Original Research Article

Land Use Changes and impacts on Livelihoods of the Communities Adjacent to Mt Elgon Forest Ecosystem

Abstract

Forests play a critical role in providing essential goods and services to forest adjacent communities. There is, however, insufficient information on how land uses affect the availability and use of forest products and services by forest adjacent communities. This study analysed the impacts of land use changes on the livelihoods of Mt Elgon forests adjacent communities. Land use changes were assessed for the period 1977-2019 segmented into four time periods corresponding to remote sensing data obtained for the years 1977, 1986, 1999 and 2019. Household surveys were conducted using structured questionnaires administered to 387 respondents. The questionnaires assessed how changes in land uses has impacted livelihoods. Analysis of data revealed that between 1977 and 2019, the size of land under natural forest has declined by 18%, bamboo declined by 15% while grasslands declined by 13%. On the contrary, the size of land under mixed farming and fallow increased by 30% and 27% respectively. Majority of the households (91%) were affirmative that they obtained products from Mt Elgon forest pointing to the importance of the forest to the communities living adjacent to the forest. Households closer to the forest were more reliant on the forest than those that lived farther away. The use of forest resources has been declining from 1970s with herbal medicine, game meat and wild fruits experiencing the highest decline of 28%, 27% and 24% respectively. The high dependency of the forest-adjacent communities on the Mt. Elgon forests call for enhanced conservation of the forest ecosystem and sustainable utilization of forest resources.

Keywords - Land use changes; Livelihoods; Mt Elgon forest ecosystem, forests, communities

Introduction

The United Nation Economic Commission of Europe defines land use as the manner in which land is utilized (UNECE, 2004). Land use is characterized by the arrangements, activities and inputs people undertake in certain land cover types to produce, and maintain change. Land use changes worldwide have become a global concern because of the negative impacts often associated with them (Lambin and Meyfroidt, 2011). These changes may occur in the form of intensification and extensification in which case one or more land uses expand at the expense of other land use type. Intensification of agriculture, for example, can be at the expense of grazing land, forestry, and settlement (Mungo, 2003).

In the recent past, land uses have been transforming land cover at both local and global scales (Arnoldo, 2000). The significance of these changes is reflected in the consequences on biodiversity, ecosystem services and livelihoods of the forest adjacent communities (Mungo, 2003; Svein et al. 2002). Whereas as agricultural production is easy to quantify in monetary terms, quantifying forest products can be a challenge given that, many of them are derived in the form of ecosystem services (Maua et al. 2018; Johnson, 2000).). Changes in land uses from natural forests to agricultural land can lead to a decline in essential ecosystem services ultimately, impacting the livelihoods of the forest adjacent communities (Ahlcrona, 1986; FAO, 2004). These livelihoods may include animal fodder, wild fruits, wild vegetable, firewood, game meat, timber, ornamental services and herbal medicines.

Despite the significance of services provided by forests, land use changes continue to interfere with the livelihoods of forest-dependent communities (IUFRO, 2005). FAO (2004) reported that the expansion of land under sugarcane in Swaziland has led to a decline in the community livelihoods such as timber and game viewing in the savannas. Anisara & Rajendra (2008) reported inadequate studies on the relationship between land use changes and the livelihoods of the forest-adjacent communities. IUFRO (2005) reported that forest ecosystem services are generally ignored until the negative human consequences of their disruption are reflected in their loss. Land use changes play a critical role in the livelihoods of the Mt Elgon forest community, given that majority of the households are dependent on the forest for subsistence (Kaboggoza et al. 2006).. Assessing the impacts of land use changes on livelihood strategies is crucial in understanding community-based conservation of forest resources (UNEP, 2001; CBD, 2010).

This study assessed land use changes and analyzed their impacts on the livelihoods of communities adjacent to Mt Elgon forest ecosystem.

Methods

Location and size of Mt Elgon

Mount Elgon forest is a transboundary ecosystem located in North-western Kenya and Eastern Uganda. This study was carried out in Kenya's Mt. Elgon forest ecosystem (figure 1). Mt Elgon forest is located at lies at latitude 1° 08' N and longitude 34° 45' E. Mount Elgon Ecosystem is located approximately 150 km northeast of Lake Victoria. The region receives a bimodally distributed rainfall, with the wettest months occurring from April to October (van Heist, 1994). Rainfall amounts change with altitude where the upper slopes receive relatively heavier rainfall compared to low lying areas. It receives an annual precipitation of 1280 mm with a minimum of 1000mm per annum and a maximum of 2000mm per annum. The dry seasons run from June to August and from December to March, although it can rain at any time. The forest zone receives the maximum rainfall of 3000mm (Synott, 1968). The region experiences a minimum and maximum temperature of 9°c and 22°c respectively. The forest ecosystem covers some 72,874ha part of which is gazetted as a National Park, and another part as a Forest Reserve.

The forest is structured. First there is the montane forest zone which runs from the park boundary up to about 2500m altitude. Then there is the bamboo and low canopied forest from about 2500m to 3000m, above that is the high montane heath zone covering 3000m to 3500m. Over 3500m vegetation gives way to open moor land. At about 3800m there is zone of Afro alpine vegetation. All this diversity in vegetation provides habitats for various species of wildlife and birds.

The Mt. Elgon forest ecosystem serves as a catchment for the drainage system of three major lakes including L. Victoria and L. Turkana in Kenya and L. Kyoga in Uganda. The key rivers include the Suam River which becomes the Turkwel River downstream and drains into Lake Turkana. Other rivers in the forest ecosystem flow into Lake Victoria. The Nzoia river flows south through into Lake Victoria, while Turkwel runs north into Lake Turkana. Malakisi River - flows westwards, providing and enters Uganda.

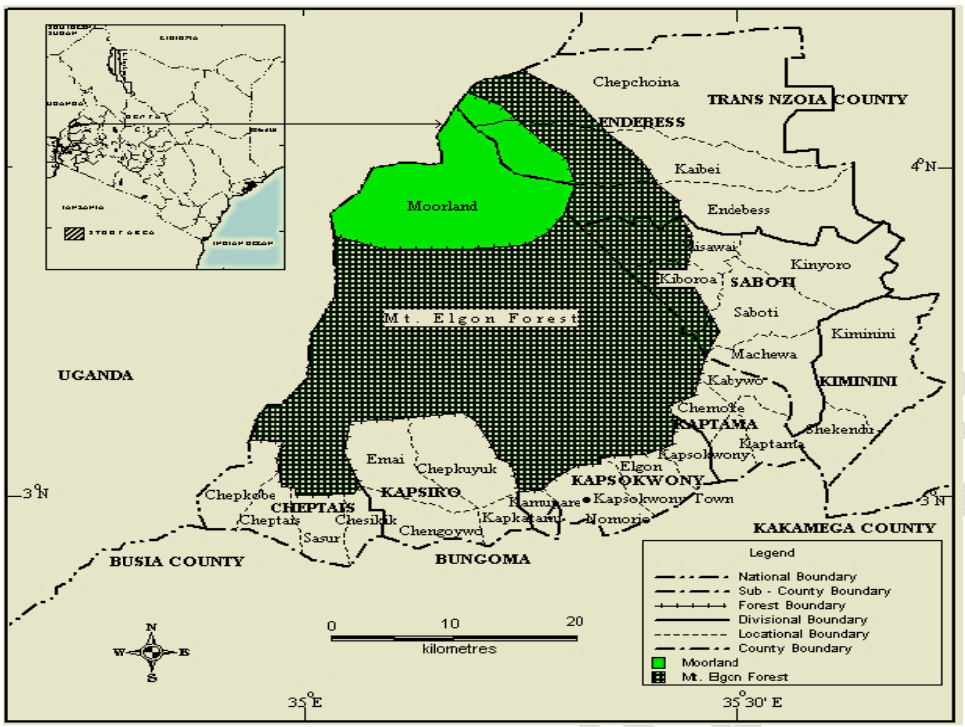

Figure 1: Map of Mt. Elgon ecosystem and Adjacent Regions.

Analysis of Land Use Changes

Satellite imageries downloaded from the USGS website Data was analyzed. In addition, structure questionnaires were used to collect data on changes in livelihoods. Land use changes between 1977 and 2019 were analyzed using satellite imagery for 1977, 1986, 1999 and 2019. The 1977 Multi Spectral Scanner (MSS) satellite image that was used was taken on 28th December 1977 and had (Path/Row 170/59). The image had a resolution of 60m. Other images used included the Landsat 4-5 Thematic Mapper™ for 1986 and 1999 taken on 18th March 1986 and 17th December 1999 respectively. For the 1986 and 1999 images, Path/Row 170/59 was used. Landsat images for 1986, 1999 and 2019 consisted of seven spectral bands with a spatial resolution of 30 metres for Bands 1 to 5. The downloaded satellite images from https://earthexplorer.usgs.gov/ had the global reference system World Geodetic System 1984 (WGS84) and the projection Universal Transverse Mercator (UTM) 37N.

The administrative state boundary map for the study area was also brought to Universal Transverse Mercator project in zone 37 and later the satellite imageries were clipped with the administrative boundary of Mt. Elgon forest and the adjacent region (figure 1). The different False Colour Composite (FCC) of the Mt. Elgon region for the different stated periods were prepared. The preparation ensured that the pixel grids of the images for the year 1977 conformed to the corresponding images of the year 1986, 1999 and 2019. This enabled pixel by pixel comparison of the images. Ground truthing on land uses changes was carried out for seventy points obtained in the field with a Garmin Etrex 30x Global positioning Systems (GPS).

A supervised multispectral classification was performed using Arc GIS 10.5 to distinguish between the seven possible classes which included natural forests, planted forests, tea farming, mixed farming, grasslands, bamboo forest and fallow land. Some 50 training samples were

created for each land use. Change analysis was run between 1977 and 1986, 1986-1999, and 1999-2019 imageries which created change maps. Change analysis was done by use of Idrisi Selva 17.0 software. These maps showed the changes that have occurred over the periods under study. An accuracy assessment via ground truthing was done from the change maps in order to verify any land use change that may not have been captured.

Assessment of Livelihoods

Data for this study were collected from Mt Elgon forest ecosystem and communities living in adjacent administrative units (Cheptais, Chesikaki, Chepyuk, Kapkateny, Kaptama, Elgon, Forest, Saboti and Endebess). These wards were purposively sampled because of their key influence and proximity to the forest ecosystem. Data from these wards was very important in establishing the land use changes and effects of land use change on biodiversity and the livelihoods of the forest adjacent communities. In particular respondents were asked to fill a questionnaire that would provide information on the changes that have occurred in land uses and how these changes have affected biodiversity and livelihoods of the forest adjacent communities. Questionnaires were constructed based on the researchers background of the study area. To ensure validity of the testing instrument experts in the field of study including university professors and data analysts checked at the instruments in the questionnaires (Nachmias and Chava, 2002). To ensure reliability of the questionnaires, twenty questionnaires were pretested in Chimuche ward adjacent to Malava forest and the Cronbach alpha value was 0.81 was considered good.

The study adopted Yamame (1967) formula used by Israel (2013) and Singh and Masuku (2014). A total of 387 respondents were chosen as the desired sample size. Random sampling was used to select members of each ward to be interviewed that was proportionate to 2009 Kenya population census (KNBS 2010). The sample size of each ward was calculated by taking the population of the ward as a fraction of the total population and multiplied by the sample size.
The sample size was calculated as follows:

$$n = \frac{N}{1 + N\,(e)^2}$$

Where n- Sample size
N-Population size
e- Level of precision

Table 1.1: Population and Area of Sampled Wards

Ward	**Total Population**	**Sample Size**
Cheptais	28639	26
Chesikaki	23874	22
Chepyuk	25329	23
Kapkateny	28628	26
Kaptama	33402	30
Elgon	31476	28
Subtotal	**171348**	**155**
Ward		

Saboti	166,482	150
Endebess	91,192	82
Subtotal	257,674	232
Total Population	**429,022**	
Total Sample Size		**387**

Source: Source: IEBC 2019

The respondents included were house hold heads aged fifty years and above and had lived in the region for more than thirty years.

3.5 Data Collection Techniques

The study was preceded by a reconnaissance survey of the Mt Elgon forest ecosystem. The reconnaissance ensured familiarization with the areas of study, making necessary logistical arrangements with respondents and local authorities, and the collection of background information.

Questionnaires were used to collect data on impacts of land use change on the livelihoods of the forest adjacent community. The livelihoods that were of interest to the researcher included: the use of herbal medicine, timber, wood fuel, fodder, indigenous fruits, indigenous vegetables, game meat and ornamental products. To evaluate impacts of land use changes on these livelihoods, the respondents were asked to list benefits that the acquired from the forest starting from the 1970s to 2010s. They were then asked to note the changes that have occurred in the acquisition of this land uses and the reasons for the changes in the benefits that were acquired from the forest. In cases where some benefits had declined, they were asked to indicate the alternative ways of meeting for the declined livelihoods.

Observations were made on status the status of vegetation cover and livelihoods of the local community. Accessible areas of the forest such as Kaberwa were visited by the help of forest guards from Kenya Forest Services and livelihoods such as the use of herbal medicine were captured. Observations were also made on the local markets such as Kapsokwony and Cheptais to capture data on the use of wood fuel, herbal medicines and timber. This data was captured by use of a 20.1 Mega pixel, Wide 5x zoom Nikon camera.

To validate data acquired by questionnaires, two Focus Group Discussions comprising of ten members were constituted. The FGD were constituted at Chepyuk and in Endebess. The Focus Group discussion comprised of community leaders, village elders, old women and old men. The selected people were adult males and females aged above fifty years and had lived in the region for more than fifty years. This age group was selected to ensure that the participants had information on land use change and its effects on livelihoods of the local community from 1972.

Interviews were carried out on various stake holders who included county traditional medical practitioners, Kenya Wildlife Service (KWS) and Kenya Forest Research Service representative. The interviews sought to identify rules and regulations governing the use of forest livelihoods and the changes that have taken place in the utilization of forest livelihoods.

Household surveys were conducted by administering structured questionnaires with closed and open-ended questions to collect qualitative and quantitative data on households and their

activities. Specific livelihoods analyzed included, grazing fields, wood fuel, herbal medicine, timber, wild vegetables, wild fruits and ornamental products. A total of 387 respondents were selected as derived from the sample size determination. These respondents were required to have lived within the forest ecosystem for the last 30 years. Random sampling was used to identify members of households to be interviewed based on the Kenya's 2009 population census. The surveyed households data was analyzed by use of Statistical Package for the Social Sciences (SPSS).

RESULTS

Land Use Change

The land use change analysis conducted for three time periods (1977, 1986, 1999 and 2019) and the results are presented in the figure 2.

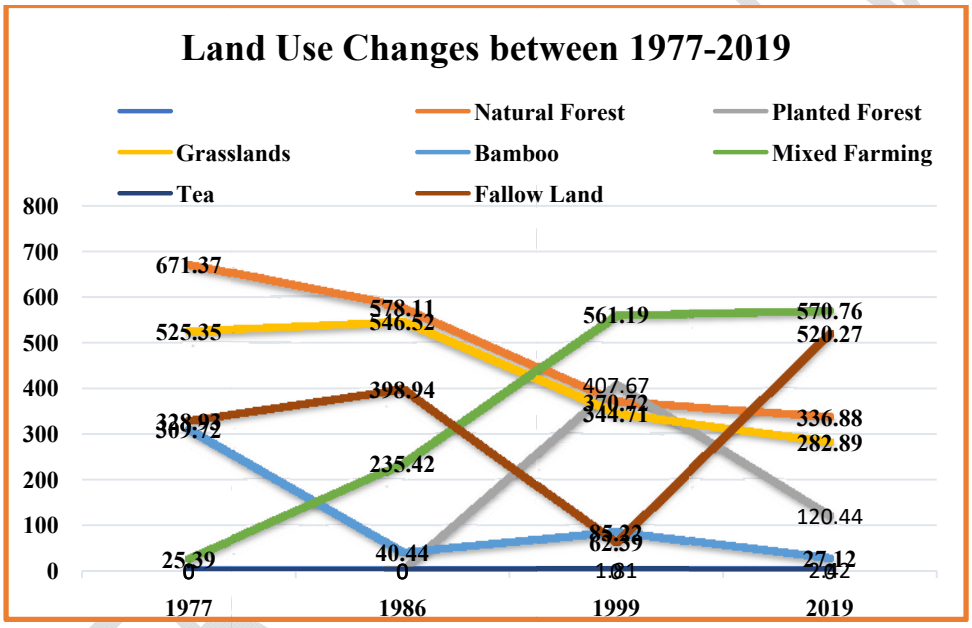

Figure 2: Land Use/ land cover changes in Mt Elgon forest ecosystem between 1977-2019.

In 1977, natural forest was the dominant land use. However, the natural forest cover has declined 3.95% in 1986, 16.17% in 1999 and 18% in 2019. In total, natural forest declined by 18% between 1977 and 2019. This decline was highest in the years 1986-1999 at -12.2%) and lowest in the years 1999-2019. Whereas in the 1977-1986 period, grasslands experienced a 1.1% increase, in subsequent years, there was a marked decrease in the area covered by grasslands with the highest decline occurring in the years, 1986-1999. The decline in natural forests and grasslands was driven by encroachment into the forest to create land for the Nyayo Tea Zone Plantation and the establishment of the second (1742ha) and third phase (2865ha) of the Mt Elgon resettlement scheme. The introduction of the resettlement schemes led to an increase in land under mixed farming, the highest of which was 17.48% between 1986 and 1999. In total, mixed farming in Mt Elgon forest ecosystem has recorded a 29.27% increase between 1977 and 2019 (figure 3).

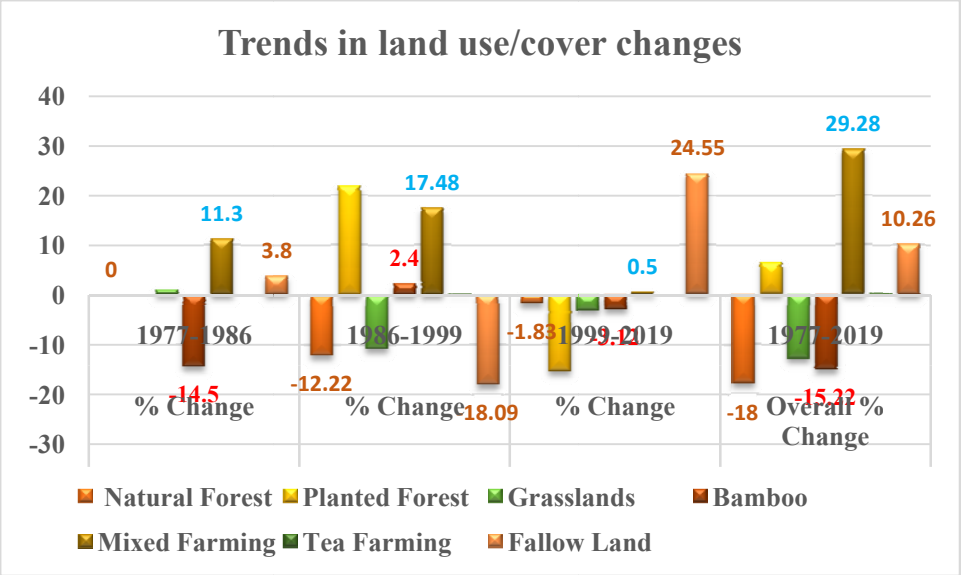

Figure 3: Trends in changes in land use/land cover

Analyses of the Landsat Images of 1999 established that plantation forests and tea farming were the added land uses in the Mt. Elgon ecosystem. The size of land under plantation forest increased by 21.89% to 407.67 km^2 in 1999. Both indigenous plantations comprising of the Elgon teak species and exotic plantations of cyprus and eucalyptus trees were advocated by the government. These tree species have both commercial and household use. Tea farming (Nyayo Tea Zone-NTZ), established as a buffer zone to prevent further encroachment by the forest-adjacent communities into the forest covered some 0.01% (1.81km^2) of the total forest land area. The introduction of plantation forest and Nyayo Tea Zone, further reduced land under natural forest, grasslands and fallow land.

At present, more than 58% of study area is under agriculture with 30.63% under mixed farming, 27.92% under fallow land and 0.13% under tea farming whereas natural forest area has declined to about 18% and planted forest area is 6.46%. This is one of the major change of land use of Mt Elgon forest ecosystem.

Assessment of Rural Livelihoods

Results of questionnaire analyses revealed that majority of the households in the Mt. Elgon forest ecosystem had varied sources of income. Ninety one percent 91% (n=332) derived their income from the forest. Sixty-five (65.6; n=229) percent reported farming as their primary sources of income, business 11.7% (n=48), government employment 11.46% (n=47), employment in the private sector 7.8% (n=32) and charcoal burning 2.9% (n=12) (figure 2). Despite having additional sources of income, it was clear that they majority were dependent on the forest for livelihoods.

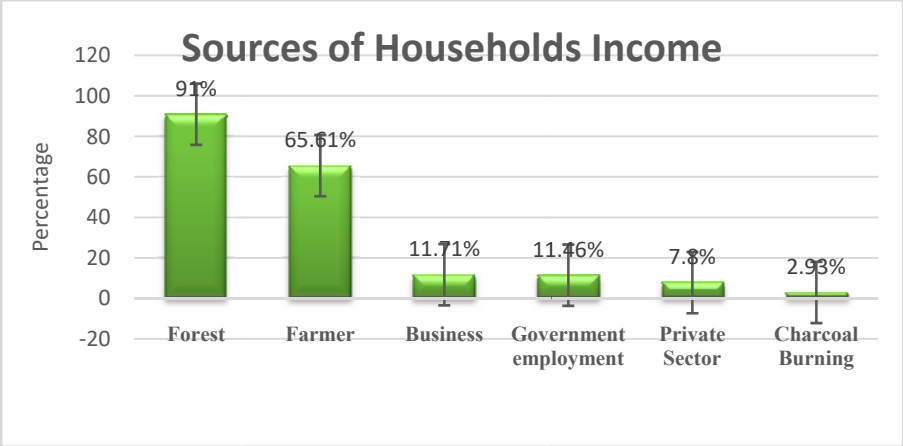

Figure 4: Sources of Income of the forest adjacent communities in Mt Elgon forest ecosystem

Firewood, being a major source of fuel energy in the area was the most sought-after livelihood. Ninety-one (91.7; n=330) percent of the households were dependent of wood fuel from the forest. Use of grass and fodder were reported by a further 91% (n=328) of the households that own livestock. Some 54% (n=200) of the forest adjacent-communities rely on the forest for construction materials such as timber. Forty-seven (47; n=171) percent of the households obtain herbal medicine from forest. Forty-three (43.8; n=160) percent of the households obtained wild vegetables, game meat 41.6% (n=152), wild fruits 38.5% (n=140) and ornamental resources 24% (n=89) from the forest (figure 2).

Distance Effects on Household-dependence on the Mt Elgon ecosystem

The distance from the forest significantly influenced the likelihood of dependence on the forest for livelihoods. Respondents living closer to the forest were more dependent on the forest than households further away from the forest. Analysis of data revealed that some 42% (n=137) of the respondents living less than 2km obtained majority of their livelihoods from the forest compared with those who lived further away (figure 5). These findings clearly demonstrate that household dependence on the forest is inversely proportional to distance.

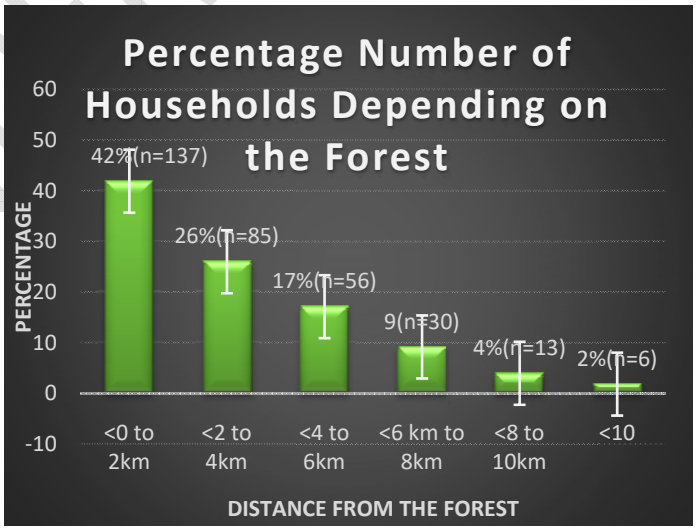

Figure 5: Distance Effect on Households dependence on the Mt Elgon ecosystem

Changes in Forest Livelihoods

Results of this study show that, there have been significant decline in majority of livelihoods among the communities living adjacent to the Mt. Elgon forest. Over the last 50 years (1970 to 2019), the use of herbal medicine, fodder, timber and wood fuel show a declining trend. The highest decline is in the use of herbal medicine between 1970 and 2010 followed by wild fruits (figure 6). The least decline was in the harvesting of wood fuel.

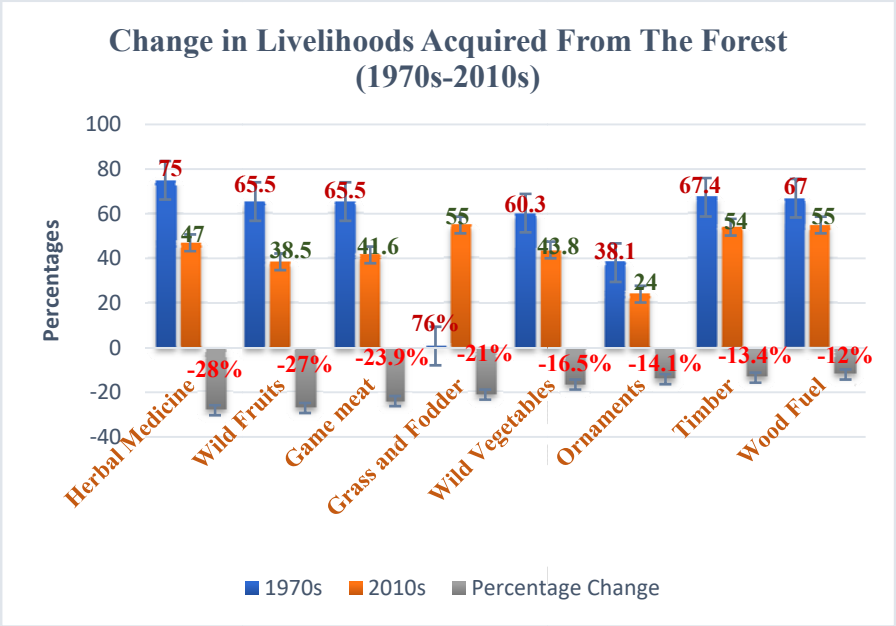

Figure 6: Percentage decline in livelihoods obtained from Mt Elgon forest

There were notable trends in livelihoods. Between 1970 and 1980, there was an increase in the use of majority of forest products with the use of wild vegetables having the highest increase followed by wood fuel , timber, fodder, game meat, wild fruits and herbal medicine. Between 1980 and 1990 there were declining trends with the highest decline being in the use of game meat and wild fruits. Similarly, the use of wood fuel, timber, ornamental products, wild vegetables, herbal medicines and fodder declined respectively. Further declines were witnessed between 1990 and 2000 with herbal medicine and wild vegetables exhibiting the highest decline. Fodder, wild fruits and timber experienced moderate decline as were ornamental products; timber and wood fuel. Additionally, game meat, wood, and wild vegetables declined (figure 7).

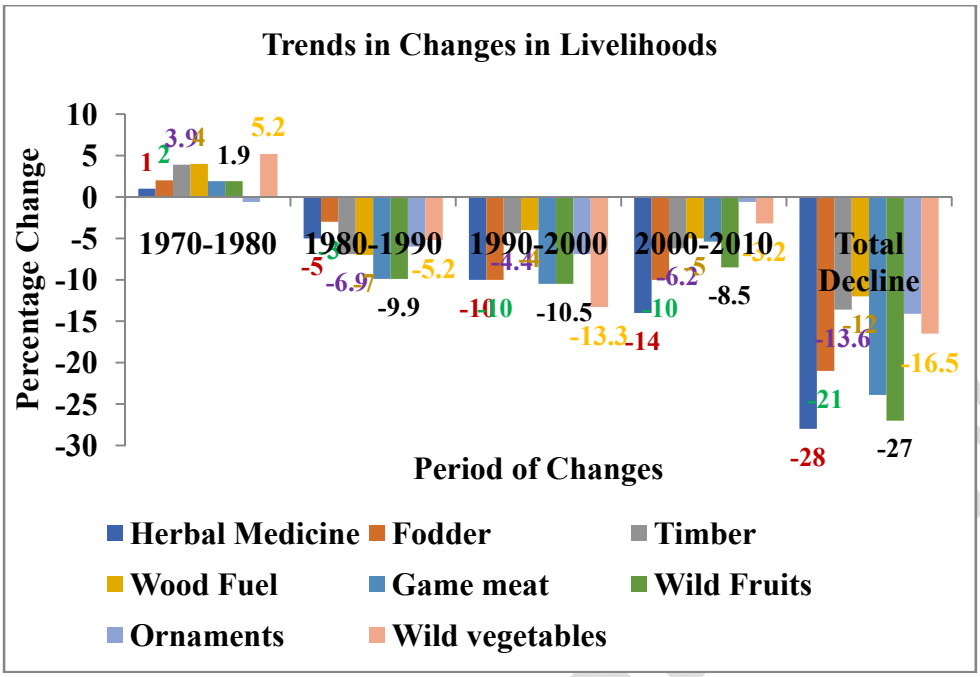

Figure 7: Trends in Changes in livelihoods in Mt Elgon Forest Ecosystem.

The decrease in the use of herbal medicines, corresponded to a decline in abundance of medicinal plants. For instance, *Melia volkensis* and *Warbugia ugandensis* had greatest decline in the ecosystem as reported by 24.1% (n=88) and 12.6% (n=46) of the respondents respectively. Other herbal plant species that declined considerably and included *Diospyros abyssinica* (9%; n=33), *Grewia trichocarp* (7.9%; n=29), *Croton macrostachyus* (5.8%; n=21) and *Aloe elgonica* (4.9%; n=18). A number of wild vegetables have also declined in the Mt Elgon forest ecosystem and include *Amaranthus retroflexus* (67.7%; n=248), *Vegetable amaranth* (62.7%; n=229), *Basella alba* (49%; n=180), *Urtica dioica* (46.3%; n=169), *Solanum nigrum* (3.3%; n=12), *Brassica oleraceae* (2.2%; n=8), *Bidens pilosa* (1.4%; n=5) young shoots of *Bambusa vulgaris* (1.4%; n=5) and forest mushrooms (0.8%; n=3). There has also been reported decline in some ornamental plant species that include *Bambuso ideae* (43.68%), *Markamia lutea* (21.58%) *Erythrina abyssinica* 10.53%, *Diospyros abyssinica* (9.47%), *Olea europea* (6.32%), *Tectona grandis* (3.16%) and *Entada abyssinica and Spathodea campanulata* (2.11%).

Figure 6 provides a summary of trends in changes in land uses and livelihoods in Mt Elgon forest. It is clear that natural forests, bamboo forests and grasslands have been on the declining trend between 1977 and 2019. Land under agriculture (mixed farming, fallow land and tea farming) has expanded over the same period (figure 8). All forest-dependent livelihoods continue to decline with wild fruits and game meat showing significant declines.

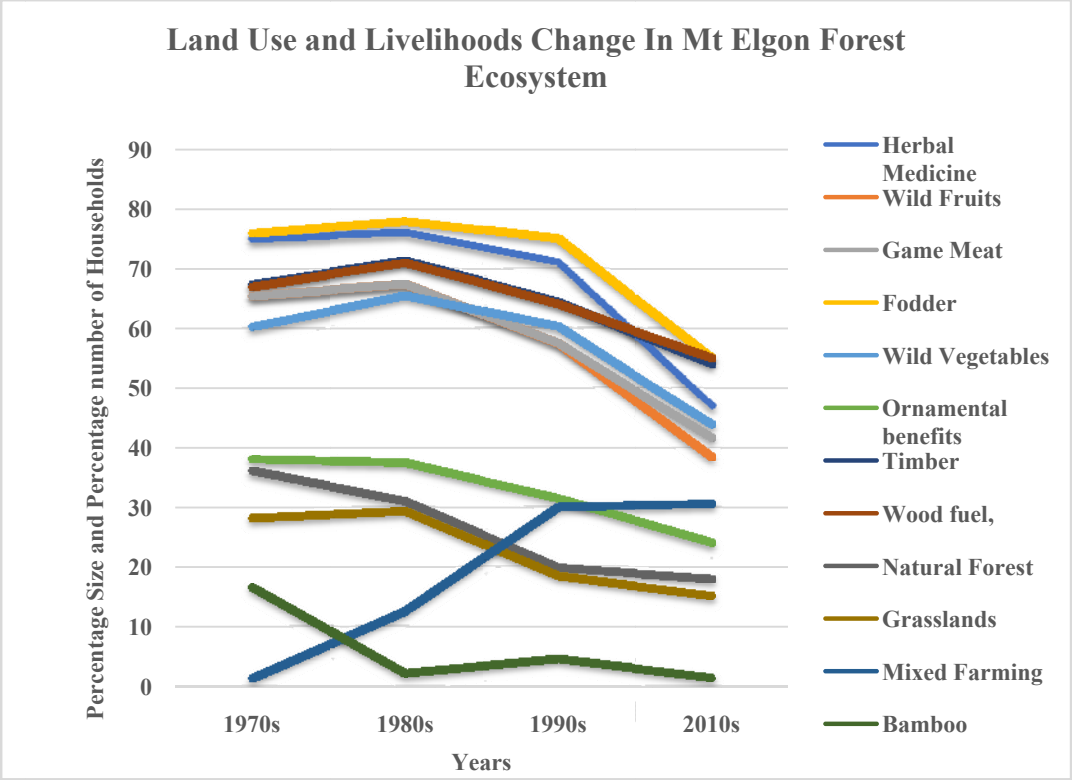

Figure 8: Land Use/Land Cover and Livelihood Changes in Mt Elgon Forest Ecosystem

Discussion

Results of the analyses of Landsat images clearly show that 18% decline in natural forest and a 29% and 10% increase in mixed farming and fallow land respectively. This demonstrates that in the Mt Elgon forest ecosystem, there has been a clear shift changes in land uses, from dependency on livelihoods from the forest by the forest-adjacent communities, to agricultural activities as mitigation and adaptation strategies to reduced access to forest resource. The profitability of agriculture coupled with the government policies that prohibit and limit utilization of forest resources appears to be the main driver for the shift by the forest-adjacent communities to agriculture. The decline in natural forest may explain the decline in forest-derived livelihoods. Githae et al. (2007) concurs that currently, the capacity of tropical forests to sustain and improve livelihoods has declined. Albinus et al. (2008) reported that major land use changes observed in the sub-catchments of Lake Victoria region are the transformation from perennial to annual cropping, forest encroachment and conversion of wetlands to agriculture; and this has led to a decline in land productivity. Gautam (2008) confirmed that land use changes significantly impacted livelihoods of the people of Madertala village in Khulna District who dependent on land directly or indirectly. Asaha and Deakin, (2016) opined that the disappearance of primary forest was the main driver for the dwindling non-timber forest products (NTFPs) such as bush mangoes in Cameroon. This has in turn, encouraged the domestication and cultivation of these fruits.

Results of this study also established that distance influences access to the forest. Households within a 2km radius of the forest were highly dependent on the forest compared to those far away. A number of studies have also reported similar observations on the distance-effects on the utilisation of forest products (Maua et al. 2018; Dash et al. 2016; Timko et al. 2010). Most

livelihoods have declined in Mt Elgon forest ecosystem. Herbal medicine, wild fruits, timber, wild vegetables, ornamental products, wood fuel and fodder have all declined. Kokwaro (1976) reported that some 58 tree species were medicinally exploited for their bark in Kenya and their abundance was declining. For instance, Overexploitation of *Warburgia ugandensis,* a much sought-after medicinal species has declined significantly in forests bordering Nairobi. In Kakamega forest, *Olea capensis* is being excessively debarked for similar reasons (Mutangah et al. 1992). IUCN (1996) affirmed that forests supply many foodstuffs such as, wild fruits, vegetables, fibres, nuts and tubers that constitute a regular and integral part of a household's diet. These tend to gathered for immediate consumption or used as dry-season or emergency foods. Asaha and Deakin (2016) reported that in Cameroon, hunting and fishing were carried out at a minimal level of less than 10% of the households. Increasing government regulations as well as dwindling numbers of wildlife were reported to contribute to the unavailability of bush meat and fish in the Cameroon. Wass (1994) confirmed that ornamental products obtained from Kenyan forest, are dwindling due to changes in land uses.

Conclusion

Changes in land uses has led to a dramatic decline in extents of natural forest, bamboo forests and grasslands cover and an accompanying expansion in land under agriculture. Consequently, majority of the household that obtain products from the forest are affected. Large areas of the natural forest have been converted to mixed farms and tea plantations driven by dwindling forest livelihoods and the high income and prohibitive government laws and policies that discourage forest livelihoods. Consequently, majority of the livelihoods that were derived from the forest have declined. There is also a distance-effect on forest dependency. Households that live within a 2km radius are more dependent on forest livelihoods that those farther away. There is the need to enhance sustainable forest management strategies should be adopted to safeguard the livelihoods of the forest-adjacent communities. Further, there is need to enlighten forest-adjacent communities on sustainable exploitation of forest livelihoods.

Compliance of Ethical Standards. As part of PhD thesis, the research proposal was approved by the graduate school of Moi University after meeting the post graduate guidelines of the university.

Data Availability Statement. The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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