Pastoral Responses to Climate and Forage Variability in Kapoeta Region of South Sudan

Francis A. Onono[1*], Sadhat S. Walusimbi[2], Emmanuel Zziwa[3]

[1] Department of Animal Production, School of Natural Resources and Environmental Studies, University of Juba, P.O. BOX 82, Juba, South Sudan.

[2, 3] Department of Agricultural Production, School of Agricultural Sciences, College of Agriculture and Environmental Studies, Makerere University, P.O. Box 7062, Kampala, Uganda

*Corresponding author: saburiemmanuel8@gmail.com

ABSTRACT

Climate and forage variability are real and hurting livestock production in semi-arid areas of South Sudan. In Kapoeta region, climate and forage variability compelled pastoralists to use coping and adaptation strategies to alleviate its impact on livestock production. The study assessed pastoral knowledge, perceptions, coping and adaptation strategies, and factors that influence their decisions to respond to climate and forage variability in semi-arid area of Kapoeta. A cross-sectional survey of pastoral households was conducted between March and April 2016 using structured and semi-structured questionnaires. Descriptive statistics was used to present pastoral knowledge, perceptions and responses to climate and forage variability. Logistic regression was run to establish factors influencing their decisions to cope and adapt to climate and forage variability. The results showed that the majority of the pastoralists (63 percent) observed changes in climate and 66 percent of the respondents mentioned that they migrate in search of forage and water for their livestock. Their movement was instigated by distance to water points in dry season and the need to conserve pasture *in-situ*. Further, 40 percent of the respondents cited changing from rearing cattle to sheep and goats as their adaptation strategy to climate and forage variability. These adaptation strategies were significantly influenced by household grazing land owned and accessed ($P<0.05$).Pastoral coping and adaptation strategies are the means to endure the impact of climate and forage variability on livestock production which is critical for designing future interventions to improve their livelihoods.

Key words: Climate, Forage, Pastoralists, Coping Strategies

INTRODUCTION

Pastoralists endure unreliable and inadequate forage and water availability emanating from climate change in semi-arid areas of East Africa. In South Sudan, pastoralists in Eastern Equatoria State (EES) experience insufficient forage and water availability for livestock production. Consequently, they use coping and adaptation mechanisms to avert the menace of climate and forage variability on livestock production. According to Levina and Tirpak (2006), coping strategies are pastoral means of escaping the risk of climate and forage variability in semi-arid areas.

In Kapoeta, similar to East African semi-arid areas, pastoralists practise transhumance and nomadic livestock production systems supplemented by cultivation of crops to escape the risks of climate and forage variability (Egeru, 2015).The transhumance livestock production system consists of horizontal and vertical migration in search of pasture in dry and wet seasons (REACH, 2018).The horizontal transhumance is defined as the pastoral migration from high land into valleys and swampy areas in dry seasons whereas the migration of pastoralists during wet season to mountainous and hilly areas in search of pasture is known as vertical transhumance (vertical migration). The horizontal migration was used to move into the valleys and swampy areas of Lofon and Namerikinyang in dry seasons. In wet season, pastoralists practise vertical transhumance to migrate into hilly and mountainous areas of Muragippi, Kimotong and Napak (Jones, 2001; REACH, 2018).Other pastoral coping strategies include assistance from Non-Governmental Organizations (NGOs), selling or sharing livestock with relatives and crop cultivation (Opiyo *et al*., 2015;Sulieman& Ahmed, 2013). Furthermore, pastoralists also practise nomadic livestock production systems. Overall, these pastoral coping strategies enable them to overcome seasonal impacts of climate change and forage variability on their livestock production.

Pastoralists often employ adaptation strategies to alleviate prevailing or expected risk of climate change and forage variability on livestock production (Levina and Tirpak, 2006). This involves including more small ruminants in their herd. Small ruminants such as goats and sheep are known to be resilient to diseases, droughts and forage scarcity (Opiyo *et al*., 2015). Other viable pastoral adaptation strategies include crop cultivation and forage preservation in dry season (Opiyo *et al*., 2015). However, pastoral adaptation mechanisms differ from coping strategies because the former is a long-term adjustment to climate change and forage variabilities. Ultimately, coping and adaptation mechanisms are pastoral responses to avert the impact of climate change and forage scarcity on livestock production. No studies have been carried out on the pastoralists in Kapoeta region of South Sudan to explain their responses to the prevailing climate changes and shortages of forage. Therefore, this study provides insight on pastoral knowledge, perceptions and responses to climate and forage variability essential for management of livestock production in South Sudan. Specifically, the study establishes factors influencing pastoral decisions to cope and adapt to climate and forage variability in semi-arid area of Kapoeta.

MATERIALS AND METHODS

Study area

Kapoeta region is a semi-arid area covering three counties of EES (Figure.1) with an estimated population of 35,000 people (SSCCSE, 2010) who experience endemic low annual rainfall and high temperature (FEWS NET, 2011). As such, livestock production is the primary source of livelihood stemming from ineffective rain-fed crop production (SSNBS, 2011). The livestock kept under transhumance and nomadic livestock production systems in this region include: sheep, goats, cattle, camels, horses and donkeys. They graze and browse on communal grazing land endowed with annual grasses and shrub species.

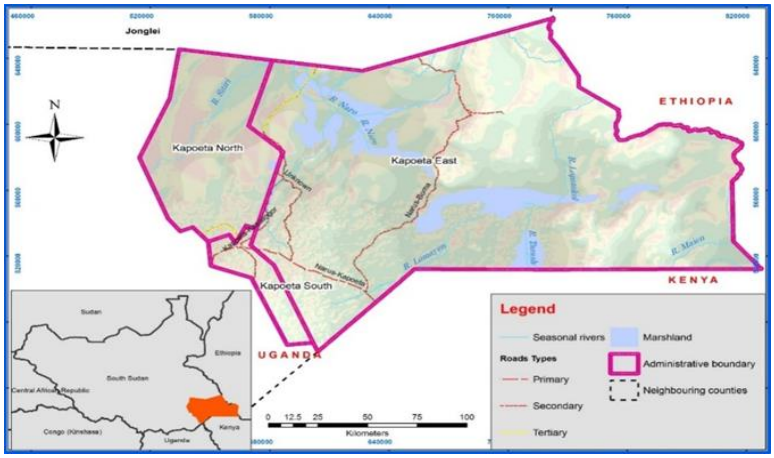

Figure 1. Map showing the three counties of Kapoeta region

Cross-sectional survey

To ascertain the number of pastoralists for the cross-sectional survey, a multistage sampling technique was employed: three counties of EES were chosen on the basis of their occurrence in semi-arid area of Kapoeta, four payams selected from each county, five bomas selected from each payam, and three household members were randomly chosen from each village (known as boma). The pastoralists interviewed were those who keep Toposa cattle. The Toposa culturally prefer keeping their Toposa cattle as a source of livelihood (SSNBS, 2011). The sample size of 164 pastoralists were selected from different families and was determined using online survey monkey sample size calculator. The sample size was calculated from the population of 35,000 people, 80 percent level of confidence and five percent margin of error from the formula (https://www.surveymonkey. Com /mp/ lp/ sample-size-calculator):

$$n = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Where **n** is the sample size; **z**, the z-score, **e** is the margin of error, **p,** the proportion of Toposa people keeping livestock and **N** represents the total population in Kapoeta region.

Semi-structured and structured questionnaires were used to interview pastoral respondents between March and April 2016 to document how they cope and adapt to climate and forage variability. The questionnaires were administered by trained enumerators who understood and spoke Toposa and English languages.

Data analysis

Descriptive statistic using pivot table in excel 2013 version was used to produce charts and graphs of pastoral knowledge, perceptions, coping and adaptation mechanisms to climate change and forage variability in Kapoeta.

Furthermore, logistic regression was employed to establish the factors influencing pastoral decisions to cope and adapt with climate and forage variability (Fadina and Barjolle, 2018). The factors influencing pastoral decisions to respond to climate and forage variability were used as dependent variables to run the logistic model against the independent variables such as sex, age and literacy level. The Logistic Regression was represented by the formula (http://www.ncss.com):

$$Logit(P) = In\left(\frac{P}{1-P}\right)$$

Where **P** represents pastoral proportion that cope and adapt with climate and forage variability while **1-P** represents the pastoralists who never used coping and adaptation mechanisms against climate and forage variability.

The Logistic Regression employed the model (http://www.ncss.com):

$$Y = \beta_0 + \beta_1 \chi_1 + \ldots \beta_5 \chi_5$$

Where **Y** denotes coping and adaptation strategies of pastoralists to climate and forage variability, β_0 signifies constant of pastoralists that did not use coping and adaptation strategies to climate and forage variability, $\beta_{1\ldots}\beta_5$ represent the coefficient of the regression model and $X_1 \ldots X_5$ represent the factors influencing the pastoral knowledge, perceptions, coping and adaptation mechanisms to climate and forage variability. The model was run in the statistical package for Social Sciences, IBM version 23 (SPSS 23). In SPSS, Code 1 denotes those who use coping and adaptation strategies to climate and forage variability while those who did not employ coping and adaptation strategies were coded 0**.** This coding was employed for all the dependent variables while independent variables were coded according to their categories. The dependent variable was run against the independent variable to establish the factors influencing pastoral knowledge, perceptions, coping and adaptation mechanisms to climate and forage variability.

RESULTS

The basic information of pastoral households

The demographic information of pastoral households (N=164) in Kapoeta region obtained in 2016 during the cross-sectional household survey are presented in Table 1. A total of 164 pastoral household members selected from different families were interviewed to establish their knowledge, perceptions and how they coped and adapted to climate and forage variability in semi-arid area of Kapoeta. The majority of the pastoralists interviewed were adults of age more than 40 years (Table. 1), though

literacy level was low among the pastoral communities. Eighty-Four (84) percent of the pastoralists had no formal education but were experienced in livestock production (51 percent) especially, cattle rearing for more than 20 years. They grazed and browsed their livestock in open natural rangeland of the communities (Table. 1).

Table 1. Pastoralists' household basic Information

Location: Kapoeta South, North and East Counties	Number	Percentages
Households	**164.00**	**100.00**
Age of Respondents		
18-30 Years	39.00	24.00
31-40 Years	66.00	40.00
41-50 Years	41.00	25.00
51-60 Years	16.00	10.00
61-70 Years	2.00	1.00
Total	**164.00**	**100.00**
Literacy Level		
No Formal Education	137.00	84.00
Primary Level	20.00	12.00
Secondary Level	5.00	3.00
Higher Institution	1.00	1.00
Total	**163.00**	**100.00**
Experience in cattle production		
0-5 Years	18.00	11.00
6-10 Years	17.00	10.00
11-15 Years	45.00	28.00
>20 Years	82.00	51.00
Total	**162.00**	**100.00**
Household land Size Owned		
0.004-0.020 Km^2	30.00	11.00
0.024-0.040 Km^2	32.00	10.00
0.045-0.081 Km^2	S26.00	28.00
Use Open Grazing Land	45.00	51.00
Total	**133.00**	**100.00**
Community Land	92.00	97.00
Bought Land	2.00	2.00
Government Land	1.00	1.00
Roadside Land	0.00	0.00
Rented Land	0.00	0.00
Total	**95.00**	**100.00**

Survey Location: Kapoeta South, North & East County

The pastoral knowledge and perceptions on climate change

In the case of climate variability, 63 percent of the pastoralists observed changes in climate from 1984 to 2016 (Figure. 2). However, pastoral knowledge on the changes in climate and forage resources were not influenced by any demographic factors in the study (Table. 2), though they attributed climate change to bush burning and deforestation (Figure. 3) which was influenced by literacy level (Table. 3). Pastoralists perceived that climate change was manifested by reduced rainfall, forage and water availability, seasonal variability and frequent droughts (Figure. 4). They observed that frequent severe droughts had paramount effect on livestock production particularly cattle (Table. 4).

Pastoral coping strategies to climate and forage variability

To cope up with climate change and forage variability, 66 percent of the pastoralists said they often

migrated to access pasture in swamps, valleys and mountainous areas during forage scarcity in dry and wet seasons in and around Kapoeta region (Figure. 5).

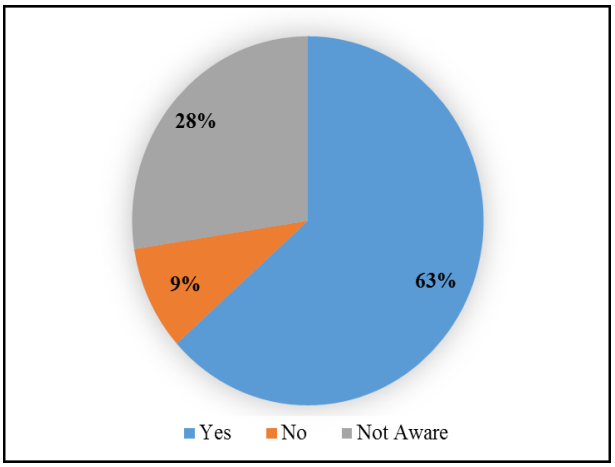

Figure 2. Knowledge of climate change among pastoralists

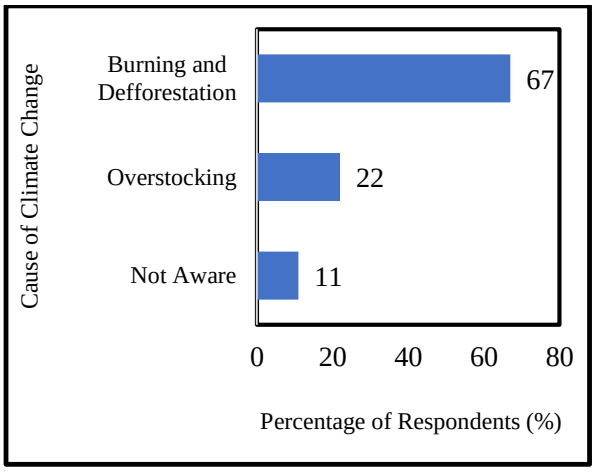

Figure 3. Causes of climate change perceived by pastoralists

Table 2. Factors influencing pastoral knowledge on climate change

Explanatory Variable	Yes		No		Not Aware	
	Exp(B)	P-Value	Exp(B)	P-Value	Exp(B)	P-Value
Sex	1.029	0.935	0.433	0.217	1.334	0.452
Age	0.943	0.734	1.357	0.261	0.949	0.786
Literacy level	1.490	0.276	0.412	0.295	0.862	0.708
Production experience	1.230	0.169	0.918	0.724	0.825	0.237

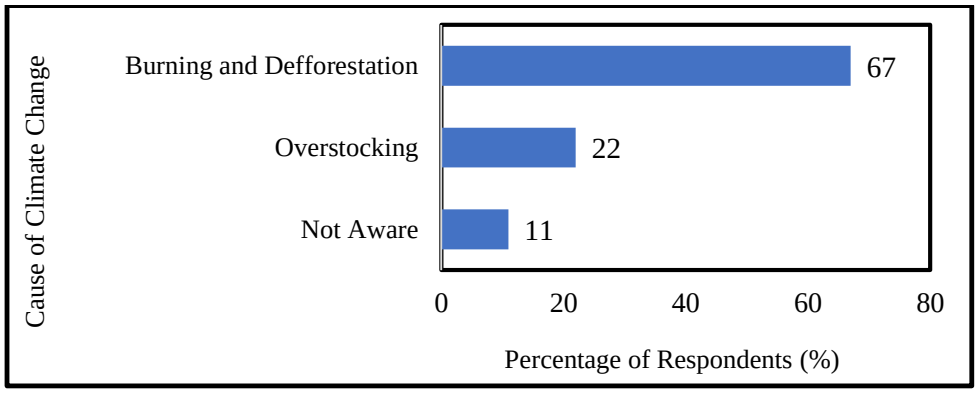

Figure 4. The Causes of Climate Change Perceived by the Pastoralists

Table 3. Factors Influencing Pastoral Perception on Climate Change

Explanatory Variable	**Burning & Deforestation**		**Overstocking**		**Not Aware**	
	Exp(B)	**P-Value**	**Exp(B)**	**P-Value**	**Exp(B)**	**P-Value**
Sex	0.307	0.299	0.000	0.997	0.659	0.376
Age	0.415	0.122	0.701	0.664	0.915	0.685
Literacy level	1.150	0.827	1.532	0.641	2.101	0.031*
Production experience	0.948	0.897	0.895	0.870	0.757	0.120

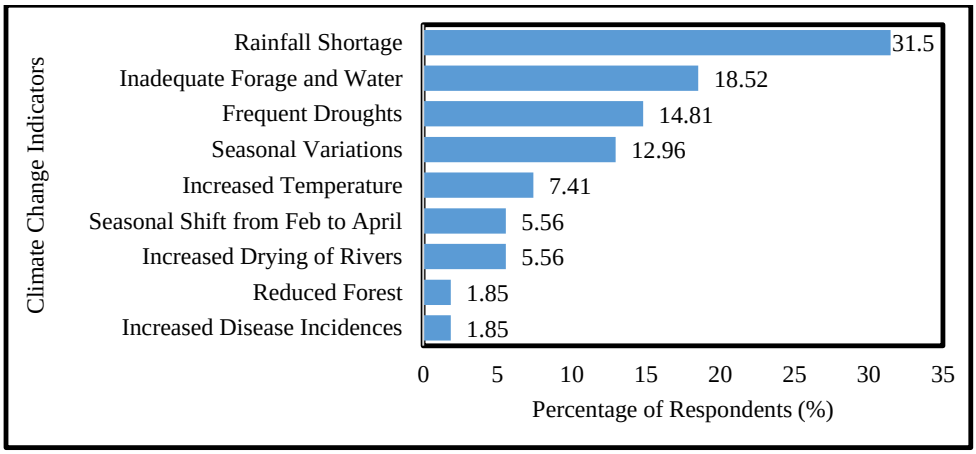

Figure 5. Indicators of Climate Change Observed by the Pastoralists

Table 4. Pastoral Perception on the Effect of Climate Change on Livestock (Cattle) Production

	N	Minimum Likert Scale	Maximum Likert Scale	Sum	%	Mean	Standard Deviation	Rank
Frequent Severe Droughts	164	0	5	589	14.56	3.59	1.886	1
Unreliable Rainfall	164	0	5	540	13.36	3.29	1.912	2
New Diseases	164	0	5	503	12.44	3.07	1.847	3
Reduced Pasture Availability	164	0	5	499	12.34	3.04	1.784	4
Increased Temperature	164	0	5	491	12.14	2.99	1.891	5
Increased fight over pasture	164	0	5	470	11.63	2.87	1.822	6
Observe drying of Rivers	164	0	5	410	10.14	2.50	1.939	7
Increased cattle rustling	164	0	5	364	9.00	2.22	1.950	8
Frequent Severe Floods	164	0	5	177	4.38	1.08	1.800	9
Valid Total Number	164			4043	100.0			

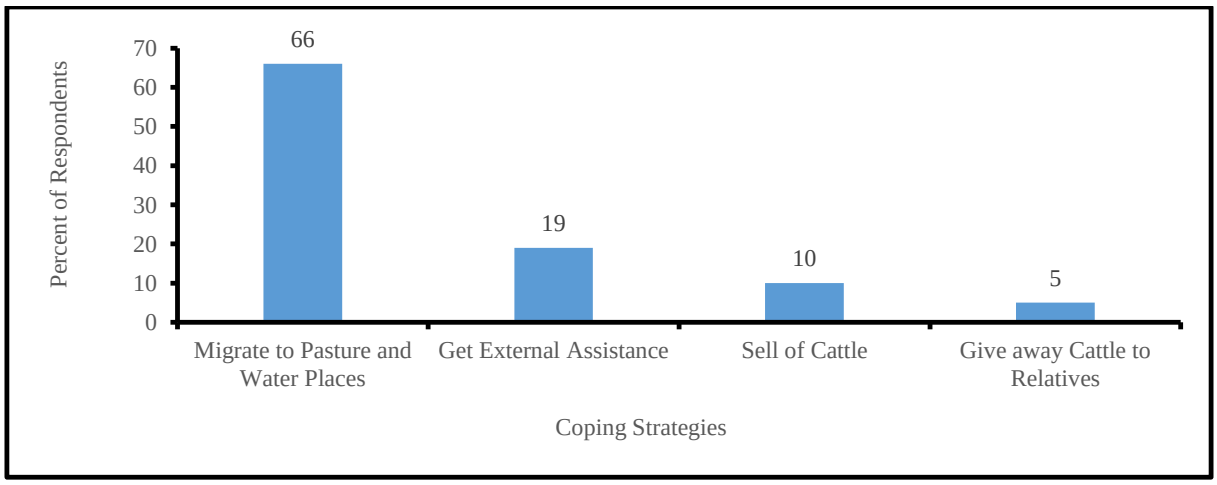

Figure 6. Coping Strategies to Climate Variability and Pasture Scarcity

Migration in search of livestock pasture was used as means of conserving pasture during climate and forage variability. In addition, pastoralists migrated to access distant water sources in dry seasons. Conversely, they depended on external assistance to cope with climate and forage variability. The external assistance given to the pastoralists was influenced by experience in livestock rearing, livestock land size owned and accessed, and livestock grazing systems in Kapoeta region (Table 5). The Figure. 5 shows short term pastoral coping strategies employed during dry and wet seasons in order to sustain

livestock productivity in Kapoeta region. The respondents often used multiple coping strategies to climate and forage variability during dry and wet seasons, but mostly seasonal migration in search of pasture. The Table 5 indicates factors influencing pastoral decisions when making a particular choice(s) on a specific coping strategy to be employed during prevailing climate and forage variability in wet and dry seasons. The choice of particular coping strategy was significant at <0.05.

Table 5. Factors influencing pastoral decisions to cope with climate and forage variability

Explanatory Variable	Migrate to Pasture Places		Get External Assistance		Sale of Cattle		Loaning Relative Cattle	
	Exp(B)	P-Value	Exp(B)	P-Value	Exp(B)	P-Value	Exp(B)	P-Value
Sex	0.907	0.814	1.407	0.454	1.063	0.916	0.147	0.076
Age	0.871	0.495	0.905	0.680	1.612	0.114	0.817	0.571
Education	2.803	0.103	1.312	0.526	0.983	0.978	0.876	0.815
Experience in Cattle Rearing	0.865	0.454	1.844	0.022*	1.383	0.287	1.416	0.372
Economic Activities of Husband	0.714	0.234	1.112	0.725	0.804	0.727	0.766	0.701
Economic Activities of Wife	1.310	0.187	0.613	0.060	1.204	0.540	0.914	0.789
Economic Activities of Male Children	0.934	0.755	1.214	0.491	0.744	0.483	0.776	0.561
Economic Activities of Female Children	0.947	0.738	0.705	0.086	1.304	0.249	1.155	0.578
Household Land Size Owned	1.045	0.744	1.658	0.005*	1.528	0.068	0.997	0.992
Household Land Access	0.641	0.227	0.264	0.005*	0.185	0.008*	0.525	0.342
Livestock Grazing Systems	0.549	0.187	0.375	0.110	0.727	0.582	0.797	0.727
Forage Resources	1.812	0.355	3.885	0.022*	3.921	0.067	1.954	0.461
Forage Grass Species	2.568	0.082	0.099	0.026*	0.375	0.398	0.240	0.223
Forage Legumes Species	1.025	0.966	29.206	0.001*	25.793	0.004*	5.548	0.133
Pasture Conservation Methods	0.728	0.011*	1.089	0.524	0.881	0.519	1.261	0.239
Type of Crop Residues Utilized	0.824	0.639	0.434	0.065	2.716	0.123	1.601	0.484
Supplementary Feed Used	1.490	0.407	1.210	0.716	0.853	0.828	0.367	0.136
Livestock Water Sources	1.115	0.538	0.950	0.774	0.919	0.717	0.741	0.425
Distant from Water in Dry Seasons	0.513	0.001*	1.358	0.126	0.977	0.927	1.063	0.843
Water Distant in Wet Seasons	1.367	0.134	0.691	0.117	0.571	0.086	1.230	0.504
Livestock Disease Occurrence	0.984	0.892	0.800	0.128	0.696	0.076	0.925	0.688

Exp (B) = Exponential Coefficient of Logistic Regression, *=Significant at 0.05

Pastoral adaptation strategies to climate and forage variability

When the pastoral respondents were asked about their adaptation strategies to climate and forage variability, 40 percent majority preferred changing from rearing large ruminants to small ruminants (Figure. 6).

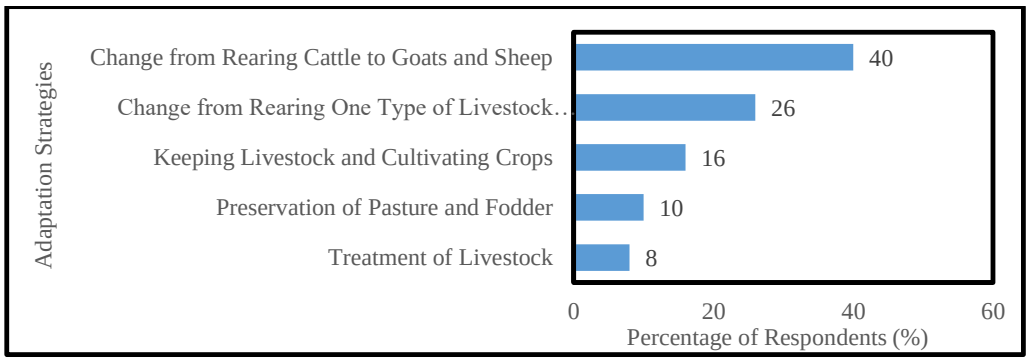

Figure 7**.** Adaptation strategies to climate variability and pasture scarcity

The pastoral decision to rear small ruminants especially goats and sheep emanated from the house hold land size owned and accessed for livestock production (Tables 6a and 6b).Subsequently, in Figure 6, 26 percent of the pastoralists cited diversification of livestock species in their herd as an adaptation strategy to climate and forage variability. Livestock enterprise diversification is dictated by pastoral household land size owned and forage species available for livestock feeding (Tables 6a and 6b).Other pastoral adaptation strategies to climate and forage variability indicated in Figure 6 included rearing

livestock production supplemented by crop cultivation, preserving pasture and treating livestock against diseases.

Table 6a. Factors influencing pastoral decisions to adapt to climate and forage variability

Explanatory Variable	Change from cattle to Goats & Sheep		Diversify Livestock Types		Livestock and Crop Production	
	Exp(B)	P-Value	Exp(B)	P-Value	Exp(B)	P-Value
Sex	0.541	0.134	1.193	0.687	2.519	0.079
Age	0.847	0.395	0.859	0.501	1.360	0.298
Education	1.196	0.620	1.125	0.772	1.163	0.772
Experience in Cattle Rearing	1.304	0.150	1.234	0.290	1.879	0.072
Husband Economic Activities	0.772	0.488	1.232	0.457	1.351	0.393
Wife Economic Activities	0.756	0.148	0.765	0.223	0.801	0.469
Economic Activities of Male Children	1.188	0.387	1.047	0.859	0.794	0.577
Economic Activities of Female Children	1.275	0.107	0.870	0.426	0.937	0.787
Household Land Size Owned	0.733	0.016*	1.610	0.003*	1.123	0.571
Household Land Access	2.756	0.008*	0.929	0.860	0.179	0.002*
Livestock Grazing Systems	2.115	0.060	1.001	0.998	0.022	0.085
Forage Resources	0.646	0.407	2.789	0.083	2.162	0.366
Forage Grass Species	1.914	0.151	0.193	0.010*	0.002	0.702
Forage Legumes Species	0.931	0.873	4.817	0.016*	63819.8	0.500*
Forage Conservation	0.820	0.069	0.820	0.127	1.238	0.311
Crop Residues Utilized	1.124	0.740	0.541	0.146	0.252	0.059
Supplementary Feed	1.690	0.235	1.016	0.975	0.920	0.917
Livestock Water Sources	0.862	0.314	0.712	0.076	1.308	0.342
Water Distant in Dry Season	1.157	0.312	0.845	0.353	0.649	0.159
Water Distant in Wet Season	0.862	0.395	0.896	0.620	0.725	0.310
Livestock Disease Occurrence	1.090	0.362	0.845	0.193	0.753	0.170

Exp (B)=Exponential Coefficient of Logistic Regression,*=Significant at 0.05

The factors influencing pastoral decisions to make a particular choice(s) on a specific long-term adaptation strategy during prevailing climate and forage variability in wet and dry seasons. The choice of particular adaptation strategy was significant at <0.05.

DISCUSSION

The study sought to provide insight on pastoral knowledge and perceptions, and how they cope and adapt to climate and forage variability. The study particularly establishes factors influencing pastoral decisions to cope and adapt to climate and forage variability in semi-arid area of Kapoeta. The study found that pastoralists were knowledgeable about climate change and their perceptions, though influenced by educational level, showed that climate change resulted from human activities such as burning bushes and deforestation.

Further, the study shows that pastoral coping and adaptation strategies to climate change were migration to pasture places and majorly were rearing small ruminants. However, pastoral coping and adaptation strategies were driven by water source distances and household livestock production land owned.

Pastoral knowledge and perception on climate change

The study showed that pastoralists in semi-arid areas of South Sudan were knowledgeable of the occurrence of climate change in the last 30 years. This agrees with the reports of studies conducted on climate change in the semi-arid areas of South Sudan by FEWS NET, (2011) and USAID, (2016). However, pastoral knowledge on climate change was not influenced by socio-demographic parameters. They, however, attributed changes in climate and forage resources to bush burning and deforestation. The education level of the pastoralists influenced their perception. Similarly, pastoral

communities dwelling in semi-arid areas of East Africa pinpointed bush burning and deforestation as the major cause of climate change in the last 10 years (Egeru *et al*., 2015; Nimusiima *et al*., 2013).

Table 6b. Factors influencing pastoral decisions to adapt to climate and forage variability

Explanatory Variable	Preserve Pasture		Treat Livestock	
	Exp(B)	P-Value	Exp(B)	P-Value
Sex	1.655	0.412	0.124	0.104
Age	0.916	0.794	0.421	0.114
Education	0.378	0.328	3.164	0.074
Experience in Cattle Rearing	0.713	0.209	3.702	0.076
Husband Economic Activities	1.338	0.488	1.019	0.985
Wife Economic Activities	0.929	0.795	1.002	0.997
Economic Activities of Male Children	0.385	0.088	0.494	0.185
Economic Activities of Female Children	1.810	0.011*	3.245	0.008*
Household Land Size Owned	0.862	0.487	0.251	0.006*
Household Land Access	0.858	0.796	0.654	0.529
Livestock Grazing Systems	0.805	0.722	0.276	0.500*
Forage Resources	0.451	0.377	6.273	0.056
Forage Grass Species	0.211	0.111	0.079	0.033*
Forage Legumes Species	2.465	0.397	0.534	0.674
Forage Conservation	2.465	0.397	0.749	0.250
Crop Residues Utilized	11.817	0.008*	0.542	0.422
Supplementary Feed	0.305	0.123	0.954	0.961
Livestock Water Sources	1.360	0.210	0.992	0.975
Water Distant in Dry Season	5.265	0.003*	1.107	0.744
Water Distant in Wet Season	1.138	0.656	1.876	0.108
Livestock Disease Occurrence	1.190	0.384	1.131	0.595

Exp (B) = Exponential Coefficient of Logistic Regression,*=Significant at 0.05

The factors influencing pastoral decisions to make a particular choice(s) on a specific long-term adaptation strategy during prevailing climate and forage variability in wet and dry seasons. The choice of particular adaptation strategy was significant at <0.05.

Evidently, climate change has been known to cause a reduction in the amount of annual rainfall, forage and water availability, frequent droughts, seasonal shifts, increased temperature, drying of rivers and livestock diseases that undermine pastoral coping and adaptive capacity (FEWS NET, 2011; USAID, 2016).Pastoralists indicated that rainfall variability affected forage and water availability for their livestock (Egeru*et al*., 2015). As such, they ranked frequent severe droughts as one of the climate parameters with profound impact on livestock production. Nevertheless, the effect of droughts may be reduced through improvement in management of rangeland resources. The study found that pastoral respondents were knowledgeable of climate change and they believed that changes in climate was caused by vegetation damage in semi-arid area of Kapoeta.

Pastoral coping strategies to climate and forage variability

The pastoralists use coping strategies to alleviate the impact of climate and forage variability on livestock production. Levina and Tirpak (2006) defined coping strategies as short-term response to climate and forage variability in semi-arid area. In this study, 66 percent of the respondents said that they usually migrated to access pasture for their livestock, especially, forage and water during dry and wet seasons in Kapoeta. Migration of livestock in search of pasture and water in dry and wet seasons was also reported by Egeru (2015) in East Africa and Sulieman and Ahmed (2013) in Eastern Sudan. Although pastoral migration is currently unrestricted in the communal rangeland of Kapoeta, future pastoral migration depends on land tenure systems. Sulieman and Ahmed (2013) of Eastern Sudan showed that agricultural mechanization hinders access to palatable forage resources in wet and dry

seasons. In Kapoeta, pastoral migration is the means to conserve pasture and access water for livestock in wet and dry seasons. Pastoral migration offers pasture deferments for forage regeneration *In-situ* (Egeru, 2015; Opiyo *et al*., 2015; REACH, 2018; Sulieman and Ahmed, 2013).

Furthermore, pastoralists cope with climate and forage variability through external assistance, sales and lending livestock to relatives in semi-arid area of Kapoeta (Table 5). The external assistance rendered by Non-Governmental Organization (NGOs), Government Institutions and Community Based Organizations (CBOs) that include livestock vaccination, building dams and livestock units, depend on pastoral experience in rearing livestock, households owning and accessing land, and availability of livestock forage resources. Sulieman and Ahmed (2013) observed that solutions to pastoral problems should surface from understanding the causes of the problems. Therefore, effective early warning mechanisms and awareness to improve livestock production, and build pastoral resilience to climate change and forage variability are essential (Bobadoye *et al*., 2016). The study shows that pastoral coping strategies offer relief to livestock production during climate and forage variability in semi-arid area of Kapoeta.

Pastoral adaptation strategies to climate and forage variability

Pastoralists use adaptation strategies defined as long-term adjustment, to reduce actual or expected effect of climate change on their livelihoods (Levina and Tirpak, 2006; Opiyo *et al*., 2015). Changing from rearing cattle to goats and sheep, diversifying livestock species, keeping livestock and producing crops, preserving pasture, and treating animal against diseases were the most important adaptation strategies used by pastoralists in Kapoeta region for climate change and forage variability. They prefer small ruminants because of their resilience to diseases, forage and water scarcity.

However, pastoral preference of small ruminant is influenced by land size owned and accessed by household for livestock production. Similar perception of farmers was reported in six agro-ecological zones of Uganda by Okonya *et al*., (2013). Significantly, livestock diversification as perceived by the pastoral communities in Kapoeta region, maintains ecological balance and broadened family resources base, thus reducing pastoral household losses from diseases, droughts and forage scarcity (Bobadoye *et al*., 2016). The browsing and grazing habits of the small ruminants allow proper utilization of grasses and shrubs forage resources in Kapoeta.

Pastoralists cultivate crops to supplement livestock production, though mostly done by women. Crop residues provide alternative source of livestock feeds in dry seasons, but mechanized agriculture encroaches on livestock grazing land, exacerbating conflict between pastoralists and crop farmers (Suleiman and Ahmed, 2013).

Therefore, pasture preservation offers critical avenue to maintain livestock production in semi-arid area of Kapoeta. The study showed that preserving crop residues assists livestock feeding during dry seasons and forage scarcity. Accordingly, practising good livestock feeding will support their treatment against diseases. This is influenced by household economic activities, land size owned, and grazing systems.

The pastoral perceptions, and their coping and adaptation strategies to climate change was influenced by education level, pasture conservation techniques, distance to water sources in dry seasons, household land owned and accessed. This is critical for designing future climate mitigation policies to improve pastoral resilience and livelihoods in Kapoeta region of South Sudan.

There is need for improvement in regulating access to water sources and individual household lands, in addition to provision of opportunities to conserve feeds using a variety of techniques, and improvement in pastoral resilience to reduce their vulnerability to climate and forage variability in Kapoeta.

ACKNOWLEDGEMENTS

We are thankful for the financial support of NORHED under CAPSNAC Project through the University of Juba that was implemented in Makerere University, Kampala-Uganda.

REFERENCES

Bobadoye, A. O., Ogara, W. O., Ouma, G. O. and Onono, J. O. (2016). Assessing Climate Change Adaptation Strategies among Rural Maasai pastoralist in Kenya. *Science and Education Publishing (SciEP), 4*(6), 120–128. https://doi.org/10.12691/ajrd-4-6-1

Egeru, A. (2015). Climate Risk Management Information, Sources and Responses in a Pastoral Region in East Africa. *Elservier*, 11: 1-14. (http://doi.org/10.1016/j.crm.2015.12.001).

Egeru, A., Wasonga, O., Mburu, J., Yazan, E., Majaliwa, M. G. J. and Macopiyo, L. (2015). Drivers of forage availability : An integration of remote sensing and traditional ecological knowledge in Karamoja sub-region , Uganda.*Springer*, 1–15. https://doi.org/10.1186/s13570-015-0037-6

Fadina, A. M. R. and Barjolle, D. (2018). Farmers ' Adaptation Strategies to Climate Change and Their Implications in the Zou Department of South Benin. *Environments*, *5*(15): 1–17. https://doi.org/10.3390/environments5010015

FEWS NET. (2011). A Climate Trend Analysis of Sudan. *U. S. Geological Survey*. Reston, 1-6. https://pubs.usgs.gov/fs/2011/3072/pdf/FS2011-3072.pdf

Jones, B. (2001). Review of Rinderpest Control in Southern Sudan. *Prepared for the Community-based Animal Health and Epidemiology (CAPE) Unit of the Pan African Programme for the Control of Epizootics (PACE).* 1-39

Levina, E. and Tirpak, D. (2006). Key Adaptation Concepts and Terms (draft). *Oragnisation for Economic Co-Operation and Development*.

Monkey Survey Sample Size Calculator (2019). https://www.surveymonkey.com/mp/sample-size-calculator/

NCSS (2018). Logistic Regression. *National Council for Social Studies.* http://www.ncss.com

Nimusiima, A., Basalirwa, C. P., Majaliwa, J. G. M., Otim-Nape, W., Okello-Onen, J., Rubaire-Akiiki, C. & Ogwal-Byenek, S. (2013). Nature and Dynamics of Climate Variability in the Uganda Cattle Corridor. *African Journal of Environmental Science and Technology*, *7*(8): 770–782. https://doi.org/10.5897/AJEST2013.1435

Okonya, J. S., Syndikus, K. and Kroschel, J. (2013). Farmers ' Perception of and Coping Strategies to Climate Change : *Evidence From Six Agro-Ecological Zones of Uganda*. *5*(8): 252–263. https://doi.org/10.5539/jas.v5n8p252

Opiyo, F., Wasonga, O., Nyangito, M. and Schilling, J. (2015). Drought Adaptation and Coping Strategies among the Turkana Pastoralists of Northern Kenya. *International Journal of Disaster Risk Science*, 6 (3): 295–309. https://doi.org/10.1007/s13753-015-0063-4

REACH. (2018). Greater Kapoeta Cattle Migration and Cholera Transmission Brief Greater Kapoeta Cattle Displacement Brief, (March). http://www. Researchresourcecentre.info/system/files/resourcedocuments/ reach_ssd_greater_kapoeta_cattle_migration_brief_march_2018.pdf

SSCCSE. (2010). Statistical Yearbook for Southern Sudan. *Southern Sudan Centre for Census, Statistics and Evaluation*, 31–32. Retrieved from www.ssccse.org

SSNBS. (2011). Key Indicators for Eastern Equatoria. Juba. Retrieved from (www.ssccse.org)

Sulieman, H. M. & Ahmed, A. G. M. (2013). Monitoring Changes in Pastoral Resources in Eastern Sudan : A Synthesis of Remote Sensing and Local Knowledge. *Spinger*, *3*(22), 1–16. http://www.pastoralismjournal.com/content/3/1/22%0AR

USAID. (2016). Climate Change Risk Profile in South Sudan: Country Fact Sheet. 1-5.://www.climatelinks.org/resources/climate-change-risk-profile-south-sudan