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Implications of livestock grazing on sustainable management of montane forests: a case of South West Mau forest, Kenya

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Abstract

Overgrazing is an emerging concern in Kenya's indigenous forests. It affects regeneration, species structure and composition and soil. However, information on permissible grazing threshold and effects of overgrazing on forest ecosystem has not been adequately established in Kenya. This study was undertaken in South West Mau; the largest block forming Kenya's biggest water tower, Mau Complex. Grazing is the main driver of degradation in the forest. The objectives of the study were to determine; dependence of forest adjacent communities on forest for grazing, effects of grazing on forest structure and composition, permissible forage off-take levels and ecologically sustainable carrying capacity. Data and information was collected through household surveys, Focus Group Discussions, vegetation assessment under varied grazing intensities (heavy, moderate and light), estimation of primary forage productivity, livestock census and computation of carrying capacity. The study found that 96% of the households grazed their livestock in the forest throughout the year. Although the forest generally showed natural regeneration as exhibited by reversed exponential curve, there was no regeneration in heavily grazed areas. Further, significant variation existed in species diversity, stand density and basal area across the grazing intensity levels. Physical count survey estimated a total 17,263 livestock (14,804 ±396 cattle, 2,365 sheep, 44 goats and 50 donkeys) grazed in the forest daily. The available forage was estimated at 14 million Kg DM/ year. This forage can support 6,104 Tropical Livestock Units (TLUs) throughout the year. Currently, the forest supports 10,629 TLUs, hence grazing threshold has been exceeded by 74%. There is need therefore, to maintain sustainable grazing threshold that would ensure forest regeneration and adequate forage availability. The study will inform grazing policies in Kenya for sustained forest management.

Keywords: Deforestation and forest degradation; Biodiversity conservation; Climate change; Governance; Sustainable forest management

Introduction, scope and main objectives

The effect of grazing and browsing on forest structure and composition, soil and ecosystem function is highly dependent on selective browsing of some plants by herbivores and avoidance of others coupled with the intensity of grazing (disturbance) and frequency (Mtimbanjayo 2017; Aryal 2010). Forest grazing can be sustainable at moderate levels (Mayer & Huovinen 2007) and is an integral forestry management tool because it can enhance tree growth by reducing grass competition on tree seedlings (Varga et al. 2020; Darabant et al. 2007). Contrary, heavy and persistent livestock grazing in natural ecosystems can contribute to changes in vegetation structure and composition (Kikoti and Mligo 2015). The selective and intensive browsing of preferred tree species (i.e. palatable) may result to death or stunted growth and loss of competitive ability by those species (Johansson et al. 2009). As a result, the non-palatable species dominate (Calvert, 2001) leading to loss of diversity, richness and structure. Overgrazing also has the potential to alter physico-chemical properties of soil as a result of depletion of nutrients, soil erosion, compaction and acidification (Barnes et al. 1998; Belsky & Blumenthal 1997). These negative responses of plants to grazing affect the resilience of forest ecosystems and hampers sustainable management.

In Kenya, the forest adjacent communities largely depend on the forest for provision of livestock forage due to abundance and lower demand for inputs. Although the Forest Conservation and Management Act 2016, legalizes forest grazing in the country, unsustainable grazing in forest reserves and community forests has been identified as one of the key drivers of forest deforestation and degradation in Kenya (MENR 2016). This is because the traditional uncontrolled and free grazing system promotes grazing and trampling throughout the year. Additionally, the ecologically sustainable carrying capacity is poorly documented for indigenous forests and may have been surpassed leading to overgrazing. This may be affecting plant composition and structure in these fragile ecosystems. This study was carried out in Ndoinet indigenous public forest (20,032 ha), a sub-block of South West Mau, part of the larger Mau forest ecosystem. The altitude ranges between 2,000 and 2, 800m with an annual rainfall ranging from 1,500 to 2,100mm. A section of the forest was illegally occupied in the past. This prompted the government to evict the illegal occupants between 2005 and 2009. The disturbance left extensive grasslands suitable for grazing. Ndoinet forest is therefore, degraded by cattle-grazing, since it forms the main grazing ground of the entire block (KFS 2018). This study was carried out to assess the dependence of local community on the forest for grazing, determine the effects of forest grazing on floristic structure and species composition under varying grazing intensities and to estimate the permissible grazing threshold. The findings will support the development of viable options for sustainable management of forest grazing in montane ecosystems in Kenya and beyond.

Methodology

1-Socio-economic survey

The information on community utilization of the forest for grazing was collected through household survey, Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). The study area was divided into four administrative units: Kapkembu, Kapno, Chematich and Kipkoris sub-locations. The households within five kilometre stretch from the forest boundary totaling about 5,235 formed the research population. Within the selected administrative units, nineteen villages were randomly selected for sampling based on socio-economic heterogeneity. The sample size for each study village was determined using proportionate sampling techniques (Mugenda & Mugenda, 2013). Sample households were randomly selected from detailed household list. Semi-structured household questionnaire was used to collect information on socio-demographic, utilization of the forest for grazing and livestock numbers and types grazed in the forest in 381 households. The head of the household was targeted for interview, in his absence, the spouse or the eldest adult child was interviewed. The information obtained from the respondents was triangulated using KIIs (8) and FGDs (3).

2-Vegetation assessment

Vegetation survey was undertaken to assess the status of the forest using stratified-systematic sampling technique. An exploratory survey was first carried out to stratify the study area into degradation levels based on the level of recovery and grazing levels. Correspondingly, the forest was stratified into three grazing intensities patches; light, moderate and heavy that commensurate forest degradation levels (less, moderately and heavily disturbed respectively). A less disturbed forest site (light grazing intensity) was defined as the primary forest area which was last disturbed over 50 years ago and has since recovered with minimal forest gaps to support grazing. Moderately disturbed site (moderate grazing intensity) was classified as a site which had once been deforested and converted to farmlands but has since undergone minimal or no disturbance since evictions in 2009 and recovery is noticeable but still have some openings with forage which allows livestock grazing. The heavily disturbed site (heavy grazing intensity) was defined as forest site which was disturbed but has not recovered since then and is grassy open fields (grasslands).

Three line transects were randomly established from the edge of the forest bordering the farmlands towards interior. The edge of the forest coincided with heavily disturbed sites and the disturbance declined towards the interior. Therefore, transects traversed the three categories of forest disturbances/grazing intensities. Along each transect, sample plots were established systematically at an interval of about 50m. Nested plot design was used to assess the vegetation. Main plot of 10m by 10m was established to visually assess disturbance indicators within the plot and woody plants with DBH ≥10cm. Sub-plot of 5m by 5m was established at the first corner of the main plot and used to assess woody plants within ≥2-9.9cm DBH range. A 1m by 1m sub-plot was nested inside the 5m by 5m sub-plot and used to assess tree seedlings of DBH < 2cm. A total of 28 plots were sampled. Live woody plant species were identified to species level with the assistance of a botanist and para- taxonomist.

3-Livestock census survey

Physical sample count of livestock was undertaken. The study area was stratified into ridges (territorial forest segments accessible to different clans for livestock grazing and other permissible uses). The study area comprises 13 such ridges. In each ridge, the numbers of livestock entry points were identified (31 in total) in a participatory manner through KII and FGDs. Out of 13 ridges, 8 were sampled. The actual numbers of livestock types driven in and out of the selected entry points were physically counted consecutively for five days. Sample counts of livestock domiciled in the forest were also carried out.

4-Estimation of forage productivity

The forage productivity was determined using direct methods of grass clipping and weighing. Plots of 2m by 2m were randomly established within the fenced plots on areas where grass was ready for harvesting based on preferred harvestable height as a proxy of forage offtake by livestock. Forage within the plot was clipped to ground level including all stems originating from the plot and all aboveground parts that extend beyond the plot boundary. Fresh weights of the harvested forage were recorded and were air dried to a constant weight and dry matter content determined.

5-Data analysis

Vegetation structure was expressed in terms of density (stems/ha) and basal area (m^2/ha). Species composition was computed as species richness and diversity using Shannon Diversity Index (Shannon and Weaver 1963). Analysis of variance (ANOVA) was applied to calculate variation in density, basal area and diversity across the grazing levels and separated by Tukeys HSD. Descriptive statistics were applied for socio-economic data, while the total forage productivity (Kg DM/year) was obtained by escalating dry matter content per ha. Data collected on livestock numbers from the physical count and household survey were extrapolated to obtain the total population and respective Tropical Livestock Units (TLU) [1] and differences in population tested by T-test. Carrying capacity and stocking rates were determined using methodologies developed by (Hocking and Mattick 1993) by considering four factors: primary pasture productivity, total area available for grazing, percentage of sustainable pasture utilization and dry matter intake. Carrying capacity (TLU/ha) was estimated by multiplying total amount of forage/ha (forage supply) by correction factors and dividing by the average yearly feed requirements of a TLU (forage demand). All statistical tests were carried out using SPSS version 21 software at 95% confidence level.

[1] One Tropical Livestock Unit (TLU) denotes the feed requirement of a standard animal of a certain live weight (usually 250 kg). The conversion factors are: cattle = 0.7, sheep = 0.1, goats = 0.1, pigs = 0.2, chicken = 0.01 (Dida, 2017).

Results

1. Dependence on the forest for grazing

The main types of livestock kept by the households were cattle (55%), sheep (37%), goats (6%) and donkeys (2%). Majority of the households (96%) grazed their livestock in the forest, out of which 73% exclusively grazed throughout the year. The fodder resources mostly utilized were grasses, bamboo, shrubs, herbs and trees. About 97% of the sampled plots showed evidences of vegetation damage through trampling, browsing and grazing. Disturbance was notably high in heavily and moderately grazed areas.

2. Effects of grazing on species composition and forest structure

The sampled forest area constituted a species richness of 33. Generally, species richness varied across the grazing intensities and the age classes (see Table 1). The forest had a species diversity of H'= 2.72. Significant variation in species diversity existed across the grazing intensities ($F_{2, 37}$=5.527, P=0.008). Least species diversity was recorded in the heavily grazed sites (H'=0.92). The species diversity in moderately and lightly grazed forest sites were nearly similar with H'= 2.36 and 2.27 respectively.

Table 1: Species richness across grazing intensities per cohort

Grazing intensity	Trees	Saplings	Seedlings
Heavily	3	-	-
Moderately	9	16	7
Lightly	12	8	12

The forest generally depicted a low stocked forest with a stand density of 439±72 stems/ha. A slightly high density was found in lightly (689±70 stems/ha) and moderately (556±138 stems/ha) grazed areas, while heavily grazed areas had the lowest density (110±67 stems/ha). Significant difference existed in stem densities across the grazing intensities ($F_{2, 25}$=10.416, p=0.001). The mean basal area of trees in the forest was 27.73±7.13 m^2/ha. Basal areas were significantly different across the grazing intensities ($F_{2, 25}$ =23.90, P=0.00). Less and moderately disturbed forests had mean basal areas of 70.70±12.98 and 14.00±3.73 m^2/ha respectively, whereas heavily disturbed sites had trees with basal area of about 1.43±0.80 m^2/ha. The forest generally demonstrated a reverse exponential curve with high number of regenerates and few mature trees depicting a forest undergoing regeneration (Fig. 1). However, regeneration was not occurring at all in heavily disturbed areas.

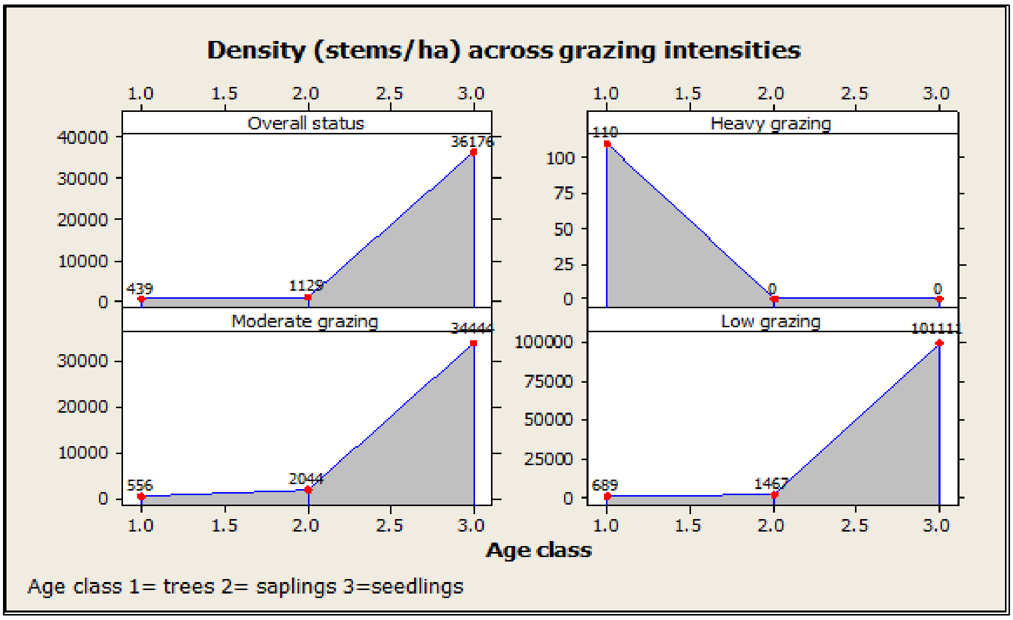

Fig. 1: Curves showing natural regeneration and recruitment among the grazing intensities

3. Forage productivity, livestock population and carrying capacity

The available forage after taking into consideration the proper use and sustainability factors was estimated at 14 million Kg DM/year. This forage can support about 6,104 TLUs (0.94TLU/ha) throughout the year. The number of cattle grazing in the forest through physical count and household survey data did not deviate significantly (t=8.277, df_{257}, P<.05). Physical count estimated the total number of livestock grazing in the forest daily at 17,263 (10,629 TLUs or 2TLU/ha). This comprised of 14,804±396 heads of cattle, 2,365 sheep, 44 goats and 50 donkeys. Household survey found a total of 22,612 livestock heads (10,103 TLUs or 2 TLU/ha), composed of 12, 879±1684 cattle, 9,101 sheep, 346 goats and 286 donkeys. With the 10,629 livestock units grazed in the forest, the carrying capacity had been exceeded by about 74%.

Discussion

Similarly to this study, other authors have found high dependence of forest-adjacent communities on the forest for grazing (Giday et al. 2018). The local communities grazed in the forest throughout the year with influx during dry season as also reported by (Maina and Nzengya 2021) who found that the shortage of forage on-farm triggered switching of grazing into the protected forest. During this period, woody plants species are key resource, thus vulnerable to damage and loss. Further, the most important factor for successful livestock maintenance on natural pasture is not to exceed the carrying capacity of the area. However, this study found that the carrying capacity had been exceeded by about 74% which contributes largely to the degradation of the ecosystem. Additionally, it was observed that a number of goats (mainly browsers) and donkeys (non-selective grazers as well as browsers) grazed illegally in the forest. The feeding habits of goats and donkeys are known to cause detrimental effect on plant composition and structure in the long term (Süss and Schwabe 2007). The nexus of these factors through persistent damage and loss of vegetation via trampling, defoliation and browsing has had significant effect on vegetation attributes in the forest.

Mtimbanjayo (2017) found that the effect of grazing on vegetation attributes is highly dependent on degree of grazing. Accordingly, this study found that heavy grazing has had a significant effect on community structure, composition and ecosystem stability as exhibited by extensive open ground in the heavily grazed areas characterized by low structural and composition complexity. Heavily grazed areas exhibited significantly low diversity compared to lightly and moderately grazed areas. This could be attributed to high disturbance through uncontrolled grazing coupled with intensive deforestation in the past which may have affected the seed bank. Correspondingly, other studies also reported decreased plant diversity with increased grazing intensities (Kikoti and Mligo 2015; Dorrough et al. 2007) and highest plant diversity at transitional levels of grazing (Bustamante 2006; Taddese et al. 2002). Further, low species richness in the heavily grazed areas is similar with the finding by Mtimbanjayo (2017); Ratovonamana et al. (2013) who reported significant decline in plant species at high grazing intensities. One of the presumed driving forces is the selective browsing effects. Moreover, the density of heavily grazed forest areas (110 stems/ha) was below the average range of 435-934 stems/ha in indigenous tropical forests (Naidu and Kumar 2016; Wekesa et al. 2016; Nandy and Kumar 2013). Further, the basal area of trees in heavy grazing intensity level (1.43m^2/ha) was lower than expected range (26-74 m^2/ha) for tropical natural forest (Naidu and Kumar 2016; Nandy and Kumar 2013). Further, natural regeneration was not occurring at all in heavily grazed areas. The existence of regeneration in moderately and least grazed areas indicate ongoing natural succession and recruitment. The inhibited natural regeneration and recruitment in heavily grazed areas can presumably be due to effects of livestock grazing via persistent trampling and browsing on recruits coupled with other site factors such as lost seed banks due to repeated disturbance which results in disrupted succession patterns and processes. Other studies have also documented significant decline in regeneration density with increasing grazing intensity (Lempesi et al. 2017; Kikoti et al. 2015). The significantly low species diversity and richness, density, basal area and regeneration in heavily grazed areas indicates that plant species in Mau ecosystem are highly sensitive to livestock grazing disturbance and in addition they lack or have not developed adaptation mechanisms to tolerate grazing and co-exist with livestock. The continuity of this disturbance trend will likely hamper the development, integrity and sustainability of Mau forest.

Conclusions

Majority of the households (96%) adjoining Ndoinet forest grazed their livestock mainly cattle, sheep, goats and donkeys throughout the year. This is an indication of high forest dependence for livestock fodder. This study concludes that overgrazing is occurring as exhibited by exceeded carrying capacity, and coupled with the persistent traditional and uncontrolled grazing systems; it has had detrimental effects on plant community structure and composition as shown by the variation in vegetation attributes across the livestock grazing intensities. In terms of species composition, significantly higher plant species richness and diversity in moderately and lightly grazed areas was found than in heavily grazed areas. The structure of heavily grazed forest sites demonstrated significantly low densities and basal area compared to lightly and moderately grazed areas which indicate the long term negative impacts of livestock grazing on stand structure. Moreover, as a result of overgrazing, regeneration was not occurring at all in heavily grazed areas. These have strong negative implications on the ecosystem integrity and resilience by reducing provision of ecosystem services. Therefore, this fragile ecosystem should be protected from grazing and other anthropogenic disturbance to ensure biodiversity conservation and its role as a water catchment. Sustainable forest grazing should be undertaken through periodic regulation of grazing intensity based on availability of forage.

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