Analysis of Socio-Economic Drivers of Cattle Grazing and Grass Harvesting in the Mount Kenya West Protected Forest, Kenya

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Abstract

Management of community utilization of protected resources in protected forests is a huge challenge, particularly in the Mount Kenya region because of limited research data on the dynamics and characteristics of households living adjacent to protected forests. This research, conducted in the Mount Kenya West protected forest, sought to examine household perceptions on the different sources of pasture and fodder, to assess the significant household characteristics in driving smallholder farmers dependence on protected forests for pasture and to assess the significance of household characteristics in driving smallholder farmers' dependence on protected forests for grass harvesting for livestock fodder. The research followed a cross-sectional research design with smallholder farmers dwelling adjacent to three forest blocks, namely, Kahurura, Hombe, and Chehe as the target population. The data was collected from May to October 2019. Questionnaires were used to collect data from a sample of 453 participants. Multiple logistic regression was used to assess the significant household characteristics in driving forest dependence cattle grazing and grass harvesting. Results obtained revealed that significant household characteristics driving forest dependence for pasture were the ownership of zero-grazing unit ($p=0.03 < 0.05$), the proportion of cattle under zero grazing ($p=0.04 < 0.05$) and proximity to the forest ($p=0.08 <0.1$). The proportion of cattle in zero-grazing units had the highest marginal effect, followed by ownership of zero-grazing units with proximity to the forest having the lowest marginal effects. Significant household characteristics driving smallholder famers' dependence on protected forests for grass harvesting for cattle included: a household's socio-economic status ($p=0.06<0.1$), a household's total size of land owned ($p= 0.02 < 0.05$), and proportion of cattle kept under a zero-grazing unit ($p=0.07<0.1$). The proportion of cattle in zero-grazing unit had the highest marginal effects followed by the total size of land owned. These findings contribute to knowledge on the significant micro-level characteristics driving the two forms of forest dependence investigated. Future studies are needed to explore the meso-and- macro-level factors that interact with household characteristics identified to drive forest dependence for livestock grazing and grass harvesting.

Keywords: Forest dependency; Local communities; Logistic regression, Livestock, Livelihoods, Mount Kenya West protected forest

1.0 Introduction and background

Sub-Saharan Africa has one of the highest rates of forest degradation rates through deforestation. According to Rudel (2013), forest cover may disappear completely by 2050 if no strategies are put in place. Deforestation is not just an environmental concern but also a rural development issue; one of the biggest challenges to development of rural economies and livelihoods in the region. According to Mapulanga and Naito (2019), increased deforestation negatively impacted access to clean drinking water in Malawi. Maseko et al. (2017) noted that in Malawi, the 14% deforestation rate in the last decade contributed to reduced access to clean drinking water and reduced rainfall. In addition, deforestation has been reported to have far-reaching implications on malnutrition amongst rural children since forests contribute to local diets and nutrition as sources of wild fruits. Similar studies were conducted by Galway et al. (2018).

According to a study conducted in 160 countries across the world, deforestation and poverty worsen the incidences of malaria illnesses (Pattanayak et al., 2006). Using data from 17 Sub-Saharan countries, recent studies by Bauhoff and Busch (2020) have further supported the findings of Pattanayak et al. (2006). Forests buffer forest fridge communities from extreme temperatures associated with climate change. Reduced land cover has been reported to expose millions of people to an increased likelihood of heat illness. Wolff et al. (2018), working in India, reported that villagers from forested areas were more likely to report a cooling effect than those from recently deforested or fragmented landscapes. Enbakom et al. (2017) argued that deforestation negatively affects livelihoods by reducing land productivity, agriculture, and livestock production a concept supported by Kutiote et al. (2019); Deresa and Legesse (2015) and Aliyu et al. (2014).

2.0 Communities and conservation of mountain ecosystem services in Kenya

Between 1990 and 2012, Kenya lost 6.5 per cent of her forest cover, posing a major national environmental challenge (Ongugo et al., 2014). A 2018 countrywide survey conducted by the Kenya Forest Service (KFS) and the Kenya Forestry several community-based approaches Research Institute (KeFRI) indicated that forest cover, then at 7.4 %, was way below the UN recommendation of 10% (KFS, 2018). The Kenyan government has adopted several community-engagement strategies in the conservation of mountain ecosystems and promotion of rural development. These include Community Forest associations, community-based wildlife management and community-water user associations and are faced with numerous challenges. These efforts are a part of the government's strategy towards achieving 15 per cent tree cover by the year 2022. Kenya has close to 300 registered CFAs that work with the KFS towards the conservation of the country's forest cover. Currently, 177 forest management plans have been approved by KFS to enable the CFAs to legally participate in forest conservation and management.

3.0 Significance of household characteristics on forest dependence on protected forests for pasture and grass harvesting for livestock

Various household characteristics influence dependence on protected forests for livestock pastures. Research by Duguma et al. (2019) in Ethiopia and the Maasai Mau Forest in Kenya identified socio-demographic factors including rising demand for forest products due to increasing population as a driver of deforestation. The significant drivers were classified as necessity, market and governance driven. Similarly, Ouko et al. (2018) also investigated community perceptions of

ecosystem services and the management of the Mt. Marsabit forest in Kenya, where family size, education level and age as the significant drivers noted of the level of involvement in forest management. The insignificant drivers were the existence of local institutions and land use. In the study by Chakraborty et al. (2018), the variables appraised included age, gender, education status, size of the household, major incomes of households, total land holdings and use of alternative fuels. Chakraborty et al. (2018) work authors reported that significant determinants of forest dependence were income sources, gender, age of the respondent, household size, education status, total landholding, and the number of livestock a household owned. The study however failed to capture the gender distribution of both men and women, but the focus was on women hence failing to take cognizant of the role played by men in forest exploitation.

The research by Chakraborty et al. (2018) failed to operationalize education levels in respective categories. Education level is likely to influence forest dependence, especially where value addition is required. The study by Duguma et al. (2019) focused on deforestation and forest degradation as an environmental behaviour and the study noted socio-demographic factors including rising demand for forest products due to increasing population as a significant driver. However, Duguma et al. (2019) work-study gap was that the researchers failed to break down socio-demographic drivers to give policy guidance in specific interventions. The study by Mishra and Mishra (2012) noted the independent variables were forest distance, occupation, number of children in the homestead, education level of the female member and gender activity. The study findings suggested that although deforestation increases women's work in forest-related collection and gathering activities, the net impacts are also mediated through processes of commercialization of the subsistence economy.

A study by Enbakom et al. (2017) on the impact of deforestation on the livelihood of smallholder farmers in Ethiopia noted socio-demographic variables, mainly age of the respondents and household size as significant drivers influencing deforestation. Olarewaju et al. (2017) study noted that the independent variables were age, gender of household head, number of household members working or earning income, number of children and youth in the household, income-earning from tree crops, livestock, hunting, artisan, trading, and non-timber forest products. The findings of the study by Olarewaju et al. (2017) indicated that there is the disparity in the livelihood returns across the non-degraded and degraded forests. The study concluded that gender, number of household members working and with income, number of children in homestead, earning income from the tree crops and earning from hunting were statistically significant factors influencing forest degradation in the area.

Uberhuaga et al. (2011) work in Bolivia focussed on forest dependence for household income. The identified independent variables used in the study in Bolivia were household size, sex of the household head and size of the land and were identified as significant determinants of forest income. Jannat et al. (2018) work in Bangladesh study identified two major variables as the significant drivers of forest dependence which were income and forest-related occupations. The study by Jannat et al. (2018) noted that household size was an insignificant driver and the respondent's education level significantly reduced their dependence on forest resources. A critique on these findings is that education level may create high demand for forest products due to adopting of value addition technologies. Lepetu et al. (2009) in Botswana study noted that there is a positive association between household size and forest income indicating that larger households tended to derive more income from the forest. However, these findings contradict the study by Jannat et al. (2018) that noted that household size was not a significant driver,

especially in areas where population density is not a considerable factor. According to Lepetu et al. (2009), income and household size were significant drivers and the study also noted that livestock numbers was an insignificant driver. The household size contradicted the study done by Olarewaju et al. (2017).

Tripti et al. (2015) in India noted that NTFPs are significant tools to address poverty related matters for forest-dependent and marginalized communities and the study concluded that food security, income obtained from the forest and household health were significant drivers. The work by Kumar (2015) has shown that sources of income from the forest to the rural communities are significant drivers of forest dependence since they help in the improvement of their social-economic conditions and help to increase income level and employment opportunities. Chakma et al. (2020) in Bangladesh investigated Forest Dependence and Conservation Attitude of Indigenous Communities. Forms of dependence investigated included food products, household building materials and medicinal plants as significant drivers. Household size was insignificant (Chakma et al., 2020) contrary to the study done by Lepetu et al. (2009).

Jain and Sajjad (2016) investigated household dependency on natural forest resources in the Sariska Tiger Reserve (STR) in India. Livestock population and the agricultural land per household were noted as the significant variables. In Rwanda, Munanura et al. (2018) investigated household poverty dimensions influencing forest dependence at Volcanoes National Park. This study focused on bushmeat and medicinal plants. Different forms of poverty were significant drivers. However, one of the critiques is that the researchers failed to control for SES and household size. In Peru, Piana and Marsden investigated the impact of cattle grazing on forest protected areas.

Adam's (2014) study noted that income from agriculture, age of household head, size of the household and access to the outside market were the major drivers of forest dependency. It is interesting to note that age had a negative relationship to forest dependency implying that younger households were more dependent on forest resources contrary to the study of other scholars that confirmed that age was an insignificant driver (Adam, 2014; Olarewaju et al., 2017). The circumstances that may confirm age as a factor include the type of forest product being extracted and the proximity to the forest. Adam (2014) research confirmed that education, gender, landholding were insignificant drivers to forest dependency. The study by Lobovikov et al. (2010) investigated extra sectoral drivers of forest change and noted the significant drivers of landscape transformation as increase in demand for raw materials, price of forest commodities and the increased scale and pace of extra sectoral investment in the forest frontier. However, the study failed to test socio-demographic drivers which may influence forest pressure.

A household SES is a better predictor of household dependence of forest for pasture since the income status in a family determines the preferred and the most affordable means to access the forest. This concept is supported by the theory of livelihood transformation that posits that an intervention is based on what underpins livelihood as supported by the study by Kumar (2015). However, other theories might explain the lack of significance in household SES as a driver of forest dependence for pasture, especially where forest adjacent communities have alternative better sources of income apart from forest products. The size of land owned by smallholder communities as well as the agricultural activities they undertake influence forest dependence to different levels. Pouliot et al. (2012) researched Burkina Faso and Ghana and confirmed that agricultural land size and non-forest environmental activities were significant drivers of

deforestation. Chakraborty et al. (2018) explored the link between forest and local communities through participatory assessments and household surveys in the Himalayan region and identified significant variables like the respondents' major source of income, their age group, household size, total land holdings, number of livestock and usage of alternative fuels. Other studies on related scope include works by Nelson et al. (2015) (in Malaysia), Adhikari et al. (2003) (in Nepal) and Widiyanto (2019) (in Java, Indonesia).

3.1 Size of land, smallholder agricultural practices and influence on dependence in protected forests

The study by Pouliot et al. (2012) on deforestation and the limited contribution of forests to rural livelihoods in Ghana confirmed that agricultural land size and the non-forest environmental activities as more significant to livelihoods compared to forests. Chakraborty et al. (2018) study reported that total landholding was a significant factor that influenced forest dependence. The variables investigated by Nelson et al. (2015) that influence forest dependence included land ownership, land use, distance from the forest, forest resource utilization, estimated monthly income and expenditure. One of the significant drivers identified were land use and forest resource utilization which significantly predicted the abundance of forest cover. The study concluded that land use significantly predicted wildlife abundance. The work of Uberhuaga et al. (2011) in Bolivia focused on forest dependence for household income and noted that the area of cultivated land was a significant determinant of forest income. Adhikari et al. (2003) study outlined one of the independent variables as ownership of land as significant drivers that influenced forest dependence in Nepal. Research by Widiyanto (2019) investigated factors influencing farmer's decisions in community-based forest management and the study confirmed that land use or the land allocated by the farmer to manage was a significant driver influencing forest dependency.

The number of cattle kept by a household has a bearing on forest dependence and degradation. According to Buffum et al. (2009), who investigated natural regeneration and forest grazing in Bhutan, South Asia, the number of cattle grazing inside the community forest was a significant driver that impacted negatively on ecosystem degradation. Similarly, Shrestha et al. (2004) examined soil erosion caused by cattle grazing in Nepal and concluded that cattle numbers and land use were significant drivers that contributed to soil and vegetation loss. Other related studies include Silori and Mishra (2001) (in Mudumalai Wildlife Sanctuary, South India), Duguma et al. (2019) (in Tanzania), Hosonuma et al. (2012) (conducted in 46 countries) and Ratovonamana et al. (2013) (in Madagascar).

3.2 Livestock grazing livelihoods, number of cattle, land holding and influence on dependence in protected forests

Buffum et al. (2009) investigated forest grazing and natural regeneration in a community forest in Bhutan. The research confirmed that the number of cattle grazing in the forest is a significant driver that impacted negatively on ecosystem degradation. Tucker (1986) work focused on the evolution of grazing in the Himalayas Mountains in Asia and a cattle grazing was a significant driver influencing vegetation deterioration in the region. Shrestha et al. (2004) research concluded that cattle numbers was a significant driver that contributed to soil and vegetation loss. Belsky and Blumenthal (1997) investigated the effects of cattle grazing on the soils in the forest in America and noted that cattle's grazing was a significant driver that influences the changes in forest cover and tree species composition. Shrestha et al. (2004) work examined soil

erosion caused by cattle grazing in Nepal. Cattle's grazing was noted as a significant driver that contributed to the increase in soil erosion from the forest valleys. Silori and Mishra's (2001) work focused on cattle grazing pressure in and around the elephant corridors in India. The study noted that livestock grazing was a significant driver negatively influencing forest regeneration. Study by Doggart et al. (2020) investigated main drivers of deforestation in Tanzania and noted that livestock grazing as an agricultural activity was a significant driver.

Kikoti and Mligo (2015) investigated the impact of livestock grazing on Montane Forest in Mt. Kilimanjaro in Tanzania. The study 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 livestock grazing was a significant driver in causing prolonged drought and increasing demand for livestock grazing land. The study by Soofi et al. (2018) focused on livestock grazing in protected areas and its effect on wildlife in Iran and the study noted that livestock grazing intensity was one of the significant drivers causing increasing threats on wildlife species. On the influence of livestock grazing on small animals in Brazil forest noted that livestock grazing intensity was a significant factor in influencing the natural habitat of small mammals in the forest (Mbiba et al., 2019). Gurung et al. (2009) investigated the impact of grazing restrictions on livestock composition and husbandly practices in Nepal. The study noted livestock grazing as a significant driver and was strongly associated with high livelihood dependence on cattle pasture. Cattle grazing did not come out as a significant NTFPs practice in most of the literature reviewed, for example study done by Kiplagat et al. (2008); Koech et al., (2009); Koyuncu and Yilmaz, (2009); Sarmah et al. (2011); Steve, (2017). A study by Munanura et al. (2018) investigated forms and drivers of forest dependence in Rwanda and the drivers of forest dependence included demand for forest products like livestock grass, food security and unemployment.

Research by Hosonuma et al. (2012) assessed deforestation and forest degradation. The significant drivers of forest dependence were timber extraction, fuel wood collection, charcoal production, uncontrolled fire, and livestock grazing. The study by Hosonuma et al. (2012) noted insignificant drivers of forest degradation as mining, urban expansion, and infrastructural development. The study by Ratovonamana et al. (2013) investigated the impact of livestock grazing on forest structure, plant species and composition in Madagascar. A study by Matiku et al. (2013) that was conducted in Arabuko-Sokoke Forest in Kenya noted a strong positive correlation between forest adjacent community's closeness to the forest and exploitation the natural resources and the fact that majority of communities living in forest proximity live in poverty (MEA, 2005; Ruwanza and Shackleton, 2017). A similar outcome was noted by the research by Piana and Marsden (2014) in Peru, who noted that distance from the forest as an insignificant driver of forest dependence. The study by Hartter (2009) around Kibale National Park, Uganda observed that majority of the respondents preferred to live closer to forest fragments and wetlands because of greater access to natural resources despite the challenge of primates and human-wildlife related conflicts. Miah et al. (2012) also examined the contribution of forests to the livelihoods of the Chakma tribe in Bangladesh Hill tracts, and noted that forest income, quantity of forest products harvested from the forest and household proximity to the natural resources were significant predictors of forest dependence.

3.3 Proximity to protected forests and dependence of protected forests

Matiku et al. (2013) argued that proximity to the forest mainly below 5 km buffer zone is a major driver that enhances dependence for daily sustenance since the closer one is to the resource, the higher the chances of exploitation making it a significant driver. The study noted that there is a strong positive correlation between forest adjacent community's closeness to the forest and exploitation the natural resources, a concept also supported by MEA (2005). Also, a study by Ruwanza and Shackleton (2017) confirmed that majority of communities living in forest proximity live in poverty. A similar outcome was noted by the study by Piana and Marsden (2014) in Peru that concluded distance from the forest as an insignificant driver. Study by Adhikari et al. (2003) in Nepal noted that number of cattle in the homestead as a significant driver. The study by Hartter (2009) focused on the attitudes of rural communities towards forest fragments in Uganda and noted that proximity to the forest was a significant driver influencing access to natural resources.

Chakraborty et al. (2018) study found that distance to the forest was a significant variable that affected forest income out of the eight independent variables considered in the regression model. The findings seem to corroborate the work by Miah et al. (2012) in Bangladesh Hill tracts who also reported that household proximity to forest has significant influence on dependence on forest products. Mishra and Pathak's (2015) study observed that supply and production of quality animal products is a challenge faced by farmers and entrepreneurs due to poor availability of quality fodder and trained labour. However, the research did not find statistically significant relationship between dependence on forest for grazing and proximity to the forest. Chornesky et al. (2005) study on socio-demographic factors in resource exploitation noted proximity to the forest was a significant variable. The study by Wunder et al. (2014) on forest, livelihoods, and conservation found that communities living near the forest needed a paradigm shift since it's a significant driver.

4.0 Participatory Forest Management (PFM) and Sustainable livelihood framework perspective

Focus on sustainable rural livelihood emphasis on the perceived relationship that exists between the forest as an independent resource and the forest fringe communities as dependents of the resource. According to Appiah's (2009) study in Ghana, the issue of rural sustainable livelihoods in forest fringe communities is an important approach in meeting the conservation and management of forest resources. There are assets to forest fridge communities that comprise a portfolio that enable them to have access forests to come out of poverty. These assets are human, natural, physical, social capital and financial and they determine the livelihood gains. To help manage protected forests, PFMs seek to improve the livelihoods of forest-adjacent communities by organizing the factors that constrain or enhance livelihood opportunities to enhance sustainability. Sustainable livelihoods are those that can cope with and recover from stresses and shocks, maintain, or enhance their capabilities and assets without damaging the resource base (Schreckenberg & Luttrell, 2009). It is important for local communities to derive their livelihood from the protected forests but still ensure that their economic activities do not compromise the future of the forests. Socio-economically, PFM targets sustainable exploitation of forest resources, forest conservation awareness, conflict resolution, forest production and equity (Koech et al., 2009; Matias et al., 2018; Ongugo et al., 2008). The extent to which forest-adjacent communities engage in forest protection and conservation depends on their level of participation in the PFM implementation process (Ngatia et al., 2017).

The Kenya Forest Act (2005) requires the local community, through legally formed Community Forest Associations (CFAs), to work with the Kenya Forest Service (KFS) to protect and conserve forest resources. Schreckenberg and Luttrell (2009) outlined the different capitals from a livelihood framework perspective that make implementation of PFM to facilitate poverty reduction among forest-adjacent communities. Pro-poor PFM enhances their assets and capabilities towards more productive and sustainable livelihoods. Physical assets like basic infrastructure and producer goods help support livelihoods (Martindale, 2014). According to Schreckenberg and Luttrell (2009), one of the immediate impacts of PFM is change in community-level governance and social cohesion through networking. Nawrotzki et al. (2012) outlined the role of human capital in rural livelihoods and argued that livelihoods are composed of capabilities and human capital plays a role to enhance sustainable livelihood. Social capital also encourages the formation of CFAs and user groups to facilitate access to forest resources (Mutune et al., 2015).

4.1 The hypotheses tested during the research included:

i. Household socio-economic status (SES) is positively associated with smallholder farmers' dependence on protected forest for pasture
ii. After controlling for household SES, there is no statistically significant relationship between smallholder farmers' household characteristics and dependence on protected forest for pasture.
iii. Household socio-economic status (SES) is positively associated with smallholder farmers' dependence on protected forest for pasture
iv. After controlling for SES, there is no statistically significant relationship between smallholder farmers' household characteristics and dependence on protected forest for grass harvesting.

4.2 The conceptual framework

As brought out in the contextual review of literature in the introduction, the variables of our study can be presented in a visual form as the conceptual framework as follows.

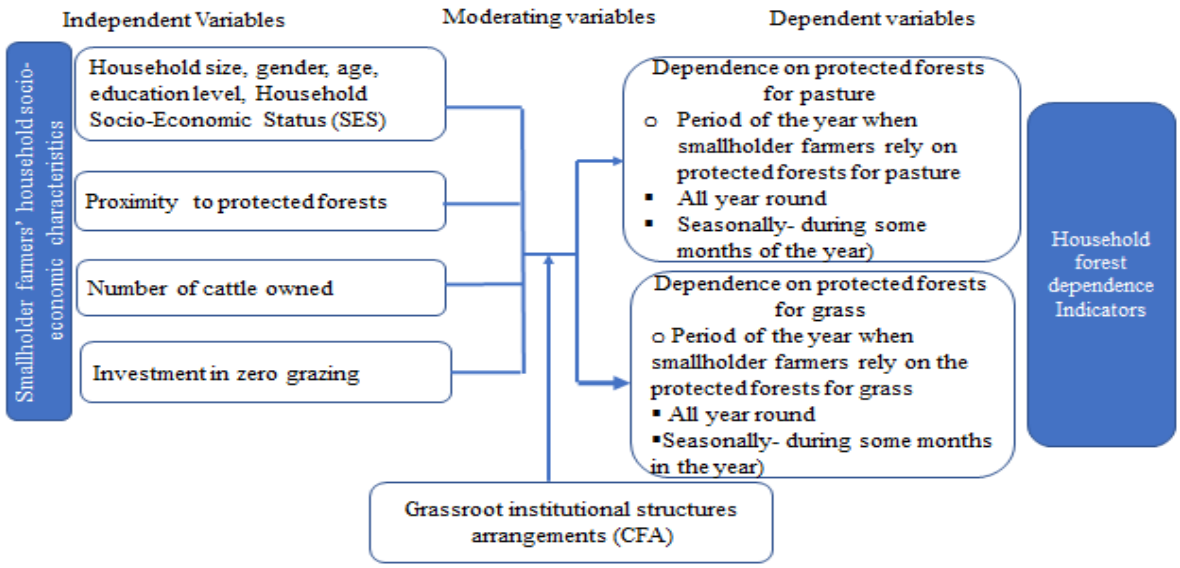

Figure 1: Conceptual Framework

5.0 Methods

5.1 Study sites

The study site was composed of the three protected forest blocks namely, Hombe, Hombe and Kahurura. The three forest blocks were chosen for the research because they were the initial blocks in the region to embrace the concept of participatory forest management by developing and implementing a forest management plan.

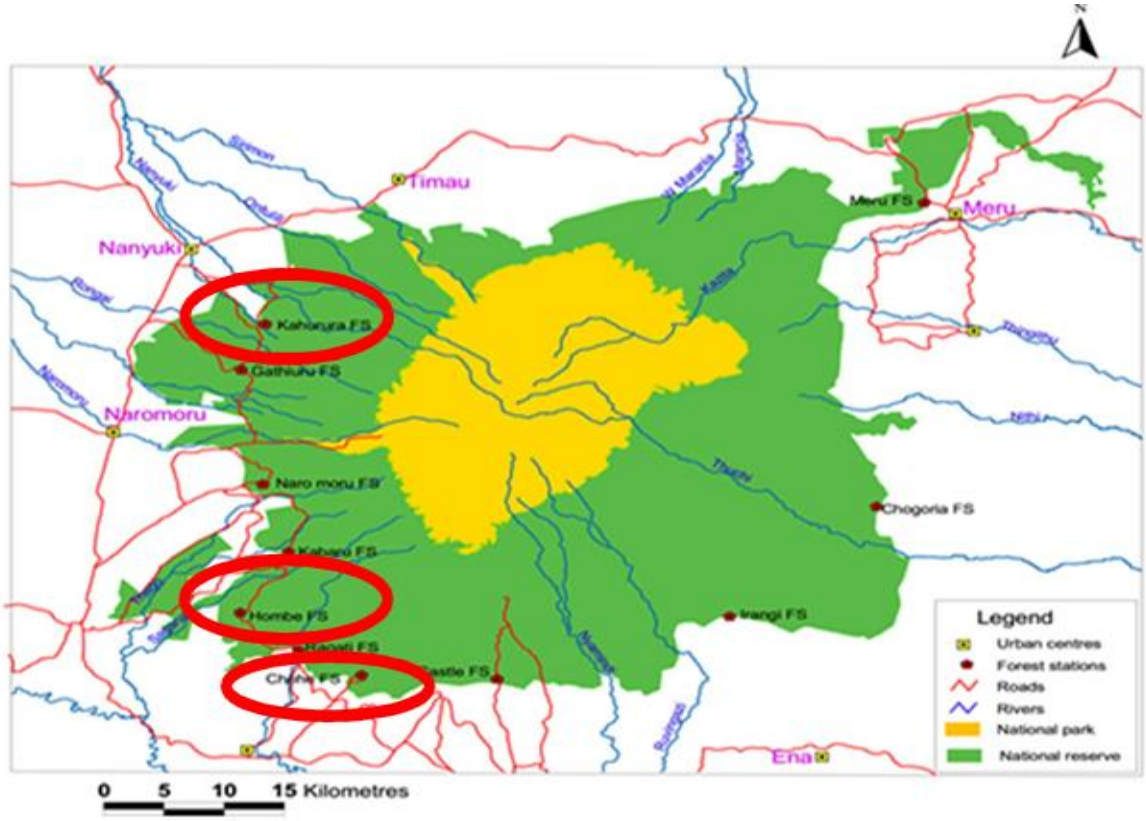

Figure 2: Area of Study:

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

5.2 Research design and data collection methods

The study used a cross-sectional research design. Data were gathered using closed ended questionnaires from sample smallholder farmers living adjacent to the three forest blocks: Hombe, Kahurura and Chehe forest blocks in Mt. Kenya West. 30% of smallholder cattle farmers living adjacent to Hombe, Kahurura and Chehe forest blocks in Mt. Kenya West and involved in grazing and grass harvesting formed the sample population of this study (1,530 x 30% = 459) based on Krejcie and Morgan (1970) and Orodho (2013).

5.3 Data analysis

This study used statistical methods to analyse and interpret results. Descriptive statistical methods were used to describe the sample. Multiple logistic regression was used to assess the significance of selected household socio-economic characteristics on forest dependence for pasture. In addition, multivariate logistic regression was used to assess the significance of selected household socio-economic characteristics on forest dependence for grass harvesting for cattle.

6.0 Results

6.1 Demographic Information of Respondents

Table 4. 1a: Demographic Characteristic

Demographic Characteristic	Frequency	Per cent
Sex		
Male	276	60.9%
Female	177	39.1%
Age (years)		
20 – 30	**7**	1.5%
31 – 40	69	15.2%
41 – 60	275	60.7%
61 & above	102	22.5%
Marital Status		
Married	373	82.3%
Single	37	8.2%
Widowed	43	9.5%
Highest Education Level		
Primary	238	52.5%
Secondary	177	39.1%
Post-secondary	38	8.4%

Source: Author's survey data (2019)

6.2 Descriptive statistics for cattle grazing and grass harvesting

Table 4.1b: Description of the sample that participated in the survey (n = 453)

	CHEHE - (n=151)	HOMBE –n =153	KAHURURA –n= 149
VARIABLE	MEAN ± SD/ (%)	MEAN ± SD/ (%)	MEAN ± SD/ (%)
Household size	4.17 ± 1.58	4.03 ± 1.47	4.32 ± 1.76
Household SES			
Poorest	0.70%	9.80%	50.30%
Poorer	4.60%	36.60%	18.80%
Poor	22.50%	21.60%	15.40%
Less poor	31.80%	20.30%	8.10%
Least poor	40.40%	11.80%	7.40%
Graze in the forest most part of the year (YES)	48.30%	77.10%	67.10%
Household relies on Grass harvesting for the better part of the year (YES)	87.20%	32.70%	43.90%
Size of Land Owned	1.02 ±0.94	1.74 ± 1.56	1.22 ± 1.49

Proportion of Land under Fodder Production	26%	17%	16%
Number of Cattle in a Homestead	5.08 ±3.40	5.56 ± 4.36	4.89 ± 5.27
Proportion of cattle under zero grazing	41%	17%	12%
Proximity to Forest	46.12 ±31.41	29.02±29.49	26.09±21.71
Household has invested in zero-grazing unit (YES)	81.50%	36.20%	22.60%
How many months in a year farmers graze in the forest	10.0±2.1	10.5±1.4	10.2±2.1
How many months in a year grass is harvested from the forest	9.5±2.72	5.3±3.51	6.5±3.99
Farmers with rented land for fodder production	23.1%	7.5%	6.8%
Size of land rented for fodder production (acres)	1.1±4.24	0.5±0.52	0.9±1.39
Approximate quantity (number of 50 kg bags) of grass obtained from the forest per month	36.4±25.6	63.0±74.15	36.0±27.31
Number of mentions in involvement in grass value addition activities by grass harvesting farmers	40	2	20
Is the grass obtained from the forest used to make silage? YES	1.6%	1.9%	4.5%
How many bags of fodder are produced per acre (dry season)	9.7±8.92	-	100±133.42
How many bags of fodder are produced per acre (dry season)	19.4±31.40	-	42.5±71.82

Source: Authors Survey Data (2019)

Table: Major categories of sources of cattle feeds in study sites (n=453)

Category	Exact test item	Cheap	Moderate	Expensive
Forest based sources	Grazing in the forest during Dry season months	80%	3%	17%
	Grazing in the forest during most part of the year	79%	2%	19%
	Purchasing Grass from the forest during most part of the year	44%	10%	46%
	Purchasing Grass from the Forest during Dry season months	46%	8%	46%
	Obtaining Forest leaves and shrubs	92%	4%	4%
Farm - based Feeds	Maize stalk from your own farm	93%	1%	5%
	Growing Napier grass on my own farm	89%	3%	8%
	Lucerne from your own farm	47%	2%	52%
	Making your own Silage to feed your cattle	20%	2%	78%
Bought from neighbours	Purchasing Maize stalk from other farmers	46%	6%	47%
	Purchasing Napier grass from another famer, neighbours	29%	8%	63%
	Purchasing Lucerne from other farmers	10%	3%	88%
Commercial Feeds	Purchasing silage to feed your cattle	8%	2%	90%
	Relying on full time Zero grazing	7%	7%	87%
	Purchasing Commercial feeds for your cattle	4%	5%	91%
	Buying hay (grass cut and dried)	4%	4%	92%
Others	Using peels and vegetable waste to feed cattle	96%	2%	1%
	Using banana leaves to feed cattle	95%	3%	2%
	Collecting *Magutiani /Mandara* from the roadside	93%	3%	5%

Source: Author's survey data (2019)

Association between Forest block type and Household SES

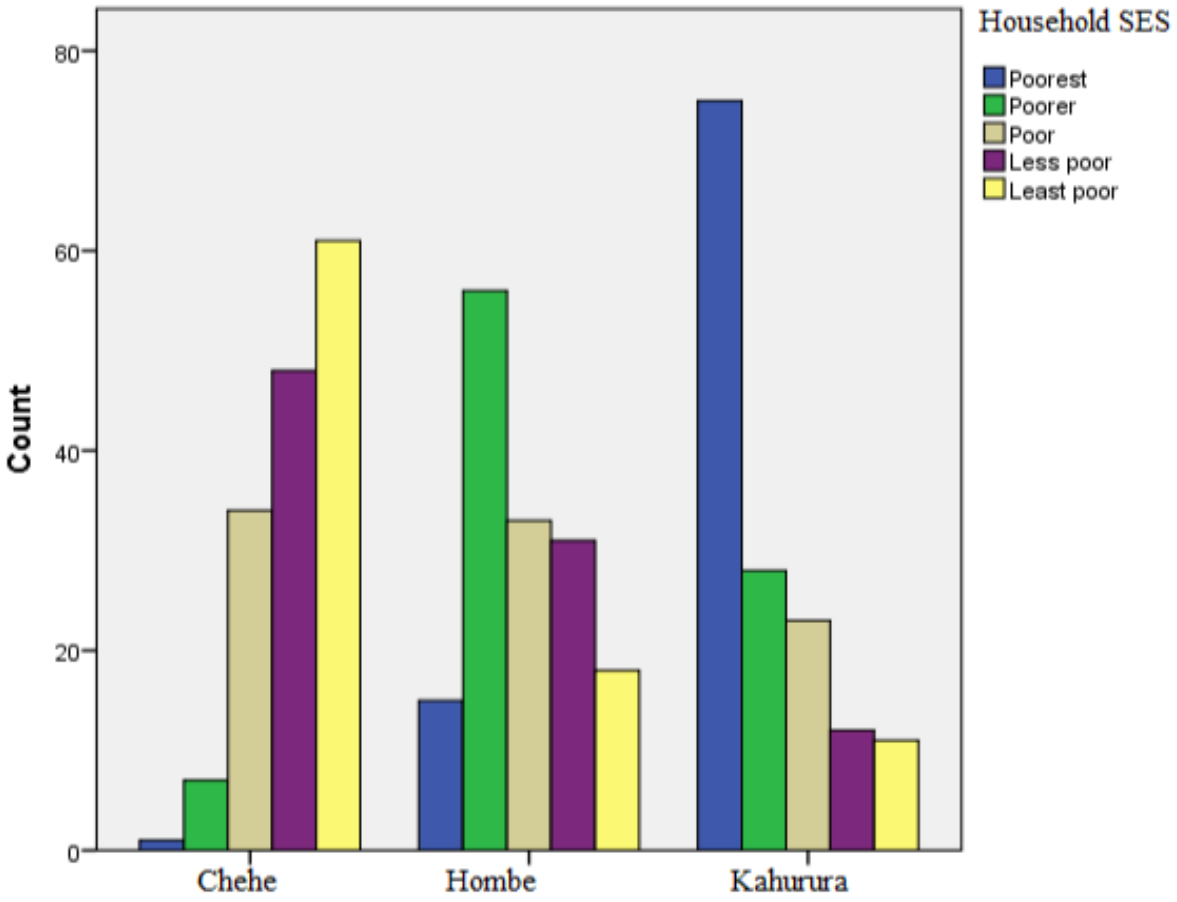

Figure 4.1 b: Household wealth classes in the 3 different forest blocks (Author's survey data).

Results revealed that the number of households in the poorest category was smallest in the Chehe forest block, followed by Hombe, but highest in the Kahurura forest block.

Logistic model: Relationship between smallholder farmers' household socio-economic characteristics and dependence on protected forest for pasture

As presented in Table 4.2a, the results revealed that after controlling for sex, household size, education level and SES, the statistically significant variables at 95% confidence level were ownership of zero-grazing unit (p=0.03) and the proportion of cattle in zero-grazing unit (p=0.04). Further, proximity to the forest was found to be a statistically significant (p=0.08) driver for grazing at 90% confidence level. All other variables were identified as statistically insignificant drivers of forest grazing. An increase in the number of cattle in the homestead increased the levels of cattle grazing in protected forest for smallholder farmers in Mt. Kenya West protected forest by a certain margin as discussed in the marginal effect model. However, it should be noted that the effect was insignificant for the number of cattle and total land size.

Table 4.2a: Logistic regression model: relationship between smallholder Farmers' household socio-economic characteristics and dependence of protected forest for pasture

Table 4.2a: Logistic regression for cattle grazing in Mt Kenya West protected forest

	Model 1		Model 2		Model 3	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Sex (Male)	-1.52	0.17	-1.58	0.20	-1.54	0.28
Household size	0.07	0.81	0.28	0.36	0.38	0.28
Education Level		1.00		1.00		0.99
Primary	-0.47	1.00	16.99	1.00	18.34	1.00
High school	-17.72	1.00	-0.49	1.00	0.86	1.00
College certification	-18.11	1.00	-0.17	1.00	1.96	1.00
Diploma	0.00	1.00	18.30	1.00	21.20	1.00
Degree	0.02	1.00	19.56	1.00	21.70	1.00
Household SES				0.98		0.99
Poorest			19.32	1.00	17.53	1.00
Poorer			19.51	1.00	17.71	1.00
Poor			19.56	1.00	19.82	1.00
Less poor			0.66	0.50	0.64	0.56
Proximity to the forest					0.00	0.08
Total land size					0.00	0.58
Proportion of land under fodder production					6.10	0.96
Own zero-grazing unit (Yes)					-16.31	0.03
Number of cattle in a homestead					0.06	0.69
Proportion of cattle in zero-grazing unit					2.62	0.04

Source: Author's survey data (2019)

Marginal effects: Combined logistic regression model for dependence on forest for pasture

After controlling for sex, household size, education level and SES, it was found that a unit increase in distance away from the forest reduced cattle grazing in protected forest by 3% (-0.03), a unit increase in the proportion of land under fodder production reduced cattle grazing in protected forests by 4% (-0.04) and ownership of zero-grazing unit reduced cattle grazing in protected forest by 5% (-0.05). Additionally, a unit increase in the proportion of cattle under zero-grazing units reduced cattle grazing in protected forest by 7% (-0.07).

Logistic regression results: Relationship between smallholder farmers' household socio-economic characteristics and dependence of protected forest for grass

After controlling for sex, household size, education level and SES, only total size of land owned and the proportion of cattle in zero-grazing unit were statistically significant ($p=0.02<0.05$) drivers at 95% and 90% confidence level, respectively. Additionally, SES emerged as a critical control variable with its statistical significance evident ($p=0.06$) at 90% confidence level.

Table 4.3a: Logistic regression Model: Relationship between smallholder farmers' household socio-economic characteristics and dependence of protected forest for grass for cattle

	Model 1		Model 2		Model 3	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Sex (Male)	-0.03	0.91	-0.21	0.53	-0.14	0.68
Household size	0.12	0.19	0.11	0.27	0.11	0.27
Education Level		0.11		0.20		0.41
Primary	-0.96	0.46	-0.88	0.51	-0.75	0.58
High school	-0.91	0.44	-1.21	0.32	-1.22	0.34
College certification	-0.35	0.77	-0.69	0.56	-0.82	0.51
Diploma	1.10	0.43	0.73	0.60	0.44	0.77
Degree	20.22	1.00	20.07	1.00	19.65	1.00
Household SES				0.01		0.06
Poorest			-1.40	0.05	-1.29	0.11
Poorer			0.15	0.77	0.42	0.49
Poor			-0.18	0.69	-0.18	0.74
Less poor			0.87	0.06	0.61	0.23
Proximity to the forest					0.01	0.24
Total land size					0.00	0.02
Proportion of land under fodder production					-0.39	0.39
Own zero-grazing unit (Yes)					0.19	0.68
Number of cattle in a homestead					0.03	0.56
Proportion of cattle in zero-grazing unit					1.00	0.07

Source: Author's survey data

Marginal effects combined model: Relationship between smallholder farmers' household socio-economic characteristics and dependence of protected forest for grass for cattle

After controlling for sex, household size, education level and SES in the study region, it was found that a unit increase in the total size of land owned reduced dependence on forest for grass harvesting by 14% (-0.14) as shown in Table 4.3b. Similarly, a unit increase in the proportion of cattle in zero-grazing unit increased forest dependence through grass harvesting by 17% (0.17) while ownership of zero-grazing unit increased dependence on forest for grass harvesting by 5% (0.05). Additionally, a unit increase in the proportion of cattle kept under zero-grazing increased dependence on forest for grass harvesting in Mt. Kenya West protected forest by 9% (0.09).

7.0 Discussion

The three forest blocks showed a statistically significant relationship between SES and household size and dependence on protected forest for pasture. However, after controlling for sex, household size, education level and SES, only a proportion of land under fodder was significant in Kahurura forest block ($p=0.00<0.05$). These results are consistent with outcome of this research because the marginal effects of dependence on cattle grazing reduces by 20%, 13% and 12% with a unit change in the proportion of land under fodder, ownership of zero-grazing and proportion of cattle under zero-grazing unit. Farmers who utilized sections of their land for fodder production were least dependent on forests for cattle grazing.

Proximity to the forest was a significant driver ($p=0.04<0.05$) for forest dependence for cattle grazing in Hombe. Farmers living closer to the forest tended to practice grazing in the forest for

most part of the year compared to those who lived further away. The results presented in the descriptive statistics identified Hombe as having the highest dependence on forest with 77.1% of farmers grazing in the forest throughout the year compared to Chehe at 48.3% and Kahurura 67.1%. These findings were supported by the highest average number of cattle per household for farmers in Hombe5.56 (approximately 6 animals). This poses great threat to forest ecosystem sustainability.

Results of the combined sequential logistic regression model revealed a statistically significant relationship between dependence on protected forest for pasture and proximity to the forest ($p=0.08<0.1$), proportion of cattle under zero-grazing ($p=0.04<0.05$) and ownership of zero-grazing unit ($p=0.03<0.05$). The study found that a unit increase in the time it takes to the forest reduces forest dependence by 5%. Proximity to the forest as brought out in this study carries a potential risk to forest sustainability as supported by earlier studies by (Adhikari et al., 2003; Chakraborty et al., 2018). On average, farmers set aside a relatively low average 20% of their land for fodder production purposes, with a unit increase in the proportion of land under zero-grazing reducing forest dependence for grazing and grass harvesting by 10%. The adoption of zero-grazing units across the three forest blocks was also identified as a significant driver of forest dependence for cattle grazing. Since zero-grazing units are capital intensive, strategies to encourage poorer households to transition towards ownership of zero-grazing units may include targeted microfinance and subsidies.

Smallholder farmers' household socio-economic characteristics and dependence on protected forest for grass

Household socio-economic status (SES) had a statistically significant relationship with dependence on protected forest for pasture across the three forest blocks. However, after controlling for sex, household size, education level and SES, only proportion of cattle under zero-grazing units and total land size owned were the statistically significant drivers. In Kahurura, a unit increase in the proportion of land under fodder production reduced grass harvesting by 13% while in Chehe, such unit increase reduced grass harvesting by 9%. Since most farmers had better SES and lived relatively further from the forest boundary, they relied on commercial methods to harvest grass making it a more attractive NTFP compared to cattle grazing.

In Hombe, a unit increase in the proportion of land under fodder and proportion of cattle under zero-grazing unit reduced dependence on grass harvesting by 12% and 25% respectively. This suggests that by encouraging farmers in Hombe to invest more in zero-grazing units, dependence on grass harvesting would reduce by at least 25%. The results of the combined sequential logistic regression model revealed a statistically significant relationship between dependence on protected forest for grass and the proportion of cattle under zero-grazing ($p=0.07<0.1$); total size of land owned ($p=0.02<0.05$) and household SES ($p=0.06<0.1$). The study found that a unit increase in the proportion of cattle under zero-grazing units resulted in an increase in grass harvesting by 17% across the three forest blocks. Encouraging transition to zero-grazing in Hombe and Kahurura as a forest-dependence mitigation might be a challenge owing to high proportions of lower SES (poorer households) in these blocks; Hombe had 9.8 % poorest; 36.6 % poorer, 21.6 % poor, 20.3 % less poor and 11.8 least poor. Kahurura had 50.3 % poorest; 18.8 % poorer, 15.4 % poor, 8.1 % less poor and 7.4 % least poor.

8.0 Conclusion and recommendations

From the findings obtained, it can be concluded that socio-economic status (SES) of the smallholder's farmers vary significantly across the three forest blocks investigated, and this has influence on the form of forest dependence for households keeping cattle. Significant drivers for forest dependence for pasture include proximity to the forest, ownership of zero grazing units, and the proportion of cattle a smallholder keeps under zero grazing. However, for forest dependence for grass harvesting, significant drivers include a smallholder SES, total size of land a household owns, and proportion of cattle a smallholder farmer keeps under zero grazing. A high proportion of less poor smallholders' farmers living adjacent is correlated with dependence on forest for fodder as noted in Chehe forest block where grass harvesting for fodder was the predominant form of forest dependence for smallholder farmers keeping cattle for a livelihood. Where majority of smallholder farmers fell in the very poor category as was noted in Kahurura, the predominant form of forest dependence for smallholder famers was livestock grazing.

There were differences observed between the drivers of livestock grazing and grass harvesting in protected forests. Under cattle grazing, ownership of zero grazing was noted as a significant driver. The increase in the number of farmers owning zero grazing units may trigger the increase in grass harvesting to support the zero grazing units. Again, the proportion of cattle in zero-grazing unit was a significant driver under cattle grazing implying that if more animals are kept in the zero-grazing unit, there can be reduction in grazing practice. However, increase in the number of animals under zero grazing unit may subsequently increase dependence on forest grass. Proximity to the forest is a significant driver under cattle grazing category and famers near the forest prefer to graze that cut grass from the forest because grass cutting is relatively expensive compared to cattle grazing implying that the least poor in the society are likely to focus more on cattle grazing hence threatening the forest ecosystem. Farmers who depend on grass harvesting use various transportation methods hence distance from the forest boundary is not a deterrent.

Under grass harvesting category, total size of land owned was a significant driver indicating that at a unit increase the total size of land owned reduced dependence on forest for grass harvesting. Land ownership is based on availability of resource and unless the least poor involved in cattle grazing accumulate assets, possibility of increasing land size to plant fodder remains a challenge. Proportion of cattle in zero-grazing unit was a significant driver under grass harvesting category and this has an association with cattle grazers since reduction in number of animals in zero grazing unit means that farmers will opt to undertake cattle grazing which is the cheapest option. Based on the findings of this study, the new knowledge is that socio-economic factors influence dependency on forest resources in quite different ways. Drivers of forest dependence identified can be tested in other forest blocks; however, they vary and cannot be generalized across other mountain ecosystems since the household's characteristics are likely to be different. This trend can be applicable to all other NTFP including those not covered by the study such as bee keeping in the forest and extraction of herbs. Therefore, this study has proved that there should never be a blanket policy regarding NTFP. Every NTPF should have its own policy statement as informed by the socio-economic drivers for a particular NTFP.

On policy recommendations, the heterogeneity in smallholder SES across different forest blocks is critical for policy aimed at addressing challenges associated with sustainability of forest dependence by communities living adjacent to protected forests. There is need for the county, national government, and other agencies to find ways to deal with factors on why majority of farmers in Kahurura are poor and come up with sustainable initiatives and interventions for example subsidies. National and county government should also come up with policies to promote zero grazing units, for example through targeted microfinance. This has implications on forest dependence in Kahurura for pasture. Rural development agencies need to come up with ways of incentivizing alternative strategies of cheaper fodder production due to its implication on forest dependence.

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