Journal of Popular Education in Africa
April, May & June 2021, Volume 5, Number 4, 5 & 6
ISSN 2523-2800 (online)
Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis

By

Paul Mwari Maina & Daniel M Nzengya
Faculty of Social Sciences, St Paul's University
P.O. Private Bag, Limuru - 00217, Kenya
Email: mainapaul72@gmail.com

Abstract
Mount Kenya comprises Kenya's largest mountain ecosystem, largest protected forests, mountain wildlife areas, and water catchment for Tana River that supports over half of country's hydroelectric power supply. The ecosystem is a hotspot for many threatened and endangered species, and a leading destination for mountain ecotourism in Eastern Africa. During the last ten years, Mount Kenya ecosystem has become increasingly threatened by wide-spread degradation. Despite the threats, current government policy provisions allow communities living adjacent to protected forests access to, and utilization of a variety of non-timber forest products, including livestock grazing. The overall objective of this research conducted in Mount Kenya West protected forest was to analyse seasonality patterns of smallholder dependence on protected forest for livestock grazing. The specific objectives of this paper were to (i) investigate monthly seasonality and trends in cattle grazing in Hombe, Chehe and Kahurura protected forests during 2013 to 2018 (ii) analyse annual trends of cattle grazing in the protected forests during the same period. Monthly data for the six years were obtained from the Kenya Forest Service (KFS). Results of the time series analysis revealed significant monthly and seasonality patterns in cattle grazing in all the three forest blocks. However, the findings indicated that there were significant differences in the magnitude of peaks of influxes and low seasons across the three forest blocks. It was found that all the three forest blocks experienced highest cattle influxes during the month of July, with Kahurura experiencing the highest cattle influx, compared to Hombe and Chehe. Yearly trends revealed a persistent decline in cattle grazing in all the forest blocks throughout the 2013 to 2017, with sharp rise beginning 2018. Proper forest management by KFS and Community Forest Associations might be required to ensure the influx during the peak season is well managed to minimize conflicts between forest conversation benefits and costs. On policy issues, the government and stakeholders need to incentivize smallholder's farmers during high season peaks to provide alternatives livelihood sources for rural households.

Key words: Mountain Kenya ecosystem; protected forests; livestock grazing trends; livelihoods; forest pasture

Journal of Popular Education in Africa
April, May & June 2021, Volume 5, Number 4, 5 & 6
ISSN 2523-2800 (online)
Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis

By

Paul Mwari Maina & Daniel M Nzengya

1.0 Introduction and background

Globally, mountain ecosystems have been particularly important to more than 2 billion people because they form an important source of products and services for their livelihood along with other environmental benefits (Issaka, & Richard, 2016). Mount Kenya is the largest mountain ecosystem in Kenya, comprising the country's largest protected forest and mountain wildlife areas (FAO, 2015). It is a hotspot of the country's mountain biodiversity, and majority of the country's threatened and endangered species. However, Mount Kenya is threatened by wide-spread environmental degradation. The Kenya Forest Conservation and Management Act (2016) allows communities living adjacent to protected forests, access to a variety of non-timber forest products, that includes fruits, nuts, fibre, livestock grazing, among others, for a modest fee. Hombe, Chehe and Kahurura forests are part of the expansive Mount Kenya Forest Reserve managed by the Kenya Forest Service (KFS).

Communities living adjacent to protected forests are required to form Community Forest Associations (CFA) to participate in the co-management of the protected forests. The three forest blocks have developed Joint Forest Management Plan (JFMP) and signed Forest Management Agreement (FMA) which are documents that guides on the management of the forest and how best to sustainably utilize the user rights in the forest ecosystem. Members of the CFAs have a variety of user rights, among them, livestock grazing. Grazing of cattle is allowed in the protected forests through livestock user groups, with the forest management charging a monthly fee of $1 per cow. The current policy and legislative provisions are expected to trigger a rise in forest dependence for livestock grazing particularly because of the rising prices of livestock feeds, compounded by a declining farm sizes due to rising population, as well as declining farm productivity due to climate change.

Major actors who participate in forest management are the KFS, CFA, Non-Governmental organizations and Government of Kenya Ministry of Environment and Ministry of Tourism. All the three forests have management programs in plantation development, natural forest management, infrastructure and equipment, protection and security, human resource management, water, community participation in conservation, tourism and wildlife and research and monitoring program. A major challenge facing KFS is insufficient data to regulate livestock grazing in protected forests. The objectives of this paper was investigate monthly seasonality and trends in cattle grazing in Hombe, Chehe and Kahurura forest protected forests and to analyse annual trends of cattle grazing in the protected forests during 2013 to 2018.

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

2.0 Statement of the Problem

Forest ecosystems are very fragile habitats and are faced with numerous environmental threats including excessive use of Non Timber Forest Products (NTFPs) by forest adjacent communities according to Shackleton et al. (2018). Despite the environmental threats, government policies, particularly here in Kenya, continue to support local community access of NTFPs including livestock grazing in the protected forest. These activities, though well-intended, increase the severity of environmental threats to the forest ecosystem. These practices have the potential to exacerbate forest degradation which not only threatens to trigger far reaching implications on the national and regional economies but also predisposes communities living adjacent to such forests to various vulnerabilities, including unsustainable livelihoods development. Previous studies in other countries have focused on livestock grazing pressure without capturing livestock head count. Researchers, for example in Tanzania investigated impacts of livestock grazing without focusing on season's intensity to help inform policy. Other scholars have investigated livestock grazing in protected areas but failed to measure trends and threats over the years or consider periods when destruction of forest was less or more intense. Understanding of the seasonal and annual trends offers opportunities to generate insights into grazing pressures experienced in the three forest blocks and the possible implications on the Mount Kenya forest structure, functions, and ecosystem services. These factors are not well researched by previous scholars and this is what the researchers sought to clarify through this study by examining the trends on forest dependence for pasture for a period of 6 years (2013 to 2018).

3.0 Review of Related Literature

Forest degradation due to cattle grazing presents real challenges to the Kenyan ecosystems in protected forests (Stiebert et al., 2012). At independence in 1963, Kenya's forest cover stood at 12% and it has reduced to 7.4%, losing 12,000 hectares of forests cover per year (GOK, 2012). Allowing livestock grazing in protected forests is likely to be counter-productive to the country's ambitions to restore Kenya's forest cover and combat degradation of the county's forest ecosystems particularly the fragile mountain ecosystems. Giday et al., (2018) have reported a strong correlation between grazing pressure on forests from cattle and the potential of forests biomass feed production and current cattle density relation to the sustainable stocking rate. The researchers showed that cattle forest interaction had evidence of negative effects of cattle grazing in protected forest areas on vegetation attributes on forest reserve. Schmitz and Asselstine, (2020) have revealed the negative effects of grazing system on grassland plant species richness and vegetation characteristics by comparing horse and cattle grazing. The authors reported statistically significant differences among grazing systems for different vegetation variables.

The authors however noted that compared to experimental studies, observational studies are more challenging in data analysis as effects of land use are confounded with those of the site conditions (Schmitz & Asselstine, 2020). Dettenmaier et al., (2017) have reported that while cattle's grazing is not only the predominant use of rangelands but has been implicated in most literature in declines of grouse populations. The authors observed that cattle have predominately negative effects on wildlife and their habitats as supported by the study by Schieltz &

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

Rubenstein (2016). However, evidence in the meta-analysis lacked the knowledge of the direct effects of cattle grazing needed to develop best management practices to balance cattle grazing and forest ecosystem. The gap can be addressed by the study on grazing trends indicating seasonality and annual trends, cattle type, timing and frequency of grazing, duration and stocking rate.

Buffum et al. (2009) investigated forest grazing and natural regeneration in a community forest in Bhutan, South Asia, a country with one of the highest forests covers at 83.9%. Main critique of these findings is that the analysis failed to reveal the monthly, yearly or seasonality patterns when there were peak and low seasons to help inform policy. Tucker (1986) work done in Punjab Himalayas Mountains in Asia focused on the evolution of transhumance grazing which is a region with an average forest cover of 12.8 %. The region is characterised by seasonal movement of livestock in the mountain regions. The critique on the study is that the author failed to provide data on the impact of migratory herders indicating grazing seasonality patterns outlining the severe and less severe periods to help the Indian Forest Service to make informed forest grazing land regulations.

Research by Hosonumal et al. (2012) conducted an assessment of deforestation and forest degradation in 46 countries. One of the critiques of the study is that livestock grazing as a forest degradation driver was classified as both large and small scale with no actual numbers as operationalized by previous researchers to indicate grazing intensities. Ratovonamana et al. (2013) work was done in Madagascar and the researchers investigated the impact of livestock grazing on forest structure, plant species and composition in Madagascar. The work noted that plant diversity decreased with increase in livestock grazing pressure. The critique of the findings is based on the fact categories of grazing pressure was based on seasons, type of animal and consumption rate per unit livestock per day. There was no quantitative data to determine animal influx in the forest and seasonality patterns and trends over the years. Piana & Masden (2014) research in Peru with a national forest cover at 53.1% and the region has the largest tract of forest remaining in that part of the country. The research noted that distance from the forest as an insignificant driver and there was no significant correlation between cattle density and distance from the forest. The research however failed to capture cattle density in numbers and it was estimated using defecation and dung decay piles and there was no conversation on seasonality trends and patterns based on high or low animal influxes to the protected forest.

Mazzini et al. (2018) have investigated available evidences on positive, negative and neutral effect of cattle grazing on forest ecosystems. According to the authors, 66% of studies reviewed indicate that cattle grazing has negative effect on ecological variables such as vegetation cover. 16% of the studies indicated a positive effect of cattle grazing on forest ecosystems while 18% of the studies indicated that cattle grazing has neutral effects on forest ecosystem and concluded that there no specific ecological variables explicitly mentioned by any of the studies that are positively affected by cattle grazing which came out as a gap in the study.

The livestock sector globally is dynamic and is one of the fastest growing agricultural sectors in developing world due to increased demand for cattle products (Shree & Sridhar, 2016). Cattle grazing support livelihoods of 600 million poor smallholder farmers in the developing world across the globe causing massive forest destruction (Godde et al., 2018). However, the

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

study did not consider the periods when destruction of forest was less or more intense**.** For instance, in the Congo Basin 30 million people live adjacent to the forests and 75 million rely on it for their livelihoods, mainly for food and fodder. There is a need to assess grazing capacities, allocate and enforce grazing quotas, coordinate between forest custodians and the cattle grazers to enhance ecosystem in a sustainable manner (Soofi et al., 2018).

Kikoti & Mligo (2015) investigated the impacts of livestock grazing on Montane forest in Mt Kilimanjaro Tanzania was motivated by the ecology value of forests and the negative effect of livestock grazing on plant species in the hilly forest. The research noted that there has been loss in ecological services of forest due to overgrazing caused by prolonged drought and increasing demand for livestock grazing land. Kikoti & Mligo (2015) research established that livestock grazing on protected forest have serious impacts on vegetation community composition and if measures were not taken, the entire forest ecosystem can be destroyed, a fact also supported by Rosenthal (2010) study. The concern for the research was that the demand for livestock products is increasing which is a big threat since the protected forests are the safety nets for the forest adjacent communities. Kikoti & Mligo (2015) research however did not focus on seasons in a year when livestock grazing is less or more intense on plant species destruction. The research also did not acknowledge the relevance of the rainy and the dry season in an ecosystem. The period of study was limited and did not measure seasonality patterns and threats over the years to inform decision making.

Further research by Mbiba et al. (2019) on the influence of livestock grazing on small animals in Brazil forest was motivated by how the activity affect habitat characteristic changing the structure of the vegetation and reducing biomass cover. The objective of the study was to establish the impact of livestock grazing on other small forest wildlife. Mbiba et al. (2019) study concluded that the presence of livestock in the forest negatively affect the natural habitat of small mammals in the forest. The research however did not take into consideration seasonality patterns and livestock intensity. There was need to confirm if increase in the number of livestock in the forest correlated with the decline in forest natural habitat characteristic. Researchers in India have investigated livestock grazing pressure in and around the elephant corridors. Livestock head was however not captured to determine carrying capacity (Silori & Mishra, 2001). Researchers in Iran have investigated livestock grazing in protected areas and its effect on wildlife in Iran. The study confirmed livestock intensity was a threat but there were no trends to confirm (Soofi *et al.,* 2018). The researchers investigated livestock grazing in National parks across several countries. The period of study was limited and did not measure trends and threats over the years to inform decision (Rosenthal, 2010). Researchers in America documented the negative effects of the practice effects of livestock grazing (Mazzini et al., 2018). However, no data on peaks and off peaks season to guide on policy.

Journal of Popular Education in Africa
April, May & June 2021, Volume 5, Number 4, 5 & 6
ISSN 2523-2800 (online)
Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

4.0 Materials and Methods

4. 1 Brief Overview of the Study Sites

The study was conducted in Mt Kenya West in central Kenya in three protected forest blocks: Hombe, Chehe and Kahurura as shown in Figure 1.

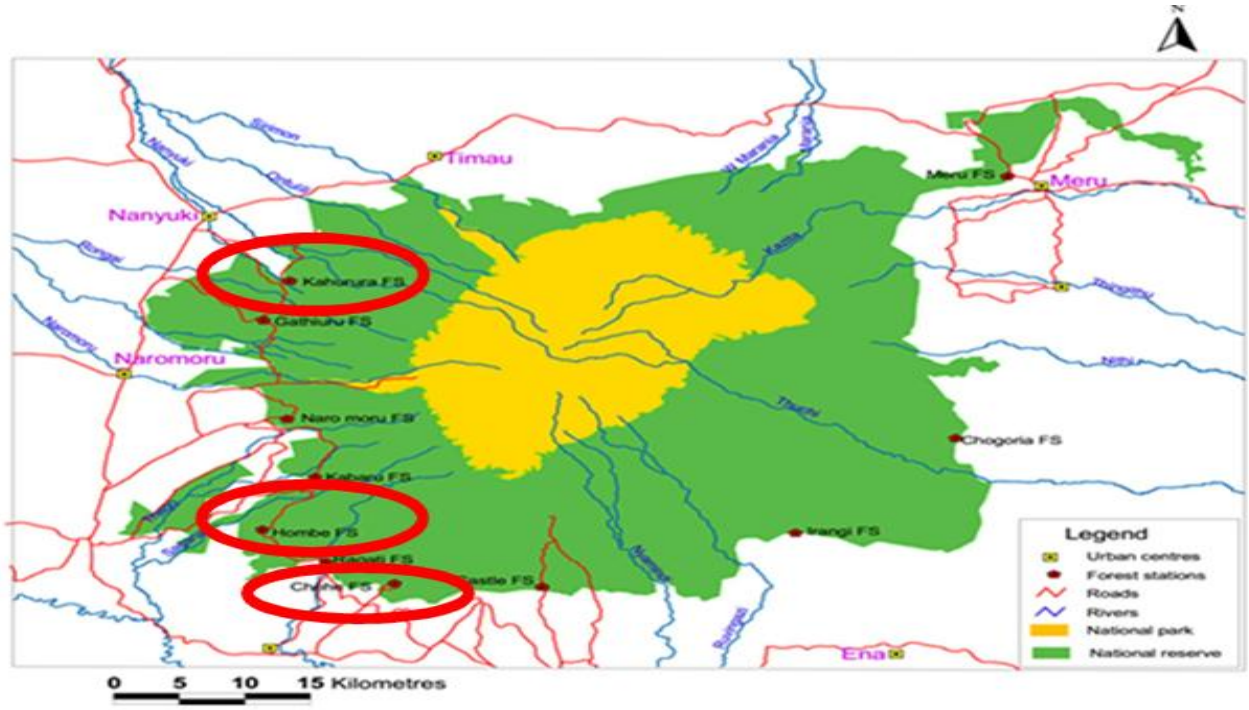


Figure 1: Area of Study:
Source: The Courtesy of Kenya Forest Working Group, East African Wildlife Society, (2014)

The study sites are part of the expansive Mt. Kenya Forest Reserve which was originally gazetted in 1932 as a crown forest. The total area of Hombe forest is 3618.7 hectares, Chehe 4945 ha and Kahurura 9855 ha. The Hombe CFA membership is the largest in terms of members comprising a total of 748 members, followed by 684 (Kahurura) and 528 members in Chehe respectively. Topographically, the site lies between the heights of 1800-2500 m above sea level and experiences bimodal rainfall ranging from 600 mm to 1500 mm (an average of 1200 mm), with long rains between March and June, and short rains between October and November. Majority of the farm holdings ranges between 1-5 acres (60%) with those less than one acre in size accounting for (35%) according to socio - economic survey (2011). Agriculture is the main economic activities for communities in the study site and livestock farming is a major socio - economic activity.

Journal of Popular Education in Africa
April, May & June 2021, Volume 5, Number 4, 5 & 6
ISSN 2523-2800 (online)
Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

4.2 Data Collection and Analysis

To examine seasonality patterns on smallholder dependence on protected forest in the Mt Kenya West region for pasture, the researcher obtained monthly records of the number of cattle grazing in the protected forest from January 2013 to December 2018. Monthly records were obtained from KFS for each forest block. The data was sorted using an Excel Spread sheet while missing data points were checked with the KFS forest reserve officers retrieved from older catalogues and accurately filled. Data was entered into the Excel sheet and analysed for seasonality patterns using the time series analysis. Time series uses seasonality and random components in the analysis of time series data, making the data stationary (Park et al., 2007). Making time series stationary is a statistical technique of accounting for the recurring patterns in the data over the period under investigation, in this case, the 6 years period. The research followed the decomposition method of aggregating monthly data to create annual data. This decomposition method is important in making the time series data smooth by minimizing data aggregation which transforms monthly data into annual data. To analyse seasonality patterns, the months were averaged to give an averagely 12 month long repeating pattern.

5.0 Results and discussion

5.1 Seasonality patterns on forest dependence for pasture

The results of analysis of data from KFS on livestock grazing in the protected forest for seasonality of forest dependence are summarized in Figure 2.

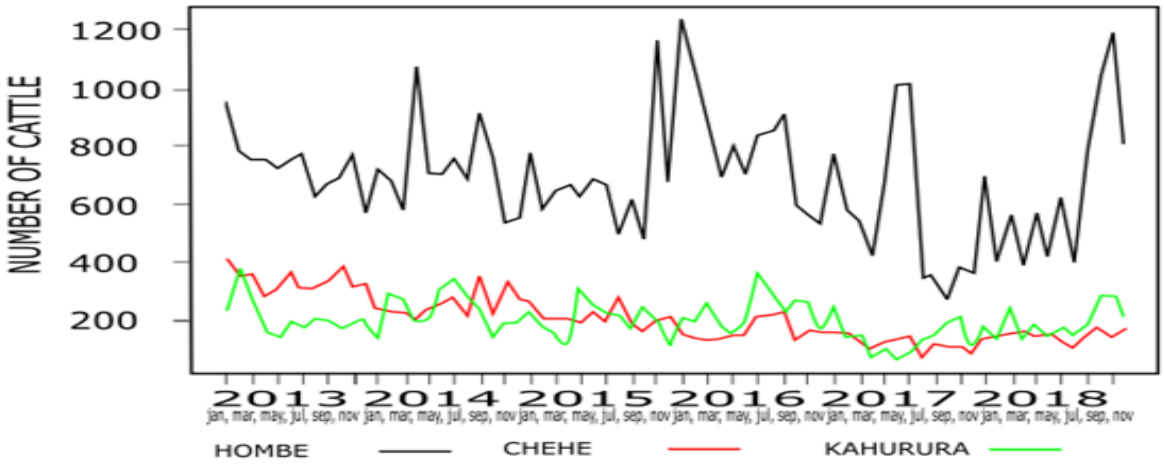


Figure 2: Monthly and seasonality patterns of smallholder farmers' dependence on protected forest for pasture (2013 – 2018)
Source: (Author, 2019)

Results revealed that the three forest blocks experienced seasonality patterns in forest dependence for pasture as indicated in Figure 2. Comparatively, Hombe had the highest number

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

of cattle entries to the forest throughout 2013 to 2018. Results revealed that minimum cattle counts were observed in the year 2017, while maximum counts were achieved in the early months of the year 2016 and in 2018. As shown in figure 2, in general, the early months of the year (January) and middle year (July) exhibited peaks in cattle grazing whilst August, October and December had a characteristic low count in cattle numbers recorded. The months February, March, April and May were noted to have the lowest influx of forest dependence for pasture. Generally, these four months had comparable figures of about seven hundred cattle. The grazing activities began peaking again in June and capped in July such that the following two months, that is June and July showed an average of eight hundred cattle. Again, the figures dropped in the following month of August where they were continually observed to be below the previous low of seven hundred, albeit the numbers in these months (August, September, October, November and December) varied between six hundred and four hundred or even lower (three hundred) such as those observed in the year 2017. The cycle repeated itself throughout the study period.

Hombe seemed to record the highest influxes beginning in January of each year (Table 1). Grazing activities tended to decline in the subsequent months of February, March, April and May. The period around the middle of the year, July, exhibited influxes in cattle grazing whilst August, October and December featured lower figures (Figure 2). The seasonality in forest dependence for pasture was probably influenced by rainfall seasons where the heavy downpours of long rains in March, April and May was associated with minimum cattle grazing while the lighter rains of the short rainy season in September, through December favourable for grass growth, coincided with peak cattle grazing in the blocks. Eventually, these favourable conditions manifested in that, part of the farmers, directly switched to minimal or maximum dependence on the forest for pasture. One approach to a manage influxes in peak seasons could be by closing some sections of the forest block to allow for grass to recover.

Table 1: Monthly seasonality indices on smallholder farmers' dependence on forest for pasture

FOREST BLOCK	Month											
	Jan	Feb	Mar	April	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Hombe	179	0.3	-18	-11.5	4.6	29.5	116	-83	13	-116	13	-127
Chehe	-7.2	-21	-20	-26.2	-13	3.2	13.1	9.8	35	-1.9	17	11.3
Kahurura	2.2	-8.7	18.9	-5.3	-5.5	-4.9	38.3	26.6	2.8	9.4	12	-38

Source: (Author, 2019)

Negative indices indicate activities drop in the month relative to other months on average through 2013 to 2018 period (that is a low season). The graph indicates that Chehe and Kahurura had relatively low numbers of animals entering the forest compared to the Hombe forest. In Chehe, the first half of the records showed low forest dependence for pasture compared to the

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

rest of the year (July through December). In Chehe, results revealed that in general, the last half of the year months exhibited peaks in cattle grazing whilst the first half months (January through June) had a characteristic low count in cattle numbers recorded (See Table 1).

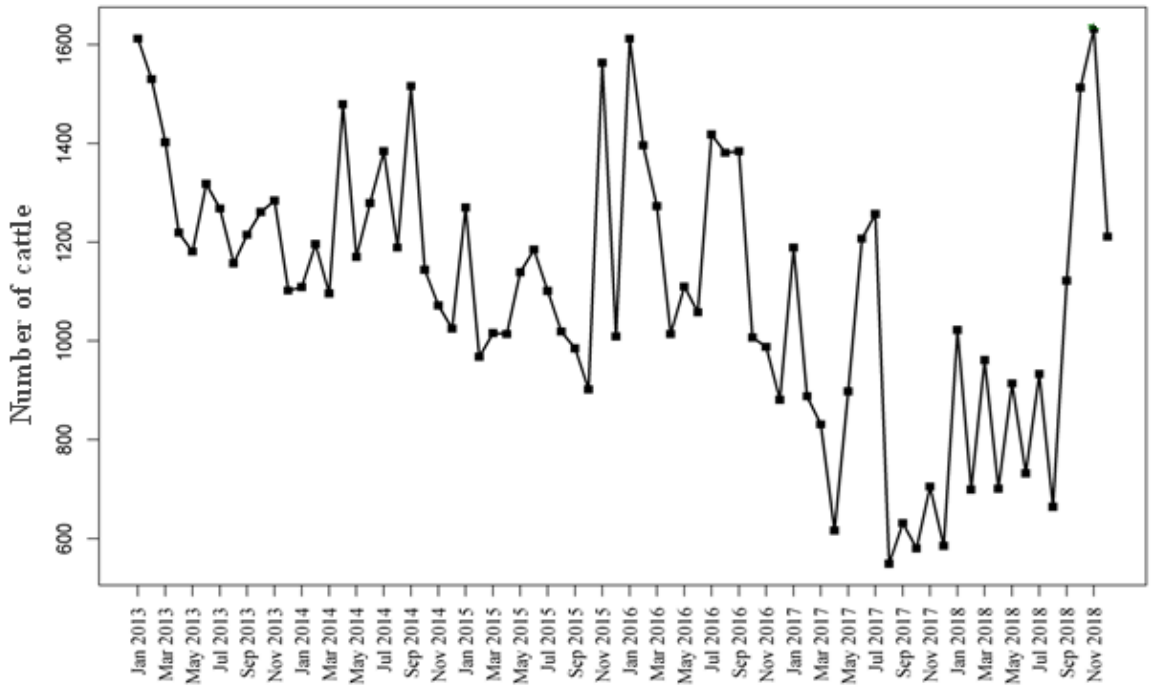
In summary, Chehe experienced the lowest forest dependence in the month of April, with the peaks and the lows in Chehe representing a change of about 50 cattle up or down and the cycle repeated itself throughout 2013 -2018. Results on seasonality patterns analysis revealed repeating seasonality on forest dependence for pasture. In Chehe, the observed rainfall data was obtained from a meteorological weather station within the forest block managed by KFS and the adjacent community for the years 2009 to 2018. In Chehe, the years 2012 through 2016 had an apparent suppressed rainfall compared to the other years in study period albeit the peak seasons of March to May and October to November were maintained. The better part of December to February months during those years observed zero rainfall. Generally, the region exhibits two rainy seasons and two dry seasons that coincide with rainfall regimes of the East African highlands. Here, heavy downpours of the long rains were exhibited in March to May and lighter showers in October to December in some years.

The rainfall data analysis indicated that an increase in values of rainfall was likely to lead to suppressed grazing activities over the Chehe forest block by a unit value, about a month or two, later while a decrease in values of rainfall was likely to lead to increased grazing activities in the Chehe forest block by a unit value, about a month or two, later. A possible reason for this relationship is that light shower rains in the short rain season favour grass growth, leading to enhanced grazing, or suppressed rainfall leads to reduced pasture for farmers, hence they flock to this forest reserve for grazing. The peak season in the January of each year is followed by a decline in cattle numbers, the lowest being in the month of April. Therefore, the seasonality patterns on livestock grazing in Chehe are apparently influenced by rainfall patterns.

In general, Kahurura seemed to experience two seasons of high influxes and two low seasons. The month of April and the month of December experienced extremely low cattle grazing activities in Kahurura while March and July exhibited characteristic high peak season. Comparatively, the high and the low seasons, the numbers did not change so rapidly from one season to the other as compared to the seasonality patterns in Hombe. Kahurura seemed to experience influxes in the month of May, June and July and August and eventually dropped back into a low in December. Generally, the low season of January to March and September to November were months having stable figures while the other months had varied numbers.

A change in cattle number from low to high season seemed to average around 80 cattle. July seemed to be the major peak season with cattle number around 350, followed by another in March with an average of 300 cattle. The seasonality patterns in forest grazing in Kahurura were apparently influenced by rainfall seasons. This is strongly associated to rainfall seasons where the heavy downpours of long rain season of March, April and May reflected minimum cattle grazing while the lighter rains of the short rain season in September through December, which are favourable for grass growth, coincided with peak cattle grazing in the blocks. Eventually these favourable conditions manifested in that part of the farmers, directly switched to minimal or maximum cattle grazing activities.

Journal of Popular Education in Africa
April, May & June 2021, Volume 5, Number 4, 5 & 6
ISSN 2523-2800 (online)
Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.



Source: (Author, 2019)

Figure 3: Monthly and seasonality patterns on smallholder farmers' dependence on protected forest for pasture (2013 – 2018): Combined data for the three forest blocks

Results of the combined data for the 3 forest blocks revealed that in general, the first half of the year experienced a low number compared to the later part of the year. Comparing the two, the high and low seasons within which the figures are comparable, the cattle numbers did not change so rapidly from one season going to the other. For example, the peak season in September was followed by a low season in January with a drop of about 150 cattle. Seasonality in forest dependency for pasture for the three forest blocks combined revealed a low season in the month of April. Grazing activities tended to increase in the month of July, August, September, October, November and December.

6.0 Discussions

The findings of this study revealed that there were significant seasonality patterns in forest dependence for pasture in all the forest blocks. However, there were significant differences in the magnitudes (seasonality indices) across the three forest blocks, with Hombe showing the highest numbers of influxes. Also, there were differences in high and low peak seasons amongst the three forest blocks. Hombe forest block seemed to have two distinct peak seasons, with a primary peak season occurring in January and a secondary peak season occurring in June and July of each year. Chehe seemed to experience remarkably low seasons during the first months of the year, (January to May), with influxes during the later months of the year. Kahurura seemed to experience low influxes during the first months of the year, with the exception of January and March; however, influxes began to manifest during the latter part of the year, that is,

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

July to November. All the three forest blocks seemingly experienced low seasons during April and peak seasons during July, September and November.

Although all the three forest blocks are within the West Mt Kenya region, there were differences in the seasonally patterns and also magnitudes of forest dependence for pasture. This implies complex interactions of socio-ecological and socio-environmental factors influencing smallholder farmers' choice of switching from cattle grazing in the protected forest. Rainfall patterns are a possible factor influencing these switching decisions. However, there are time lags because on-set of rains may not necessarily imply a switch away from grazing in the protected forest since it takes time for alternative grazing sources to pick to sustain significant quantities of pasture. The findings of this study are supported by Giridhar and Samireddypalle (2015) work in New Delhi that established that seasonality fluctuations affect availability of forage for livestock. Also, an on-set of a dry spell does not necessarily imply an immediate switch to grazing into the forest. This is because after rainfall cessation, farmers still have alternative sources of pasture still available, such as crop waste that may be significant to sustain cattle before farmers are faced with shortages to trigger switching into the protected forest. Similar results were found in Nepal, that climatic fluctuations make it difficult to switch between forest dependence and reliance on fodder (Gurung, Nelson & Smith, 2009).

Also, as Murray et al. (2017) has pointed out, climate change has interrupted the cycles of wet and dry seasons. There is therefore significant year to year variability on the onset and cessation of rainfall. This variability may further complicate farmers' responses to switching between forest dependence for pasture and other alternative but free options mentioned by respondents such as grazing on the roadside and seeking for available crop wastes for sustaining livestock. Poor rainfall patterns trigger crop failures and also interfere with the quantities of fodder produced and also quantities of crop waste from farms, implying extended decisions to rely on forest for pasture. Conversely, extended periods of rainfall months may be accompanied by huge quantities of pasture availability outside of the protected forest, and also huge and significant availability of farm waste that are able to sustain cattle for longer periods without the need to depend on the forest for pasture. Furthermore, behaviour such as harvesting and purchasing crop waste for feeding cattle during the dry season months further complicated seasonality behaviours on forest dependence observed amongst the three forest blocks. Further research is needed to investigate how smallholder farmer practices such as harvesting and purchasing farm waste such as maize to sustain cattle during dry spells influences seasonality patterns and decisions to graze in the protected forest.

This seems to be supported by the results of analysis of rainfall at Chehe forest block (2009 to 2018) using time series that revealed that evidently, the area experiences dry seasons some of the year characterized by least rainfall compared to other months. Low rainfall months include December to February and June to September of every year. In some years, these months seemed to experience a completely dry spell, with zero observed rainfall during some months. The high rainfall peaks were noticeable in March to May and October-November months of the year. Results corroborate with the Kenya Meteorological report (2019) in this region which noted that generally, the Mt Kenya region exhibits two rainy seasons and two dry seasons that coincide with rainfall regimes of the East African highlands. Heavy down pours are characteristic of the

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

long rains, March to May and lighter showers in October to December in some years. In between those seasons are the drier seasons of June to September and a shorter one of January to February. The lighter rains of the short rain season are favourable for grass and leguminous crops' growth.

Results of the scatters plot revealed a negative correlation between livestock grazing data and rainfall data. This therefore suggests that lower rainfall values are associated with increases in cattle grazing in protected forest. Several authors have noted extreme climate changes events such as prolonged droughts to be associated with farmers and pastoral communities opting to graze on protected forest and protected wildlife areas (Munanura et al., 2018). The Kenyan print media has also further reported influxes of pastoral communities moving to graze animals in protected forest and national parks as noted in the year 2017. Areas reported to be affected by this phenomenon include wildlife sanctuaries and also forest in the central Kenya region (Boles et al., 2019), including Mt Kenya forest.

7.0 Conclusions and Recommendations

The research concluded that monthly and seasonal variation in livestock dependence for pasture exist across the three forest blocks; however, with significant differences in the magnitude of peaks of cattle influxes. Of the three forest blocks investigated in this study, Kahurura was found to experience high cattle grazing influxes during most of the months of the year with characteristic primary peaks in January and secondary peaks in July respectively. On the contrary, Chehe was found to experience a low peak season during most of the earlier months of the year, with very marginal influxes experienced during the months of July. The magnitude of influxes during the month of July in Chehe was low compared to Kahurura which experienced almost nine times the number of cattle influxes reported in Chehe during the same period. Secondly, the Kenya Forest Service needs to determine dry season period carrying capacity when the forest blocks experience influxes to avoid overgrazing problems. KFS also need to devise ways of regulating grazing activities during high season peaks.

The government need to incentivize smallholder's farmers during high season peaks to provide alternatives for rural households pressed to graze animals during the months identified. Proper forest management may be required to ensure the influx during the peak season is well managed to minimize conflicts between forest conservation benefits and costs. Further studies are needed to understand clearly rainfall and grazing patterns in the long run sustainability therefore there is need for long term data of more than 30 years which include grazing hours, area, opening and closing of grazing sites. There is also need to corroborate the trends revealed with field observation, surveys with smallholder farmers, and data from remote sensing data on trends of vegetation cover the last 6 years. Similar studies are needed for other forest blocks, and for other mountain ecosystems in East Africa, for comparison.

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

8.0 References

Ates, S., Cicek, H., Bell, L. W., Norman, H. C., Mayberry, D. E., Kassam, S., & Louhaichi, M. (2018); Sustainable development of smallholder crop-livestock farming in developing countries. In *IOP Conference Series: Earth and Environmental Science*

Bernes C., Jonsson, B. G., Junninen, K., Lõhmus, A., Macdonald, E., Müller, J., & Sandström, J. (2016); What are the impacts of manipulating grazing and browsing by ungulates on plants and invertebrates in temperate and boreal forests? A systematic review protocols: *Environmental Evidence*

Boles, O. J., Shoemaker, A., Mustaphi, C. J. C., Petek, N., Ekblom, A., & Lane, P. J. (2019). Historical ecologies of pastoralist overgrazing in Kenya: long-term perspectives on cause and effect. *Human Ecology*, *47*(3), 419-434.

Buffum, B., Gratzer, G., & Tenzin, Y. (2009); Forest grazing and natural regeneration in a late successional broadleaved community forest in Bhutan: *Mountain Research and development*,

CIFOR, FAO, CIFOR, IFRI and World Bank (2016); National socioeconomic and conservation, sustainable management of forests

Dettenmaier, S. J., Messmer, T. A., Hovick, T. J., & Dahlgren, D. K. (2017); Effects of Cattle Grazing on Rangeland Biodiversity: A Meta-Analysis of Grouse Populations. *Ecology and evolution*, *7*(19), 7620-7627

EMCA (1999); Environmental Protection in Kenya: Will the Environmental Management and Co-ordination Act (1999) Make a Difference: *SC Envtl. LJ*, *9*, 181

FAO (2015); Global Resources Assessment: Reducing Emissions from Deforestation and forest degradation

Giday, K., Humnessa, B., Muys, B., Taheri, F., & Azadi, H. (2018); Effects of cattle grazing on key vegetation attributes of a remnant forest reserve: The case of Desa'a Forest in northern Ethiopia. *Global ecology and conservation*

Godde, C. M., Garnett, T., Thornton, P. K., Ash, A. J., & Herrero, M. (2018); Grazing systems expansion and intensification: Drivers, dynamics, and trade-offs. *Global food security*, *16*, 93-105.

GOK, (2012); Kenya's Climate Change Action Plan: Mitigation Forestry Seton Stiebert, Deborah Murphy, Jason Dion and Scott McFatridge (IISD)

GOK, (2016) Land Degradation Assessment in Kenya-March 2016; The Need for Land Degradation Assessment (LADA) for Kenya; www.environment.go.ke › uploads › 2018/08 › LADA.

Giridhar, K., & Samireddypalle, A. (2015); Impact of climate change on forage availability for livestock: In *Climate change Impact on livestock: adaptation and mitigation* (pp. 97-112). Springer, New Delhi

Gurung, B., Nelson, K. C., & Smith, J. L. (2009); Impact of Grazing Restrictions On Livestock Composition And Husbandry Practices in Madi Valley, Chitwan National Park, Nepal. *Environmental Conservation*, 338-347.

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

Hosonumal, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., & Romijn, E. (2012): An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*

Issaka, B. Y., & Richard, Y. N. (2016); Non-Timber Forest Products and Climate Change Resilience: The Case of the Savannah Woodlands Northern Ghana, 8.

Kikoti, I. A., & Mligo, C. (2015); Impacts of livestock grazing on plant species composition in montane forests on the northern slope of Mount Kilimanjaro, Tanzania: *International Journal of Biodiversity Science, Ecosystem Services & Management*, *11*(2), 114-127.

Mligo, (2015); Excessive Livestock Grazing Contributes to Massive Soil Erosion Due to Livestock Trails in Montane Forest

Mazzini, F., Relva, M. A., & Malizia, L. R. (2018); Impacts of Domestic Cattle on Forest and Woody Ecosystems in Southern South America: *Plant ecology*, *219*(8), 913-925

Mbiba, M., Collinson, M., Hunter, L., & Twine, W. (2019); Social capital is Subordinate to Natural Capital in Buffering Rural Livelihoods from Negative Shocks: Insights from rural South Africa. *Journal of rural studies*, *65*, 12-21

Murray-Tortarolo, G., Jaramillo, V. J., Maass, M., Friedlingstein, P., & Sitch, S. (2017). The decreasing range between dry-and wet-season precipitation over land and its effect on vegetation primary productivity: *PloS one*, *12*(12)

Munanura, I. E., Backman, K. F., Sabuhoro, E., Powell, R. B., & Hallo, J. C. (2018). The perceived forms and drivers of forest dependence at Volcanoes National Park, Rwanda: *Environmental Sociology*, *4*(3), 343-357.

Piana, R. P., & Marsden, S. J. (2014); Impacts of cattle grazing on forest structure and raptor distribution within a Neotropical protected area. *Biodiversity and conservation*

Ratovonamana, Y. R., Rajeriarison, C., Roger, E., Kiefer, I., & Ganzhorn (2013); Impact of livestock grazing on forest structure, plant species composition and biomass in south western Madagascar - *Scripta Botanica Belgica*, *50*, 82-92.

Rosenthal, J. S. (2010); A review of the role of protected areas in conserving global domestic animal diversity. *Animal Genetic Resources/Resources génétiques animals /Recursos genéticos animales*, *47*, 101-113.

Soofi, M., Ghoddousi, A., Zeppenfeld, T., Shokri, S., Soufi, M., Jafari, A., & Waltert, M. (2018); Livestock grazing in protected areas and its effects on large mammals in the Hyrcanian forest, Iran. *Biological Conservation*, *217*, 377-382.

Shackleton, C. M., Ticktin, T., & Cunningham, A. B. (2018). Nontimber Forest Products As Ecological And Biocultural Keystone Species. *Ecology and Society*, *23*(4).

Schieltz J. M., & Rubenstein, D. I. (2016); Evidence Based Review: Positive Versus Negative Effects of Cattle Grazing on Wildlife. What Do We Really Know? *Environmental Research Letters*, *11*(11), 113003

Schmitz, A., & Isselstein, J. (2020). Effect of Grazing System on Grassland Plant Species Richness and Vegetation Characteristics: Comparing Horse and Cattle Grazing

Shree & Sridhar, (2016). The livestock sector dynamics: Agricultural sector Development: *Cattle products availability and demand.*

Citation: Maina, P. M & Nzengya, D. M. (2021). Trends in Livestock Grazing in the Protected Forests at Mount Kenya Region: Evidence from year 2013 to 2018 using Time Series Analysis. *Journal of Popular Education in Africa.* 5(5), 38 – 52.

Silori, C. S., & Mishra, B. K. (2001). Assessment of Cattle Grazing Pressure In and Around the Elephant Corridors in Mudumalai Wildlife Sanctuary, South India. *Biodiversity & Conservation*, *10*(12), 2181-2195.

Tucker, R. P. (1986). The Evolution of Transhumant Grazing in the Punjab Himalaya. *Mountain Research and Development*, 17-28.

UNESCO (1997). Mount Kenya National Park/Natural Forest - UNESCO World at 5,199 Mount Kenya is the second highest peak in Africa (https://whc.unesco.org)