of extension support found statistically insignificant. Trustfully speaking, this result contradicts the findings of Arega (2013), who suggested that in context of drought-prone areas of Ethiopia where crop production is extremely affected by amount and sequential distribution of precipitation, access to credit enhanced seasonal food shortage of the households and assists in diversifying the livelihood options to cope with the resultant negative impacts of weather variability and climate change.

More importantly, almost all diversification approaches (crops, income sources and livelihoods diversification) found to reduce the livelihoods vulnerability related to prevailing climate change and linked impacts in the study community circumstances. Accordingly, income diversification and livelihoods diversification reduce the level of livelihoods vulnerability by a factor of 0.94 and 0.33, respectively, in the scale of livelihoods vulnerability measurement and the effect of these variables are significant at 1% and 5% level, respectively.

Regarding to weather factors, the majority of selected weather related parameters, such as rainfall mean standard deviation, rainfall coefficient of Variation (CV), maximum temperature mean and maximum temperature coefficient of variation (CV) found positive association with livelihoods vulnerability to climate change, indicating that a unit increase in particular weather parameters mentioned above tends to increases the likelihoods of the livelihoods vulnerability with the proportional amount of coefficient mentioned in respective of variables indicated in the Table 7 above, but the effect of majority found statistically insignificant except mean rainfall which found statistically significant. Specifically regarding rainfall, a unit increase in mean rainfall tends to reduce the level of livelihoods vulnerability to changing in climate parameters by a factor of 0.018 in the scale of livelihoods vulnerability and statistically significant at 10% significance level. In Similar manner, the effect of drought frequency was found positive to livelihoods vulnerability asserting an increase in the frequency of drought tends to increase the level of livelihoods vulnerability by a factor of about 0.42 point indicating the significant impact of drought on community livelihoods vulnerability and ultimately on the national economy, where the effect is significant at 1% significance level.

CONCLUSION AND RECOMMENDATION

The findings from primary data analysis and literatures review indicate significant impact of climate change on the livelihood of community and apparent in terms of economic burden and social instability which leads to food insecurity, where this was found to be more pronounced in lowland drought prone areas of the study. Specifically, about 95% of respondent perceived climate change associated impact as the major threat of community's livelihoods and majority of respondents' reported that natural resource which mainly farmland is suffering very severe problem as the result of climate change leading to low productivity.

Accordingly, the Livelihoods vulnerability diagnostics conducted indicate the average level of vulnerability, where comparatively lowland area livelihoods are highly vulnerable to climate change impacts and associated risks. More importantly, of total respondents, the majority perceived negative impact of climate change on community livelihoods as compare to positive influence and revealed that most practiced livelihoods are vulnerable to climate change associated risks. On the other hand, it was asserted by majority of respondents and secondary data, the most frequent natural disasters (drought and over flooding) are already identified as the major source of crisis leading to incompetence of the individuals in respective of livelihoods performance. Specifically, of total respondents in the lowland community, relatively the majority (about 53%) revealed drought occurrence more than 3 times in the past six cropping years, where about 95% of households reported serious crop related livelihood damage as the result of drought disaster.

From the total of highland respondent, 52% are severely dependent on natural resource exploitation during food shortage which practically leads to natural resource degradation leading to environmental calamity. On the other hand, the ability of the community to moderate the potential risks (adaptive capacity) found to be about average (overall about 53 % and 52% for highland and lowland, respectively) which need adequate effort to improve to higher level so that the system can sustainably manage the climate change impacts and related consequences. Additionally, the empirical evidences of research findings, suggest that global warming resulting from climate change is already affecting and will continue to affect the agro-ecological suitability required for the development of agricultural sectors which requires the adoption and sustainability of the adaptation and mitigation strategies in the farming community.

Commonly, adaptation strategy adoption only can be realized through adequate adaptive capacity of the system which resulted from the compounded effect of interacting sub-components along the production value chain in context of agriculture. However, the results of the study indicate unpromising system level adaptive capacity resulting from in adequate technical capacity, limited technological and institutional support to the farmers which commonly resulted from inadequacy of the right policy direction and strategies. Accordingly, policy level managers and technocrats need to revisit and/or redesign existing policies with its strategies to promote economically and environmentally sustainable development approaches emphasizing on the adaptive capacity improvement. Additionally, it is pick time for local community to re-emphasize on endogenous knowledge and traditional practices promotion to manage and control currently worsening environmental degradation, especially deforestation to maintain environmentally sustainable community development.

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Declaration of Competing Interests

The author declares that there are no recognized competing interests that appeared to influence the work described in this study paper.

Data Availability

Data will be made available on the request.

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REFERENCES

Abate F.S (2009). Climate Change Vulnerability and Coping strategies: A Case Study of West Arsi, Ethiopia. MSc Thesis, Lund University.

Addisu Bezabeh, Fekadu Beyene, Jema Haji, Tesfaye Lemma and Fatih Yildiz (2020). Impact of contract farming on income of smallholder malt barley farmers in Arsi and West Arsi zones of Oromia region, Ethiopia. Cogent Food & Agriculture. 6 (1). 1834662, DOI: 10.1080/23311932. 2020.1834662.

Adger, W.N. (2006). Vulnerability. Global Environmental Change.16(3),268-281. http:// doi.org/10. 1016/j.gloenvcha.2006.02.006

Alemayehu Muluneh Bitew (2015). Strategies to adapt climate change in the Central Rift Valley of Ethiopia impact assessment for on-farm adaptation. PhD Thesis Wageningen University. Wageningen.

Asfaw Negesse Senbeta, Shimalis Gizachew Daselegn, Yassin Esmael Ahmed, Beriso Bati Bukul (2020). Crop Production System and Their Constraints in East Shewa Zone, Oromia National Regional State, Ethiopia. International Journal of Energy and Environmental Science. 5 (2)30-39. doi: 10.11648/j.ijees.20200502.11.

Asfaw, S. and Lipper, L (2011). The Economics of PGRFA Management for Adaptation to Climate Change: A Review of Selected Literature. Background Study Paper no 60. Agricultural Economic Development Division (ESA), FAO, Rome, Italy.

Arega Buzzew Berlie (2013). Determinants of Rural Household Food Security in Drought-Prone Areas of Ethiopia: Case study in Lay Gaint District, Amhara Region. PhD Thesis, UNISA.

Bierens, H. J. (2004). Introduction to the Mathematical and Statistical Foundations of Econometrics (Themes in Modern Econometrics). openlibrary.org · books · OL7745559M

Dawit Woubishet Mulatu, Zerayehu Sime Eshete and Tsegaye Ginbo Gatiso (2016). The Impact of CO_2 Emissions on Agricultural Productivity and Household Welfare in Ethiopia. A Computable General Equilibrium Analysis. Environment for Development. Discussion paper. www.researchgate.net · publication · 299468283_The

Derick T. Adu, John K.M. Kuwornu, Henry Anim-Somuah and Nophea Sasaki (2013). Application of Livelihood Vulnerability Index in Assessing Vulnerability to Climate Change and Variability in Northern Ghana. Kasetsart Journal of Social Sciences.

Ebrahim AA, Miheretu BA and Alemayehu A (2022). Vulnerability of smallholder farmers to climate variability and change across different agro-ecological Zones in Oromo Nationality Administration (ONA), North east Ethiopia. PLoS ONE 17(6): e0268094. https://doi.org/10.1371.

Ethiopian National Meteorological Agency (NMA) (2007). Climate Change National Adaptation Programme Action of Ethiopia.

Getnet Zeleke, Menberu Teshome and Linger Ayele (2022). Farmers' livelihood vulnerability to climate-related risks in the North Wello Zone, northern Ethiopia: Environmental and Sustainability Indicators.www.sciencedirect.com/journal/environmental and sustainability-indicators.

FAO (2016). Ethiopia Climate-Smart Agriculture Scoping Study. Addis Ababa, Ethiopia. http://www.fao.org/3/a-i5518e.pdf.

Hahn (2008). A short scale for measuring safety climate,46(7):1047-1066. https://doi.org/10.1016/j.ssci.2007.06.002.

Howden, S.M.; Soussana, J.; Tubiello, F.N.; Chhetri, N.; Dunlop, M.; Meinke, H (2007). Adapting agriculture to climate change effects. *Proceeding of National Academy of Science. USA* 2007, *104(50),* 19680-19685.

IPCC (2007). *Impacts, Adaptation and Vulnerability: An Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK.

Marshall N.A., Marshall P.A., Tamelander J., Obura D., Malleret-King D. and Cinner J.E. (2009). A Framework for Social Adaptation to Climate Change; Sustaining Tropical Coastal Communities.

Ministry of Agriculture and Natural Resource (MoANR) (2017). Gender Equality Strategy for Ethiopia's Agriculture Sector. Addis Ababa, Ethiopia.

Mohammed Nasir Uddin, Wolfgang Bokelmann and Jason Scott Entsminger (2014). The Factors Affecting Farmers' Adaptation Strategies to Environmental Degradation and Climate Change Effects: A farm Level study in Bangladesh. In: Climate, 2(4), 223-241, https://doi.org/10.3390/cli2040223

Morton, J.F (2007). The impact of climate change on smallholder and subsistence agriculture. Proceeding of National Academy of Science. USA 2007, 104(50), 19680-19685.

Rosegrant, M.W.; C. Ringler, T.; Benson, X.; Diao, D.; Resnick, J.; Thurlow, M.; Orden, D. (2008). *Agriculture and Achieving the Millennium Development Goals*; World Bank Report; 32729-GLB; World Bank: Washington, DC, USA.

Septri WIDIONO, Ekawati Sri WAHYUNI, Lala M. KOLOPAKING, Arif SATRIA (2024). Livelihood vulnerability of indigenous people to climate change around the Kerinci Seblat National Park in Bengkulu, Indonesia, 5(4). https://doi.org/10.1016/j.regsus.2024.100181.

Shayan Javeed (2022). Climate Change and Livelihood Vulnerability of Rural Households: A Case Study from Doda District of Jammu and Kashmir, India. Global Economics Science,3(2).

Tamirat Gebiso Challa, Aman Nebo Tibesso, Ashebir Tsegayie Mamo (2019). Farming System Characterization of Arsi zone: Case of Small-Scale Farming. American Journal of Environmental and Resource Economics. 4(1). 12-24. https://doi.org/10.11648/j.ajere.20190401.12.

Tamirat Gebiso (2018). Livestock production system characterization in Arsi Zone, Ethiopia. International Journal of Livestock Production. Volume 9 (9), 2018. DOI: 10.5897/IJLP2018.0494.

Thi Anh Nguyet Vo, Thanh Xuan Hua, Ngoc Duc Nguyen and Lan Anh Pham (2024). Livelihood Vulnerability Index to Climate Change in the Mekong River Delta in Vietnam: A Case Study in Three Provinces.5(11):5620-5637. DOI: https://doi.org/10.61707/0afaz497

Thornton, P. K (2010). Livestock Production: Recent Trends, Future Prospects. International Livestock Research Institute (ILRS), 365 (1554):2853-67. DOI:10.1098/rstb.2010.0134.

Tran Thi Phuong, Nguyen Quang Tan, Nguyen Cong Dinh, Huynh Van Chuong, Hoang Dung Ha, and Hoang Thanh Hung (2023). Livelihood vulnerability to climate change: Indexes and insights from two ethnic minority communities in Central Vietnam,10. https://doi.org/10.1016/j.envc. 2022.100666.

WIKIPEDIA (2023). Arsi and East Shewa profile. The free encyclopedia.

World Bank Group (2011). Vulnerability, Risk Reduction, and Adaptation to Climate Change, Ethiopia; Country Profile, April 2011. World Bank Group 1818 H Street, Washington, DC20433

World Bank (2009). Agriculture for Development. Overview. http://siteresources.worldbank.org.

Zelalem Dendir and Belay Simane (2019). Livelihood vulnerability to climate variability and change in different agro-ecological zones of Gurage Administrative Zone. Progress in Disaster Science;3. www.elsevier.com/locate/pdisas.