The Causes and Effects of Climate Change to the Livelihoods of the Local Community in the Semi Arid Area of Central Tanzania: A Case of Dodoma Region

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Abstract

Understanding the causes and effects of climate change at local level is an important step towards planning, prioritizing, designing and execution of measures to climate change management. It is in this regard, this paper analyses the local causes and effects of climate change in the semi-arid areas of central Tanzania. In particular, a household survey and focus group discussions were used for data collection from Kongwa and Bahi districts in Dodoma region. The data were analysed using descriptive statistical method, content analysis, and Principle Component Analysis with Oblimin rotation. The finding on the causes of climate change in the area resonates around changes in climatic conditions, poor environmental management and lack of conservation education. Moreover, the findings on the extent to which the effects of climate change affect local livelihood sources and activities were depicted loadings of variables to the components. In particular, the pattern coefficients indicated that reduced water availability (0.82), reduced agricultural productivity (0.79), effect on the planting season (0.73), destruction of crops (0.71), and effects on the size of land cultivated (0.70) were the effects for component 1; reduced water availability for livestock (-0.88), reduced pasture for livestock (-0.86), and effects on the number of livestock (-0.84) for component 2; and effects experienced on socio-economic activities (0.86), natural resources degradation (0.83), and reduced household income (0.49) for component 3. From these empirical results, the paper concludes that climate change at local level affects a wide range of livelihood activities and hence the need for effective interventions. In that regard, this paper recommends the need for targeting the interventions towards addressing the question of water scarcity, promoting agricultural productivity, promotion of activities focusing on income diversification, and natural resources management.

Key Words: Climate Change, Livelihoods, Resilience, Climate Change Effects, Dodoma Region

INTRODUCTION

Climate change is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate

variability observed over comparable time periods (IPCC, 2007). Changes in climate parameters are best manifested by the increase of climate related extreme events including but not limited to extreme high temperature or heat waves, heavy precipitation, floods and drought (IPCC, 2014). Consequently, such extreme events affect both the natural and human systems by interfering with the primary productivity, health, ecological and socioeconomic systems (IPCC, 1996). In particular, changes in climate parameters are likely to affect the availability of water, shift in the growing season, flooding pattern, soils erosion, rise in sea levels, and distributions of diseases vectors (UNFCCC, 2007). The effects resulting from climate change are not evenly distributed and tend to affect various regions in the world differently. For instance, some parts of USA and Europe are severely affected by heat waves while most parts of Africa especially areas along the horn of Africa and Australia are interchangeably affected by drought and floods (Global Humanitarian Forum, 2009).

Unfortunately, changes in climate parameters can never be reversed within few days or a year. Evidences suggest that stabilization of the atmospheric concentrations of greenhouse gases, equilibration of climate system given a stable level of greenhouse emissions and concentrations respectively can take decades (IPCC, 1996). The same time frame is required for the restoration and/or rehabilitation of the damaged or disturbed ecological systems. The above is based on the fact that, even if the emissions of greenhouse gases is reduced to the required levels the earth will continue to warm as a result of the already existing concentrations of greenhouse gases in the atmosphere (UNFCCC, 2007). For instance, prior to industrial revolution the concentration of carbon dioxide was 278 parts per million (ppm). However, the current concentration of carbon dioxide is about 387 ppm which is ―higher than the highest point in at least the past 800,000 years‖ (World Bank, 2010).

According to Tompkins and Adger (2004), slow changes in mean climatic conditions, increased inter-annual and seasonal variability, increased frequency of extreme events, and rapid climate changes causing catastrophic shifts in ecosystems are the major ways in which climate changes are manifested. Such changes strongly call for the need for adaptation and mitigation strategies so as to deal with climate change impacts such as are melting of ice sheets, increase of climate related extreme events of which adversely affects the well being of people particularly the poor in developing countries (Mearns & Andrew, 2010). It should be noted that, the distribution of responsibility for the causes of climate change and its impacts differ widely among nations and people (UNDP, 2007). Worldwide, economic losses caused climate change related disasters amount to $ 125 billion per year, roughly equivalent to the flow of 2008 Official Development Assistance (ODA) from developed to developing countries (Mearns & Andrew, 2010). According to Global Humanitarian Forum (2009), climate change related disasters are expected to rise to 50 percent worldwide in 2030 from 40 percent in 2005. Using severe drought as an example of climate change related disaster, Australia has experienced drought for almost more than a decade (Global Humanitarian Forum, 2009). In Tanzania, climate change related disasters have been of critical concern due to their recurrence and severe social and economic effects.

Despite the challenges posed by climate change impacts, most of them can be avoided, reduced, or delayed by mitigation (IPCC, 2007). For the already unavoidable climate

change impacts, the most viable option is the use of various adaptation strategies such as planning for infrastructure, land use, agricultural diversification, and streamlining legislation (Mearns & Andrew, 2010). Worldwide, various international, regional and national efforts to address climate change are underway. Some of such efforts involve multilateral agreements and regional and national policies. For instance through negotiations and conferences, international and regional communities have made a break through by coming up with policy documents such as United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and other regional initiatives such as the East African policy on Climate Change.

At national level, various efforts geared towards addressing the problem of climate change are in place taking into consideration that Tanzania is one of the twenty (20) most vulnerable countries worldwide (Global Humanitarian Forum, 2009). Of recent, Tanzania made a bold step by formulating the National climate change strategy 2012 – 2017, and the National Environmental Action Plan 2013 -2018 among others to guide the process of climate change management country wide. This compliments previous efforts such as the preparation of the National Adaptation Programme of Action (NAPA) and establishment of CDM projects as per the requirement of the Kyoto Protocol. Nevertheless, climate change impacts are local and context specific and hence their solutions (Measham *et al.*, 2011). In this regard, the paper determine and categorizes the effects of climate change in the semi arid areas of central Tanzania on the basis of the extent to which they affect the livelihoods of the local community by using Principal Component Analysis (PCA) approach. The use of PCA is very critical for decision makers and other actors in planning and prioritizing the intervention measures for managing climate change impacts. This information is considered very useful to the local community, the government and other actors interested in climate change management in semi arid areas.

MATERIALS AND METHODS

The Study Area

This paper is based on the household survey conducted in Kongwa and Bahi districts in Dodoma region as indicated in Figure 1. The region is located in the central part of Tanzania at 4^0 to 7^0 South and 35^0-37^0 East. The region is characterised by short wet season with an average rainfall of 570mm between December to late April. The remaining period is dominated by long drought conditions. Based on the climatic conditions in the area, Dodoma region is a semi arid area particularly in its eastern and central part respectively (URT, 2006), hence making Bahi and Kongwa districts as appropriate areas for the study. Economically, residents depends on crop farming and livestock keeping all of which are prone to climate change extreme events especially droughts.

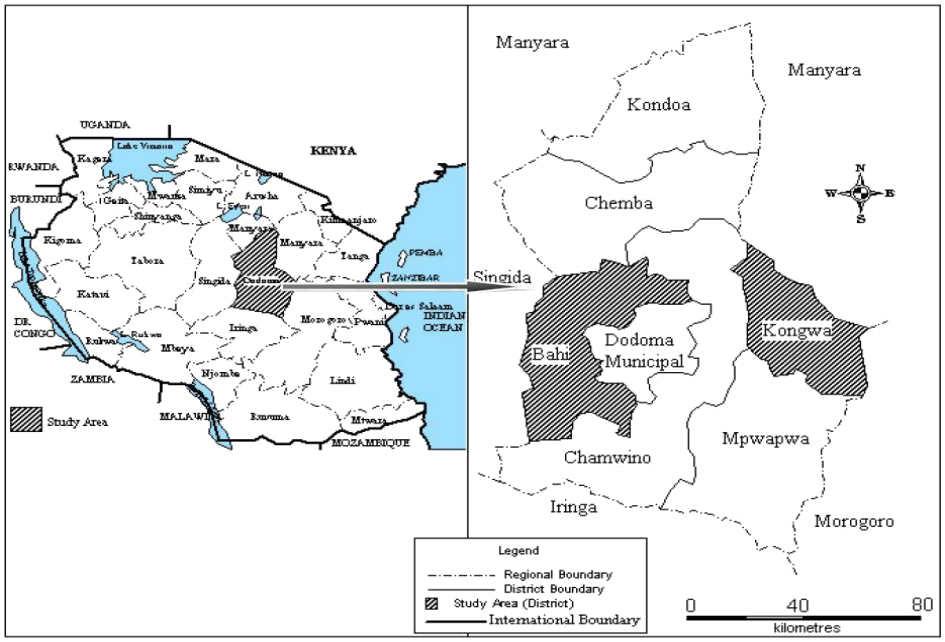

Figure 1. Map of administrative region in Tanzania and districts of Dodoma Region as the study area

Data Collection and Analysis

The data used in this paper are based on household survey administered to 398 respondents randomly selected from 10 villages in Kongwa and Bahi districts (5 villages in each district). Further information was collected using Focus Group Discussions (FGDs) from the two districts. The collected data were analysed using Statistical Packages for Social Sciences (SPSS) version 16. In particular, the Principal Component Analysis (PCA) was used to analyse the twelve (12) items considered as key in explaining the effects of climate change on households' livelihood activities. These items were reduced household income, reduced agricultural productivity, reduced water availability, effects on planting season, size of land cultivated, reduced water availability for livestock, effects on the number of livestock, reduced pasture for livestock, destruction of settlements, effects on socioeconomic activities, and natural resources degradation.

Prior to performing PCA, the suitability of data for PCA was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of 0.3 and above (Appendix 1). The Kaiser-Meyer-Olkin value (a measure of sampling adequacy) was 0.84, exceeding the recommended value of 0.6 and Bartlett's test of sphericity reached statistic significance ($x^2(398) = 2089.23, p < 0.001$), supporting the factorability of the correlation matrix. Principle component analysis using the Kaiser's criterion revealed the presence and hence accepted three eigenvalues exceeding 1. The Kaiser's criterion requires the inclusion of factors with eigenvalue of 1.0 or more for PCA (Field, 2009;

Pallant, 2011). In that regard, only three components with eigenvalues more than 1 were accepted for further analysis (Table 1). An inspection of the Scree plot (Appendix 2) also slightly showed an inflection between both the second and third components. In that regard, a decision was made to use three components during PCA on the basis of Kaiser's criterion, adequate sample size (N= 398) and scree plot (Field, 2009).

Table 1. Selection of components using eigenvalues from PCA and Kaiser's criterion

Component number	Decision based on Kaiser's criterion	
	Eigenvalue from PCA	Decision
1	4.993	Accept
2	1.621	Accept
3	1.069	Accept
4	0.931	Reject
5	0.727	Reject
6	0.613	Reject
7	0.464	Reject
8	0.405	Reject
9	0.346	Reject
10	0.313	Reject
11	0.286	Reject
12	0.232	Reject

An analysis of the three components explained a total of 64.022% of the variance, with component 1 contributing 41.610%, component 2 contributing 13.505 and component 3 contributing 8.907%. Thereafter, Oblimin rotation for revealing pattern and structure coefficients was performed in order to aid in the interpretation of three components by indicating the factor loading of each of the variables and the correlation between variables and factors (Pallant, 2011). The rotated solutions revealed both components showing a number of strong loadings in the three components. However, only variables with factor loading greater than 0.40 were used in naming the three components as suggested by Ozor et al. (2010).

FINDINGS AND DISCUSSIONS

Local Knowledge on the Causes of Changes (Extreme Events) in the Area

Respondents were asked to identify the causes of the climatic related changes that have been witnessed in their area. Findings in table 2 show that the causes of climatic related changes or extreme events as per the local community knowledge in Dodoma region include changes in climatic conditions (79.1%), haphazard cutting of trees (52.5%), environmental degradation (50.5%), destruction of natural vegetation (34.2%) and poor conservation education (28.6%). However, few respondents (3.8%) indicated that they were not aware of the causes of climate related changes despite noticing some changes resulting from climate change. In particular, more female respondents (5.8%) did not know the causes of climate change as compared to 2.5% of male respondents. From these findings it has been established that majority of respondents are aware of the climate changes and its causes.

Table 2. The perception of local community on causes of climate change within sex of respondents

Perception of respondents on the causes of climate change	Responses and percentages within sex of respondents (N = 398)		Total
	Male	Female	
Changes in climatic conditions	191 (78.6)	124 (80.0)	315(79.1)
Environmental degradation	134 (55.1)	67(43.2)	201(50.5)
Poor conservation education	83(34.2)	31(20.0)	114(28.6)
Destruction of natural vegetation	93(38.3)	43(27.7)	136(34.2)
Haphazard cutting of trees	139 (57.2)	70(45.2)	209(52.5)
Don‘t know	6(2.5)	9(5.8)	15(3.8)
Others	1(0.4)	1(0.6)	2 (0.5)

*****Dataset based on multiple responses; values in parentheses are percentages

A critical analysis of the findings suggests that most causes of climate changes in Dodoma region are related to poor environmental management and lack of conservation education. Although the problem of climate change is global and Transboundary in nature, the findings also signify that any intervention to deal with climate change should focus on addressing environmental management failures that have led to environmental degradation, destruction of natural vegetation and haphazard cutting of trees. These should be taken concurrently with awareness creation on conservation issues in order to deal with poor conservation education at the local level that accounts for 28.6% of the local causes of climate change. Furthermore, given the fact that changes in climatic conditions is a major perceived cause of climate change in the area, its complexity calls for collaborative efforts at the local, national, regional and international levels. Experiences from Zimbabwe indicate that natural changes in climate, random cutting of sacred trees, rampant deforestation, poor farming practices, and air pollution were the main causes of climate change (Mtambanengwe *et al.*, 2012; Moyo *et al.*, 2012).

Extent to which Climate Change Affects Local Livelihood Sources and Activities

In determining the extent to which climate change affects local livelihood sources and activities, respondents were asked to determine the level at which climate change hazards affects agricultural productivity, reduces water availability, affects the planting season, reduces household income, leads to destruction of crops, affects the size of land cultivated, leads to natural resources degradation, affects socioeconomic activities, leads to destruction of settlements, reduces water availability for livestock, reduces pasture for livestock, and affects the number of livestock.

An analysis of the information using principal component analysis with Oblimin rotation categorized them into three major components (Table 3) namely water and crop farming (Component 1), livestock keeping (component 2, and non agricultural activities (Component 3) as indicated by numbers 1, 2 and 3 as further explained below. It is important to note that the pattern and structure coefficients as indicated in table 3 shows the factors loadings of each of the 12 variables and information about the correlation between variables and factors (components) respectively.

Table 3. Pattern and structure matrix for PCA with Oblimin Rotation of three factor solution of effects of climate change on household's livelihoods

Item	Components[a] and Rotated factor loadings						Communalities
	Pattern coefficients[b]			Structure coefficients[c]			
	1	2	3	1	2	3	
Reduces water availability	0.82	-0.11	-0.20	0.81	-0.47	0.13	0.69
Reduces agricultural productivity	0.76	-0.001	-0.03	0.75	-0.36	0.25	0.56
Affects planting season	0.73	-0.08	0.03	0.78	-0.43	0.32	0.61
Lead to destruction of crops	0.71	0.06	0.17	0.74	-0.31	0.42	0.58
Affects the size of land cultivated	0.70	-0.10	0.10	0.79	-0.45	0.38	0.64
Reduces water availability for livestock	-0.01	-0.88	-0.11	0.41	-0.87	0.14	0.76
Reduces pasture for livestock	0.06	-0.86	-0.08	0.44	-0.87	0.09	0.77
Affect the number of livestock	0.01	-0.84	0.11	0.45	-0.86	0.26	0.75
Destruction of settlements	0.22	-0.35	0.06	0.41	-0.46	0.20	*0.26*
Affects socioeconomic activities	0.12	0.14	0.86	0.38	-0.07	0.88	0.80
Natural resources degradation	-0.13	-0.24	0.83	0.29	-0.33	0.83	0.73
Reduces household income	0.41	0.05	0.49	0.57	-0.23	0.63	0.53

[a]Components: 1= Water and crop farming; 2= livestock keeping; and 3= non agricultural activities

[b]Pattern matrix shows the factor loading of each of the variables

[c] Structure matrix provides information about correlation between variables and factors

Component 1: Water and crop farming. In this component, specific issues of interest is the larger impact of climate change on water availability (0.82), reduction in agricultural productivity (0.76), effects of climate change on planting season (0.73), destruction of crops (0.71) and effect of climate change on the size of land cultivated (0.70). In essence these are the main challenges affecting the livelihoods of local communities in the area. In general, these issues strongly influence production activities in Dodoma region. For instance, effects on water availability limit women and children to engage in other matters related to production including diversification of income generating activities. In Tanzania, house chores such as fetching water, collection of firewood is the responsibility of women and children. Climate change also strongly affects agricultural related activities as it reduces agricultural productivity, destroys crops especially during the critical period of growth e.g. at the flowering stage or harvesting as a result of rainfall unpredictability in the area, and also it influences the amount of land to be cultivated. Considering the role of water in agricultural production, climate change strongly affects water availability for irrigation purposes. This was also ascertained by FGDs participants who opined that most water sources have dried up and others become seasonal, hence reducing the irrigation potential in the area.

Component 2: Livestock keeping. In this component, the variables that loaded high regarding the effects of climate change on the livelihoods of local communities in Dodoma region were reduced availability of water for livestock (-0.88), reduced pasture

for livestock (-0.86), and the effects of climate change on the number of livestock (-0.84). From the findings, the livelihood of local communities in the aspect of livestock keeping is strongly affected by water and pasture that in turn affects the contribution of livestock in promoting the social and economic well being of the local communities. Consequently, water and pasture availability also affect the number of livestock in Dodoma region. It is in this regard, during the focus group discussion it was noted that during the time of dearth caused by drought and low rainfall local residents walked long distance and sometimes temporarily migrated in search for water and pasture for livestock.

Although the issue of settlement was also loaded (more that 0.3) in this component, its loading was generally lower when compared to the loadings of issues related to livestock keeping. The implication is that the effect of climate change on local community settlements is not strongly felt by the local as an issue of concern when compared to other livelihoods aspects. The lower importance accorded to settlement destruction can further be observed on its communality value (0.26) which is tremendously low as compared to communality values for other household livelihood aspects considered in the PCA.

Component 3: Non agricultural livelihoods activities. Regarding this component (non agricultural livelihood activities), the variables that loaded higher were the effects of climate change on socioeconomic activities (0.86), natural resources degradation (0.84) and households income (0.49). The findings signify that climate change severely affects socioeconomic activities in the area. This is based on the fact that for other activities in particular the diversification of income generating activities to flourish and for the community to effectively engage in other social activities, it requires stability in the aspect of food security particularly on food production and accessibility. However, in the study area, the issue of food security is a matter of concern following reduced agricultural productivity on one hand and poverty that impedes local community to access food among other social needs. Another emerging aspect revealed by the findings is that the effects of climate change on household income is not of high concern (factor loading of 0.49) in the area as compared to socioeconomic activities (0.86) and natural resources degradation (0.84). This is supported by the fact that majority of local community in the area are actively engaging in subsistence agricultural activities. This also has been indicated by small farm size owned and cultivated by households in the area. On average households own and cultivate 6.98 ha and 5.8 ha respectively.

Correlation among major components established using PCA. Focusing on correlations of water and crop farming, livestock keeping, and non agricultural activities; the findings in Table 4 indicate a strong negative correlation (r = -0.48) between water and crop farming and livestock keeping. In addition, the findings also show a small negative correlation (r = -0.18) between non agricultural activities and livestock keeping. The findings also show medium positive correlation (r = 0.37) between non agricultural activities on one hand and water and crop farming on the other hand.

The negative correlation between livestock keeping on one hand and water and crop farming on the other can be explained by the status of livestock keeping and crop farming in the two districts in the area where most households in Bahi district engaged in livestock keeping as compared to their counterparts in Kongwa district. The vice-versa was true for households in Kongwa district where most residents engaged in crop

farming activities as compared to livestock keeping. Secondly, the phenomenon can be explained by the animosity relationship between crop farmers and livestock keepers especially on the use of resources namely water, pasture and land. Despite the existence of such conflicts, during FGDs it was noted that land use planning and enforcement are critical parameters for conflict resolution among resource users of which for the case of Dodoma region are dominated by crop farmers and livestock keepers.

Table 4. Component correlation matrix on the effects of climate change on household's livelihoods (N=398)

Component	Water and crop farming	Livestock keeping	Non agricultural activities
Water and crop farming	1.00		
Livestock keeping	-0.48	1.00	
Non agricultural activities	0.37	-0.18	1.00

The existence of small negative correlation between non agricultural activities and livestock keeping can be explained by the fact that it is very rare for livestock keepers especially pastoralists to engage in non agricultural activities for income generations purposes. Apart from the quest for increasing their herds' size, rarely can pastoralists engage in other socioeconomic activities such as businesses, temporary employment and natural resources degradation. However, of recent, following difficulties caused by climate change, pastoralists have started to venture on new livelihood opportunities. Nonetheless, the positive correlation between water and crop farming on one hand and non agricultural activities on the other hand can be explained by the fact that the good or poor performance on water and farming can positively or negatively influence the performance of households' non agricultural activities.

In general, the findings on the effects of climate change related hazards has portrayed that interventions to deal with climate change impacts on livelihood activities should involve strategies that have the potential to buffer rainfall variability challenges. This is based on the fact that water scarcity jeopardizes the key livelihood activities in the area. Such interventions may involve developing water storage infrastructures such as community rainwater harvesting tanks, construction of dams for domestic and agricultural purposes, promotion of in-situ rainwater water harvesting, and use of agricultural techniques that minimizes moisture loss among others. The findings on the effects of climate change in the area further underscores the need for provisions of extensive extensions services and other forms of socio-economic capacity building to the local community in the area so as to better adapt to climate related hazards, and contribute to global efforts towards climate change mitigation. In general, extensions services are of critical importance in empowering the local community with good agricultural practices and other necessary practical skills for climate change adaptation and mitigation planning. The importance for the need of extension services in dealing with climate change challenges have also been underscored in Vietnam, Kenya, Nigeria and Nepal (Hoang *et al.,* 2014; Khatri *et al.,* 2013; Ajani & Igbokwe, 2013; Ozor & Cynthia, 2010).

CONCLUSIONS AND RECOMMENDATIONS

The findings presented in this paper have painted a clear picture that the local causes of climate change in the area resonates around changes in climatic conditions, poor environmental management and lack of conservation education. Moreover, the PCA with Oblimin rotation results has depicted that the effects of climate change in the semi arid areas of central Tanzania vary in terms of their enormity. Given findings on the causes and effects of climate change in the semi arid areas of Dodoma region in central Tanzania, there is need for interventions dealing with climate change challenges for the purpose of improving the threatened local community livelihood opportunities. Towards this end, we argue that climate change policies, strategies and interested actors' efforts in the area should focus on addressing the questions of water availability for domestic and agricultural use; agricultural productivity; pasture for livestock mainly through sustainable livestock keeping and land use planning; promotion of socio-economic activities including diversification of income generating activities; and strengthening local capacity in natural resources management so as to increase local community resilience to the impacts of climate change. In addition, such efforts should be complimented by resolving local level conflicts among competing interests and groups over the utilization of productive resources.

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APPENDICES

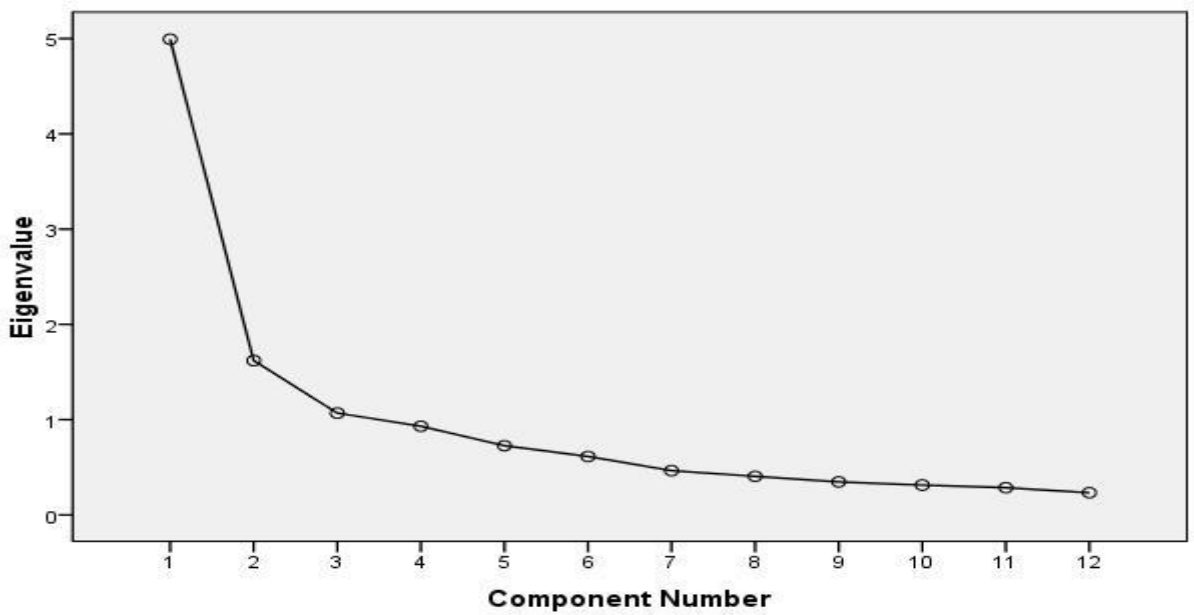
Appendix 1. Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	.574**	1.000										
3	.411**	.366**	1.000									
4	.463**	.516**	.406**	1.000								
5	.471**	.558**	.355**	.576**	1.000							
6	.351**	.396**	.719**	.369**	.454**	1.000						
7	.445**	.378**	.232**	.284**	.427**	.350**	1.000					
8	.378**	.459**	.273**	.585**	.499**	.284**	.395**	1.000				
9	.277**	.382**	.656**	.442**	.349**	.627**	.147*	.323**	1.000			
10	.209**	.327**	.172**	.198**	.325**	.268**	.326**	.318**	.294**	1.000		
11	.271**	.279**	.075	.187**	.334**	.178**	.496**	.410**	.068	.571**	1.000	
12	.176**	.298**	.262**	.344**	.403**	.275**	.222**	.248**	.357**	.262**	.094*	1.000

Note: **. Correlation is significant at the 0.01 level (2 – tailed); *. Correlation is significant at the 0.05 level (2 – tailed)

Variables: 1= Reduces agricultural productivity; 2 = affects planting season; 3 = reduces pasture for livestock; 4 = reduces water availability; 5 = affects the size of land cultivated; 6 = affects the number of livestock; 7 = reduces household income; 8 = lead to destruction of crops; 9 = reduces water availability for livestock; 10 = natural resources degradation; 11 = affects socio-economic activities; and 12 = Destruction of settlements.

Appendix 2. Scree plot showing eigenvalues for twelve components



BIO-DATA

Hozen K. Mayaya is a PhD student at the School of Environmental studies, University of Eldoret. His research interests are in climate change, environmental management, environmental education, and wildlife management.