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Analysis of Spatial Variation of Vulnerability to Climate Change and Variability in Kigoma Region, Western Tanzania

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Abstract

This study analyzed communities' vulnerability in Buhigwe and Kasulu districts, Kigoma region -western Tanzania. Study sites and respondents were selected through simple random and purposive sampling methods. Data were collected though household surveys, key informants interviews, and focus group discussions. Quantitative data analysis tools included meteorological statistics software such as Clidata, INSTANT, XLSTAT and SPSS. Findings indicate inter-annual and seasonal variability of rainfall and temperature levels from the normal across the study sites. Study revealed significant increasing trends for mean annual Maximum and Minimum temperature. Major changes in patterns and trends were decrease of seasonal and annual rainfall, unreliable onset and cessation of rainfall, and erratic seasonal rainfall. Maximum decline of seasonal rainfall had slope values of −14.51, while maximum decline of annual rainfall trends had slope values of -12.76. The minimum decline for seasonal rainfall had slope values of -2.17 and annual rainfall trends had slope values of -1.36. Villages in the highland zone were found to be highly vulnerable with 0.61 vulnerability index value. Major climate stress factors for communities' vulnerability included seasonal variability of rainfall and increase of temperature, which had effects on crop production and livestock keeping such as increase of pests and diseases, low agricultural yields and decrease in income. Non-climate stress factors such as landscape characteristics, mobility, inadequate extension services, and low household asset endowment might have been accelerating communities' vulnerability to the effects of the changing climate. Generally, changes in climate condition have been influencing communities' vulnerability. Therefore, given current and uncertainties regarding future climate conditions, concerted efforts are required to enhance adaptive capacity at household and community levels, for the sustainability of communities' livelihoods. Some of the interventions for enhancing adaptive capacity can include early warning systems, post-harvest management, awareness raising, and supporting alternative crop cultivars and animal breeds..

Keywords

Climate change; Vulnerability; Landscape; communities; Western Tanzania

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Introduction

Understanding of vulnerability to climate change impacts is still evolving and has been attracting various studies [1-3]. Vulnerability is largely discussed in relation to the magnitude of susceptibility and exposure to harm or stresses, and how capacity to adapt moderates or reduces chances of the system (Social or ecosystem) being affected [4]. High dependence on climate sensitive sectors such as agriculture and livestock keeping is one of the factors influencing need for many studies in most developing countries, largely to support policy development and decision making processes [4-10]. As a result, most of the vulnerability studies have mainly focused on how local communities' livelihoods are prone to the impacts of the changing climate, sensitive to shocks and stresses and their systems (social or ecosystem) capacities to recover from stresses or impacts [7,11,12] . Tanzania is one of the countries in developing countries prone to the impacts of climate change. The vulnerability of Tanzania to climate change and variability is attributed to various factors. Most of its economic and livelihoods sectors such as agriculture are sensitive to climate conditions and highly inclined to changes in rainfall and temperature patterns. Apparently, availability of adequate information on communities vulnerability to climate change impacts has been relatively difficult, largely due to spatial and temporal variations of resource endowment, inherent adaptive capacity of human system and vulnerable conditions, and absence of single methodology to achieve robust information that suits policy development and decision making processes [1,7,12,13]. Therefore, these functional and interconnected factors motivated undertaking locational and context specific study in order to contribute to the scientific debate on the spatial variations of vulnerability in Kasulu and Buhigwe districts, western Tanzania. We applied mixed method approach in order to capture diversity of attributes for communities' vulnerability. In particular, the paper analyzed climate and non-climate factors that influence vulnerability relative to landscape characteristics (i.e. lowland and highland) [1].

Methodology

Study area

This study was conducted in Kasulu and Buhigwe districts of Kigoma Region (Figure 1). The study districts are located between latitude 4° 34´S and Longitude 30° 6´E. They are largely characterised by lowlands (Up to 1200 m above mean sea level) and highlands (Up to 1800 m above mean sea level) landscapes, which intersect in various agro-ecological characteristics and influence socio-economic activities, demographic and biophysical resources[14-16]. The highland and lowland intersections was among the reasons that attracted this study in order to analyse spatial and temporal attributes of communities vulnerability to the impacts of climate change [1].

Sampling design

Both probability and non-probability sampling procedures were used to obtain study area and the sample for the study [17]. Non-probability techniques were used to select study wards across the study area and study villages in the lowland transect. Study villages in the lowland transect were selected purposively in order to obtain relevant villages for the study, while villages in the highland zone were selected

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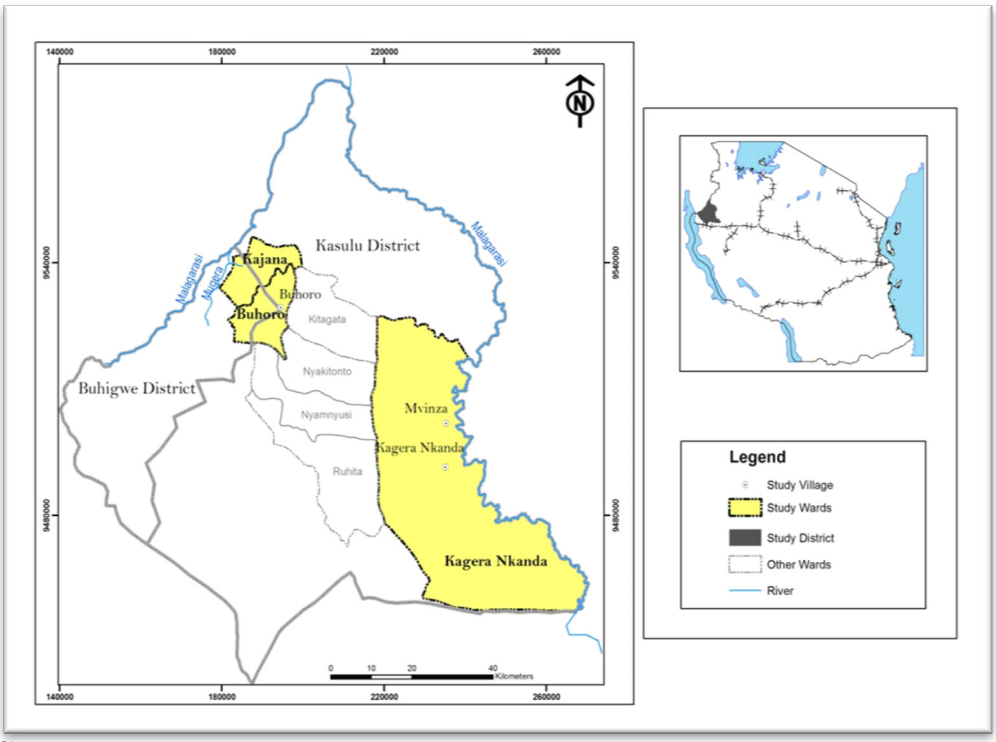
randomly due to wide range of relevant villages that could be selected for the study. A total of four villages, two from highland transect and two from lowland transect were selected for the purpose of this study. Major consideration in the selection of study villages included landscape characteristics (lowland and highlands) relative to indication of climate change and variability, and interdependences between the highlands and lowland zones. Two villages, Kajana village in Kajana ward, Buhoro village in Buhoro ward, were selected randomly from highland transect. Mvinza and Kagerankanda villages in Kagerankanda ward in the lowland zone were selected purposively (Figure 2).

Respondents included key informants, focus group discussion participants and members of household from the government, non-governmental organizations, and villagers. Key informants and focus group discussion participants were selected purposively, while household survey respondents were selected randomly in order to obtain representative sample by giving equal chance to all units in the population to be included in the study [18]. Random selection of respondents aimed to achieve a minimum sample size of 10 % of total households in each sample village (Table 1). The selection of a minimum sample size of 10 per cent of households within each sample village presupposed the representation of the households in the selected villages [19].

In this study, key informants were considered as those people who are skilled or semi-skilled and have knowledge about the specific themes of the study as well as specific characteristics of the population being studied [20]. These included regional, district and ward level officers for forest, land, water, wildlife, livestock, agriculture, community development, cooperatives, village and ward executive officers, and ward councilors. Other key informants were drawn from non-governmental organizations. Focus group discussions (FGDs) participants were selected among the village government leaders (Village chairpersons), village environmental committees' members and sub-village chairpersons. FGDs were intended to obtain information that complements household survey datasets.

Data collection methods

Secondary data were collated from published and unpublished sources and analyzed to enrich primary data from the field. Secondary data were obtained using remote sensed data, meteorological records and documentary reviews. Meteorological data covered a period of 30 yr from 1984 to 2014. Primary data were collected through questionnaire, focus group discussions, key informants interviews, and direct field observation techniques. The use of questionnaire for household surveys considered that most studies on vulnerability rely on scientific experiments, putting little consideration of communities' knowledge and experience. Therefore, this study contended that climate change and variability, vulnerability and impacts on livelihoods and natural resources management can be adequately covered through learning from rich experience of communities [21]. Interviews with key informants were guided by a checklist that intended to collect information related to climate and non-climate stress factors for vulnerability in the study area. Information and datasets collected through key informants were used to validate and complement information collected through focus group discussions and household surveys. FGDs were conducted for 2 - 3 hr, involving up to 12 participants per village [22]. Direct field observation was also used in order to validate and complement information generated through other survey methods and GIS analysis.



Source: Field Survey (2017)

Source: Field Survey (2017)

Figure 1: Location of study villages with elevation estimates. Source: IRA GIS Lab (2017).

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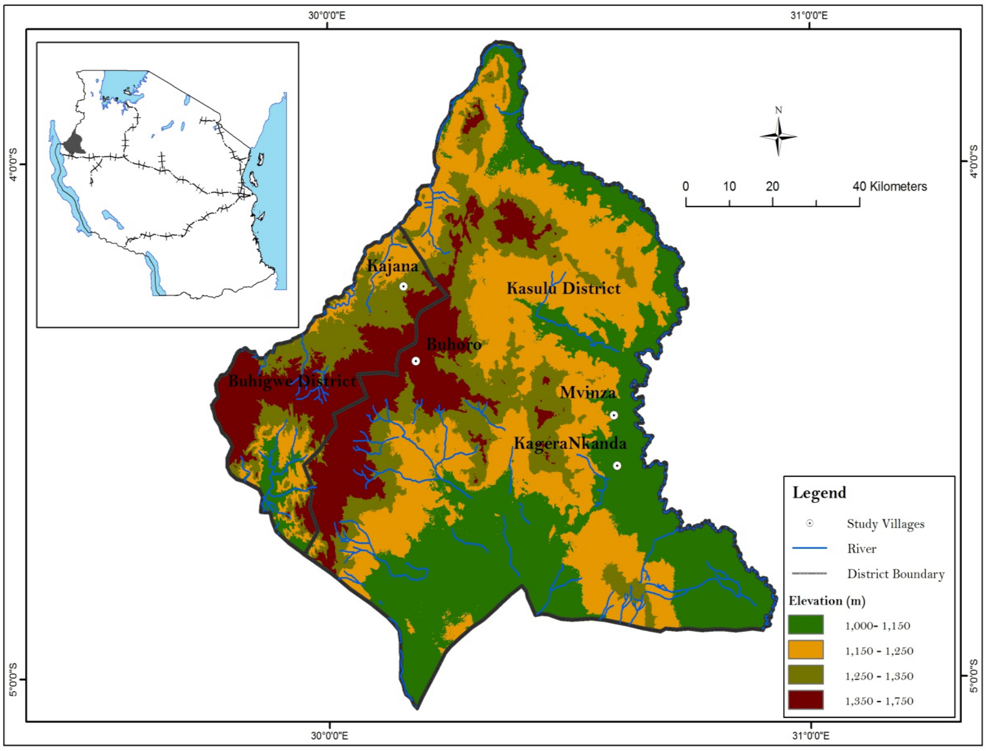


Source: Field Survey (2017)

Figure 2: Location of study villages with elevation estimates.

Data Processing, analysis and presentation

Analysis of qualitative data : Qualitative approach was used to analyze information collected through key informant interviews and Focus Group Discussion (FGD). Theme – content analysis technique (Lyanga, 1999), was applied to analyze qualitative data. In this technique, information from the field was grouped in themes to represent key focus of the research objectives to generate key findings, and then the grouped findings were presented to answer the key research questions [23].

Computing the vulnerability index (VI): Computation of VI adopted the social-environmental vulnerability dimension that considers that vulnerability is a function of both biophysical and social factors, and takes into account the dependency of local population on their local resources and infrastructure[5,9,24]. Computation of VI applied Human Development Index (HDI) approach developed by UNDP to normalize the indicators in order to obtain figures which are unit free and standardize their values. In calculating VI, there were two functional relationships for variables i.e. vulnerability increases with increase in the value of indicator to be measured (↑) e.g. poverty level and frequency of extreme weather events; and vulnerability decrease with increase in the value of indicator (↓) e.g. literacy level, income level and early warning system.

With reference to the formula for normalization of variables with functional relation (FR) ↑

$$x_{ij}=\frac{x_{ij}-\min\{x_{ij}\}}{\max\{x_{ij}\}-\min\{x_{ij}\}}$$

With score variables in percentage and with the maximum value of 91 for number of household members of Mvinza Village in lowland and minimum of 72 for Buhoro in highland region. Therefore, the normalization of this is calculated as follow: -

$$x_{ij}=\frac{x_{ij}-72}{91-72}=\frac{x_{ij}-72}{19}$$

Therefore, to normalize the score variable for Number of household members for Kagerankanda village in lowland region, the process should be:

$$x_{ij}=\frac{84-72}{19}=0.63$$

All the variables with similar functional relations were calculated by this formula throughout the computation process. For the normalization of variables with functional relation (FR) ↓ like literacy rate of the community in Kajana Village is computed by the following formula.

$$y_{ij}=\frac{\max\{x_{ij}\}-x_{ij}}{\max\{x_{ij}\}-\min x_{ij}}$$

Where,

y_{ij} = variables with functional relation ↓ FR

$\max x_{ij}$ = Maximum value of Normalized scores for the variables having ↓ FR

$\min x_{ij}$ =Minimum value of Normalized scores for the variables having ↓ FR

In this case normalization will be calculated as follows: for example, in social safety nets

$$y_{ij} = \frac{3 - x_{ij}}{3 - 0} = \frac{3 - x_{ij}}{3}$$

Therefore, example normalization of social safety nets variables for the upper zone can be calculated as:

$$y_{ij} = \frac{3 - 1}{3} = 0.67$$

The computation of normalized scores is followed by the computation of the Vulnerability Index. The index is calculated either by giving equal weights to all indicators or unequal weights. For this study the indicators were given equal weights and the vulnerability index is calculated by the formula hereunder.

$$VI = \frac{\sum j x_{ij} + \sum j y_{ij}}{k}$$

VI= Susceptibility index

Σ= Summation

xij= Normalized scores for the variables having ↑functional relation

yij = Normalized scores for the variables having ↓ functional relation

K= Number of indicators involved

For example, the susceptibility index for Buhoro Village can be calculated as follows:

$$VI = \frac{8.14 + 3.56}{24} = 0.48$$

Descriptive statistics and regression analysis: Statistical Product and Service Solutions (SPSS) software version 20 was used for analysis of quantitative data for descriptive statistics (i.e. percentage tables, pie charts and graphs) and regression analysis. Hierarchical multiple regression analysis was used to estimate correlations among key variables (Independent and dependent variables) of the study objectives [25-27]. The hierarchical regression analysis involved comparison of different models in relation to vulnerability to climate change. Analysis of vulnerability to climate change used two regression models. The first model refers to the first stage (block) in the hierarchy that considers presence of crop pest and diseases, higher household size (11-15), literacy and fertile soils as predictor variables. Model 2 refers to the final model in which the first model predictor variables in addition to land size of less than 1 acre possessed by households were included. Data for climate induced migration was analyzed using two models. The first model used average good harvest, access to remittance, literacy, extended family and soil fertility as major predictors; while climate induced migration was considered as dependent variable. The second model added big household size predictor. Models for the analysis of the impacts of climate change on crops used literacy, location (highland or lowland) of the study villages and increase in temperature as major predictors. The first model composed of two predictors (Literacy and location of the village) while the second model added the increase in temperature on top of the predictors in the first model. On testing whether the model significantly predict the outcome, ANOVA was deployed. From the ANOVA the *F*-ratio was derived. The *F*-ratio is the ratio of the improvement in prediction that results from fitting the model at the 'regression' on the table in relation to the inaccuracy that exists in the model 'residual'. In this case, if the perfection due to fitting the regression model is greater than the inaccuracy within the model, the value of *F* will be greater than 1 and in this case the exact probability of obtaining the *F* value by chance has been calculated. Moreover, the hierarchical models use form of an equation that contains a coefficient (*b*) for each predictor. Model 1 estimate of coefficients indicates the individual contribution of each predictor variable within the model. These values show the interrelationship between average good harvest with each predictor and the value can be positive or negative. If the value is positive, then it marks a positive relationship between the predictor and the outcome, and likewise for the negative value.

Analysis of meteorological data: Daily rainfall and temperature data recorded at Kasulu and Kigoma Meteorological Stations, for a period of 30 years was used to analyze climate trends and patterns from 1984-2014. Major approaches for statistical tests included the use of XLSTAT programmer to analyze and perform Mann-Kendalls trend test (MKT) for rainfall and temperature data [28]. Other analyses extreme rainfall events, onset and cessation of rainfall seasons, and temperature trends for the past 30 years. Running MKT test of seasonal and annual rainfall data was based on the calculation of Kendall's tau whereby the *p* value obtained was compared with a significance level (α) estimated at 0.05. Running of MKT trend tests was based on alternative (Ha) and null (Ho) hypotheses. The alternative hypothesis was stated as 'there is trend (Decrease/increase of rainfall or temperature data) in the time series'; while the null hypothesis was framed as 'there is no trend (Decrease/increase of rainfall or temperature data) of time series'. In this regard, the null hypothesis (Ho) (There is no trend in the time series of data) would be rejected if the p value is less than the significance level (α) estimated at 0.05. Rejecting Ha indicates that there is a trend in the time series of data, while accepting Ho indicates no trend is detected. Therefore, rejecting the null hypothesis implies that the result is statistically significant at α = 0.05 level of significance. INSTAT computer software program was also used to examine onset and cessation of the rainfall season and Climate Database Management system (CLIDATA) was used for analysis of extreme rainfall events values.

Results and Discussion

Communities vulnerability

Vulnerability indices for study villages: Vulnerability for study villages was examined based on landscape characteristics. The analysis compared vulnerability of villages located in the lowland transects and those located in the highland transect. The highland zone lies between 1350 to 1750 m above the mean sea level and the lowland zone which lies between 1000 to 1150 m above the mean sea level as illustrated in Figure 2. In this regard, analysis indicated that villages located in the highland zone were highly vulnerable to climate and non-climate stress factors compared to the villages located in the lowland zone. Kajana village had the highest VI (0.74) compared to all other three villages. Vulnerability of communities in the highland zone was largely associated with degradation of natural resources, which accelerated impacts of the changing climate. However, given socio-ecological interdependences between the villages in the highland and lowland zones, there were likelihoods that natural resources supporting communities' livelihoods in the lowland zone would also be susceptible to the impacts of the changing climate. Their susceptibility would be largely associated with pressure of small scale farmers from the highland zone to lowland zone. Grothmann et al. (2017) also writes that vulnerability of communities' livelihoods in the lowlands is largely motivated by natural resources degradation in the highlands. Other factors characterizing high VI in highland villages include presence of more extended families, increase in malaria and dengue fever cases, loss of labor force, lack of enough and reliable climate change information and limited decision making spaces among its village members [1] . The high degree of vulnerability is followed by Mvinza village which recorded a 0.57 and marks a higher vulnerability than Buhoro and Kagerankanda. Buhoro is the third vulnerable village for having a 0.48 VI value. The least vulnerable of the four villages is Kagerankanda which recorded a moderate vulnerable index of 0.34. This is partly so because the village has recorded a high number of families with large portion of land under cultivation, good seasonal harvests, possession of enough food and surplus, less frequency of human diseases and having enough space for decision making. Generally, based on VI values, the highland zone is most vulnerable with a VI value of 0.61 and signifies fragility of the zone to climate and non-climate stress factors. Lack of reliable climate information and inadequate land for crop production, which resulted into low crop yield were some of the major challenges that induce their vulnerability to climate and non-climate stress factors. On the other hand, villages in the low zone were considered to be relatively less vulnerable partly due to promising harvests for food and surplus for income generation. In this case the lower zone recorded a VI of 0.45 and marking less vulnerable compared to its highland zone.

Household vulnerability

Household vulnerability was analyzed by using hierarchical regression models. As described in 2.4.3 and summarized in Table 2, the hierarchical model uses the form of an equation that contains a coefficient (b) for each predictor. Model 1 estimate of coefficients indicates the individual contribution of each predictor variable within the model. These values show the interrelationship between average good harvest with each predictor and the value can be positive or negative. If the value is positive, then marks the positive relationship between predictor and outcome, and likewise for the negative value. As summarized in Table 2, the hierarchical model results show that only one predictor (farm size<1 acre) has a negative relationship, implying that the lesser the farm size possessed by household the lower the average good harvests of a household keeping other predictors (Crop pest and diseases, higher household size (11-15), literacy and fertile soils) fixed and is statistically significant at 5% level of significance. The existence of fertile soils has shown a positive statistically significant with the average good harvest ($p<0.001$), meaning that the fertility of the soil is proportional to the average good harvests for the household. In this model, fertility of the soils, $t(476)=11.61$, $p<0.001$, and farm size (<1 acre), $t(476)=-3.34$, $p<0.001$ are significant predictors for average good harvest (>5 bags of maize & >3 bags of beans). Based on the magnitude of predictors with reference to t-statistics, soil fertility has shown strength over farm size. The standardized beta values (β) show the number of standard deviations that the outcome will change if one standard deviation change in the predictor and in this case indicate the status of a predictor on the model. The β for soil fertility is 0.473 and farm size is -.133 showing that fertility has more impact in the model. Literacy, household size and crop pest and disease predictors had no significant contribution to the model (Table 2).

Climate Factors for Communities Vulnerability

Unreliable rainfall: This study found that unreliability of rainfall was among the key climate factors influencing communities' vulnerability. Discussions with FGD participants revealed that decrease of rainfall amount, unreliable onset of rainfall, recurrent dry spells, and uneven distribution of rainfall within a season had significant effects on crop production, which form major livelihoods in the study villages. Similarly, analysis of rainfall data indicated the general declining trend of seasonal and annual rainfall with minimum seasonal and annual rainfall recorded in the selected meteorological stations. As illustrated in Figure 3, Kasulu Meteorological Station recorded the maximum decline with a slope of -14.509 and -12.762 for seasonal and annual trends, while the minimum decline with a slope of - 2.174 and - 1.3653 for seasonal and annual trends respectively was recorded at Kigoma Meteorological Station (Figure 3). This implies that average amount of seasonal and annual rainfall has been decreasing in the study area. Decrease of seasonal and annual rainfall might have been affecting key livelihoods activities such as crop production in the study area given high proportions of populations depending on rainfed agriculture [28].

Table 1: Study sample.

S.No	Village Name	Total Households	Sample Households	Percentage
1	Kajana	1008	105	10.41
2	Buhoro	1050	110	10.47
3	Kagerankanda	1209*	126	10.42
4	Mvinza	1343	141	10.49
Total		**4610**	**482**	**10.79**

Source: Field survey (2014-2017)

Table 2: Hierarchical regression results for prediction of average good crop harvest.

Model		*b*	*SEb*	*β*
1	**(Constant)**	0.23	0.06	
	Literacy	0.21	0.22	0.04
	Household size (11 -15)	0.03	0.05	0.02
	Fertile soils	0.5	0.04	.50***
	Crop pest and diseases	0.06	0.05	0.04
2	**(Constant)**	0.26	0.06	
	Literacy	0.2	0.22	0.04
	Household size (11-15)	0.02	0.05	0.02
	Fertile soils	0.47	0.04	.47***
	Crop pest and diseases	0.06	0.05	0.05
	Farm size (<1 acre)	-0.26	0.08	-.13***

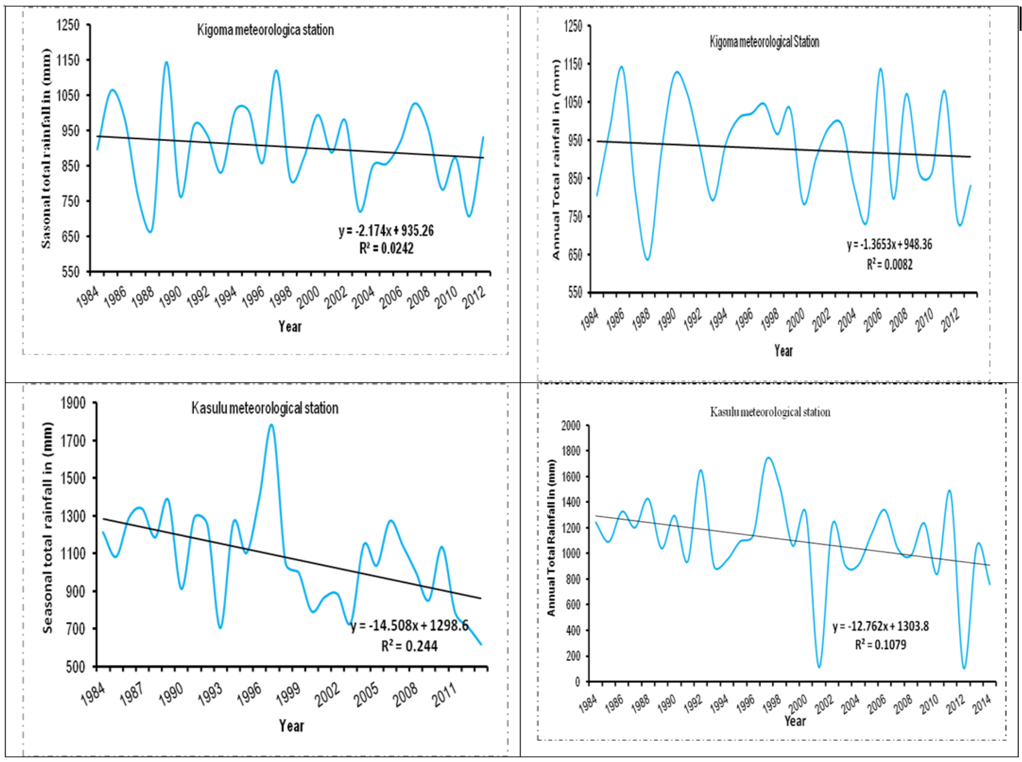
Source: Field survey data, 201

Note. R^2 = 0.26 for model 1: ΔR^2 = 0.2 for model 2 (ps<.001). ***p<0.001

Additionally, calculation of Kendall's tau (measures of connection between two successive seasonal and annual rainfall years) indicated that, the computed p-values for both annual and seasonal rainfall recorded at Kigoma Meteorological Station are greater than the significance level (α≥0.05). This implies that both seasonal and annual rainfalls indicate decreasing trends and therefore the null hypothesis H0 (There is no trend in the series) cannot be rejected. For Kasulu Meteorological Station, the computed p-value for annual rainfall trend is greater than the significance level (α≥0.05), which means annual rainfall shows decreasing trend and therefore null hypothesis H0 (There is no trend in the series) cannot also be rejected. However, the calculated p-value for seasonal rainfall trend is lower than the significance level (α≤ 0.05), which means null hypothesis H0 (There is no trend in the series) should be rejected and the alternative hypothesis Ha (There is a trend in the series) should be accepted (Table 3)

Additionally, analysis of meteorological data indicated that there has been decreasing trends of onset and cessation of the rainfall season. This is particularly so at Kasulu Meteorological Station compared to Kigoma Meteorological Station, which shows an increasing trend on the onset of the rainfall season (Figure 4). Increasing trends of onset and cessation might be attributed to a seasonal shift of rainfall and more seasonal length of rainfall onset. Unstable rainfall onset and cessation affect planting calendar, growing seasons and may influence the farmer on the choice and decision of crops to plant [29].

Accordingly, discussion with focus group participants report an increase of bad years, largely attributed to the trend of rainfall. It was also reported that rainfall season was considered to be good depending on rainfall patterns for crop production and subsequent harvest obtained by majority of households in the study villages. It was also emphasized that good and bad years can be distinguished based on the



Source: TMA data, 2016

Figure 3: Trends of seasonal and annual total rainfall amount in the study area.

Table 3: Seasonal and annual rainfall Mann–Kendall's trend test results.

Seasonal test						
Station	**No. years**	**Mann-Kendall's stat (S)**	**Var (S)**	**Kendall's tau**	**P - value**	**α**
Kigoma	31	-44	0	-0.116	0.4	0.05
Kasulu	31	-145	0	-0.333	0.009	0.05
Annual test						
Kigoma	31	-44	0	-0.108	0.424	0.05
Kasulu	31	-89	0	-0.205	0.117	0.05

Note: H0: There is no trend in the series of seasonal and annual rainfall data

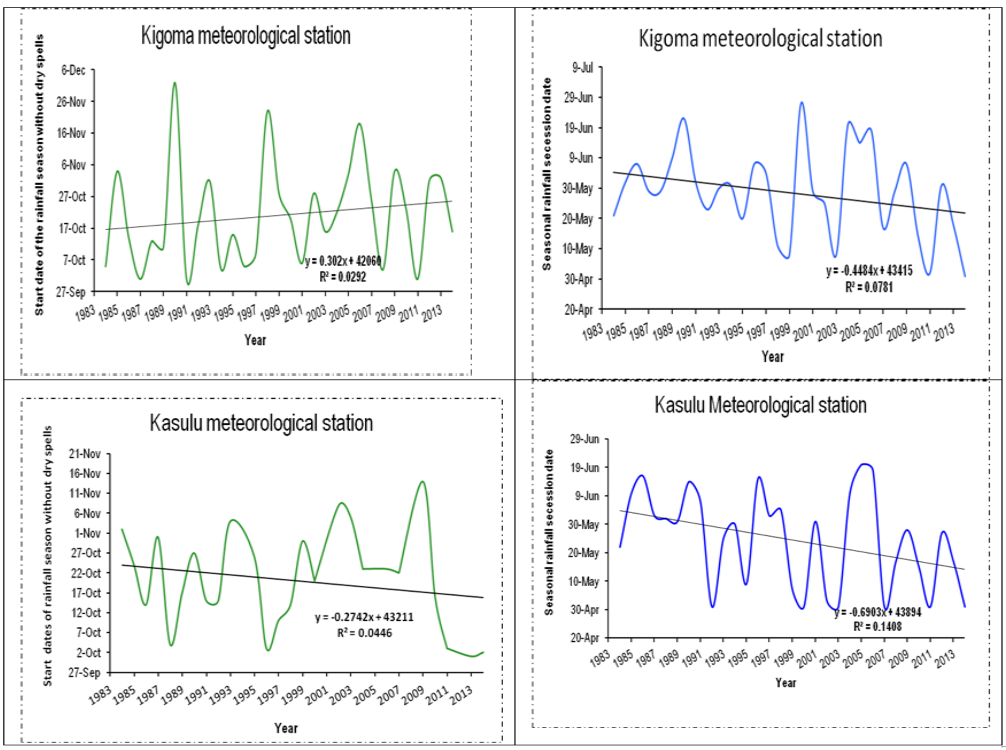
Ha: There is a trend in the series of seasonal and annual rainfall data extremes associated with rainfall patterns such as excessive rainfall or 'stone' rainfall as well as erupt of pests such as armyworms or Quelea Quelea. Some of the years mentioned by village level FGD participants as bad years were 1963, 1973, 1993, 2003, and 2013. FGD participants at village level also indicated that most of the 1980s and 1990s growing seasons were considered to be 'good years', while bad years have been increasingly steadily from 2000s. However, FGD participants mentioned 1997/1998 as the only 1990s' major bad year. This was partly linked to the fact that despite high downpour which could be favourable for crop production, it affected crop production due to high intensity and largely characteristically behaved el-Niño. Analysis of meteorological data indicated that, from 1984-2014, incidences of 24 hours extreme rainfall events of more than 50mm were observed in all selected meteorological stations. Analysis showed that Kigoma and Kasulu had the highest extremes rainfall of 98.1 mm and 141.0mm, observed between 10th April, 1992 and 01 January 2005, respectively[30]. These extreme values were the highest values since the stations were established in 1984. This partly implies that most of the rain seasons had normal and low rainfall [30].

Increase of temperature: Field survey findings indicated that temperature trend has been unstable in the study area. Analysis of time series for mean annual maximum and minimum temperature indicated general increasing trend of mean annual maximum and minimum temperatures. As illustrated in Figure 5, the trend line equations and slope has a positive value, which implies a increasing of the mean maximum and minimum temperature.

FGD participants indicated that there has been increase of temperature both maximum and minimum, which had effects on various human activities including crop production and livestock keeping. Similarly, hierarchical regression results indicates that temperature increase had negative relationship with the crop pest and diseases ($p<0.013$). This implies that the increase in temperature as perceived by the sampled population have influence over the increase in crop pest and diseases. Other studies have reported increase of temperature up to 3.4^0C between 2050 and 2100 in many parts of Tanzania, with more warming expected during dry season especially in South-western Highlands and Western part of the country [11,31,32]. Some of the effects of unstable and increasing temperature reported by respondents included crop phenology, emergence of new crop pests and diseases, human diseases, livestock pests and diseases. It was reported by key informants that increase of temperature has significant influence on phenology or growth patterns of major staple crops such as maize and paddy. However, plant responses to rising temperature are variable within and between species and are dependent on developmental stage [33]. Despite of the variations, Hatfield and Prueger (2015) indicates that increase of maximum and minimum temperature beyond range of staple crop varieties can affect grain number and reduction duration of the grain, thus low yield [34]. Such effects will have significant impacts on livelihoods of local communities in the study area partly due to their high dependence on staple crops for food and income. As whole, Kangalawe et al. (2016) indicated that increasing temperatures and changes in the hydrologic cycle are providing opportunities for a range of pathogens and vectors to change their geographic range, replication rate and transmission dynamics [10].

Non-Climate Factors for Communities Vulnerability

Endowment of household assets: Household assets (natural, human, physical, social, and financial) endowment is considered in vulnerability studies because they determine and influence adaptive capacity of household in different scales [9,35,36]. It was learnt through field survey



Source: TMA data, 2016

Figure 4: Onset and secession of the rainfall season in the study area.

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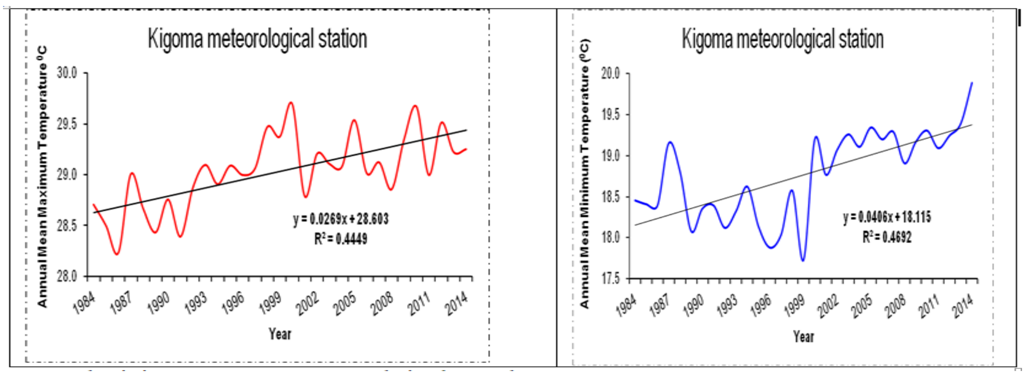
findings that there were different categories of people grouped based on their socio-economic status, which characterised level of their household assets endowment and likelihoods to adapt and/or be vulnerable to climate change related stresses. Discussion with key informants and FGD participants indicated their community was categorized into rich people (abhatunzi/abhalonsi), middle group (abhalihakili) and poor people (abhakene). Discussions with FGD participants also indicated that majority of the households in the study villages were poor and this situation made them vulnerable to the impacts of the changing climate. Discussions with FGD participants further indicated that rich people who were few compared to other population segments in the villages were considered to have high adaptive capacity partly due to adequate food, high income and diverse resources that could sustain their households in case of climate change related shocks. One of the FGD participants indicated that…"rich households with diversity of income sources and foods can easily sustain their status compared to households whose richness depends on farming (crop production) only"...

Mobility of household members: Majority of the FGD participants and key informants reported that seasonal to permanent rural- rural and rural-urban migration, both within the study districts and region, and cross-regions, has had effects on stability of households in the study villages. It was reported by FGD participants and household respondents that noticeable mobility of household members was enormous and common since mid-1990s. Primarily, any form of migration in the study area was considered by FGD participants as one of the strategies to diversify and leverage resources for improving their livelihoods. Two hierarchical models were applied to analyse the attribution of climate on communities' migration and delineating intrinsic relationship between migration and vulnerability to climate and non-climate stressors. As summarized in Table 4, results show that one variable (Access to remittance) has positive relationship, implying that access to remittance is proportional to climate migration (p<0.001). The three predictors (Literacy, extended family nature and soil fertility) have shown a negative statistical significant. Literacy indicate p<0.01; extended family nature p<0.001 and soil fertility p<0.001. This means the more literate level of people the less people can migrate due to climate. The model results also show that the extended family has influence on climate migration, and the more the fertility of an area the less the climate migrant. Standard error shows the extent of variation of values across samples and standard errors determine whether or not b values differ significantly from zero. The lower the sig. value and the greater the t value increases the contribution of the predictor. In this model, the literacy, $t(475)$ = -2.64, p <0 .01; extended family, $t(475)$ = -8.80, p < 0.001; access to remittance t(475) = 4.77, p<0 .001 and soil fertility $t(475)$ = -6.32, p < .001 are significant predictors for climate migration. Three predictors (Extended family, access to remittance and soil fertility) have shown almost similar strength in magnitude over literacy. The standardized beta values (β) show the number of standard deviations that the outcome will change if one standard deviation change in the predictor and in this case indicate the status of a predictor on the model. The β for literacy is -0.103; for extended family -0.349; for access to remittance0 .185 and soil fertility is -0.290 and this inform that access to remittance has more impact in the model. However, good harvests and household size predictors had no significant contribution to the model.

Field survey findings indicated that most of the migrations involved farmers, largely from highland villages who used to move seasonally to the lowland villages primarily looking for arable and fertile land for crop production. These patterns of migration had effects in both places of origin and destination, thus inducing vulnerability to climate and non-climate factors. While effects of migration in the origin were largely reported to affect the remaining household members in the origin, effects in the destination were diverse, sometimes affecting both migrants and receiving population. Collectively, some of the effects reported by FGD as common in the place of origin included inability of the remaining household members to afford daily sustenance especially when the migration involved the head of household. FGD findings across the study village also indicated that migration was one of the reasons for school drop-outs and early marriages especially in circumstances of migration involving all parents and leave their children without proper guardian. Conflicts over resource us, deforestation and forest degradation were some of the effects reported by FGD participants in place of destination. Regardless of the negative effects of migration, in both origin and destination of migrants, innovation in agricultural activities (e.g. adoption of new crops) was observed to be one of the positive effects of migration. Therefore, if migration is well regulated and innovations supported, it can increase diversification of livelihoods and increase capacity of receiving population withstand climate and non-climate stresses.

Inadequate agricultural extension services: Inadequate extension officers and extension services were reported to be among the non-climate challenges affecting crop production and livestock keeping in a changing climate. Discussions with FGD participants at village and sub-village levels indicated that major problems related to agricultural



Source: TMA data, 2016

Figure 5: Mean annual maximum and minimum temperature trends in the study area.

Table 4: Hierarchical regression analysis for variables climate migration (N=482).

Model		*b*	*SEb*	*B*
1	(Constant)	0.87	0.04	
	Literacy	-0.56	0.22	-.10**
	Extended family	-0.36	0.04	-.35***
	Remittance receipt	0.34	0.07	.19***
	Soil fertility	-0.3	0.05	-.29***
	Good harvests	-0.01	0.05	-0.01
2	(Constant)	0.87	0.04	
	Literacy	-0.57	0.22	-.10**
	Extended family	-0.36	0.04	-.35***
	Remittance receipt	0.34	0.07	.19***
	Soil fertility	-0.29	0.05	-.29***
	Good harvests	-0.01	0.05	-0.01
	Household Size=11 -15	-0.03	0.05	-0.02

Source: Field survey data, 2017
Note: R^2 = .30 for model 1: ΔR^2 = 0.001 for model 2 (*ps* .63) ** p<.01, *** p<.001

extension services were poor access to weather forecast information (e.g. onset of rainfall and projected trend of rainfall within a season), which could have been important for them to plan farming activities (e.g. farm preparation and planting season). It was reported by majority of the focus group participants that they were not able to get reliable weather information that could guide them on the farming calendar. Other challenges reported to have significant effects on their crop production activities included late supply of farm inputs such as fertilisers and seeds, inadequate supply of pesticides and insecticides, and inconsistency in extension education on the use of pesticides and insecticides. Accordingly, household survey findings indicated that they were relying on radio as their major source of climate change information. About 72.8% of the respondents reported that they were getting climate change information, mainly through radio (71.4%), normally after news around 8 pm. However, information received through radio was mainly general weather forecast, and coarse and unreliable they are, could have less support to farming activities. It was further reported by household respondents that the weather information were largely unreliable (69.7%) and not useful to guide crop production in the study area. Other sources of climate information which were not widely used by respondents included newspapers (0.4%), seminar (1.5%), village meetings (1.7%) and learning from neighbourhoods which was reported by 5.2 % of the respondents. Household respondents also indicated that most of these sources were mainly for few villagers who could have access to them and contained information. Therefore, improvement of agro based extension services is one of the key considerations in reducing vulnerability of communities to the climate and non-climate stresses.

Edaphic factors

This study found that soil fertility and soil infertility had greater influence on the patterns of communities' livelihoods and mobility. Fertility and infertility of the soil is largely discussed in relation to crop production. It was reported by FGD participants especially in the highland villages that soil fertility has deteriorated due to monoculture and lack of alternative farms which could allow crop rotation in order to replenish fertility of the soil. Apart from monoculture and overuse of the respondents' farms, field survey findings also observed that soil infertility in the highland villages could have been attributed by deforestation and forest degradation which deteriorated soil organic matter. URT (2014) emphasized that deforestation and forest degradation is one of the major factors that lead into decline or loss of land productivity due to reduced or depletion of soil nutrients [11]. Discussion with FGD participants indicated that infertility of the soil had significant influence on the migration of people from highland villages (Kajana and Buhoro), to lowland villages such as Kagerankanda and Mvinza villages, where soil was claimed to be fertile. According to the FGD participants, migration is considered to be cheap option compared to the cost of using fertilizer, which are unaffordable to most of the farmers. It was also reported that even some few households who could afford few bags of fertilizers were encountering defectives in supply, high costs required to cater for their farms and low returns to recover their farm operations. Accordingly, as reported by Rurinda et.al (2014), untimely and inadequate supplies as well as limited access to fertilizer constrain ability of both resource endowed and resource-constrained households to produce sufficient food for income and household consumption even during a good rainfall season [9]. Migration, among other key coping strategies, has been practices by most of the farmers migrate to other villages and practice shifting cultivation and mostly in reserved forests, where soils were reported to be relatively fertile. This is similarly to URT (2014) that migration in search of arable land which is virgin and naturally fertile for crop production and suitable for pasture are inevitable coping options among small scale farmers and livestock keepers in many parts of Tanzania where land productivity has been depleted through shifting cultivation slash-and-burn farming techniques [11].

Conclusion and Recommendations

Vulnerability of communities' livelihoods to the impacts of climate change is increasingly becoming evident in most studies. Climate variability, especially changes in rainfall amount, unstable onset and cessation, intensity, distribution, recurrent drought and extended dry spells have induced pests and diseases and affected farming calendar, crop growth and crop yield in most crops. Increase of temperature has been associated with pests and diseases for both crops and livestock resulting into low quality and quantity of crop produce and low yield. Increase of temperature has also increased frequency, intensity and severity of livestock pests and diseases, which induce livestock mortality, high costs for vaccination and treatment as well as low quality of livestock products such as meat and milk. Silly early warning system,

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inadequate technology and services for crop production and livestock keeping innovations for aggravate impacts of the changing climate. Mostly, small scale farmers are being affected by inadequate facilities for irrigation, weather forecast, pests and diseases surveillance, farm inputs, transport, storage, processing, packaging and marketing of crop produce. Livestock keepers are affected by the changing climate due to inadequate pests and diseases surveillance, charco dams, dips facilities, vaccination and value addition for livestock products. Generally, as climate is increasingly changing, agriculture, combining both crop farming and livestock keeping, which form livelihoods options in the study area are likely to be highly vulnerable and affected by the impacts of the changing climate. Therefore, adaptation interventions should address challenges related to crop and livestock production chain considering infrastructural, policy and technical requirements. Moreover, understanding interrelationship of climate and non-climate stress factors and their subsequent impacts on communities' livelihoods, especially agricultural production is a necessity for policy interventions and enhancement of communities' resilience.

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