Research Paper: Characterizing Small-scale Farmers Differential Vulnerability to Global Environmental Change: Case Studies in Anger Watershed, Southwestern Ethiopia

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ABSTRACT

Purpose: Global environmental change of climate variability and land use dynamics are emerging livelihood challenges facing local poor. Although, the synergetic impacts of these processes have been cognate in Ethiopia, vulnerability researches were fixed to climate variability, inadequate on conceptual and methodological considerations of non-climate stressors. To this attention, we assessed small-scale farmers' vulnerability situations in Anger watershed of southwestern Ethiopia.

Methods: The case study design guided by mixed methods approach was used. Multistage sampling technique was used for the study. The data collected from 335 household heads were analysed by multivariate analysis, measures of differences, and substantiated by qualitative enquiry based on focus group discussions and observations.

Result: Household's vulnerability magnitude ranges from high to moderate, while in aggregate, kolla agroecology was more vulnerable than highland. The effects of social adaptability and sensitivity to land resources were significantly contributed for the vulnerability differences. Although, climate variability was notable, structural land use dynamics was unequivocal stressor deepened the household's vulnerability in kolla.

Conclusions: Vulnerability is the result of interactive and interconnected processes of climate, non-climate stressors, and households' internal capacity in the study area. Thus, attributing local vulnerability to only climate variability, neglecting local non-climatic disturbances could mislead development planning. Hence, future studies should consider such processes simultaneously to provide comprehensive evidences on vulnerability situations. The national adaptations program needs to integrate climate change with the emerging other global changes in planning rural resilience. Policy fortifying agricultural investments should synchronize win-win strategy for relationships between investors and local community.

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1. Introduction

Global environmental change processes of climate variability and land use dynamics is emerging challenge facing local communities. However, the spatio-temporal variations in nature and magnitudes of stressors, and unique micro-scale livelihood systems sensitivity to the processes have been resulted differential vulnerability on top of internal socioeconomic capacity of a community. Thus, some areas are more vulnerable to the changes than others that the complexity in geography have been observed (Burkett et al., 2014; Shameem, Momtaz, & Rauscher, 2014) and the situations are more acute in developing countries because of vast causal linkages of the vulnerabilities with socioeconomic, historical and political milieu of the region (Adger, Barnett, Brown, Marshall, & O'Brien, 2013), while the livelihood strategies of the community such as agriculture and the immediate land resources are heavily sensitive to the impacts of these processes (Shackleton, Ziervogel, Sallu, Gill, & Tschakert, 2015). Thus, the existing climate variability have been taking place simultaneously with rapidly changing LULC (Denton et al., 2015; Fazey et al., 2018; O'Brien & Barnett, 2013) heightening vulnerability and challenging inherent adaptation and coping strategies of local community.

The synergism among such global environmental change processes in affecting life and livelihoods of poor got prominent position in today's development research (Burkett et al., 2014; Jeffers, 2013; Leichenko, O'Brien, & Soleck, 2010; Prno et al., 2011). The dynamics in land use, and associated change in local communities' access to land/and natural resources resulted from globalization; and the impacts of climate variability could be considered areas of such changes in Ethiopia. Particularly, the condition has significant implications for the small-scale farmers of Anger watershed than any community having similar livelihood background in the area. Although, there is lack of empirical data specific to the area, like any other community in Ethiopia affected by such changes (Dessalegn, 2011; Makki, 2014), the structural changes in land use and climate variability have capacity to disrupt local community's livelihood system and deny their resource access in one way or the other, and accentuate their vulnerability. On top of impacts of climate variability which have been modifying the state of the community's vulnerability, they have been affected by diminishing land size, limited access to water source and other natural resources due to structural land use dynamics. Thus, the study argued that the livelihood out-comes of small-scale farmers in the study area is the reflection of both stressors, that the processes have spatiality in the watershed, and the farmers' socioeconomic development in general and vulnerability conditions in particular are significantly constructed based on the extents of their exposure/ and sensitivity to both or one of the stressors.

Although, numbers of development institutions, practitioners and researchers are recommended for assessing vulnerability at micro-scale by considering simultaneous impacts of such contextual stressors mainly among poor like small scale farmers in Anger river watershed (Burkett et al., 2014; Butler et al., 2014; Grineski et al., 2015; Prno et al., 2011; Simonds & O'Brien, 2018), previous studies in Ethiopia were addressed the issues separately, no research considered the combined impacts of the changes, most of them were fixed to vulnerability to climate change, and attributed causalities to local human-environment interrelationship. However, we shouldn't fail to notice the extensive global economic changes that our world is facing, evolving rules of the processes on resource access/utilizations, and the pressures that these could potentially exerts on the poorest small-scale farmers. Particularly, most of the studies conducted in Ethiopia on both issues could be thematized as the impacts of land use dynamics, and vulnerability to climate change. For instance, some have focused on the impacts of land use policy, land tenure arrangements, and large-scale land acquisition on local community (Dessalegn, 2011; Lankester & Davis, 2016; Tsegaye & Spoor, 2015; Wulp, 2013) and other focus on livelihood vulnerability to climate change, vulnerability of economic sectors to climate change such as agriculture, and determinants of vulnerability to climate change (Abayineh & Simane, 2017; Kindie, Abate, Berhanu, & Belay, 2015; Paulos & Simane, 2017; Shiferaw et al., 2014; Woldeamlak, Radeny, & Mungai, 2015). Moreover, most of the studies were conducted in the central and northern highlands of the country, while other parts mainly southwestern of Ethiopia rarely researched.

These thorough review of previous studies on household's vulnerability in Ethiopia show that the researchers adopted out-come based vulnerability analysis while context specific methods are overlooked, climate change was considered as the only stressor that no research has been considered non-climate stressors in framing livelihood disturbances, and vulnerability indicators are selected deductively and applied for analysis without considering local situations. Furthermore, no research has been attempted to combine climate and other micro-scale global environmental change such as structural

land use dynamics while such contexts have had capacity to shape vulnerability situations of a community.

Therefore, further studies are needed to consider these issues and others in order to provide sufficient evidences on spatial patterns of these global environmental change processes, individual/ and simultaneous impacts of the processes on the livelihood system of a community, and to describe the associations between impacts of the processes and local specific vulnerability situations. So, this study could fill the knowledge gaps of previous studies on the local livelihood vulnerability assessment. In this regard, the justifications for this study were that the identified processes (i.e., climate variability and structural land use dynamics) have global courses and impacts, external to the 'vulnerable' unit of analysis, and boldly observed in the study area with distinguished spatiotemporal settings due to differences in agroecological, historical and political spurs. Therefore, considering the site-specific conditions and the simultaneous/ and individual impacts of these global environmental change processes have had significant implications on the vulnerability situations of households encountered by either individual or concurrent stressors.

Methodologically, the previous research on vulnerability come-up with frontiers between environmental scientists and social studies, to their incompatible epistemologies, mostly positivist and interpretivist respectively. For instance, several studies on the impacts of global economy induced large-scale land acquisition in Ethiopia are oriented by the second frontier. In this regard, most of them are restricted to qualitative approach oriented by political economic explanations. Although, the researchers reported that the processes have been increased the vulnerability of those who are dispossessed (Desalegn, 2013; Tsegaye & Spoor, 2015), their methodologies are inadequate to examine the extents of vulnerability, spatial difference in factors' effects on vulnerability. Contrary, others are highly positivists dedicated to models-based measurements of vulnerability focusing on climate change as the only stressor (Schneiderbauer, Calliari, Eidsvig, & Hagenlocher, 2017; Simonds & O'Brien, 2018), particularly fails to inductively identify site-specific non-climate external stressors and in-depth explorations of local contexts and issues qualitatively. These edge along disciplines resulted shortage of methodological exercises for holistic understanding of local vulnerability situations. Thus, in this study multiple perspectives and methods were used, believing that synergizing these disciplinary positions and lessen the methodological edge is crucial to achieve the objectives of the study. This was done through integrating relevant conceptual frameworks and models, designing case-study by considering unique issues and processes at case unit, adopting mixed research methods approach to grasp a range of data sources and types with multiple techniques of analysis.

The general objective of the study was to assess small-scale farmers' vulnerability to global environmental changes in Anger watershed of southwestern Ethiopia. Specifically, the research was intended: (1) to examine the small-scale farmers' vulnerability at household level, (2) to portray the spatial differences in magnitude of household's vulnerability, and (3) to characterize household's vulnerability factors across case studies. Therefore, in addition to measure magnitude of vulnerability at household level, the comparative case study was conducted to explore the differential vulnerability i.e., whom/ and where is more vulnerable? what is the extent of vulnerability differences along case studies? What factors' effects are contributed for the difference? and how the stressor/s have shaped the vulnerability situations of households.

The study was focused on the unique feature of the case study units i.e., kolla agroecology in Anger valley partaking tropical warm (kolla) climate, and the second case study 'highland' has subtropical (woinadega) and small area of temperate (dega) climate. In addition, the cases are different in their political economy experiences, particularly, kolla area has long history of 'development' interventions, and subsequent structural land use dynamics while the process was relatively slight in the highland. Thus, the outcome will provide new insight for vulnerability literature, contribute for emerging vulnerability frameworks, and provide policy recommendation on rural resilience. We hypothesized that high levels of vulnerability will be related to low adaptive capacity, high exposure and sensitivity to the current global environmental change processes, particularly climate variability and structural land use dynamics. In relation to differences for climate variability situation across agroecology and situation of structural land use dynamics, as found by previous empirical findings (Jeffers, 2013; Leichenko et al., 2010; Mubaya, Njuki, Mutsvangwa, Mugabe, & Nanja, 2012; Simonds & O'Brien, 2018) we expected that the households with low adaptive state, high exposure to the stressor/s, and low adaptive capacity will be more vulnerable and the situation has spatially different along the case studies.

2. Literature Review

Global environmental change was emerged as a major scientific research arena since the mid-1980s (Leichenko et al., 2010), while vulnerability to these processes has emerged as a cross-cutting theme in research on the human dimensions of the changes (Patterson, 2013; Barrett & Constas, 2014). These served to reinforce public, policy makers and development practitioners through scientific recognition that fundamental global-scale biophysical dynamics resulted climate change (IPCC, 2007), and recently different external factors such as globalizations and national economic and institutional changes (Leichenko et al., 2010) and associated structural changes in resource ownership (Dessalegn, 2011; Hjerpe & Glaas, 2012) have been happening, heightening risks and reducing opportunities, especially for poor.

Both theory of disaster and entitlement has contributed for major perspectives of human vulnerability research, while within each theory different approaches and discourse are persisting. Given the diversity of uses and definitions, the concept traces its epistemological origins to the disciplines such as disaster management, environmental sciences, economics, anthropology/ sociology, and health science by which the researchers from these disciplines addresses the concept differently based on their respective disciplinary orientations, objectives of a study, nature of a system subjected to study (Burkett et al., 2014; Eriksen & Kelly, 2007; Kelman et al., 2016; Reed et al., 2013; Wisner et al., 2003).

The diversity in conceptualization and uses (Schneiderbauer et al., 2017; Simonds & O'Brien, 2018), persistent multiple frameworks (Cutter et al., 2009; Shameem et al., 2014; Turner et al., 2003), the relationship between biophysical and social aspects in measurement, integration of the concept with other related terms such as risk, hazard, sensitivity, adaptive capacity, and overlaps with concepts such as resilience and adaptation (Costache, 2017; Miller et al., 2010) oblige to apply the concept with great caution. For instance, some argued that, different formulations of research needs, research methods, and normative implications of vulnerability research built on objectives of study or the system to be studied (Mcdowell & Hess, 2012; Reed et al., 2013). Although, the recommended approach is toward a general framing of vulnerability, the specific variables and relationships to be studied, and the methods should realistic to achieve the objectives of a study (Schneiderbauer et al., 2017), the recent studies have been criticized for fragile argument on purpose of assessing vulnerability, deficiency in condensing complex state-of-affairs such as the vulnerability of regions, households or countries into a single number that cannot then be easily used by policy makers, and lack of clarity in approaches and methods of data collections (Hinkel, 2011).

These all conceptual and methodological issues were addressed in designing the study. In this paper, vulnerability is the state of small-scale farmers' livelihood susceptibility to harm from exposure to stresses associated with environmental and historical socio-economic and cultural changes and from the absence of capacity to adapt. The reviewed literature consistently considers particularly livelihood vulnerability as a function of three key elements: exposure and sensitivity to stress/ stresses, and adaptive capacity. The situation is context specific that the households' exposure to the stressors has spatial variations, particularly climate variability along agroecology, and the structural land use dynamics vary along case units due to historical political economy of the region. Thus, coupled deductive and inductive approaches were used to identify the vulnerability indicators to index and characterize households' vulnerability. The approaches were appropriate to capture realistic indicators which comprise the situations of case studies.

The livelihood vulnerability indicators adopted from previous research works (Abayineh & Simane, 2017; Kelman et al., 2016; Pandey, Jha, Alatalo, Archie, & Gupta, 2017) were used as check list during inductive surveys beforehand conducted on local knowledge from the communities and experts to determine list of indicators (Brink & Wamsler, 2018). Thus, we able to pick out variables that approved the discriminate households in to the group of designed case studies, and the variables were added to or replaced the deductively adopted indicators. The key elements of livelihood vulnerability (Field et al., 2014) contextually operationalized based on previous empirical researches companionable in the approach, framework, methodology and purpose of this study (Dong et al., 2011; Field et al., 2014; Jeffers, 2013; Leichenko et al., 2010; Shameem et al., 2014; Simonds & O'Brien, 2018).

Exposure refers to the degree of stress upon a small-scale farmers household. In this context, it represented long-term changes, variability and the magnitude and frequency of climate extreme in one way, and undesired change in access to land and natural resources resulted from structural land use dynamics. Exposure is employed to refer to the location of the small-scale farmers and their livelihoods, environmental services and resources, infrastructure, economic, social and cultural assets that could be adversely affected by physical events

of climate variability and structural land use dynamics, thereby, are subject to harm, loss, or damage. Sensitivity refers to the degree to which a household respond to the changes i.e., to climate variability and structural land use dynamics either positively or negatively. The sensitive households respond to the changes negatively due to inability to exploit the opportunity, while less sensitive could respond positively by realizing the opportunity and reduce the threat of the changes. Adaptive capacity describes the ability of the households to adjust to actual or expected stressors' impacts, or to cope with the consequences. It is considered as a function of economic and socio-demographic status of households such as wealth, skills, infrastructure, access to resources, education, information, stability, technology, management capabilities, family conditions, social networks and etc.

Therefore, the households exposed to negative and undesired changes, negatively respond due to inability to exploit the changes and characterized by low socio-economic development are vulnerable. The household vulnerability has spatial aspects in the study area due to the contexts of the stressors. The vulnerability indicators were adopted (Abayineh & Simane, 2017; Gutu, Emana, & Mengistu, 2012), modified to the contexts of the study area. The detail of the indicators is presented in Table 1.

3. Methodology

Study area

Anger watershed lies in east Wallagga administrative zone (Figure 1) were the focus the study, while the watershed covers more areas in the region. The area within a single administrative zone was selected to reduce heterogeneity due to administrative difference because the situations are place-based and context specific that the climate and historical, political and socioeconomic outgrowths are more complex if the entire watershed is included in the study.

The study area is composed of various land forms with altitudinal ranges of 1200-3018 meters above sea level. The mean annual temperature ranges between 140c to 250c; and average annual rainfall is also between 1000 mm to 2400 mm. The rainfall shows mono-modal pattern and more than 80% of which occurs between May and October. Numbers of rivers and streams drain the watershed. There are different types of soils found in the zone. Most of the northern parts of the zone are covered by Orthic Acrisols and Cambisols; while Eutric Nitosols is the dominant in the central part; and Dystric Nitosols occur almost throughout the zone. These soils have contributed for development and good potential of agriculture in the watershed (FED, 2014).

The micro-scale climate, soil types, varied species of forest ecology, rich wild animals and other associated natural resources supported vast livelihood options. The socio-economic and demographic characteristics are shaped by the dynamics in these bio-physical factors on top of historical national and global change processes. Particularly, the physical environment, social, cultural and livelihood system of community in kolla is more unstable than highlands due to these external interventions mainly associated with introduction of large-scale agriculture and resettlement programs since 1970's. Thus, the status and trends in small scale farmers socio-economic and demography have been showed significant difference within small area due to difference in magnitude of the extrusions.

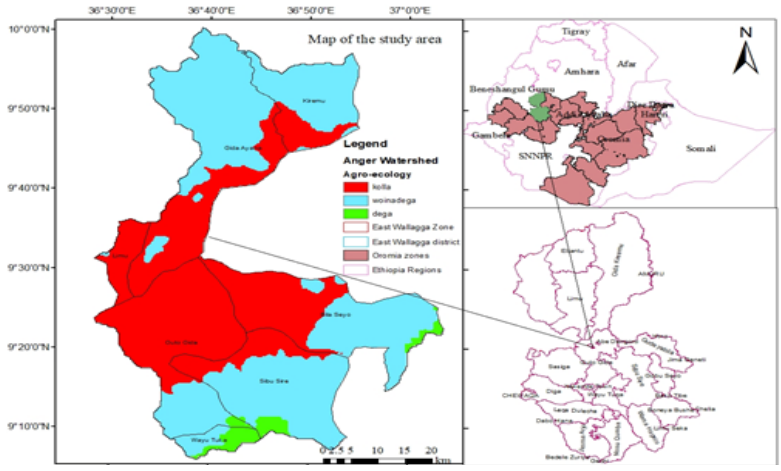

Figure 1 . Map of the study area

Currently, the estimated total population size of the zone was 1,552,689 in 2019 out of which 82.28% were rural populations directly engaged in agriculture (projected from Zone's FED 2014). Thus, agriculture is the major economic activity that different types of crops such as cereal, pulses and oil seeds are produced largely throughout the study area. Similarly, the livestock rearing, beekeeping and direct exploitations of natural resources play key livelihood roles. The infrastructure development is poor mainly among rural dwellers. The road quality/and network density is low; less than half of the rural population has supplied potable water; source of energy is limited to firewood, animals dung, crop residues and charcoal (FED, 2014).

Research Design

The study consists an array of issues from objectively examining magnitudes of vulnerability to constructing reality on who is vulnerable to what, why and how the cause/s shaped the vulnerability situation of the community through in-depth exploration of community's concerns. Therefore, mixed research method approach was used. Collection of observations and measurements of incidences of livelihood vulnerability was conducted quantitatively to make inferences about magnitude and spatial variations in households' vulnerability, while qualitative data was used to substantiate the model-based results (Creswell, 2012).

The approach was guided by the principles and procedures of survey research design. The justification for the design includes: it is one of the widely employed in mixed research approach helps to infer to the total population, and in-depth analysis of the concern of different stakeholders. It allows to ask about many things at one time, that it is compatible with cross-sectional design for the time frame of the study. The reliability and validity are critical in the study. Thus, the issue of stability, internal reliability and inter-observation consistency were checked to realize the reliability of the study. Moreover, the research validity was attained through careful sampling, appropriate instrumentation and statistical treatments of the data.

Research Techniques and Tools

The sources of data for the study include small scale farmers' household heads, group discussants drawn from elderly who lived for a long in the area with experiences of ecological and livelihoods systems, experts on the issues, and relevant published and unpublished documents.

Multistage sampling technique was used in the study. The areas found within the Anger watershed in the East Wallagga administrative zone were the focus of the study. The smallholder farmers' household heads were the unit of analysis in the study. The divisions within the region were made on the basis of agro-ecology and the situation of structural land used dynamics to discriminate households in to the group of designed case studies; which was followed by random selection of districts and kebeles represent both case studies.

Accordingly, Ukke and Anger Magarsa kebele represent the first case study. They were selected from kolla agro-ecology and both are under the influence of large-scale agricultural investment. Gari from woinadega and Haro Chalchisa from dega agro-ecology represent the second case study. Out of total 2,642 household heads, 335 were identified by the following formula (Kothari, 2004). The sample size for each kebele was determined based on the proportionality of their size and simple random sampling technique was used to select households for the questionnaire survey.

$$n = \frac{z^{٢}.pqN}{e^{٢}\left(N - ١\right) + z^{٢}.pq}$$

Data analysis was performed by STATA for principal component analysis (PCA) based vulnerability index, and T-tests and Pearson's linear correlations to characterize vulnerability factors along case units. The rationale is that PCA may perhaps use to construct indices for which there are no well-defined weights (Li, Zhang, Yuan, Liu & Fan, 2012), it helps to summarize variables in to components through looking for 'clumps' to develop small number of coherent components (Pallant, 2010), and above all, the components were used to characterize vulnerability factors across case studies.

The model specification for PCA:

Vulnerability = (Adaptive capacity) – (Sensitivity + Exposure) …….....Eq. 1

In this study, both households level index (Equation 2 and 3); and spatial (case studies) index (Equation 4) were used. The households were classified into highly vulnerable, vulnerable and less vulnerable based vulnerability index for each household; while the two case units were classified as vulnerable and less vulnerable based on net value of vulnerability index in the area. The index was computed based on relative measure, representing the

households' own perception on their socioeconomic and environmental conditions. All statistical assumptions and data suitability were realized.

The vulnerability index at household level is expressed as:

$$VIhh = (A1X1j + A1X2j + \ldots + A1Xnj) - (A1Y1j + A1Y2j + \ldots + A1Ynj) \quad \text{Eq. 2}$$

Where; VIhh is vulnerability index of the household; Xs are the values of elements of adaptive capacity; Ys are the values of elements of sensitivity and exposure for the household. The matrix of Xij showed as follows:

$$Xij/Yij = \begin{matrix}(X11+X12+\ldots+X1n)-(Y11+Y12+\ldots+Y1n)\\ (X21+X22+\ldots+X2n)-(Y21+Y22+\ldots+Y2n\ldots.)\\ (Xm1+Xm2+\ldots+Xmn)-(Ym1+Ym2+\ldots+Ymn\end{matrix} \quad \text{Eq. 3}$$

The i and j implies the number of rows (participants; n=335) and the number of columns (variables). In this regard, the first principal component of a set of variables (i.e., the linear index of all the variables that capture the largest amount of information common to all the variables) for each observation (Gutu et al., 2012) were used to label households under three vulnerability status. Moreover, the following matrix (Equation 4) was used to calculate vulnerability index along case study.

$$VIcase = \begin{matrix}A1\\ A2\\ An\end{matrix} X \begin{pmatrix} (X11+\ldots X1n)- & (Y11+\ldots+Y1n)\ldots. \\ (Xm1+\ldots+Xmn)- & (Ym1+\ldots+(Ymn) \end{pmatrix} \quad \text{Eq.4}$$

The value of X and Y obtained by normalization using mean and standard deviation from factor scores (X1=(X1-X*)/SD). The A's are the factor score of variables along case studies. Xmn are the summation of the normalized values of adaptive capacity, and Ymn are of sensitivity and exposure, VIcase is vulnerability index for case studies. The normalized values of indicators are annexed (Annex).

The PCA based components of vulnerability indicators were characterized for case study using T-tests and Pearson's linear correlations. Moreover, the FGD, field observations and discussions with experts were analysed to construct evidences on the similarities and differences in vulnerability factors across the cases studies, and assess the causalities; i.e., how the factors are caused the results, particularly outcomes and impacts.

4. Findings

We conducted factorial analysis with PCA and Varimax rotation, using eigenvalues >1. After repeated analyses, results demonstrated the better four-components solution than the others, eliminating five variables because of reported low communality. Thus, 30 variables (Table1) were used for entire analysis. Moreover, the KMO = 0.82 and Bartlett's test of sphericity $\chi 2=4179.318$, p=.00, the Cronbach's alpha coefficient (α=.85) indicated the suitability of PCA and internal consistency of the indicators.

Household Level Vulnerability

The factor score of the first principal component for entire observation was used to construct vulnerability index at household level. The value ranges from -1.72 for household characterized as highly vulnerable to +2.12 for least vulnerable among the observations. The result shows that the majority of households fall within the moderately vulnerable category in the watershed followed by high vulnerability status (Table 2).

Spatial Analysis of Vulnerability Situations

The vulnerability indicators of households were clumped in to four components for both cases based on statistical assumption of PCA. The first component was named "economic component", it included 12 items. The second component was called "social component", constituted seven items. The third component termed as "climate and environmental component", constituted seven items. The fourth component was named "land and natural resource", with four items (Table 3).

The principal component-based factor analysis was made for both case studies to identify spatial variation in extent of vulnerability in the watershed. The factor scores of the first and the second principal component was positively associated with the majority of the indicators identified under economic and social components respectively, while the third components was negatively associated with majority of climate and environment indicators in both case study. However, the fourth component was positive for most indicators under land and natural resources in highland and negative for kolla (Table 3). In order to construct index, the normalized indicators scores (Annex) were used.

The higher net value of the vulnerability index (Figure 2) show less vulnerability and vice versa. The aggregate value of social and economic components was positive for both case studies (+0.144 for kolla and +0.607 for

highlands), climate and environmental component was negative with value ranges from (-0.414) for kolla and (-0.276) for highland, while land and natural resources component shows negative for kolla and positive for highlands (-0.271 and +0.402 respectively). The net value of the index was negative (-0.281) for kolla and positive (+0.324) for highlands (Figure 2).

Table 1. Socioeconomic and environmental indicators of vulnerability

S.N	Indicators	Percent
1	Sex: female headed	19.0
2	Education: No formal education and > grade 3	76.2
3	Duration: Stay over the area for >5 years	19.9
4	Experiences on livelihood sources: >5 years	6.3
5	Number of relatives: No relatives and < 5HH	29.2
6	Number of institutions:<=2 institutions	58.0
7	Information: no access to climate and land management information	89.6
8	Dependency:> half of household size	70.8
9	Extension: no access to extension services	11.9
10	Livestock ownership:< 4.02TLU (average for household)	56.5
11	Land under perennial crop: No area under perennial crop	69.9
12	No of plot:>one plot and (separated home and farmland)	66.7
13	Non-farm income: No non-farm income	73.2
14	Crop diversity:< 50% of crop produced in the area	61.3
15	Artificial fertilizer: No access at all & <50% of land	45.5
16	Improved Seed: No access at all & <50% of land	56.8
17	Irrigation: No access to irrigation	78.3
18	Deposit: No food/money deposit for time of recession	74.7
19	SWC: No practices on the farmland	85.7
20	Land holding size:< average landholding size of the area	55.1
21	Communal/open land for grazing: No access	42.6
22	Open natural resources such as forest: No access at all	42.3
23	Competition on resource: high competition	42.0
24	Slope: > =15% (Very steepy) and flat (near 0%)	69.0
25	Vegetation: Bare land and sparsely vegetated	70.8
26	Natural fertility: Poor (require heavy fertilizer)	77.4
27	Frequency of natural hazards: Frequent (> twice in 5years)	77.7
28	Rainfall: Insufficient /and variable	90.2
29	Temperature: Increasing /and variable	92.9
30	Wind: Noticed unusual change	31.3

Source: Field survey, 2020

JSRD

Table 2. Households' classification by range of their vulnerability index.

S. N	Vulnerability Index	Vulnerability category	Frequency	%
1	<-1.00 to -1.76	Highly vulnerable	86	25.67
2	-1.00 to 1.00	Moderately vulnerable	197	58.81
3	>1.00 to 2.12	Less vulnerable	52	15.52
	Total			100

Source: Field survey, 2020

JSRD

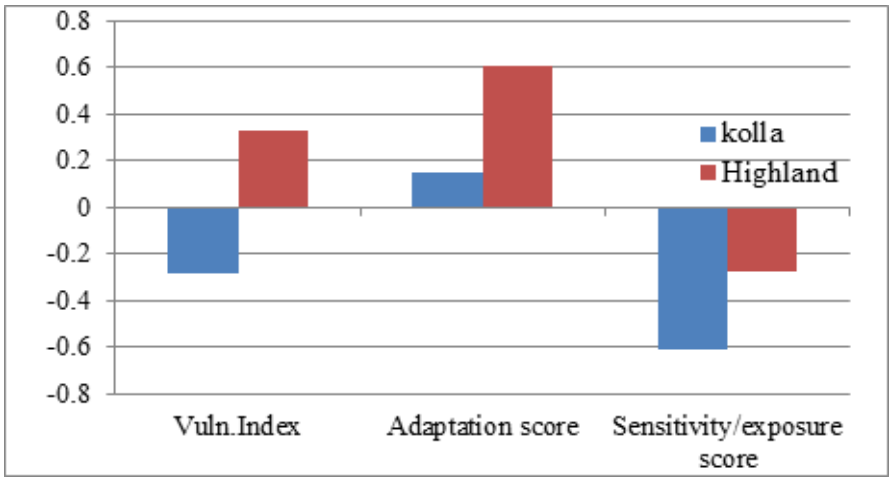

Figure 2. Vulnerability index of households along case units. Source: Field Survey, 2020

The two cases differ significantly in their social contexts such as number of institutions, education and number of relatives; economic capacity such as land size for agriculture, access to irrigation, extent of perennial crops on their farmland and livestock ownership; and environmental conditions such as status of vegetation cover and slope of farmland. Moreover, access to land and natural resource such as grazing land, and other land resources was significantly different across the case studies (Table 3).

Characterizing Vulnerability Factors

The significance of the factors scores along case studies, their relationship and differences in effects on magnitude of vulnerability along the case study were examined to attribute the underlying factors for differential vulnerability.

Descriptive analyses on vulnerability components showed higher social than economic adaptability, low sensitivity to land and natural resources access and high exposure to climate and environmental adverse in the highland. However, the situations in kolla showed relatively higher on economic than social adaptability and high sensitivity to land and natural resources access and exposure to climate and environmental adverse (see Mean and SD in Table 5).

The components difference and relationship along case unit were analysed to identify the significance of the factors' effects on households' vulnerability. Accordingly, the result of independent sample t-test shows significant differences among the components for their effects on vulnerability (Table 4). Specifically, both cases are different in their social adaptability ($t(335)= -1.54$, sign.2-tailed =.002) and sensitivity to land and natural resource component ($t(335)= -13.36$, sign.2-tailed =.000) so, highlands obtained higher scores on both social adaptability and low sensitivity to land and natural resource than kolla (see Mean and SD in Table 5). The result indicates that the difference in vulnerability status (shown on Figure 2) along the cases were significantly contributed by these two components, while the two other components show difference but statistically not significant. The economic adaptability, and climate and environmental adverse was higher in the highland.

The components correlations along case studies (Table 5(2)) demonstrated the extent by which factors are correlated in their effects of vulnerability along case studies. The economic in kolla and social factors in highland showed significant correlation ($p<0.05$) in their effects of adaptive capacity of the households. The exposure to climate and environmental in kolla and economic adaptability in highland have significant inverse relationship ($p<0.01$) which show that the effects of climate and environmental adverse in kolla contribute as significant as adaptability due to economic capability in highland for vulnerability difference. Moreover, the effect of climate and environmental adverse in highland is as significant as the effect of sensitivity to land and natural resources in the kolla ($p<0.01$).

The FGD based findings confirmed the model-based characterized factors of vulnerability. The discussants in both cases explained their livelihoods vulnerability to the adverse climate and environmental factors. The in-

creased in temperature and the variability in rainfall have been adversely affecting their livelihood. For instance, the late rain multifaceted impacts on productions and productivity of crops and shortage of grass and water for livestock (due to elongated dry season) were observed in the study area. Moreover, the rainfall concentrations in kiremt have been resulting soil degradation, increased unsuitability for crops, and destructions associated with heavy storms.

Table 3. Factor scores for principal component analysis across case studies

SN	Variables	Economic		Social		Climate and environment		Land resources	
		Kolla	High land	Kolla	High land	Kolla	High land	Kolla	High land
1	Sex of household head			-0.75	0.61				
2	Education			0.74	-0.58				
3	Duration in the area			0.81	0.77				
4	Experience			0.61	0.81				
5	Number of relatives			-0.33	0.60				
6	Extent of dependency			0.41	0.51				
7	Number of institutions			-0.92	0.53				
8	Access to information	0.71	-0.81						
9	Access to extension	0.76	0.49						
10	Livestock ownership (TLU)	-0.52	0.82						
11	Land for perennial crops	-0.41	0.76						
12	Numbers of plots	0.35	0.75						
13	Non-farm income	0.86	-0.57						
14	Amount of crop types	0.71	0.70						
15	Artificial fertilizers	0.92	0.51						
16	Improved seeds	0.60	0.58						
17	Engagement in irrigation	-0.72	0.56						
18	Landholding size	-0.53	-0.57						
19	Deposit(money/food)	0.50	0.63						
20	Extent SWC practices							-0.43	0.48
21	Access to communal grazing							-0.42	0.18
22	Access to natural forests							-0.51	-0.16
23	Competition on resource							-0.38	0.15
24	Slope on farm land					0.53	-0.46		
25	Vegetation cover					-0.51	0.64		
26	Natural fertility of land					-0.63	-0.70		
27	Natural hazards					-0.64	0.62		
28	Rainfall condition					-0.58	-0.57		
29	Temperature condition					-0.46	-0.57		
30	Wind condition					0.43	-0.18		

Source: Field survey, 2020

Table 4. Effect difference of vulnerability components along case studies

Vulnerability Component	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2 tailed)	Mean d/c	Std. Error D/c	95% Confidence Interval of the Difference	
								Lower	Upper
Economic	0.22	0.65	-0.21	22.0	0.83	-0.05	0.25	-0.57	0.46
Social	13.9	0.15	-1.54	12.0	0.02*	-0.35	0.22	-0.84	0.14
CEF	0.04	0.84	-0.31	12.0	0.76	-0.09	0.29	-0.72	0.54
LNR	1.14	0.33	-13.3	6.0	0.00**	-0.79	0.05	-0.93	-0.64

Equal variance is assumed for significant variables

Source: own computation: Survey, 2020

Table 5. Comparative factors analysis of vulnerability components

1. Independent sample t-test for case units				
Cases	Economic M, (SD)	Social M, (SD)	CEF M, (SD)	LNR M, (SD)
Anger valley	.27(.58)	.42(.58)	-.32 (.05)	-.44(.58)
Highland	.32(.62)	.77(.12)	-.27 (.57)	.35(.11)
2.Component correlations along case units				
Anger valley		Highland		
	Economic	Social	CEF	LNR
Economic	-0.17			
Social	0.57*	-0.22		
CEF	-0.96**	0.10	-0.20	0.86**
LNR	-0.12	-0.19	0.32	0.05

Level of significance for (**) p<.001 and (*) for p<0.05
M, (SD)= Mean and Standard deviations
CEF=climate and environmental factors; LNR= land and natural resources

Source: Field survey, 2020

However, climate variability was not explained as the main livelihood stressor in kolla unlike highland discussants. Although, land and natural resources mainly communal forests and grazing are the decisive livelihood assets in kolla than any other agroecological zones in the area, access to these resources have been reduced due to state interventions in various time including the current policy prefers for large scale agricultural investments. The discussants claim that 'development' induced state interventions for resource utilizations have long history in the kolla agroecology from 1970's of Dutch's large scale farm introductions, socialism-oriented state farm in the late 1975 and recent large scale private investments. These conditions have been exacerbating their vulnerability through a number of its adverse. The tenure insecurity, diminishing agricultural land and lack of access to natural resource such as forests and grazing land for economic and no-economic purposes were explained as the direct impacts of these processes.

The processes are discouraging that discussants in the kolla explained that most of small-scale farmers have no interest to stay over the area. The shift from agriculture and natural resources-based livelihoods to what they explained as 'quotidian' based income such as daily labourer and non-farm activities were increase sense of unsustainability. For example, the conditions weakened the systems they believed as vital for sustainable livelihood strategies such as productions of perennial crops,

livestock rearing and irrigations, less in agricultural land conservations, and increased sense of over-utilizations of natural resources utilization and less on conservations/ and protections. The social interactions within the agroecology/and with surrounding highland have been diminished, and withdrawal from social institutions have been increased.

5. Discussion

The study ascertained to assess the simultaneous impacts of climate variability and structural land use dynamics to understand the context specific vulnerability situations, spatial variation in magnitude of household's vulnerability and local level insistent vulnerability factors. The study revealed that the small-scale farmers' households in Anger watershed are vulnerable to the change processes, and the magnitude, causality and subsequent livelihood outcomes are varied among households and the situation showed spatial aspects. The differences in magnitude of vulnerability were the results of disparities in the households' exposure to the stressors, and their internal socioeconomic characteristics. Particularly, sensitivity to lack of access to land resources which have been associated with structural land use dynamics and social adaptability factors were significantly contributed for the vulnerability situations in the watershed.

The observed spatial variations in magnitude of vulnerability, the causalities, and resultant differential vulnerability across case studies revealed that the vulnerability is interactive and inter-connected (Barnett, 2020) in the study area, that such case based structured approach is important to construct the Barnett's 'axes of difference'. Thus, the joined effects of the stressors resulted vulnerable livelihood on those uniquely exposed to the simultaneous effects directly (Simonds & O'Brien, 2018), and indirectly deepened their vulnerability by imposing to unsustainable livelihood systems (Butler et al., 2014) and agitated their social adaptability (Adger et al., 2013), through policies and institutions which merely consider the economic and ecological dependency of local community (Dessalegn, 2011).

Although, the effects of climate variability were observed in both cases, denied access to land and natural resources due to historical state 'development' interventions was unequivocal stressor triggered vulnerability of households in kolla. The process, policies and institutions are relatively continuous and structured in kolla since 1970's; particularly, the recent large scale agricultural investments projects have been shaped the vulnerability through altering ecological, economic and social systems. On top of differential exposure to the stressors, livelihood systems context in kolla witnessed high sensitivity of the community due to the fact that communal resources (forest and grazing) are the decisive livelihood assets than any other agroecological zones in the area.

Besides, the conditions have been indirectly contributed for vulnerability pathways. First, the processes enforced the community to undesired livelihood which they described as 'quotidian' and increased the sense of unsustainability. Second, the continued interventions increased interests for the valley utilizations, unsecured land tenure systems, weakened their plan to stayover the area and hinders sustainable livelihood systems. Thus, the low social adaptability was the indirect consequences of the process in the kolla agroecology. Moreover, inter-community socioeconomic bonds with surrounding highland were weakened due to collapsing ecological ties.

The applied conceptual and methodological approach for this study enables to achieve the objective of the study and will provide insightful evidences and methodology for future research and policy recommendations. First, it implied the need for reflexive conceptualization of vulnerability. Contrary to most of the previous researches on livelihood vulnerability in Ethiopia, this study imply that the concept shouldn't 'fixed to vulnerability to climate change'. Therefore, in line with current research recommendations on the issue (Adger, Barnett, Brown, Marshall, & O'Brien, 2013; Hjerpe & Glaas, 2012; Waters & Barnett, 2018), this research showed the importance to be reflexive in conceptions, manipulating the study contexts and pragmatic methodology to provide comprehensive evidences on vulnerability situations of households encountered with dynamic disturbances, highly sensitivity to stressors hinder their access to immediate resources due to low socioeconomic developments.

Second, these previous studies have limitations in their inadequate focuses on vulnerability factors: households' capacity/ defencelessness (internal situations of 'the vulnerable') and climate change (external stressor), while other site-specific external disturbance are either unnoticed or labelled as internal to a vulnerable (Barnett, 2020). Thus, same to previous research (Leichenko, 2012; McCubbin, Smit, & Pearce, 2015; Mubaya et al., 2012) the study hopes to contribute new insights on assessment of vulnerability by considering structural land use dynamics, explained the process as global change, and labelled as non-climate external stressor. Thus, both constructed global change processes were assessed si-

multaneously through designed methods of analysing the household's exposure-sensitivity to the stressors, and digests on how the process/s are explicated in differential vulnerability. The results of this work revealed that when such non-climate processes are overlooked in area like Anger watershed, it is unlikely to identify insistent vulnerability factors, their interconnections, and difficult to capture the extent by which such processes contribute for or reduce local vulnerability.

Thirdly, the methodological efforts in this study may perhaps comprehensive for the currently endorsed research needs aimed at holistic evidences on local vulnerability. To this end, we have tried to integrate multiple perspectives and methods, to capture an array of issues ranges from model-based examination of vulnerability at household and case study level to construct reality through in-depth exploration of community's concerns on various issues. For instance, the proposed conceptual framework, the designed case-study approach by considering unique issues and processes at case unit, the attempts of case based comparative analysis of the magnitude vulnerability, and critical analysis of complex assemblages of vulnerability factors were helped us to reveal these holistic evidences on the vulnerability situations households in the study area.

Likewise, the study contributes better knowledge for decision-makers regarding the implications that global economy has had on local vulnerability situations of households through pressurizing public policy for 'development' interventions. Indispensable policy-relevant insights offered by this study may perhaps on how site-specific non-climate processes unique to an area shape the vulnerability of a given community over time, on top of the impacts of climate variability. Thus, this study hopes to bring attention to the need for better integrating development policies in general, and national adaptations program to climate change in particular with the goal of reducing local vulnerability to such global environmental processes- in our case the impacts of structural land use dynamics. Moreover, the results call up on policy that are designed to fortify large scale agricultural investments as strategies for development should have equally consider a plan to achieve win-win relationship between the investments and local poor.

Generally, granting impacts of climate change on agrarian community now a days, attributing small-scale farmers vulnerability to climate change and to the 'vulnerable' internal capacity without understanding local specific external stressors is awkward. Thus, research and policy toward rural development should not to consider these processes in isolation, rather their combined effects are vibrant mainly in areas like kolla of Anger watershed. The applied methodology has potential to comprehend vulnerability to global environmental changes, particularly in considering the spatio-temporal aspects of the processes to examine vulnerability situations at household level, portray spatial differences in extent of vulnerability, and characterize vulnerability factors.

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Conflict of Interest

The authors declared no conflicts of interest.

Annex: vulnerability index along case units for each variable (normalized PCA score using mean and standard deviation)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Kolla	-0.09	0.07	0.08	0.06	-0.07	0.05	0.09	0.06	0.07	-0.07	-0.08	0.07	0.08	0.06	0.09
High land	0.05	-0.03	0.08	0.07	0.11	0.09	0.05	-0.48	0.07	0.10	0.09	0.11	-0.36	0.14	0.02
Variable	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Kolla	0.06	-0.08	-0.07	0.05	-0.08	-0.08	-0.09	-0.07	0.04	-0.09	-0.10	-0.10	-0.10	-0.08	0.03
High land	0.06	0.08	0.10	0.15	0.12	0.07	0.11	0.10	-0.15	0.22	-0.21	0.21	-0.15	-0.24	-0.30

Note: Refer Table 1 above for the variables name represented by the numbers

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