

Degradation of Grassland Ecosystems, Climate Change and Impacts on Pastoral Communities in Kenya

*Kinyenze Jonathan Mumo¹, Margret Nzau², & Sarah Mwangi³
St. Paul's University*

Abstract

Grasslands are some of the most diverse ecosystems distributed all over the world. They also support quite a large number of the world population. This support is mainly through agricultural production and animal products from the pastoralism practices. They are however threatened by a range of anthropogenic activities that include overgrazing, conversion to farmlands, urbanization and invasion of alien species. This paper explores: the trends of degradation of grasslands in Kenya, how grassland degradation drives climate change versus how climate change exacerbates degradation of grasslands and how degradation of grasslands exacerbates the vulnerability of pastoral communities to extreme climate events such as droughts. Preliminary results reveal that the pastoral community is undergoing serious challenges due to climate change. The community is also under pressure due to land reduction, herd reduction and high rates of population especially due to migrating populations. Some of the challenges include loss of animals due to drought, loss of land or even change from pastoralism to other forms of livelihoods like farming, business, and formal employment especially by the national or county government, among others. This also means that proliferation of cash economy has pushed pastoralists to selling land and cattle than ever before. The results show more poverty and landlessness in the community. As a way of coping, the pastoralists have undertaken alternative livelihoods such as crop production and entrepreneurship, while some women have turned to prostitution, weaving of beads and selling of other market items. In addition, some pastoralists have employed strategies such as introduction of dairy animals, reduction of herds and reduction of household food consumption while others have migrated to towns in search of employment. The research recommends formulation of policies on climate change to protect the pastoral communities and their livelihoods.

Key words: *Grasslands, Ecosystem Services, Pastoral Communities, Livelihoods, Degradation*

Introduction

According to National Land Use Policy (2016) climate change has had a destructive impact on the ecosystems around the world. Actually, climate change has been known to control the distribution of ecosystems, species ranges, and process rates on Earth. Ecosystems, biodiversity and the services they support , are essentially relying on climate (Michelle et al., 2012). As Nancy et al. (2013) indicated during the twentieth century, climate change has been documented as causing serious impacts on ecological systems, and as the report indicates the impacts are expected to increase as climate change continues and perhaps even accelerates. Nancy et al. (2013) further asserts that climate change has put resources to be at risk and it has also led to major financial consequences and challenges within countries whether developing or developed. For instance, 90% of natural disasters in the countries like the United States of America have been accelerating due to extreme weather events. On the other hand, European countries are facing serious challenges of rising sea levels and extreme weather conditions, such as frequent and severe heat waves, frequent and severe flooding, droughts and storms as a result of climate change (European Environment Agency 2017). According to the European Environment Agency (AEE) (2017), most of the European regions are susceptible to climate change. However, there are regions which are more prone which experience severe impacts of climate change than others. For example, the Southern and South Eastern part of Europe are more prone to climate change impacts, which has led to high incidences of extreme heat and a decrease in precipitation and river, hence less river flows.

According to Petrorelli (2012), climate change in Africa has led to both conservation challenges and socioeconomic problem too. For example, a rise in temperature and unreliable precipitation has been experienced in Africa and it has had a negative impact in ecosystems, biodiversity and peoples especially those more dependent on the grass ecosystems.

As Casim, Majule, & Perfect (2012) explain, grassland ecosystems are of great benefit to human beings and even to animals in equal measure, but the benefits can easily diminish due to degradation of grasslands. However, even with knowledge of the importance of grasslands, there has been a continued decline in production capability of the grasslands due to human activities and climate change. This means that global environmental problems have become more acute as a consequence of ever-increasing pressures from human activities, resulting in an alarming loss of biological diversity (Kwon et al, 2015). The grass land degradation by human beings has forced the communities living in the arid and semi-arid lands (ASAL), areas and especially the pastoralists to adapt to climate variability in order to cope with this growing challenge. However, the degradation of grasslands has had negative effects to the population, especially the pastoralists who derive their livelihoods from land-based activities. For example, grassland ecosystems host over 90% of the network of Kenya's national parks and reserves. They are also home to about 50% of the total livestock population within pastoral communities and nearly 80% of the total wildlife population.

Livestock production is the most extensive system in the grasslands (USAID, 2009) and is found in several ASAL counties in Kenya. Kajiado County being one of the regions in Kenya where nomadic pastoralism is practiced as the main activity, continues to experience numerous challenges due to climate change.

The county has therefore not been spared from effects of environment degradation and climate change. Some of the serious impacts of environmental degradation due to climate change within the county include the social, economic, and environmental effects and impacts (GOK, 2017).

As a result, Kajiado County has continued to suffer devastating cases of drought over the last two decades which have led to massive losses of livestock, due to lack of pastures and drying of water sources (Opiyo, 2014).

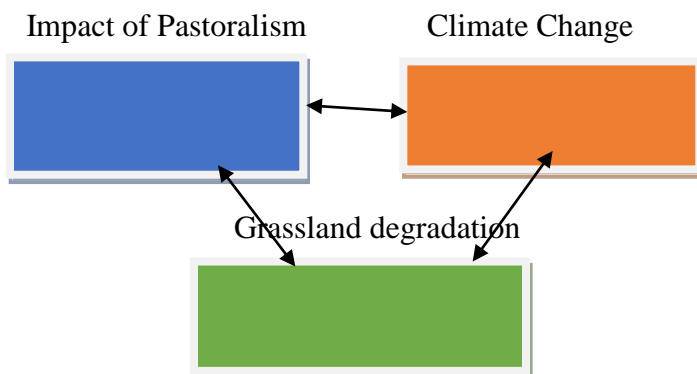
Grasslands, Pastoral Communities and Livelihoods in Kenya

According to Zwiebel & King (2014), 40% of Sub-Saharan Africa is arid or semi-arid rangeland which is composed of grasslands, dry woodlands, and desert ecosystems. These ecosystems are home to an estimated 80 million rural pastoralists within this region. The main source of livelihood for these people is livestock grazing. However, since these pastoralists practice subsistence form of pastoralism, they mainly keep cattle, goats, sheep, camel and donkeys (Zwiebel & King, 2014). The pastoral households in Sub Sahara Africa depend heavily on rainfall for pasture so as to feed their animals and then take care of their families. However due to the adverse climatic conditions in these regions of Africa, the pastoralists are already vulnerable to extreme weather events such as droughts, making them to be among the poorest group in Africa (Kochore & Watson, 2012).

At the same time loss of land and water resources to other uses such as agriculture, forestry, wildlife reserves, have also been experienced (Fratkin & Mearns, 2003). Environmental changes related to climate change have also put the pastoralist's livelihoods under pressure (Kochore & Watson, 2012).

Furthermore, there is gradual integration into the cash economy, which has pushed pastoralists to sell more animals than before (Mwanyumba, Wahome, MacOpiyo, & Kanyari, 2015). According to Mwanyumba, Wahome, MacOpiyo, & Kanyari (2015), the pastoral communities need to find sustainable ways to protect and promote livestock production, which accounts for 12 per cent of Kenya's gross domestic product (Mutanu, 2016).

Grassland degradation, climate change and pastoralism are a complex issue since each has an effect on each other (Kochore & Watson, 2012). For example, pastoral activities influence climate change due to overgrazing which causes grassland degradation. On the other hand, grassland degradation can lead to climate change. Both will then have a great impact on pastoralism (Su, Wu, & Dong, 2015). This phenomenon leads to high vulnerability and negative impact to pastoralism as animals die due to lack of pasture and water. The conceptual representation can be as below:



Climate Change is defined as the difference between long term mean values of a climate, parameter of statistics - where the mean is taken over a specified interval of time; usually several decades, climate variability includes the extremes and differences of monthly, seasonal and annual values from the climatically expected value (Opole, 2013).

Among the climate parameters that have exhibited a shift in both short and long-term trends are rainfall and temperatures. These two have impacts upon the terrestrial waters, atmosphere, cryosphere and biosphere resulting into phenomena such as the abnormal rainfall regimes, droughts, floods and changes in species composition in various ecosystems. This is what in turn degrades grasslands. In addition, Kenya's vast area consists of grassland of majority, found in arid and semi-arid lands (ASAL) which make up more than 80% of the country and are mainly found in the Rift Valley. This is home to approximately four million pastoralists who constitute more than 10% of Kenya's population plus other rangeland users (Kirbride & Grahn, 2008). Hence when these grasslands are degraded, many pastoralists are affected and hence the Kenyan economy and food supply.

Problem Statement

Increasing number of pastoralists in Kenya are losing their livelihood due to grassland degradation. This is forcing many to leave livestock-rearing, as animals die due to lack of pasture and water. The only alternative left is to sell their land hence losing livelihoods leading to much poverty. Indeed, some have become squatters as a result and others have ended up living in the urban slums (Wen et al., 2013, Kinyenze & Irungu, 2016). Grassland degradation has also led to both reduced productivity and less resilience of host species, leading invasion by unpalatable species. Excessive removal of vegetation cover through overgrazing has led to grassland degradation (Saud et al., 2015). This grassland degradation contributes to climate change.

The combination of increased climatic shocks, policies which enhance grassland degradation and lack of other viable livelihood options is pushing more and more pastoralists out of the system.

As climate change exacerbates stresses on the system, the rate of destitution among pastoralists is likely to increase, unless policies are implemented which enable adaptation and a choice of livelihoods which allows people to maintain or improve their conditions independently of livestock-keeping (Wen et al., 2013; Homewood et al. 2009). There is no adequate information on the impact of grassland degradation on climate change within pastoral communities in Kenya.

Therefore, this paper looks at the following study questions:

- i) What are the trends of degradation of grasslands within pastoral communities in Kenya?
- ii) How does grassland degradation drive climate change within pastoral communities in Kenya?
- iii) How do policies enhance degradation of grasslands within pastoral communities in Kenya?

Trends of Degradation of Grasslands Within Pastoralists in Kenya

Grasslands ecosystems face serious threats of degradation due to multiple anthropogenic activities (Ceballos et al., 2010). According to Briggs, Blair, & Nippert (2014), grassland degradation is on the increase in the pastoral land in Kenya due to activities such as overgrazing, fire suppression and agricultural activities.

According to Kinyenze and Irungu (2016), pastoralists had adapted group ranches, as early as 1985 with an aim of conserving the environment as well as increasing productivity. The expectation of the community was that the group ranches would remain, however, the colonial government endorsed individual ownership of the group ranches. Kitaiya (2012) explains the reasons for subdivision of group ranches to be lack of motivation for either groups or individual to invest in the group lands or to even protect it. Individual ownership was thought to encourage resource management by the individual land owners.

However, the land use policy changed from communal to private owned pieces of land. It introduced new ways of land use, such as crop production and development of urban centers hence causing removal of land cover which resulted to grassland degradation. On the other hand, subdivision of grasslands within pastoral community affected livestock mobility (Kioko, Warui, & Seno, 2012). Hence the reduced mobility has caused increased overgrazing, leading to land degradation (Sternberg, 2008). As Nkedianye et al., (2011) suggests, the situation in pastoral community is different today since the idea of “no man’s land” is long gone and there is little if any, underutilized land.

This idea of making use of all communal land within the pastoral societies escalates greatly the problem of land degradation in the Kenyan drylands and even in the whole of the East African region in Kenya (Ceballos et al.2010). This according to the authors has substantial environmental, social and economic costs. Consequently, land degradation reduces the ability of any agricultural land to produce, deplete the rangeland and forest resources as well (Nkedianye et al., 2011). In the long run, the costs and consequences of land degradation can be direct or indirect where we may have loss of soil nutrients, lowered production, loss of livestock carrying capacity and top soil loss as direct cost.

On the same note, Kioko, Warui, & Seno (2012) explain the indirect costs as the reduced ground water capacity, silting of rivers and dams, loss of environmental services, social and community losses due to malnutrition and poverty. According to Kioko, Warui, & Seno (2012), land degradation affects a country’s economy as well. The impact is quite huge because the figures are very disturbing, especially since the main population in Kenya is more rural than urban.

It is claimed by studies that more than 65% of the population is actually rural and hence the reason for the serious economic consequences of land degradation because the main livelihood of about 90% of these rural populations is agricultural-based (Mganga 2011). Kioko, Warui, & Seno (2012) claim that very few studies have broadly and expansively covered the real costs and the real outcomes of grassland degradation in Africa. Nevertheless, land degradation has very serious implications on the capacity of grasslands to produce fodder for animals and crops for the pastoral households found within those grasslands. This means that the pastoral households are food insecure and their animals are likely to produce less due to lack or reduced feeds and fodder (Ceballos et al.2010).

Grassland Degradation and Climate Change

Grassland degradation can have several definitions including soil erosion and long-term reduction in the amount of soil or reduction in diversity of natural vegetation composition. Nonetheless, grassland degradation can also describe the reduced capacity and biological productivity of land (Briggs, Blair, & Nippert, 2014). On the issue of the causes of land degradation, various researchers vary on the relationship between climate change and human induced factors.

The amount of soil lost due to grassland conversion affects soil structure which is supposed to facilitate the water infiltration as well as affecting the water holding capacity of soil (Casim, Majule & Perfect, 2012).

Furthermore, Zhihui, Peijun, & Chen (2008) explains that the partitioning and fragmentation of most grasslands, introduction of invasive species, overgrazing or severe grazing, and amplified or excessive use of pest and herbal chemicals have all been found to cause climate change. If hydrologic cycle, biodiversity, pollination, livestock and recreational uses are to be well maintained or even improved, then the issue of grassland degradation must be taken into serious consideration. However, it seems almost impossible to maintain the land cover due to grassland degradation. This land cover destruction according to Ebanyat, et al. (2010), occurs through human activities like charcoal burning, grassland conversion and overgrazing. When the land cover is destroyed, the land has a likelihood of developing into a desert. Natural occurrences like fire out breaks, drought and changes in land use which affects grassland vegetation, tends to prompt increase in carbon release into the atmosphere. Grassland vegetation is so important such that incase of a decrease especially due to overgrazing, it is likely to affect the soil surface since it covers like the protective cover of the top soil (Mganga, 2018).

If the protective cover of the soil is depleted, the naked truth is that the rain drops will hit the bare patches of land and splash the soil and thus increasing the intensity of soil erosion. However, with proper management of grasslands, depletion of soil cover can be prevented and thus reversing the any other serious impact of grassland degradation like reduced carbon stocks. The reduced carbon stocks can also be easily reversed, the stocks rebuilt again and thus reverting the dangers of climate change (Zhihui, Peijun, & Chen, 2008).

Policies and Grassland Degradation

According to Zhihui, Peijun, & Chen (2008), the impact of climate change is increasingly receiving international recognition as a developmental and environmental issue worldwide. The authors further assert that clarity of information is needed on the likely impacts of climate change on human society, especially in the developing nations, the possible and available options for the people in those nations to respond to climate change impacts, and the trade-offs between policy choices and their effectiveness, benefits, risks and costs (Zhihui, Peijun, & Chen, 2008). In Kenya for instance, grassland degradation is a major problem affecting productivity and sustainability within pastoral systems. These problems of low productivity can be attributed to policies which encourage land privatization (Kinyenze & Irungu, 2016). Land privatization can be attributed to grassland degradation because land is subdivided into small pieces and causing the available pasture to be extensively used by the herding households leading to destruction of vegetation cover. In addition, pastoral communities are faced by a number of challenges that hinder their way of life (Fratkin, Nathan, & Roth, 2011). These challenges include those that are caused by inappropriate development policies, climate change, marginalization and increasing resource competition. The problem of overstocking within pastoral areas causes degradation of grasslands and in most instances, policies do not take thought of the possible environmental goods and services, provided by grassland ecosystems. Grassland degradation in Kenyan such as Savannah eco-systems which is caused by overstocking of animals maybe aggravated by wrong policies.

However, preservation and protection of grasslands must rely on policies which ensure effectiveness of grassland production. Policies encouraging individual land ownership have weakened customary institutions causing serious decline of grasslands in Kenya (Archana, 2013).

Archana (2013) further explains that in most parts of the world, policies affecting effective grassland production are classified as government policies or policies which are narrow in scope. According to Kioko, Warui, & Seno (2012) there were two policies which were developed in Kenya whose aim was to revive the Kenyan grasslands. These were Arid and Semi-Arid Lands policy 2004 and the National Land Policy 2009. However, as noted by Briggs, Blair, & Nippert (2014) several policies developed previously which were aimed at reviving grasslands in Kenya and they seemed to have been biased against the livelihood of pastoralists because they emphasized on sedenterization and crop farming of the Kenyan nomadic pastoralists. The authors attribute the failure of the policies to lack of community consultation, involvement and participation, hence seeing the policies as top down and extremely discriminative. Therefore, there is need to ensure that any process which focuses on climate change mitigation and adaptation to be mainstreamed into all development policies, programs and activities for sustainable development. As explained by Briggs, Blair, & Nippert (2014), the justification and motivation for integrating climate change mitigation and adaptation programs into development strategies and practices, is to ensure increased resilience to climate change by the communities involved. Therefore, in order to mainstream climate policies, it is important to understand the challenges experienced by pastoral communities, as a result of climate change and see how those challenges are linked to their continued survival as a community (Archana, 2013).

The good thing with mainstreaming climate change policies is that it is likely to reduce the vulnerability of the communities concerned to climate change and in most cases increase the productivity of their livestock and thus increasing their survival chances as a community.

Degradation of grasslands and vulnerability of pastoral communities to extreme climate events

MEA (2004) explains that the vulnerability of communities is on the increase due to population growth hence making ecosystems to be at risk of disasters such as floods or drought. At the same time, vulnerability can also be said to have increased due to diminished resilience in either the social or ecological systems. According to Kaye-Zwiebel (2014), pastoralists tend to survive in environments considered to be limited in productivity and have high resource variability, especially if they are within grasslands. Their culture dictates that they utilize resource as a community from common pool resources and manage them socially as a community.

Conclusion

While it is true that grasslands are the largest ecosystems in the world comprising of around 40.5% of the earth's surface, degradation of grassland ecosystems and climate change are real and have adverse impacts on pastoral community in the world and Kenya in particular. Since pastoralists live and find their livelihoods within the grasslands, suggestion by researchers is that the pastoralists must find sustainable ways to protect and promote livestock production, which accounts for 12% of Kenya's gross domestic product. This includes diversification to dairy farming and having more drought resistant species. Another way is by finding alternative livelihoods which include crop farming and entrepreneurship.

The main threat to grasslands are the human activities which include expanding agriculture, charcoal burning and fuel wood collection, uncontrolled fires, human settlements, land degradation, deforestation and overgrazing in addition to climate change. Previous studies reveal that the pastoral community is undergoing serious challenges due to climate change mainly being loss of animals. As a way of coping, the pastoralists have undertaken alternative livelihoods such as crop production and entrepreneurship, while some women have turned to prostitution. In addition, some pastoralists have employed strategies such as introduction of dairy animals, reduction of herds, and reduction of household food consumption while others have migrated to the towns.

References

- Abate. T. (2016). Indigenous Ecological Knowledge and Pastoralist Perception on Rangeland Management and Degradation in Guji Zone of South Ethiopia. *The Journal of Sustainable Development* 15(1) 192-218.
- Archana K., (2013). Impact of Deforestation on Climate Change. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)* 4, Issue 2, 2319-2402.
- Ashto, B. B., & WinklerPrins, A. (2009). Pastoral Herd Management, Drought Coping Strategies, and Cattle Mobility in Southern Kenya. *Journal Annals of the Association of American Geographers*, 99, 2009(2), 309–334.
- Babu C.R, Choudhary, V. K., & Kumar, V. (2015) *Tropical Grassland Ecosystems and Climate Change*. Proceedings of 23rd International Grassland Congress.
- Bianca, O. A., Christiane, K., Llsi, I. B., EDuardo, V.-M., Hasenack, H., Julia, M., & Gerhard, E. O. (2015). Grassland degradation and restoration: a conceptual framework of stages and thresholds illustrated by southern Brazilian grasslands. *Science Direct*, (2), 95–104.
- Briggs, J., Blair, J., & Nippert, J. (2014). Grass land Ecology. *Springer Science and Business Media New York 2014*.
- Casim, U., Majule, E., & Perfect, J. (2012). Changing Trends of Natural Resources Degradation in Kagera Basin: Case Study of Kagera Sub-Basin, Uganda. *Natural Resources*, 2012(3), 95–106.
- Chunyang H., Jie T., Bin G., & Yuanyuan Z., (2015). *Differentiating climate- and human-induced drivers of grassland degradation in the Liao River Basin*. *China Chunyang Environ Monit Assess* 187, 4199.
- Casim U. T., Majule E. A., & Perfect J., (2012). Changing Trends of Natural Resources Degradation in Kagera Basin: Case Study of Kagera Sub-Basin, Uganda. *Natural Resources*, 2012, 3, 95-106. <http://www.SciRP.org/journal/nr>
- De Groot R.S., Alkemade R., Braat L., Hein L., & Willemen L. (2010) Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecol Complex* 7, 260–272

- Dong, X., Dai, G., & Ulgiati, S. (2015). *On the Relationship between Economic Development, Environmental Integrity and Well-Being: The Point of View of Herdsmen in Northern China Grassland*.
- Dua M. et al (2004) Mutual influence between human activities and climate change in the Tibetan Plateau during recent years. *Elsiever*, 41:241-249
www.journals.elsevier.com/gloplacha
- Ebanyat P., Nico R., Jager A., Delve R. J., Mateete A. B., & Giller K. E., (2010). Drivers of land use change and household determinants of sustainability in smallholder farming systems of Eastern Uganda. *Population Environment Springer Journal*, 31, 474–506
- European Environment Agency (2017). *Climate change poses increasingly severe risks for Ecosystems, human health and the economy in Europe*.
- Fratkin, E., & Mearns, R. (2003). *Sustainability and Pastoral Livelihoods: Lessons from East African Maasai and Mongolia*, 62 (2).
- Fratkin, E., Nathan, M., & Roth, E. A. (2011). *Seeking Alternative Livelihoods in Northern Kenya: Costs and Benefits in Health and Nutrition*.
- Gok (2017). *Integrated Development Plan*. Kajiado County
- Grimm, N. B., Chapin, F. S. III, Bierwagen, B., Gonzalez, P., Groffman, P. M., Luo, Y., Melton, F., Nadelhoffer, K., Pairis, A., Raymond, P. A., Schimel, J., & Williamson, C. E. (2013). *The impacts of climate change on ecosystem structure and function*, 11(9), 474–482.
- Kateiya, E. (2012). *Effects of land tenure status on land productivity and sustainable livelihood in the traditional pastoral areas of Kenya: A case of Narok District*. Thesis, University of Nairobi <http://erepository.uonbi.ac.ke/handle/123456789/20254> Kenya (2007c).
- Kaye-Zwiebel, E., and E. King. (2014). Kenyan pastoralist societies in transition: varying perceptions of the value of ecosystem services. *Ecology and Society* **19**(3): 17.
<http://dx.doi.org/10.5751/ES-06753-190317>
- Kioko, J., Warui, J., & Seno, S. O. (2012). Impacts of livestock grazing on a savanna grassland in Kenya. *Journal of Arid Land*, 4(1), 29–35.

- 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* 1(1) 107-130
- Kochore, H. H., & Watson, E. E. (2012). Religion and Climate Change in Northern Kenya: New Moral Frameworks for New Environmental Challenges? *Equinox Publishing Ltd 2012, Unit S3, Kelham House, 3, Lancaster Street, Sheffield S3 8AF.*
- Kwon, H.-Y., Nkonya, E., Timothy, J., Valerie, G., Kato, E., & Kihiu, E. (2015). A Global Estimates of the Impacts of Grassland Degradation on Livestock Productivity from 2001 to 2011. *Global Assessment for Sustainable Development Pp 197-214.*
- Lange G.M., Jiddawi N. (2009) Economic value of marine ecosystem services in Zanzibar: Implications for marine conservation and sustainable development. *Ocean Coast Manage, 52, 521–532.*
- Live Viva Grass. (2017). *Ecosystem services in different grasslands.*
- Marindany K. (2017 September 12). Hundreds of Kajiado livestock on verge of death due to drought – Lenku. Daily Nation Article.
- Mganga K. Z., Nyarik D. M., Nashon K R M., Amwata D. A. (2018). Determinants and rates of land degradation: Application of stationary time-series model to data from a semi-arid environment in Kenya. *Journal of Arid Land* 10 (1), 1–11.
- Morara, M., Macopiyo, L., & Makau, K. W. (2014). Land use, land cover, change in urban pastoral interface. A case of Kajiado County. *Academic Journals, 7(9), 192–202.*
- Mutau B. (2016, December 4). Pastoralists count losses as climate change takes a toll. Daily Nation.
- Mwanyumba, P. M., Wahome, R. G., MacOpiyo, L., & Kanyari, P. (2015). Pastoralist livelihoods, resources and strategies in Garissa County, Kenya.
- National Land Use Policy draft (2016). *Physical Planning Department Ministry of Lands and Physical Planning.*

- Nkedianye, D., Leeuw De, J., Ogutu, J. O., Said, M. Y., Saidimu, T. L., Kifugo, S. C., & Reid, R. S. (2011). Mobility and livestock mortality in communally, used pastoral areas: the impact of the 2005-2006 drought on livestock mortality in Maasailand. *Springer: Open Access*.
- Ongugo P.O, Langat. D, Oeba V.O, Kimondo J.M, Owuor. B, Njuguna. J, Okwaro. G and Russell A.J.M. (2014). *A review of Kenya's national policies relevant to climate change adaptation and mitigation: Insights from Mount Elgon*. Working Paper 155. Bogor, Indonesia: CIFOR.
- Opiyo, F. (2014). *Climate Variability and Change on Vulnerability and Adaptation among Turkana Pastoralists in North-Western Kenya*. Degree of Doctor of Philosophy in Range Management, Faculty of Agriculture, University of Nairobi.
- Parmesan C. & Yohe G. (2003A globally coherent fingerprint of climate change impacts across natural systems. *Nature* 421, 2 www.nature.com/nature
- Paul L, L. (2013). *Socioeconomic Impacts of Drought on Pastoralists, their coping strategies, and Government interventions in Marsabit County, Kenya*. Nairobi University.
- Quétier, F., Rivoal, F., Marty, P., de Chazal, J., & Thuiller, W., et al. (2010) Social representations of an alpine grassland landscape and socio-political discourses on rural development. *Environ Change*, 10: 119–130.
- Rounsevell, M.D.A., Dawson, T.P., & Harrison, P.A. (2010) A conceptual framework to assess the effects of environmental change on ecosystem services. *Biodivers Conserv* 19: 2823–2842
- Saud, L., El-Bana, M. I., Al-Bakre, D. A., Ahmad, K., Abdulaziz, A., & Basharat, M. A. (2015). Effects of open grazing and livestock exclusion on floristic composition and diversity in natural ecosystem of Western Saudi Arabia. *Saudi Journal of Biological Sciences*, 22, 430–437.
- Sternberg, T. (2008). Environmental challenges in Mongolia's dryland pastoral landscape. *Journal of Arid Environments*, 72(7), 1294–1304.
- Suttle K. B., Thomsen M.A. & Power, M. E. (2007). Species interactions reverse grassland responses to changing climate *Science* 315:640-642 www.sciencemag.org
- Su, X., Wu, Y., Don, S., Wen, L., Yuan-yuan, L., & Wang, X. (2015). Effects of grassland degradation and re-vegetation on carbon and nitrogen storage in the soils of the

- Headwater Area Nature Reserve on the Qinghai-Tibetan Plateau, China. *Journal of Mountain Science*, 12(3), 582–591.
- Tomback D.F., & Achuff P. (2010) Blister rust and western forest biodiversity: ecology, values and outlook for white pines. *For Pathol* 40: 186–225
- USAID/Kenya (2009). Kenya Land Policy: Analysis and Recommendations by Dr. John Bruce
- Veit, P. (2011). *Focus on land in Africa Placing land rights at the heart of development*.
- Wen, L., Dong, S., Li, Y., Li, X., Shi, J., Wang, Y., & Schumann, P. (13). Effect of Degradation Intensity on Grassland Ecosystem Services in the Alpine Region of Qinghai-Tibetan Plateau, China, 8(3).
- Wick, A.F., Geaumont, B.A., Sedivec, K.K., & Hendrickson, J., (2016). Grassland Degradation. In: Shroder. *Biological and Environmental Hazards, Risks, and Disasters*. Elsevier, pp. 257– 276
- Zhihui G., Peijun S., & Chen J., (2008). Estimation of Grassland Degradation Based On Historical Maximum Growth Model Using With Remote Sensing Data. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. XXXVII. Part B8.
- Zwiebel, E. K., & King, E. (2014). Kenyan pastoralist societies in transition: varying perceptions of the value of ecosystem services. *Resilience Alliance*.