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Community Livelihood Vulnerability to Climate Change in Ileje District, South-Western Tanzania

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Abstract

Community livelihood assets are important in enhancing household adaptive capacity and resilience to the impact of climate change. This paper examined the vulnerability of community livelihood assets to the impacts of climate change using Ileje District, in south-western Tanzania as a case study. Random sampling was used to select four villages, out of which two villages were sampled from midland and two from highland established agro ecological zones, constituting a total sample size of 308 households. Descriptive statistics was used in data analysis generated from household interviews. A balanced weighted average approach was performed to calculate households' livelihood vulnerability index (LVI). The results showed that climate change impacted the livelihood assets of households; and more so on social, physical and financial capital; with LVI of 0.7, 0.4, and 0.4, respectively. Households' incomes, land and water productivity, biodiversity, soil fertility and water flow from water sources were reduced; household health and employment opportunities were impacted; whereas households' food shortage and poverty increased. The results also revealed the adaptive capacity index of 0.35 (overall), 0.34 (midland zone) and 0.36 (highland zone), indicating the study area to be moderately vulnerable to climate change. This paper argues that assessing the magnitude of climate change impacts on households' livelihood assets is strategic for sustainable adaptation to climate changes as it guides policy makers and planners on appropriate management measures. Similarly, increasing the access of livelihood assets to the more vulnerable households is vital for sustaining their livelihoods.

Key words: *climate change, , livelihood, livelihood assets, vulnerability, Ileje District*

1.Introduction

Climate change is experienced in different parts of the world. The period 2011 - 2020 was the warmest decade on record, with global average temperature of about 1.2°C above the pre-industrial (1850-1900) level (WMO, 2021). Also, climate change indicators and impacts have worsened. Furthermore, the IPCC (2018) reported a global warming of 1.5°C above the pre-industrial

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levels. Generally, climate change has been experienced in different sectors impacting significantly food supply and security, water availability, infrastructure and agriculture, thus threatening peoples' livelihood assets (IPCC, 2019; Thakur & Bajagain, 2019). Livelihood assets are tangible and intangible assets that allow individual and households to meet their basic needs (Frankenberger et al., 2012). They are the basis on which livelihoods are built, and natural resources are of particular significance as a source of livelihood for the rural poor.

Many studies on climate change impacts and livelihood assets have reported poor rural households to be more vulnerable to the impacts of climate change (Olsson et al., 2014; Alamet al., 2017; Thakur & Bajagain, 2019; Zacarias, 2019). Vulnerability is the degree to which a system is susceptible to adverse effects caused by a specific hazard or stressor (IPCC, 2014).It is a function of exposure, adaptive capacity, and sensitivity (Frankenberger et al., 2012).

It has been argued that the vulnerability of rural households depends on access to, and use of, livelihood assets, and therefore perceived impacts are broadly characterised based on capital assets on which a households depends (Alam et al., 2017). The impacts of climate change on households' livelihoods and resources are resulting in an increased sense of vulnerability. Though many plans, policies, and strategies have been prepared and implemented, they have been inadequate (Thakur & Bajagain, 2019).

The identification of vulnerable hotspots and understanding the process and roots of vulnerability so as to govern, allocate and prioritize resource distribution are prime concerns for policymakers (Pandey et al., 2017). As it has been asserted by Alam et al. (2017), understanding the magnitude of the impact of climate change on livelihood capital will enable policy makers to identify appropriate intervention strategies, and thus assist households to build up their livelihood assets and become more resilient.

Literature has reported the magnitude of the impacts of climate change on peoples' livelihood assets for informed decision-making (Lamichhane, 2010; Lal, 2014; Piya et al., 2012; Pandey et al, 2017; Zacharias, 2019). Nonetheless, households are impacted differently by climate change due to difference in the ownership of livelihood assets.

Africa has been identified as a region that is profoundly affected by climate change. FAO and ECA (2018) state that adverse climate conditions have led to a decline in Africa's agriculture, which is important for future youth employment; and has also threatened food security as food insecurity is negatively affecting health, ,and nutrition and disrupt or destroy peoples' livelihoods. The high vulnerability of African agriculture to climate change is associated with heavy reliance on rain-fed systems. Tanzania, like other African countries, has experienced changes in the trends and patterns of climate that have impacting peoples' livelihoods (URT, 2006, 2016; Kihupi et al, 2015; Kangalawe et al, 2016; Mkonda & He, 2017). In the southern highlands particularly Mbeya region and Songwe region, where Ileje district located has be reported to experience an increase in temperature (URT, 2008; URT, 2016).

Generally, the majority of rural people have limited access to assets and possesses low adaptive capacity (Kangalawe & Lyimo, 2013) which require enhancement of social ecological sources of resilience. According to the UNDP's statistical update report of 2018, Tanzania is in the low human development category; positioned at 154 out of 189 countries and territories, and scoring a human development index (HDI) value of 0.538 in the year 2017.This indicates how the country is vulnerable to climate change given also that the vast majority of the population's livelihoods are dependent on climate-change sensitive agriculture.

Most initiatives on climate change adaptation are silent on adaptive capacity, which is a significant aspect in creating and maintaining resilience (Norris et al. 2008 in Nyamwanza, 2012). Even agricultural policies have only lightly addressed and enforced the implementations of adaptation strategies to reduce climate change impacts and vulnerability (Mkonda & He, 2017). For example, livelihood assets in Ileje district have been threatened by the impacts of climate change (Bamwenda et al., 2015). This necessitates the determination of the magnitude of the impacts of climate change on livelihood assets for appropriate management. It is in this regard that this paper quantifies the magnitude of the impacts of climate change on household's livelihood assets for informed decisions in the endeavour to sustain adaptation to the impacts of climate change in Ileje district, and other areas with similar geographic conditions.

2.Context and Methods

2.1 Study Area

The Ileje district lies between latitudes 9°14'and 9°37' south, and longitudes 32° 80'and 33° 45'east. Figure 1 shows the location of the four study villages: Yenzebwe, Iwala (midland zone), Kalembo and Makoga (highland zone). It is bordered by Kyela, Mbeya rural, Mbozi, Momba and Rungwe districts to the east, north, north-west, west and north-east, respectively. The Songwe River in the south marks the boundary with the Republic of Malawi. The district covers an area of 1908km^2 which is divided into two agro-ecological zones: (Highland, and Midland)(URT 2013).

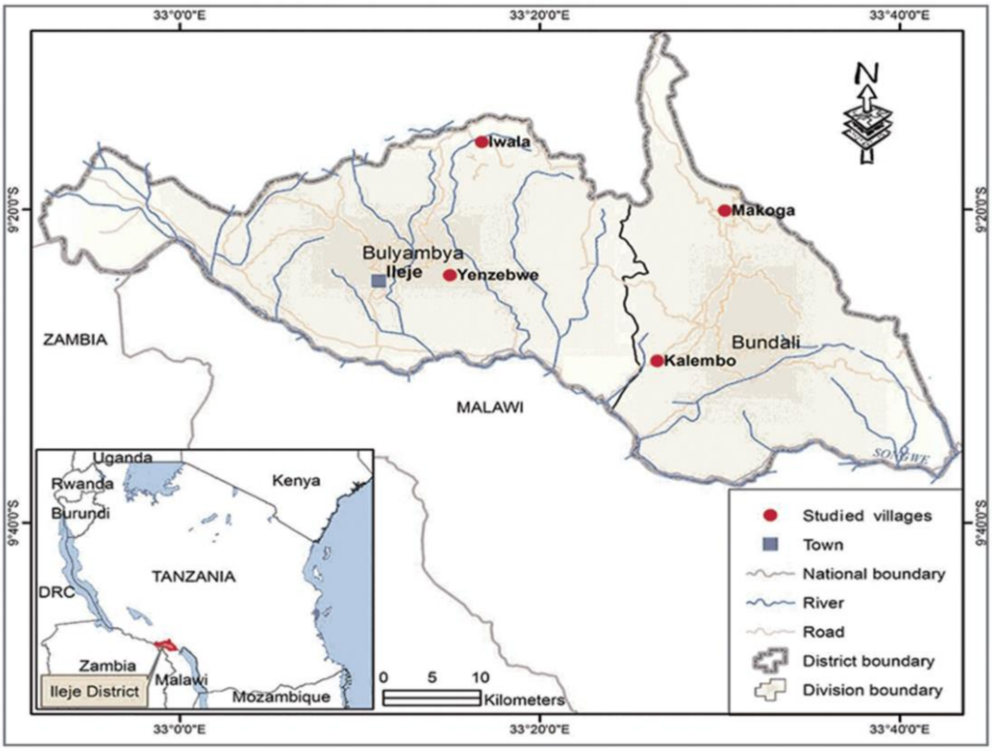

Figure 1: A Map of Ileje District Showing the Location of the Study Villages

Agriculture is the main source of livelihood in the district (Bamwenda et al., 2015), and main economic activities are farming and livestock keeping. The main crops grown are maize, round potatoes, wheat, pulses, finger millet, sunflower, pyrethrum (*bulambya*), maize, cassava, banana, yams, sweet potatoes, pulses, coffee, cardamom, and garlic (*bundali*).

The district's topography is undulating with wide plateau, and slopes with elevations ranging from less than 1,300m to 2,500m above sea level (URT, 2016). Rainfall ranges from 750mm to 2000mm, and starts from November to April, except in Bundali highlands where it ends in June (URT, 2006). Temperatures range from 16°C to 32°C, and soils vary from clay to poor sandy. The 'natural' vegetation is evergreen forest and tropical savannah, open woodland at higher and lower elevations, respectively. Forests cover 14,651.6ha, equivalent to 7.6percent of the total land area. Ileje district is endowed with perennial rivers and 1,016km^2 of arable land, out of which 104,000ha are suitable for agriculture (Bamwenda et al., 2015). It has a total population of 124,451 and 31,113 households (URT, 2013).

2.2 Sampling Approach and Data Collection Methods

Four villages were randomly selected, two villages from each of the two agro ecological zones (midland and highland zones) to capture the differences in zones regarding households' characteristics, livelihood assets, and impacts of climate change faced. Secondary and primary data were collected through household survey and literature review, respectively. Secondary data were obtained mainly through review of various relevant literature, including books, journals, official government reports and other published and unpublished materials from various sources, including the internet. In addition, meteorological data including rainfall and temperature were obtained from the Tanzania Meteorological Agency.

Primary data was collected through focus group discussion, key informant interview and participatory field observation. In every study village one focus group discussions (FGDs)was conducted to obtain additional information that supplement the data gathered through other data collection techniques such as the questionnaire and key informant interview. The FGDs involved both young and older people, both female and male. These were selected through collaboration with village officers to identify the participants who are knowledgeable to the issue understudy. Household survey questionnaires were employed to collect data from household heads or their representatives. Structured questionnaire of both closed and open ended questions were used to collect both quantitative and qualitative data from household respondents

A total of 308 households were selected from the 4 (four) randomly selected study villages using formula (1) as provided by Israel (1992):

$$n = \frac{N}{1 + N(e)^2} \qquad (1)$$

Where n=sample size, N=population size for households in the sampled villages (1403); and$e$= the level of precision (0.05).

2.3 Data Analysis and Presentation

Qualitative data were analysed through content analysis method and where necessary responses were written word verbatim. Quantitative data from the household questionnaire survey were coded and entered into the Statistical Product and Service Solutions (SPSS IBM Statistics, 20 edition) whereby descriptive statistics was used in data analysis where .means, frequencies, and percentages used to summary the results. The results were presented in the form of figures, tables, and charts. A balanced weighted average approach was performed to calculate the index for livelihood vulnerability. Multinomial logit (MNL) used to analyse non-climatic factors that accelerate the impacts of climate change.

2.4 Analytical Framework

The livelihood vulnerability index (LVI) was calculated according to Lamichhane (2010) to indicate the magnitude of the impacts of climate change on Ileje households' livelihood assets. The purpose was to determine the most vulnerable assets which may assist during planning processes to build peoples' adaptive capacity to climate change. The IPCC-VI used to assess the community's vulnerability to climate change (Suryanto & Rahman, 2019; Zacharias, 2019).

A balanced weighted average approach was performed to calculate the index for livelihood vulnerability. The selected vulnerability indicators (Table 2) were first standardized to ensure indicators are comparable, and then each variable was normalized to the range of values in the data set by applying formula (2) used to calculate the life expectancy index as derived in the UNDP (2007):

$$\text{Index} = \frac{\text{Observed value} - \text{minimum value}}{\text{Maximum value} - \text{minimum value}} \qquad (2)$$

The range of LVI lies between 0 and 1. Zero (0) denotes that the variable (indicator) component is not vulnerable, and 1 denotes that it is highly vulnerable. Inverses of variables -- such as education, life expectancy, and crop diversification -- were used to provide values that would tend to be more or less zero (0), meaning less vulnerability; otherwise, the values would be 1 or above, which would mean more vulnerability. Inverses were calculated using formula (3):

$$\text{Index Inverses} = \frac{1}{1 + \text{observed index}} \qquad (3)$$

Regarding variables that were measured in percentages (of respondents), the minimum value was set at 0, and the maximum at 100.

IPCC-VI was calculated by deploying the IPCC's definition of vulnerability with formula (4):

$$\text{IPCC} - \text{VI} = [\text{Exposure index} - \text{Adaptive capacity index}] \times \text{Sensitivity index} \qquad (4)$$

IPCC-VI varied from -1 to +1, where -1 denotes least vulnerable (adaptive capacity is more than exposure); 0 denotes moderately vulnerable (exposure and adaptive capacity are equal); and 1 denotes extremely vulnerable (exposure is very high than adaptive capacity). The indicators that were used to calculate the LVI were categorized into the IPCC's model to calculate the IPCC-VI. However, indices for components like crop diversification, education, and agricultural livelihood diversification were used instead of inverses since components increase households' adaptive capacity to impacts of climate change. The inverse (life expectancy) was used under sensitivity (for a detailed description of the method see Lamichhane (2010)).

3. Results and Discussion

3.1 Socio-economic Characteristics of the Households

Information from the household's survey gave a respective picture of households' characteristics in the study area. In the study sample (n = 308), the age of households varied between 19 to 86 years (43.7 years on average).This ensured the collection of the wide range of information from the well experienced household.. However, it was reported that respondents over 65 years were more vulnerable on human capital. Only 17.9 percent (n = 55) of the respondents were illiterate. Men dominated the sample (64 percent) (n = 196) and were found to be more vulnerable on human and social capital; whereas females (covering 36 percent (n = 112))were more vulnerable on natural capital. The average household size was 4.86 people; and the majority (62 percent) (n = 190) had household size of between 0–5 people. The average landholding was 2.94 acres; with a majority ((54 percent) (n = 165)) owning 2.1–5.0 acres of land. Households with less than an acre were more vulnerable to financial capital.

3.2 Impacts of Climate Change on Respondents' Livelihoods

The findings revealed that climate change had impacted 36percent of the total respondents. However, people had been differently impacted by climate change due to differences in the ownership of livelihood assets. The impacts of climate change are provided in Table 1.

Table 1:Negative Impacts of Climate Change to Respondents' Livelihoods

Variable	Overall percent	Midland Zone percent	Highland Zone percent
HH impacted by CC	36.1	27.7	52.0
Reduced incomes	26.6	31.1	23.0
Increased food shortage and poverty	23.1	17.1	28.2
Reduction in productivity	22.3	22.6	22.0
Reduction in natural capital	16.3	18.6	14.5
Reduction in biodiversity	6.5	2.4	10.0
Reduction in human capital	1.9	3.0	0.9
Reduced employment	1.9	4.1	0
Interfering fishing activities	0.3	0	0.5
Others	1.1	1.1	0.9
Total	**100**	**100**	**100**

Source: Field Survey, 2017

According to the respondents, increases in temperature and decreases in rainfall negatively affected farming and other socio-economic activities, and thus households' livelihoods. Aspects reported to be affected by the changes included incomes (26.6 percent), food (23.1 percent), land productivity (22.3 percent), natural capital (16.3 percent) and human capital (1.9 percent) as well as biodiversity (6.5 percent).

Households' Reduced Income

About 82 percent of households in the study area depended on agriculture to earn their incomes by selling crops (cash and food) and livestock. Business, mining and employment were other activities undertaken for the same. The increased impact of climate change negatively affect crop production where farmers get less yield and consequently reduce their income accrued from crop sales. Similarly increased occurrence of pests and diseases due to among other factors climate change damage crops as well as increasing animal mortality, consequently reduced crop yields and livestock production/development.

Human Capital

Limited households' access to health and education (knowledge) services and employment opportunities reduced the quality of the households' labour force that eventually affected their livelihoods. Households were limited to access health centres but also meeting places where they share knowledge due to damaged roads and poor transportation system. They were also limited to agricultural labour opportunities as agriculture was affected by climate change. Therefore, human capital in terms of health, knowledge and labour was affected by climate change.

Reduced land Productivity in the Study Area

Climate change reported to affect the natural capital, for instance, land as it reduced productivity of crop land and rangelands. Increased evaporation rates of soil moisture and water bodies and evapotranspiration rate of plants reduced land and livestock productivity. Flowering stage of coffee and cardamom crops were reported to be affected but also bean seasons interrupted. As farmers of Highland zone reported climate changes to hinder flowering of some crops including cardamom, banana, and coffee. Also limited application of agricultural inputs including fertilizers, pesticides and improved agricultural seeds emanated from reduced households' income led to the same. Nonetheless, rotting of crops due to heavy rains (El Niño) reduced crop yields. The above increased not only households' food shortage but also poverty**.**

Definitely, selling food crops led to reduced food availability and increased poverty especially for poor households. . Climate change also increased occurrence of landslides and soil erosion and hence reduced soil fertility. Similarly, it reduced water availability from water sources that limited access water for domestic and agricultural uses. Pasture availability was affected by climate change both in quality and quantity that negatively influenced livestock production. As IISD (2003) state that climate changes will both directly affect crop yields and will produce changes to ecosystem distributions and species ranges. Impacts of climate change reported correspond with what observed by Mkonda and He (2018) in Tanzania and elsewhere in Africa (Zacarias, 2019).

3.3 Impacts of Climate Change to Households' Livelihood Assets

The perceived impacts of climate change were characterized based on the capital assets on which the household livelihood depends. Using Resilience Assessment Framework that considers capital and capacity of the households [After Frankenberg et al. (2012)] the Livelihood Vulnerability Indices for livelihood assets (Human, Natural, Social, Financial, Physical and Political) were calculated using a balanced weighted average approach adopted from Lamichhanes' (2010) work as already explained on section 2.4 of this document. Results indicated livelihood vulnerability indices of 0.4 (Overall), 0.41 (the Midland zone) and 0.39 (the Highland zone) (Figure 2 and Table 2).

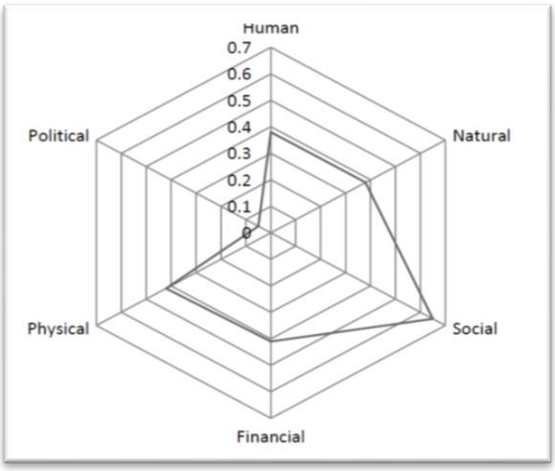

Figure 2a: Overall Vulnerability Radar Diagram of 6 Livelihood Assets

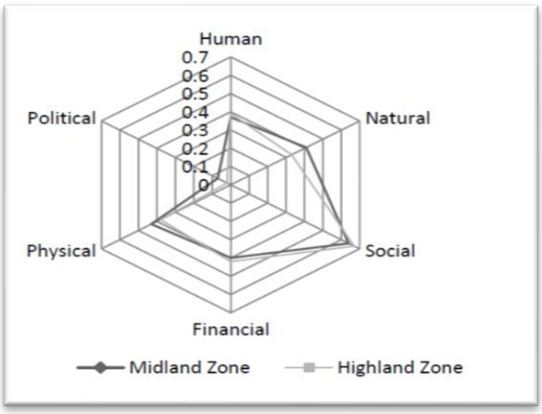

Figure 2b: Vulnerability Radar of 6 Livelihood Assets by Zone
Source: Field Survey, 2017

Table 2: Livelihood Vulnerability Index – 6 Capitals, 13 Components and 52 Contributing Factors For Vulnerability in the Study Area

Capital	Component	Sub-component	Unit	Overall VI	Midland VI	Highland VI
Human	Health	% of HHs where a family member had to miss work or school due to illness in past one month	Per cent	0.026	0.02	0.0378
		% of HHs where a family member is infected by a communicable disease	Per cent	0.036	0.035	0.038
		Average time to nearest health centre	Minutes	0.5	0.56	0.382
		Inverse of Life Expectancy	Years	0.577	0.577	0.577
	Health Vulnerability (A)				**0.298**	**0.259**
	Food	Average food insufficient months	Months	0.07	0.054	0.1
		Inverse of crop diversification index	1/1+Crops	0.85	0.92	0.74
	Food and Nutrition Vulnerability (B)			**0.46**	**0.487**	**0.42**
	Knowledge and Skills	Inverse of education index	Number	0.694	0.694	0.694
		No. of adults with formal education	number	0.35	0.34	0.38
		Years of education HH head	number	0.38	0.36	0.379
		% of HHs that do not access weather information	Per cent	0.11	0.134	0.067
		Average time to Agricultural/Veterinary centre	Minutes	0.461	0.428	0.52
		% of HHs where no member has attended training on farming	Per cent	0.464	0.326	0.727
	Knowledge and Skills Vulnerability (C)			**0.410**	**0.383**	**0.461**
Weighted Average of A, B, C (A1): Human Capital Vulnerability				**0. 376**	**0.370**	**0.387**
Natural	Land	% of HHs reporting land degradation by climate related extremes during past 30 years	Per cent	0.515	0.515	0.122
	Land Vulnerability (D)			**0.38**	**0.515**	**0.122**

Forest	% of HHs using only Forest based energy for cooking	Per cent	0.932	0.98	0.863
	Average time to fetch firewood	Minutes	0.311	0.277	0.375
	% of HHs reporting that firewood is being scarce now in comparison to 30 years back	Per cent	0.617	0.575	0.698
Forest Vulnerability (E)			**0.620**	**0.609**	**0.645**
Water	% of HHs reporting they have heard any conflict over water in the community	Per cent	0.104	0.148	0.0174
	% of HHs that collect water directly from river, streams, pond	Per cent	0.764	0.813	0.692
	% of HHs that do not have daily water supply	Per cent	0.091	0.128	0.017
	Average time to fetch water	Minutes	0.224	0.261	0.153
Water Vulnerability (F)			**0.3**	**0.338**	**0.22**
Climate Variability and Natural Disasters	Average number of floods during last 30 years	Count			
	Mean standard deviation of mean average Maximum temperature by month	Celsius	0.43	0.43	0.43
	Mean standard deviation of mean average Minimum temperature by month	Celsius	0.38	0.38	0.38
	Mean standard deviation of precipitation by month	Millimetre	0.54	0.54	0.54
	% of HHs reporting death of a family member due to climate related disaster	Per cent	0.019	0.29	0.00
	% of HHs reporting injury of a family member due to climate related disaster	Per cent	0.006	0.009	0.00
Climate Vulnerability (G)			**0.275**	**0.33**	**0.27**
Weighted Average of D,E,F,G : Natural Capital Vulnerability (A2)			**0.382**	**0.41**	**0.330**

Social	Demography	Dependency Ratio	Ratio	0.924	0.924	0.924
		Average family member in a HHs	Number	0.351	0.365	0.325
	Demographic Vulnerability (H)			**0.637**	**0.644**	**0.624**
	Network and Relationship	% of HHs that have not been assisted this season by relatives/friends in face of impacts of climate change	Per cent	0.734	0.7027	0.7936
		% of HHs that have not provided any support/help to friends/neighbour impacted by climate change	Per cent	0.321	0.313	0.34
		% of HHs that have not gone to local government for any kind of assistance in past 12 month	Per cent	0.971	0.960	0.99
		% of HHs where a family member is not affiliated with any organization	Per cent	0.607	0.599	0.622
	Network and Relationship Vulnerability (I)			**0.658**	**0.644**	**0.686**
Weighted Average of H and I : Social Vulnerability (A3)				**0.651**	**0.644**	**0.666**
Financial	Assets	Inverse of Average land holding	Acre	0.83	0.81	0.8754
		LSU	Units	0.195	0.2	0.187
	Assets Vulnerability (J)			**0.513**	**0.505**	**0.531**
	Finance	Inverse of income index	Number	0.59	0.59	0.59
		Total savings	Tshs	0.067	0.066	0.07
		Non-farm incomes	Tshs	0.032	0.026	0.043
		Total income	Tshs	0.152	0.146	0.084
		Agriculture income	Tshs	0.119	0.114	0.128
		% of HHs that have no access to any financial institution	Per cent	0.955	0.956	0.954
		% of HHs that have not received any financial assistance or subsidy for farming from the government	Per cent	0.325	0.297	0.378
		% of HHs that has no any family members working outside the village for high earnings	Per cent	0.844	0.703	0.886
	Financial Vulnerability (K)			**0.411**	**0.362**	**0.392**

Weighted Average of J and K : Financial Capital Vulnerability (A4)				0.41	**0.391**	0.42
Physical	Infrastructure	Average time to reach nearest road	Minutes	0.356	0.3	0.379
		% of HHs not accessing tap water	Per cent	0.832	0.921	0.698
		% of HHs not receiving security information	Per cent	0.026	0.029	0.017
		Average time to nearest market centre	Minutes	0.489	0.483	0.5
		Average time to nearest school	Minutes	0.411	0.419	0.4
Physical Capital Vulnerability (A5)				**0.42**	**0.428**	**0.382**
Political	Political issues	% of HHs not attending meetings	Per cent	0.019	0.029	0.0
		% of HHs that have no voice in decision making	Per cent	0.088	0.12	0.029
		% of HHs not voted in election	Per cent	0.045	0.064	0.009
Political Capital Vulnerability (A6)				**0.051**	**0.071**	**0.019**
Livelihood Vulnerability Index (Weighted average of A1, A2, A3, A4, A5, A6)				**0.402**	**0.409**	**0.389**

Overall vulnerability to climate change was found to be moderate with a score of Livelihood Vulnerability Index of 0.4 (Figure 2a; Table 2). The scale for LVI is 0 to 1, where 0 indicates least vulnerability of the area and 1 indicates the area to be highly vulnerable.

Specifically, households were more vulnerable on social capital with a score of LVI of 0.65 but moderately vulnerable to physical, financial, human and natural capitals indicating LVI of 0.42, 0.41, 0.38 and 0.38 respectively. However, households were less vulnerable to political capital with a score of LVI of 0.05.

3.2.1 Vulnerability in Terms of Social Capital

Households in Ileje district were found to be more vulnerable on social capital (LVI of 0.65). Literature reported peoples' vulnerability to social capital (Olsson et al., 2014; Alam et al., 2017; Zacarias, 2019) due to households not being member of any organization, eroded institution, disruption of informal social networks between households and limited organizations. Results revealed that high dependency ratio (LVI of 0.93) possibly increased household's vulnerability in the study area. As Piyaet al. (2012) assert that high dependency ratio had more burdens on the earning members that reduced household's adaptive capacity to climate change in the Mid-Hills of Nepal. Further, limited network and relationship (LVI of 0.7) possibly contributed to vulnerability on social capital.

A total of 97 percent, of households reported that they have not gone to local government for any kind of assistance in the past 12 month, 73 percent have not been assisted by relatives/friends in face of impacts of climate change during the season, and 61 percent family member was not affiliated with any organization indicating the limited network and relationship hence vulnerability to climate change. As Zacarias (2019) report that a large part of the households in Inhambane municipality of Mozambique were not belonging to community organizations or groups, which in turn increased their vulnerability as the social relations of mutual assistance between family and other community members were almost non-existent.

Alamet al. (2017) also note that limited cooperation between farmers' groups and inadequate organizations increased vulnerability on social capital in Bangladesh. Further, it has been asserted that organizations and institutions increase households' incomes; awareness creation, information; building capacity and creating an enabling environment (Aboniyo & Mourad, 2017). Yet Non-Governmental Organizations (NGOs) provide valuable outside support by reaching indigenous peoples for actions and decision-making (Kronik & Verner, 2010) including climate change. However, the study area had few organizations and inadequate institutions as there is only one NGO, 11 Community-Based organizations social groups and 2 (two) religious groups existed. Therefore, increasing the number of organizations and institutions might reduce households' vulnerability to climate change by increasing information on the changes and households' assistance in case of difficulties in the study area.

3.2.2 Vulnerability in Terms of Physical Capital

The results also indicated that households were vulnerable to physical capital (LVI of 0.42). This has been due to damage of infrastructures and households' properties (Alam et al., 2017; Thakur and Bajagain, 2019; Zacarias, 2019). In the study area it was due to limited infrastructures including water supply system (tap water), market and health centre. The 83 percent of the households used spring or river water that increased vulnerability because a few numbers of boreholes most non-operational. It has been argued that using water directly from spring or river increases vulnerability due to water borne diseases but also reduces the coping range of actors (IPCC, 2014).

It was further revealed that no health centre (LVI of 0.5) existed in the study area except dispensaries. Households had to spend more than two hours to go either to Itumba or Ibaba or Isoko (for the Midland zone) or Tukuyu or Igogwe Hospital (for the Highland zone) to get health services. Similarly, Alam et al. (2017) report that residents of Bangladesh have to travel a longer distance (more than 2.5 km) to reach the health centre and hence access to health services is one of the limiting factors of enhancing resilience of households.

Also, there was no any recognized market (LVI of 0.5) infrastructure found in the study area. Households had to go to either Itumba or Ilembo or Iwiji (for the Midland zone) or Ibungo or Ikuti in Rungwe District in Mbeya Region (for the Highland zone), which took them more than two hours to get there. Otherwise, households depended more on open markets organized in their respective villages. Limited access to markets affected households in building their adaptive capacity to climate change. Availability of water supply system, market and health centres in the study area will decrease households' vulnerability to climate change. As it has been argued that availability of infrastructures close to dwelling will increase households' access to information, inputs and resources which will help to absorb shocks and decrease the vulnerability (Lal, 2014).

3.2.3 Vulnerability in Terms of Financial Capital

Households were found to be vulnerable to financial capital (LVI of 0.41). Financial capital vulnerability is associated with losses of farm income, increased costs of living, inadequate transportation system to access credit facilities and market centres (Alam et al., 2017; Zacarias, 2019). This study found 95 percent of households had no access to any financial institution. Only 7 Village Community Bank (VICOBA), one Savings and Credit Cooperative Society (SACCOs) existed and a few households were assisted by Tanzania Social Action Fund (TASAF) in the study area. This indicated how households were limited to access credit services.

It was also revealed that 84 percent of households had no any family members working outside the village for high earnings. Moreover, the study found vulnerability index of 0.83 on average land holding. Yet reduced crop yields also affected households' incomes (LVI of 0.6) since their main sources of income were obtained through sales of agricultural products. As Zacarias (2019) asserts that lack of access to financial resources and the absence of households residing in more developed spatial realities, inhibits the community's ability to add value and ensure greater resilience in case of natural disasters as communities are largely dependent on the natural resources.

3.2.6Households' Vulnerability by zones

Comparatively, the Midland zone was found to be more vulnerable (LVI of 0.41) than the Highland zone (LVI of 0.39). The former suffered more on physical and natural capitals as it scored LVI of 0.43 and0.38 whereas the latter scored LVI of 0.41 and 0.33 respectively (Figure 2b); Inadequate and/or absence of dispensaries in some villages in the Midland zone were the possible reason for vulnerability to physical capital. Households had to get health services at Itumba hospital, more than two (2) hours to get there.

Regarding vulnerability to natural capital, literature associate it with reduced water availability, soil quality deterioration, reduced pasture availability, land loss and degradation (Lamichhane, 2010; Piya et al., 2012; Olsson et al., 2014; Alam et al., 2017; Pandey et al, 2017). However, this study found vulnerability to natural capital (0.38) because 93 percent, , of households found using only forest based energy for cooking purpose, 76 percent collecting water directly either from river or streams or pond, 62 percent reported that firewood was being scarce compared to 30 years back.

Further, the mean standard deviation of precipitation by month was found to be 13.3 mm with LVI of 0.54 for the study area. Nevertheless, in the Midland zone households encountered land degradation (LVI of 0.4) possibly because of high rate of deforestation since only 7.6 percent of the area is covered by forest. Deforestation is at increase in the country (URT, 2017) but there is a high deforestation rate in Ileje district (Bamwenda et al. 2015). It has been argued that the poor are more heavily dependent on ecosystem services and therefore most severely affected by deteriorating environmental conditions and factors limiting resource access (IISD 2003).

On the other hand, Highland zone suffered more on social and human capital as it scored LVI of 0.67 and 0.39 whereas the Midland scored LVI of 0.64 and 0.37 respectively. Vulnerability to human capital was attributed by limited knowledge as 73 percent of households reported to have no member attended training on farming in the Highland zone. Nevertheless, vulnerability to human capital was also reported elsewhere (Olsson et al., 2014; Alam et al., 2017; Piya et al., 2019).

Increased access to physical, natural and social, human capital in the Midland zone and Highland zone respectively should therefore be focused for the intention of improving and increasing households' adaptive capacity to build their resilience to climate change. The most vulnerable households' livelihood assets observed should be considered during planning process for building peoples' adaptive capacity to climate change. The concern should be on gender, age, land holdings and marital status of the households. As it has been argued that the analysis of vulnerabilities can help answer where and how society can best invest in vulnerability reduction (Alam et al., 2017; Piya et al., 2019).

3.5 Exposure, Sensitivity and Adaptive Capacity of the System Using IPCC-VI

IPCC-VI model was used to calculate exposure, adaptive capacity and sensitivity of the system. Same livelihood vulnerability indicators used to calculate the LVI were used after being categorized into the IPCC's model as already explained under section 2.4. Basically, the magnitude of impact of climate change depended on vulnerability of respective households, which is mostly influenced by the adaptive capacities they possess; exposure and sensitivity to climate change (Piya et al., 2019). By deploying IPCC-VI formula to assess households' adaptive capacity, findings revealed an index of 0.35 (Overall), 0.34 (the Midland Zone) and 0.36 (the Highland Zone) (Table 3).

Vulnerability being a function of exposure, sensitivity and adaptive capacity, the area was found to be moderately vulnerable to impacts of climate change with a score of IPCC-VI of - 0.02 as IPCC-VI varies from -1 to +1 as per section 2. 4. In addition, the difference between adaptive capacity (IPCC-VI 0.35) and exposure (IPCC-VI 0.29) is (IPCC-VI 0.06) indicating that the exposure faced by households and their adaptive capacity were almost equal and hence moderately vulnerable. However, the sensitivity of the area to climate change was 0.346. Comparatively, the Midland zone was more exposed to impact of climate change than the Highland zone as it scored IPCC-VI of 0.31 whereas the Highland zone scored 0.25. Since it was more exposed to climate change it had less adaptive capacity (IPCC-VI of 0.34) than the Highland zone (IPCC-VI of 0.37) (Table 3). The Midland zone was more sensitive to impact of climate change and other social factors compared to the Highland zone as they scored IPCC-VI of 0.35 and 0.32 respectively (Table 3).

Table 3: IPCC's Components And Contributing Factors for Vulnerability in the Study Area

		IPCC - Vulnerability Index		
		Overall	**Midland**	**Highland**
Exposure	% of HHs reporting land degradation by climate extreme and disaster during 30 years	0.38	0.515	0.122
	% of HHs reporting that firewood is being scarce now in comparison to 30 years back	0.617	0.575	0.698
	% of HHs reporting that they have heard any conflict over water in the community	0.104	0.148	0.017
	Mean SD of average maximum temperature by month	0.43	0.43	0.43
	Mean SD of average minimum temperature by month	0.38	0.38	0.38
	Mean SD of precipitation by month	0.54	0.54	0.54
	% of HHs reporting death of a family member due to climate related disaster	0.019	0.023	0.00
	% of HHs reporting injury of a member climate related disaster	0.006	0.009	0.00
	% of HHs reporting that do not have consistence water supply	0.091	0.128	0.017
Average Exposure Index (EI)		**0.285**	**0.305**	**0.245**
Adaptive capacity	Crop diversification index	0.177	0.087	0.35
	Education index	0.44	0.44	0.44
	% of HHs that access security information	0.974	0.971	0.983
	No. of adult that at least attended P/E (average)	0.35	0.34	0.38
	% of HHs that use tap water	0.185	0.079	0.387
	% of HHs received help/support from neighbour during the past impact	0.266	0.023	0.378
	% of HHs supported and helped to neighbour in the past one month	0.679	0.688	0.66
	% of HHs gone to local government for assistance in the past 12 months	0.029	0.04	0.009
	% of respondents who have voted in 2016 election of leaders	0.955	0.936	0.99
	% of HHs who a family member is affiliated with any organization	0.393	0.401	0.378
	land holdings	0.2	0.23	0.142
	Government credit for farming	0.675	0.703	0.622
	Income index	0.5	0.5	0.5

	Total savings	0.067	0.066	0.07
	Non-farm incomes	0.032	0.026	**0.043**
	Agriculture income	0.119	0.114	0.128
	Total income	0.153	0.147	0.085
	% of HHs who have access to financial services to any financial institution	0.045	0.044	0.047
	Livestock (LSU)	0.195	0.2	0.187
	Irrigated land	0.072	0.032	0.147
	% family member work outside the village	0.156	0.178	0.113
	Dependency ratio	0.924	0.924	0.924
	Average time to nearest health centre	0.377	0.56	0.382
	Average time to reach nearest road	0.356	0.3	0.379
	Average time to reach nearest school	0.411	0.41	0.4
	Average time to reach nearest market	0.487	0.482	0.5
Average Adaptive Capacity Index (AI)		**0.355**	**0.343**	**0.370**
Sensitivity	% of HHs where a family member had to miss work/school due to illness in one past month	0.026	0.02	0.013
	Inverse of life expectancy (0.73) 0.5772	0.577	0.577	0.577
	Average food insufficient months	0.07	0.054	0.1
	% of HHs using forest-based energy for cooking purpose	0.932	0.976	0.863
	Average time to fetch firewood	0.311	0.278	0.379
	% of HHs that collect water directly from river, ponds, spring	0.841	0.925	0.47
	Average time used to fetch water	0.311	0.261	0.446
	Average family member in a HH	0.331	0.365	0.325
	% of HHs where a family member is infected by a communicable disease	0.036	0.035	0.038
	% HHs that do not access security information	0.026	0.029	0.017
Average Sensitivity Index (SI)		**0.346**	**0.352**	**0.323**
IPCC-VI = (EI - AI) × SI		**- 0.024**	**- 0.013**	**- 0.040**

Scarcity of firewood faced by households (62 percent) and rainfall variability (54 percent) were factors for exposure in the community. 93 percent of households that used forest-based energy for cooking, and those (84 percent) collected water directly from river, ponds, spring were influential to sensitivity of the study area.

The accessed security information (97 percent), increased interest in electoral processes (96 percent) and accessed government credit for farming (68 percent) support and helping neighbours (68 percent) influenced households' adaptive capacity. The accessed security information possibly increased households' awareness creation on climate change that played an important role in increasing peoples' adaptive capacity. Increased interest in electoral processes assured the participation of households in the planning processes whereas community knowledge was probably accommodated to manage climate change. Yet the accessed government credit for farming enhanced farmers' awareness on climate change, adaptation decision making as well as planning as it assured farmers to have the information for decision making and the means to take up relevant adaptation measures. Nevertheless, non-climatic stressors reported to increase the vulnerability of the community.

4.3.6 Non-climate Stressors Reported to Accelerate the Impacts

A number of non-climate stressors were reported by respondents to accelerate the impacts (Figure 3) including inadequate farming input and services; limited knowledge for improving productive assets; poor farm implements and production tools; limited technology; and limited provision of social and public services found to be significant having $P < 0.05$.

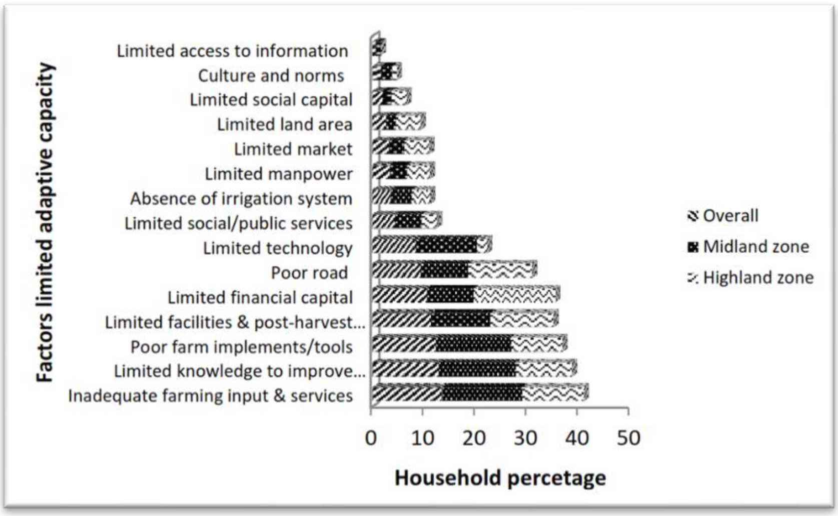

Figure 3: Non-Climatic Factors that Accelerated Impacts of Climate Change in the study Area
Source: Field Survey, 2017

Basically, households in Ileje district were impacted differently by climate change. However, the situation was considered to be exacerbated by non-climate factors. Poor households were more impacted and this is due to limited ownership of livelihood assets. Limited access to assets, for instance in Ileje district led to forest clearing for agricultural production (with particular to finger millet), fuel wood and charcoal making to meet their necessities (see Plate 1). As Olsson et al. (2014) state that poor people depend upon direct use of natural resources for their livelihoods and therefore most severely affected if limited to access them or when the environment is degraded. Deforestation is at increase in potential forest regions, Songwe inclusive, as the estimated rate between 1990 and 2017 was 469,420 hectares per year country wide (URT, 2017).

Plate 1: Deforestation in Yenzebwe Forest (Yenzebwe village) in the Midland zone
Source: Field Survey, 2017

5. Conclusion

This paper assessed and quantified the magnitude of impacts of climate change on household's livelihood assets and determined the non-climate stressors that accelerated the impacts of climate change in Ileje District. It has found that social capital was more impacted whereas political capital was least impacted to climate change. The increased damage and limited access to infrastructures, absence of market structures and a few existing institutions that limited networks and relationship in the area affected households' social and physical capital. Reduced agricultural labour and few existing financial institutions had limited households to access financial capital.

Yet the reduced water bodies, soil fertility, productivity of cropland and rangelands and increased landslides were effects on natural capital possibly caused by high rate of deforestation taking place in the area. In general climate change poses risks for households' incomes and food production; risks for human capital including health, knowledge and labour amplifying food shortage and poverty particularly for poor households. The paper conclude that the magnitude of the impact on livelihood assets will lead to informed decision enabling planners and policy makers to consider appropriate interventions that will build up peoples' livelihood assets and hence become more resilient to climate change.

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