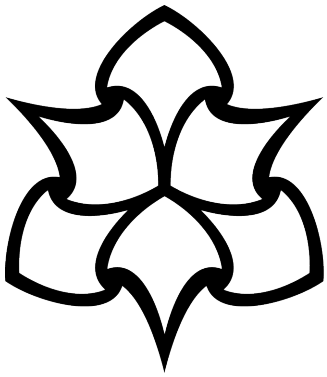


Climate Change Responses among the Maasai Community in Kenya

Walter Leal Filho[a], Daniel Nzengya [b], Gladys Muasya [c],
Judith Chemuliti [e], Jokastah Wanzuu Kalungu [f]

Climatic Change, November 2017, Volume 145, Issue 1–2, pp 71–83
https://link.springer.com/article/10.1007/s10584-017-2087-9

a) Manchester Metropolitan University. School of Science and the Environment, Chester Street, Manchester M1 5GD, UK, E-mail: *w.leal@mmu.ac.uk*

b) St Paul's University, P. O. Private Bag, Limuru, 00217, Kenya. Email: dnzengya@yahoo.com

c) St Paul's University, P. O. Private Bag, Limuru, 00217, Kenya: Email: gladysmuasya5@gmail.com

d) Judith Kusimba Chemuliti, Kenya Agricultural and Livestock Research Organization (KALRO)-Biotechnology Research Centre (Muguga), P.O Box 362-00902, Kikuyu, Kenya E-mail: *chemuliti@gmail.com*

e) South Eastern Kenya University, P.O. Box 170-90200, Kitui, Kenya, E-mail: *jwanzuu@yahoo.com*,

Abstract

The impacts of climate change to the dryland areas of East Africa are especially strong, especially if it is considered thatthese areas have weak institutions and governance systems. Climate change has also affected many rural communities in a severe way, reducing crop yields and sometimes causing crop failure. In Kenya and Tanzania, where drylands cover over around 80% and 50% of their respective land areas, rural populations have been especially affected. Among them is the tribal group of the Maasai, legendary nomad warriors, who have been suffering from persistent droughts and the negative impacts on their cattle herds. This paper describes how climate change affects the Maasai communities in Kenya, and the changes seen in their habits and diet, in order to adapt to a changing climate.

Key-words:Climate change – Africa – Maasai - Adaptation

Introduction and theoretical referential: climate change trends in Kenya

Kenya is a country located in eastern Africa, characterized by arid and semi-arid lands (ASALs) which cover more than 80% (Mwang'ombe et. al., 2011) of its total land area. Semi-arid areas are often vulnerable to climate change because they are already climatically stressed with high temperatures, low rainfall and long dry seasons (New, 2015). These zones exhibit ecological

constraints which set limits mainly to nomadic pastoralism. This is because the areas are characterized by low erratic rainfall, periodic droughts and different associations of vegetative cover, soils and high rate of potential evapotranspiration (Zwaagstra, 2010). Moreover, weeds grow more vigorously than cultivated crops and compete for scarce reserves of moisture. Weeds also pose a great challenge to rehabilitation programmes in the ASALs as they compete with sown grasses for the available soil nutrients and limited soil moisture in the semi-arid environment (Mganga et al., 2010). Other constraints in the region include low organic matter levels (Githae et al. 2011), except for short periods after harvesting or manure applications; and highly variable responses to fertilizer. Figure 1 shows the arid and semi arid areas of Kenya

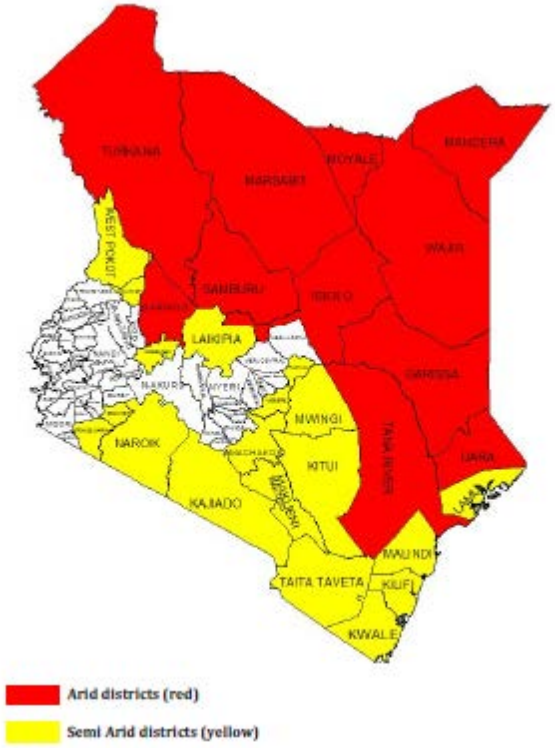


Figure 1 Arid and Semi arid areas of Kenya (Source: GoK, 2012)

The theoretical reference of this paper bears in mind a variety of publications (e.g. IPCC 2014, Leal Filho 2015) and studies (e.g. World Bank 2013) which have shown that the African continent will be the most hit by impacts of climatic change. Kenya has not been spared with over the past decades having faced extreme climatic events especially floods and droughts. Since climate change policy-making in Kenya is slow, and its implementation is irregular (Njoroge, Ratter, Atieno, 2017), the country faces a rather big challenge in coping with problems such as drought.

Historical data shows that major droughts occur about every 10 years with moderate droughts or floods occurring every three to four years (AEA Group, 2008a). This has led to loss of human lives as well as costing the government approximately 8.0 per cent of GDP every five years (AEA Group, 2008b). Interestingly, studies have shown that there has not been significant change in maximum and daily maximum temperatures since 1905. However, there has been significant rise in daily minimum temperatures (Christy and McNider, 2009). According to McSweeney (et al. 2009) mean annual temperatures have increased by 1.0°C since 1960. This is an average rate of 0.21°C per decade. It is also noted that, both the average and maximum temperatures are likely to increase in the range of 1-3 ^{o}C by 2050s (SEI, 2011), 1 ^{o}C by 2020s and 4^{o}C by 2100 (AEA Group, 2008a). Depending on the scenario, under high emissions, mean annual temperature may increase by 4.5 ^{o}C between 1990 – 2100 (WHO, 2016). In coastal region, it has become warmer with cooling near the large water bodies between the year 1961 – 1993 (Mwanga, 2015, NCCRS, 2009). This has led to depletion of glaciers in Mount Kenya (IPCC 2007, UNEP, 2009, NCCRS, 2009). However, according to Funk (et al., 2010), the projected warming will vary from one County to another.

The short rains have become wetter (October – December) (GoK, 2010) with overall decrease in mean annual precipitation (AEA Group, 2008a; Funk et al., 2010). Five out of seven models show an increase of rainfall from month of March to May in Wajir County in Northern Kenya (Bowden et al (2005), SEI, 2011). However, different models have mixed results for increase or decrease of precipitation between December and January, with a tendency of early rainy season in September and October (SEI, 2009. Overall, many models indicate probability of heavy rainfall and increase of flood risks (AEA Group, 2008a; SEI, 2009).Seventeen percent of Mombasa area may be submerged by 30cm sea rise by 2100 (Orindi and Adwera, 2008).

Indigenous peoples of Kajiado County have lived within these constraints for centuries. Just like other indigenous peoples in Kenya Masaai community are mainly pastoralists who are mostly confined predominantly in the arid and semi-arid regions of the country (Hughes,2006). They have existed on the productivity provided locally and have used their knowledge to devise coping and adaptive strategies. One of these coping strategies is use of sand dams (Opiyo et. al., 2011).

Keeping large herds of cattle has been the culture of the Maasai community as it associated with wealth (GoK, 2007b). However, with diminishing grazing land, Maasai have adjusted the number of their herds (Butt et al. 2009) while embracing the expansion of grazing land. Expansion of grazing land is accompanied by conflicts as well as instances of violence among the grazing groups

(Maasai Chief 2011; Maasai Elder 2011). In extreme occasion, the community practice regional raiding in order to secure watering and pasture points, as well as slaughtering their animals when there is no folder (Schilling and Remlinga, 2014).

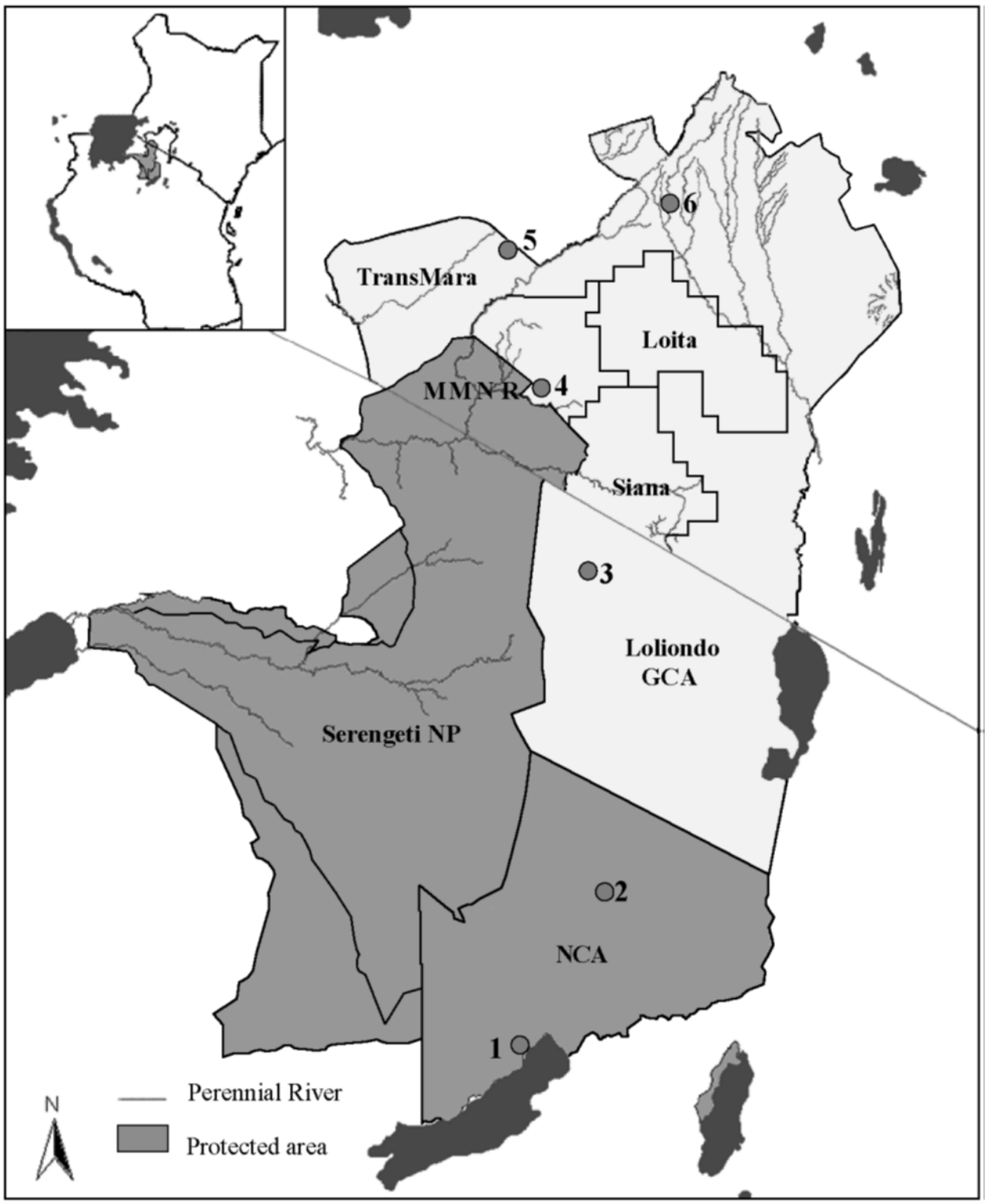
Thus, it is increasingly becoming urgent to do more to integrate community based climate adaptation into agricultural, social and economic developments for sustainability.

Approaches used amongst Maasai agro-pastoralists in East Africa

The Maasai are a Nilotic ethnic group, whose population is estimated to be about 15 million. They have traditionally inhabited the rangelands that straddle across the southern part of Kenya and northern part of Tanzania (see Figure 2) (Galvin et al., 2004; Homewood, 2004), along the Great Rift Valley, distributed over a total of 16.000 km^2 of semi-arid and arid lands. The Maasai society is comprised of sixteen sections (known in Maasai as Iloshon): Ildamat, Ilpurko, Ilkeekonyokie, Iloitai, Ilkaputiei, Ilkankere, Isiria, Ilmoitanik, Iloodokilani, Iloitokitoki, Ilarusa, Ilmatatapato, Ilwuasinkishu, Kore, Parakuyu, and Ilkisonko, also known as Isikirari (Tanzania's Maasai) (Maasai Association 2017). The majority of the Maasai populaton lives in Kenya.

Maasai agro-pastoralists have in the past been able to successfully discern and track climate variability and employed a diversity of adaptation strategies to secure their livelihoods. The strategies included, for example, transhumance and migration; herd splitting and keeping species specific herds. These activities were interspersed with minimal cultivation (Galvin, 2001; Homewood et al., 2009). Increasingly, most of these adaptation strategies have become untenable due to major demographic, economic and environmental changes that have taken or are taking place within the ecosystem (Ekaya, 2005; Homewood et al., 2009; Musimba and Nyariki, 2003; Wangui, 2008). A rapid expansion of human population, shift in livelihoods from agro-pastoralism to more sedentary mixed crop-livestock production, change in land tenure from communal to individual, destruction of natural vegetation and soil degradation, are some of the changes that seriously threaten the ability of Maasai agro-pastoralists to cope and adjust to climate change. Furthermore, the nature of climate variability currently being experienced has changed. The magnitude of variability, frequency of extreme weather events (floods and drought) and rate of change within climate systems has exacerbated the situation. (Dessai and Hulme 2003; Hulme 2003).

Maasai agro-pastoralists like other smallholder farmers across sub-Sahara Africa are highly diverse and heterogeneous (Tittonell et al, 2011). Much of the heterogeneity is caused by spatial variability in climate, soils, landscape and their interactions with complex socio-economic and environmental conditions. This heterogeneity influences farmers' decisions and choice of adaptation options to climate variability and change. A wide array of coping and adaptation strategies have been reported across sites within the Maasai ecosystem. Change in crop variety in favor of drought tolerant and disease resistant types, early land preparation, early and staggered planting, crop rotation, destocking, breed improvement and diversification of livestock to include



Source: Homewood et al., 2004.

Figure 2: The Tanzania/Kenya border showing the East African rangelands

non-traditional livestock species has been documented (Bobadoye et al., 2016; Chemuliti et al., 2015). For example, in Kajiado County in Kenya, camels were introduced as a means of mitigating the devastating impacts of prolonged drought (Bukachi et al., 2003). Migration and diversification of livelihoods has also been used to spread the risk of climate-induced catastrophes on livelihoods (Yanda and Williams, 2010; McCabe et al., 2014, Rufino et al, 2013).

In many parts within of Maasai land, farmers have diversified from traditional livelihood activities of livestock keeping and crop cultivation into various income generating enterprises including for example, bee-keeping, farm forestry (exotic fast-growing species), artisanal mining, off-farm wage employment mainly in the informal sector and small business. Most of these adaptations are occurring autonomously with very minimal support from government and policies but clearly transcend the climate dimension (Vermuelen et al., 2008; Ziervogel et al., 2008; Berrang-Ford et al., 2011). For example, the reduction in herd size may be correlated to subdivision of the previously communal land or breed improvement may be profit- driven rather than a response to the changing weather pattern. The entwined nature of disturbances and change-inducing factors in livelihoods cannot be ignored and is widely recognized in the literature (Campbell, 1999), including attempts to disaggregate the effects and show their linkages (Blaikie and Brookfield, 1987). Adaptation to climate change occurs alongside other livelihood pressures and therefore cannot be easily disaggregated. However, it is important for climate change to be recognized as a significant factor, and for the subtle dimensions of climate parameter change, which are the experienced realities, to be understood and reacted to.

Methodology

The study was carried out in selected villages in Kajiado County in Kenya. Kajiado County borders Nairobi County to the North and Tanzania to the South. The county is also predominantly inhabited by Maasai whose main source of livelihood is pastoral with few being agro-pastoral (GoK 2007b; Maasai Chief 2011; Maasai Elder 2011, Nyariki et al. 2009). The County is located between longitudes 36º5 and 37º5 and latitudes 100 and 300 South (Amwata, 2013). Figure 3 shows the map of Kajiado County.

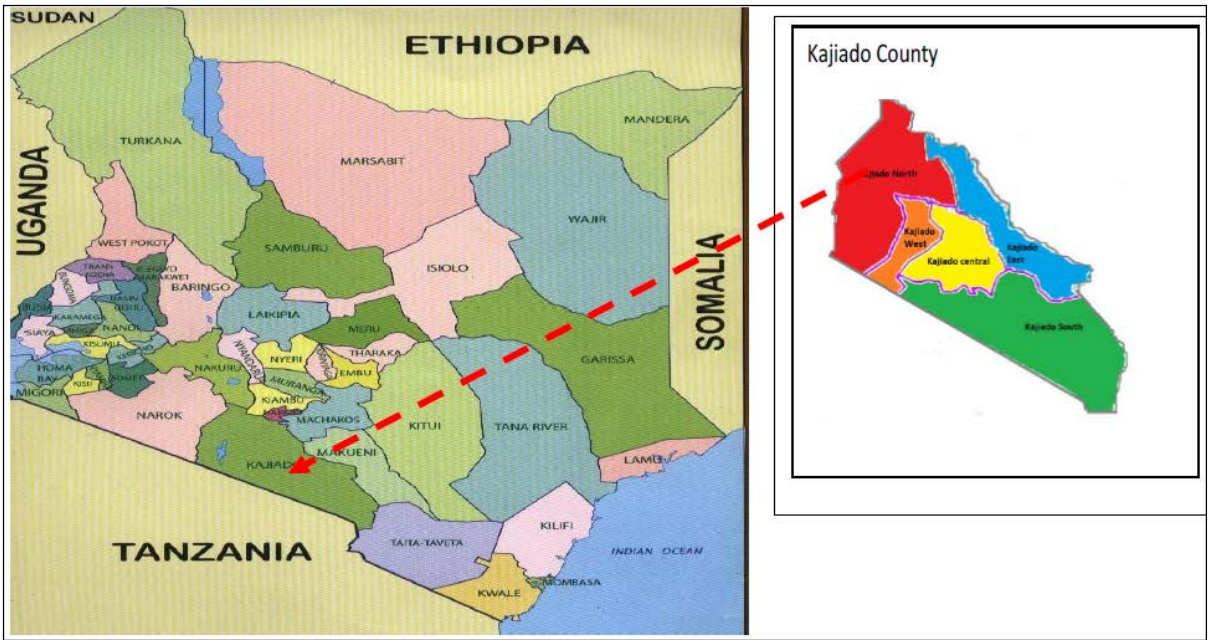


Figure 3 Location of Kajiado County in Kenya.

Data in the study area was collected primarily through 50 randomly selected respondents. Thus fifty (50) household questionnaires were administered between January 2017 and March 2017. The households selected were of Masaai community involved majority in pastoralist. A two-way analysis of variance, percentage analysis and Garrett ranking technique were applied to a set of primary data collected from 50 randomly sampled farmers with the aid of questionnaires from Kajiado County.

Results and Discussions

An empirical assessment of perceptions of climate change among the Maasai

The Maasai people perceive climate change as one the greatest threats to the livelihood. When asked about the three top threats, a frequent response was drought and famine, inadequate pasture, inadequate rainfall and too much sun. In fact, when asked about the number one threat to Maasai livestock keeping, majority of the respondents will mention increased prevalence of droughts. These perceptions are held across men and women alike. Results of a preliminary survey with 44 randomly selected respondents comprising 34.1% females and 65.1% males, participants were asked to what extent they perceived changes in temperature. Perceptions of temperature variability consisted four items, namely, 1) daytime temperature have increased during the last twenty years; the number of hot days has increased during the last twenty years; the number of warm nights has increased during the last twenty years; and finally, the degree of coldness or cold seasons had increased during the last twenty years. The participants were asked to indicate their perceptions according to scale provided 5 = to a great extent to 1 = Not observed or experienced this at all. The mean scores of participants' responses to each item are summarized in Table 1.

It is apparent that majority of respondents strongly perceive that the number of hot days have increased significantly during the last twenty years. Also, majority of participants strongly perceive day time temperature to have increased during the last twenty years. Perceptions related to increase in the number of warm nights and the degree of coldness of cold seasons having increased during the last 20 years seem moderate. Maasai community rely on pastoral livelihoods, thus they are likely to notice changes in day time temperatures and also increase in the number of hot days, hence the observed results. While men spent the day time looking after cattle, sheep and goats, women, on the other hand, spent the day time looking for water for drinking and cooking. Thus, both women and men are likely to perceive changes in day time temperatures and increase in the number of hot days. Participants did not seem to perceive changes in warm nights, nor changes in the degree of coldness of cold seasons during the last 15 years. There are probable reasons for this. The Maasai people, especially those who live in rural villages, still rely on traditionally grass thatched mud houses. These are usually designed to insulate people from cold nights and warm from cooking traditional three stone firewood stoves is likely to remain over nights. This may be a probable reason why respondents seemed to indicate that there were not sure if there have been changes in warm nights or degree of coldness of cold seasons.

Results of a two-way ANOVA analysis, with gender and education level as independent variables, and a composite of variability in temperature as the dependent variable, show that perceptions of changes in temperature varied significantly among participants' levels of education, F (2,38) = 5.64, $p < 0.05$. However, perceptions do not differ significantly between male and female respondents, F (1, 38) = 0.23, $p > 0.05$. Also, interactions effects between participant's gender and education level were not statistically significant, F (2, 38) = 0.03, $p > 0.05$.

Another indicator of climate change was perceptions of changes in rainfall patterns. Perceptions of rainfall variability consisted seven items, namely, the onset of rainfall has become more and more unpredictable; the cessation of rainfall has become more and more unpredictable; the frequency of occurrence of droughts has increased; the number of rainy days has decreased; the amount of rainfall has decreased; the occurrence of untimely rainfall has increased; the intensity of rainfall has increased. Recent studies on perceptions and adaption to climate variability and change amongst Maasai show an increased recognition of the changing climatic trends (Bobadoye et al., 2016; Chemuliti et al., 2015). Similar to this study, rainfall was found to be the most significant parameter through which the farmers perceived long term changes in climate. Understandably so because variations in pattern and intensity of precipitation affects crop and livestock productivity with direct implications on livelihoods, food and nutrition security. Perceived changes in rainfall have been variously described as insufficient, unpredictable, short and intense, delayed onset, poorly distributed, increased frequency of droughts and prolonged drought. Among these descriptions, unpredictability of intra-seasonal factors and frequency of occurrence of extreme weather events (especially drought) were the most common parameters that farmers associated with long-term changes in climate in the past 30 to 50 years. Farmers' observations and assessments of the weather conditions correlate with precipitation data for

eastern Africa which show a general decrease in rainfall) in the region during the same period. (Williams and Funk, 2011; Funk et al., 2008).

For each item, the respondents were asked to indicate their perceptions according to scale provided 5 = to a great extent to 1 = not observed or experienced this at all. The mean scores of the responses are summarized in Table 1.

Table 1: Mean Score of Respondents Perceptions of Climate Variability Indicators (n = 44)

Item	Mean Score
Perception of Temperature Variability	
Day time temperature have increased	4.80
Number of hot days has increased	4.68
The degree of coldness of cold seasons has increased	3.60
The number of warm nights has increased	2.93
Perception of Rainfall Variability Indicators	
The onset of rainfall has become more and more unpredictable	4.80
The cessation of rainfall has become more and more unpredictable	4.68
The frequency of occurrence of droughts has increased	4.66
The number of rainy days has decreased	4.57
The amount of rainfall has decreased	4.30
The occurrence of untimely rainfall has increased	3.75
The intensity of rainfall has increased	2.36

Source: Author's Survey Data, 2017

According to the results obtained, it is evident that Maasai people perceive that there have been changes in rainfall during the last fifteen years. However, perceptions relating the specific indicator, *increases in the intensity of rainfall* seem low. There are probable reasons to this. Intensity of rainfall generally refers to the increasing incidences of increased intensity in rainfall often over a short period of time, usually generating to huge amounts of run-offs and floods. However, while this phenomenon is readily observable using meteorological instruments, , this may not register in the memory of ordinary people who may not be paying attention to duration of outpours and intensity.

Results of a two-way ANOVA analysis on gender and education level, as independent variables and a composite of variability of rainfall as the dependent variable, show that perceptions of variability of rainfall varied significantly among levels of participant's education, F (2,38) = 4.65, $p < 0.05$. However, perceptions did not differ significantly by gender, F (1, 38) = 0.01, $p > 0.05$. Also, interactions effects between participant's gender and education level in relation to perceptions of variability of rainfall were not statistically significant, F (2, 38) = 0.12, $p > 0.05$.

4) Challenges to secure their livelihoods

A common saying among the Maasai people is that “all cows belong to the Maasai people, and all grass belongs to cows”. This saying underscores the importance of cattle keeping as the backbone of Maasai sources of livelihood. The Maasai community have traditionally relied largely on pastoralism for their livelihood. The Maasai people occupy arid and semi-arid (asals) in East Africa. Traditionally the Maasai people relied on rely on migratory strategies to cope with scarcity of pasture of water and pasture for their cattle, sheep and goats. With plenty of land to roam, the Maasai were able to designate low-lying areas for grazing during high rainy seasons, and relatively wet and cold mountainous areas for grazing during dry seasons (Lesorogol, 2008).

Unfortunately, asals have been shrinking remarkably for a variety of reasons that include: increased human population, urbanization, privatization and illegal sub-division of communal ranchers (Lesorogol, 2008; Kinyenze & Irungu 2016). For years other tribes in East Africa used to regard asals unattractive for settlement, thus with low population, Maasai people were left to roam in these lands with their cattle. Sadly, with dramatic population growth in East Africa, and the resulting shortage of land, people from other communities have moved to settle in these marginal lands. Also, asals have been targets by large scale farmers who have bought huge chunks of lands for irrigated commercial wheat and vegetable production (Galaty, 1992; Lesorogol, 2008, Galaty 2016). Consequently, the pastoral land has shrunk dramatically in the recent years.

Arid and semi-arid lands are ecologically fragile ecosystems (UNDP, 2013). Thus, increased moisture stress from extreme and prevalent droughts have exacerbated increased loss of vegetation cover, exposing asals to accelerated soil loss from wind and water erosion (UNDP, 2013). This has set in motion a positive feedback with increasing demand for wood leading to more harvests, hence vulnerability to prevalent and extreme droughts, further leading to less and less capacity of land to support vegetation cover, further driving the pressure to harvest whatever is available for survival (UNDP, 2013). Incidentally, the Maasai population has grown remarkably over the years (KNBS, 2009)

From a few hundred thousand of people, the population of Maasai in Kenya today is estimated to be close to 2 million people (KNBS, 2009). That has reduced remarkably the per capita acreage of land per Maasai household. Sadly, with little room to roam, it means the pressure on the land from grazing has increased loss of vegetation cover due to overgrazing. The forces of privatization of land have further accelerated increased loss of Maasai land from illegal land sub-division. Weakening cultural and traditional values among the Maasai are partly to blame for this negative trend (Molua. & Kagwanja, 2015). Land in Maasai community was traditionally held under communal tenure systems. However, with land privatization, cartels have poured money and Maasai men, unable to resist the temptation, have resulted in the sale of communal land, often without their wives and children knowledge, often leading into landlessness and squatters (Kinyenze & Irungu 2016). Corruption, poor governance of the land sector in Kenya has also contributed to this illegal land sub-division (Molua. & Kagwanja, 2015).

Urbanization especially in Narok and Kajiado counties in Kenya have also driven up land prices. With little land for urban expansion, the communal land on the urban fridge has been targeted by land developers often offering amazingly huge sums of money (Mwangi, 2005; Kinyenze & Irungu 2016). Today, much of the run-away huge Chinese enterprises and establishment in East Africa is thriving on land that was traditionally designated as Maasai communal land. Although recently, there have been claims suggesting that that climate change is forcing a shift in the sources of livelihood for the Maasai people, there seems to be little empirical evidence on this (Mutsotso, Bikuri, & Mutsotso, 2015). In one of the leading print media paper, Muiruri (2017) featured an article titled "livestock giving way to crop farming in Maasailand: vanishing pastures, caused by severe drought forced this pastoralist community to rethink its options in the face of dwindling fortunes", the author claimed that Maasai people were shifting to crop farming to cope with the effects of climate change. However, findings from interviews with 50 randomly selected respondents summarized in table 2 do not suggest crop farming to be an attractive way of coping with droughts among the Maasai.

Data for Table 2 was obtained by asking Maasai rural households to what extent households had considered the measures mentioned as ways of coping with prevalent and extreme droughts. Responses were ranked according to scale: 5 = To a great extent to 1 = Not considered this at all

Table 2: Maasai households' coping strategies with prevalent and extreme droughts (n = 44)

Item Strategy for coping with prevalent and extreme droughts	Mean Score
Start water harvesting and storage for livestock	4.61
Make arrangements for fodder / hay	4.11
Reduce the number of cattle	3.89
Shift from keeping cattle to small businesses	3.60
Shift from cattle keeping to crop farming	2.93
Shift from cattle keeping to irrigated farming	2.73
Shift from cattle keeping to growing fruits / vegetables	2.48
Shift from cattle keeping to keeping goats and sheep	2.57
Shift from cattle keeping to keeping poultry	2.30
Shift from cattle keeping to bee keeping	2.00
Shift from cattle keeping to keeping camels	1.50
Shift from cattle keeping to keeping donkeys	1.41
Shift from cattle keeping to keeping pigs	1.25

Source: Authors' survey, 2017

Keeping camels and donkeys are ranked lowest among the options that the Maasai people are pursuing to cope with droughts. Interestingly, water harvesting, reducing number of cattle, adopting fodder and hay are still ranked highly among the ways of coping with drought. Pursuing small business is ranked fourthly among coping strategies.

Conclusions

This paper describes trends on climate change in the drylands of Kenya and focused on a case study from the Maasai. There were various financial (e.g. limited funding for the study and for the stays in the field), logistical (problems related to travel and access to the Maasai areas) and cultural differences seen in the undertaking of study, which reflect the difficulties seen in performing climate-related field research in Africa. Nonetheless, the information gathered and presented on this paper provides a welcome addition to the knowledge on the impacts of climate change on indigenous groups in Africa, and offers valuable insights into the mechanisms they use to adapt.

As this paper, has tried to illustrate, the studied problem, namely the impacts of climate change to the dryland areas of Eastern Africa are strong, and many rural populations have been especially affected. Among them, the Maasai have been suffering from persistent droughts and the negative impacts on their cattle herds, and have implemented a variety of changes in their traditional pastoral migration patterns, which have been partly disrupted. The respondents clearly indicated that they had perceived that temperatures had increased with rainfall becoming more

and more unpredictable. As a result, they have been compelled to use smaller areas of land for their cattle, and overgrazing has become a real problem.

The consequences of this trend are manyfold. One of them is the loss of traditional cultures, since the Maasai's way of life and traditional farming methods have been changing. In addition, disruptions in water cycles and intensive use of water reserves (e.g. by the diversion of scarce water resources for tourists), has been leaving the Maasai and other local people short of water. In order to alleviate the impacts of climate change water harvesting and storage for livestock use as well as making arrangements for fodder / hay is ranked as the most appropriate measures to deal with these impacts. Finally, as a result of the pressures posed by climate change crop growing which could allow them to capitalize on the market for grain and hence diversify their income, is made very difficult.

In terms of future perspectives, one of the means to address the problem may include the provision of climate services to reach the Maasai and warn them of forthcoming periods of dry spell, so they may plan. Also, a diversification of livestock as a mean to ensure food and economic security could be useful, as a way for the Maasai to confront frequent droughts. By doing so, some degree of resilience may be achieved, consequently reducing their vulnerability.

References

AEA Group. (2008a). *Final report. Kenya: Climate screening and information exchange* (ED 05603, Issue 2). http://www.dewpoint.org.uk/Asset%20Library/DFID/Climate%20Risk%20Assessment%20Report%20-%20 Kenya.pdf

Audho J. O, Ojango N E, Oyieng, E, Okeyo A.M and Ojango JMK. 2015. Milk from indigenous sheep breeds: An adaptation approach to climate change by women in Isinya, Kajiado County in Kenya. In: *Animal Genetics Training Resource*. Ojango JM, Malmfors B and Okeyo AM (eds). International Livestock Research Institute, Nairobi, Kenya, and Swedish University of Agricultural Sciences, Uppsala, Sweden

Amwata, D.A. (2013). The influence of climate variability and change on Land–use and Livelihoods in Kenya's Southern rangelands. A PhD thesis submitted to the Department of Land Resource Management and Agricultural Technology, University of Nairobi.

Blaikie P.M. and Brookfield H.C (1987). Land degradation and society. Taylor & Francis Books, London.

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. American Journal of Rural Development. 2016; 4(6):120-128. doi: 10.12691/ajrd-4-6-1.

Bobadoye A.O., Ogara W.O., Ouma G.O., Onono J.O.. Assessing Climate Change Adaptation Strategies among Rural Maasai pastoralist in Kenya. American Journal of Rural Development. 2016; 4(6):120-128. doi: 10.12691/ajrd-4-6-1.

Bobadoye A.O, Ogara W.O , Ouma, G.O, Onono, J.O (2016) Pastoralist Perceptions on Climate Change and Variability in Kajiado in Relation to Meteorology Evidence , Academic Journal of Interdisciplinary Studies MCSER Publishing, Rome-Italy, E-ISSN 2281-4612, ISSN 2281-3993 Vol 5 No 1

Bowden, J. H., F. H. M. Semazzi, R. O. Anyah, and C. Schreck, 2005: Decadal temperature, rainfall and hydrological trends over the Greater Horn of Africa. 85th AMS Annual Mee ng, San-Diego, California, 9-13 Jan 2005.

Butt, Bilal; Shortridge, Ashton; WinklerPrins, Antoinette M. G. A., 2009: "Pastoral Herd Management, Drought Coping Strategies, and Cattle Mobility in Southern Kenya", in: Annals of the Association of American Geographers, 99, 2: 309-334.

Bukachi S.A. Chemuliti J.K. and Njiru Z.K. (2003). Constraints experienced in the introduction of camels in tsetse fly infested areas: the case of Kajiado District, Kenya.

Campbell D.J. and Olson J.M (1991). Environment and development in Kenya: flying the kite in Kajiado District. Centen Rev 35:295–314.

Chemuliti, J. (2015). An assessment of the feasibility of carbon trading afforestation contracts in Trans Mara sub-County, Kenya. PhD Thesis, University of Nairobi, Department of Agricultural Economics.

Christy, J.R. W.B. Norris, and R.T. McNider, (2009) Surface Temperature Variations In East Africa And Possible Causes. J. Climate, in press).
2008/papers/igad.pdf

Dessai S. and Hulme M (2003) Does climate policy need probabilities? Tyndall centre for climate change research working paper 34. UEA, Norwich

Ekaya, W.N. (2005). Shift from mobile pastoralism to sedentary crop-livestock farming in the drylands of eastern Africa. Some issues and challenges for research. African Crop Science Conference Proceedings, 7: 1513-1519.

Funk C.J. Michaelsen and Marshall M. (2012). Mapping recent decadal climate variations in precipitation and temperature across Eastern Africa and the Sahel. In: Remote Sensing of Drought: Innovative Monitoring Approaches [Wardlow, B.D., M.C. Anderson, and J.P. Verdin (eds.)]. CRC Press, Boca Raton, FL, USA, pp. 331-358.

Funk, C., Eilerts, G., Davenport, F., & Michaelsen, J. (2010). *A climate trend analysis of Kenya – August 2010* [Fact Sheet 2010-3074]. United States Geological Survey. Retrieved from http://www.fews.net/docs/Publications/FEWS%20Kenya%20Climate%20Trend%20Analysis.pdf

Galvin, K.A. Thornton P.K. Boone, R.B. and Sunderland, J (2004). Climate variability and impacts on east African livestock herders: the Maasai of Ngorongoro Conservation Area. Tanzania. African Journal of Range and Forage Science. 21(3): 183-189.

Galaty John G. (1992). "The Land Is Yours": Social and Economic Factors in the Privatization, Sub-Division and Sale of Maasai Ranches. Nomadic Peoples, No. 30, pp. 26-40

Galaty John G (2016). Reasserting the commons: Pastoral Contestations of Private and State Lands in East Africa- International Journal of the Commons. Vol. 10, no 2.

GoK (2007b). National Policy for the Sustainable Development of Arid

and Semi Arid Lands (Nairobi: Government of Kenya).
GoK (2012). Vision 2030, Development Strategy for Northern Kenya and Other Arid Lands
Homewood, K. Kristjanson, P. and Trench, P.C (2009). Changing land use, livelihoods and wildlife conservation in Maasailand, staying Maasai? In, K. Homewood, P. Kristjanson, and P.C. Trench, eds. (Springer New York), pp. 1-42.
Homewood, K. Coast, E. and Thompson, M (2004). In-migrants and exclusion in east African rangelands: access, tenure and conflict. Africa, 74 (4). pp. 567-610. ISSN 0001- 9720 DOI: 10.3366/afr.2004.74.4.567
Hulme M (2003). Abrupt climate change: can society cope? Philos Trans R Soc A 361:2001–2019
Intergovernmental Authority on Development Climate Prediction and Applications Centre (ICPAC). (2007). Climate Change and Human Development in Africa: Assessing the risks and vulnerability of climate change in Kenya, Malawi and Ethiopia (Draft Report). Human Development Report Office Occasional Paper. http://hdr.undp.org/en/ reports/global/hdr2007-

IPCC (2014) Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Kenya National Bureau of Statistics (KNBS) (2009) Kenya Census Report
Kinyenze J. M. and Irungu C. (2016). An Analysis of the Social and Economic Effects of Land Tenure Practices among the Maasai Community in Ngong Division, Kajiado County, Kenya. African Multidisciplinary journal of research Vol 1(1) 107-130

Leal Filho, W. (Ed) (2015) Handbook of Climate Change Adaptation. Springer, Berlin.

Lesorogol C. K, (2008). Land Privatization and Pastoralist Well-being in Kenya. Development and Change 39(2): 309–331
Masai Chief, 2011: Interview on "Social and climatic changes in Kajiado". Interviewee's affiliation: Masai Community. Namanga, 9 March 2011.
Masai Elder, 2011: Interview on "Social and climatic changes in Kajiado". Interviewee's affiliation: Masai Community. Namanga, 9 March 2011.
McCabe J.T. Smith N.M. Leslie P.W. and Telligman, M. (2014). Livelihood diversification through migration among a pastoral people: contrasting case of Maasai in northern Tanzania. Hum Organ. 73(4): 389–400.
McSweeney, C., New, M., & Lizcano, G. (2009). *UNDP climate change country profile: Kenya*. Retrieved from http://ncsp. undp.org/sites/default/files/Kenya.oxford.report.pdf
Mngoli M. (2014). Land Use Change, Water Availability and Adaptation Strategies in Changing and Variable Climate In Kajiado North, Kenya, A thesis submitted in partial fulfillment of the requirements for the award of degree of Master of Science in Land and Water Management University of Nairobi
Molua E. L. & Kagwanja J., (2015). Institutional Requirements for Building Resilience and Sustainability in Agricultural Land Management in the Central African Sub-region Journal of Management and Sustainability Vol. 5, No. 3; 123
Muiruri P (2017) Livestock giving way to crop farming in Maasailand: Vanishing pastures,

Caused by severe drought, have forced this pastoralist community to rethink its options in the face of dwindling fortunes: Wednesday Daily Nation, Kenya Feb 15th, 2017

Mutsotso B M, Bikuri K, and Mutsotso S.O, (2015).The Commodification of Land and Rapid Land Sales among The Maasai Pastoralists of Kajiado County. Online Journal of African Affairs. Kenya Volume 4, Issue 3, 50-63.7479.

Mwang'ombe, A.W, Ekaya, W.N, Muiru, W.M, Wasonga, V. O, Mnene, W.M, Mong'are, P.N and Chege, S.W. (2011), Livelihoods under climate variability and change: an analysis of adaptive capacity of rural poor to water scarcity in Kenya's Drylands, Journal of Environmental Science and Technology 4: 403-410.

Mwanga D. (2015). Effects of Climate Change and Global Warming in Kenya**, UNEP Breif,** climate-change-news-climate-change-in-kenya-and-global-warming

Mwangi E (2005).The Transformation of Property Rights in Kenya's Maasailand: Triggers and Motivations. Cgiar System wide Program on Collective Action and Property Rights. International Food Policy Research Institute

Musimba, N.K.R., and Nyariki, D.M. (2003). Development of and policy on the range and pastoral industry with special reference to Kenya. Anthropologist, 5(4): 261-267.

Mganga KZ, Musimba NKR, Nyariki DM, Nyangito MM, Mwang'ombe AW, Ekaya WN and Muiru WM. (2010), *The Challenges Posed by Ipomoea Kituensis and the Grass-Weed Interaction in a Reseeded Semi-Arid Environment in Kenya*, International Journal of Current Research 11: 001-005.

NCCRS, 2009: Kenya Climate Change Response Strategy. Ministry of Environment and Mineral Resources (MEMR) 2009.

Njoroge, J.M., Ratter, B.M.W., Atieno, L. (2017) Climate change policy-making process in Kenya: deliberative inclusionary processes in play. International Journal of Climate Change Strategies and Management, 9 (4), pp.535-554 https://doi.org/10.1108/IJCCSM-10-2016-0154

Nyariki D. M. Mwang'ombe, A. and Thompson D.M. (2009) Land-use change and livestock production challenges in an integrated system: the Masai-Mara ecosystem, Kenya, in: *Journal of Human Ecology*, 26,3: 163-173.

New M. (2015), Are semi-arid regions climate change hot-spots? Evidence from Southern Africa, Adaptation at Scale in Semi-Arid Regions.

Opiyo F.E.O Mureithi S.M and Ngugi R.K. (2011). The Influence of Water Availability on Pastoralist's Resource Use in Mwingi and Kitui Districts in Kenya, Journal of Human Ecology, 35(1): 43-52.

Opiyo F.E.O. Ekaya W.N. Nyariki D.M. and Mureithi S.M. (2011b), Seedbed preparation influence on morphometric characteristics of perennial grasses of semi-arid rangeland in *Kenya*, African Journal of Plant Science 5 (8): 460-468.

Osunga, Otieno G. , 2009: Annual Report 2009 - Arid Lands Resource Management Project:Kajiado District<http://www.aridland.go.ke/semi_annual_reports/semi_arid_08-09/kajiado_08-09.pdf>.

Rufino, M.C. Thornton, P.K. Ng'ang'a, S.K. Mutiea I. Jones P.G. van Wijk, M.T. and Herrero, M. (2013). Transitions in agro-pastoralist systems of East Africa: Impacts on food security and poverty. Agriculture, Ecosystems and Environment 179: 215– 230

Stockholm Environment Institute (SEI). (2009). Economics of climate change in Kenya: Final report submitted in advance of COP15. Available from http://www.sei-international.org/mediamanager/documents/Publications/Climate-mitigation-adaptation/kenya-climatechange.pdf

Schilling J. and Remling E. (2014). Local Adaptation and National Climate Change Policy in Kenya: Discrepancies, Options, and the Way Forward, Research Group Climate Change and Security, Institute for Geography and Klima Campus,Hamburg University, Grindelberg 7, 20144 Hamburg, Germany, Working Paper **CLISEC-14** https://www.clisec.uni-hamburg.de/en/pdf/working-paper-clisec-14.pdf

Tittonell P. Vanlauwe B. Misiko M. and Giller K (2011). Targeting resources within diverse, heterogeneous and dynamic farming systems: Towards a 'Uniquely African Green Revolution'. In: Bationo A., Waswa B., Okeyo J., Maina F., Kihara J. (eds) Innovations as Key to the Green Revolution in Africa. Springer, Dordrecht

UNEP (2009). KENYA: Atlas of Our Changing Environment;© 2009, United Nations Environment Programme; ISBN: 978-92-807-2995-5 (pages 14-17Mount Kenya: Disappearing Glaciers).

UNDP (2013). Combating Desertification in Kenya: Emerging Lessons from Empowering Local Communities. Nairobi.

Vermuelen S.K. Dossou D. Macqueen D. Walubengo and E. and Nangoma, E (2008) Spring Back: Climate Resilience at Africa's Grassroots. Sustainable Development Opinion, International Institute for Environment and Development (IIED), London, UK, 2 pp

Wangui E.E (2008). Development interventions, changing livelihoods, the making of female Maasai pastoralists. Agric Hum Values 25:365–378. DOI 10.1007/s10460-007-9111-z

Williams A.P. and C. Funk C (2011: A westward extension of the warm pool leads to a westward extension of the Walker circulation, drying eastern Africa. Climate Dynamics, 37(11-12), 2417-2435

WORLD BANK (2013): Africa Development Indicators 2012/13. Washington, DC (https://openknowledge.worldbank.org/bitstream/handle/10986/13504/9780821396162.pdf ?sequence=1)

Yanda, Z.P., William, C (2010). Livelihood diversification and implication on food security and poverty levels in the Maasai plains: the case of Simanjiro District, Northern Tanzania. African Journal of Environmental Sciences and Technology 4(3) 154-166.

Ziervogel, G., A. Taylor, S. Hachigonta, and J. Hoffmaister, 2008: Climate Adaptation in Southern Africa: Addressing the Needs of Vulnerable Communities. Stockholm Environment Institute (SEI), Stockholm, Sweden, 56 pp.

Zwaagstra L. Sharif Z. Wambile A. Leeuw J. Johnson N. Njuki J. Said M. Ericksen, P. and Herrero, M.(2010). *An assessment of the response to the 2008-2009 Drought in Kenya* ILRI. Nairobi, Kenya.

581
582
583
584