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Socio-Economic and Environmental Interactions in the Maasai Mau Forest Kenya: A Comprehensive Household Survey Analysis

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ABSTRACT

Maasai Mau Forest contains a diversity of flora and fauna, which are a source of livelihood for the local communities and provide various valuable ecosystem services. However, it is under threat from illegal subsistence farming in the Mau catchment and its surrounding areas due to anthropogenic activities leading to deforestation. The main objective of the study was to look at socioeconomic and environmental contexts of the households to inform sustainable land management (SLM) and conservation efforts. A descriptive cross-sectional research design was employed with a study area located in the Maasai Mau Forest region, Narok County, Kenya, which comprises of communities living within and around the Maasai Mau Forest. The study participants included Maasai communities, with a study population being mainly household-headed in the Maasai Mau Forest, which mainly depended on agriculture and animal farming for their livelihoods. A multi-stage sampling approach was also used in selecting the sampling units, such as villages, which were then further stratified into different areas or locations depending on the boundaries. The final sample size comprised of 385 households. Data were collected using semi-structured household questionnaires. Data was analyzed by the software SPSS using frequencies and percentages for nominal data and means for numeric data. About 59.5% of the respondents were women, a higher proportion compared to male-headed households of 76.1%. The major source of education of respondents was primary education (49.9%) followed by secondary education (29.6%) while only 14% had no formal education. Sources of income included crop farming (37.4%); livestock production (28.2%) followed by casual employment (15.8%). About 77.9% of the households had monthly incomes of below KES 15,000. Land ownership was freehold with 97.7% of the land in the freehold status and an average of a freehold land size at 1.4 acres. Most households kept various livestock including cattle (71.7%), poultry (12.5%) followed by other livestock kept. Crop production declined from the past years; with maize (96.4%) and beans (90.9%) being the main crops grown followed by potatoes (30.6%) and wheat (29.8%). Food security was a main concern with 54% of households indicating a downward trend in crop production over time. The survey objectives were met, showing that there are challenges with socio-economic issues, resource base, agricultural productivity and food security impacting the Maasai Mau Forest. However, there are opportunities for investing in sustainable agriculture and enhancing community involvement in conservation. The study recommended an integrated conservation approach that addressed the economic related issues, improved sustainable farming practices and enhanced community involvement, by: Improving land use planning and its management; Improving agricultural productivity and increasing market access; and Increasing food and water security to support improved sustainability of the Maasai Mau Forest Ecosystem.

Keywords: Environmental Conservation, Household Survey, Maasai Mau Forest, Socio-Economic Conditions, Sustainable Agriculture

I. INTRODUCTION

The Maasai Mau Forest is part of the larger Maasai Mau Complex, located in Narok and Kirinyaga Counties in Kenya. This key ecosystem has a surface area of more than 400,000 hectares, constituting the largest closed-canopy forest ecosystem in East Africa (Baldyga et al., 2007). It plays important roles in biodiversity conservation, providing a major water catchment, and helping to maintain the climate (Baldyga et al., 2007). However, this vital ecosystem continues to be under severe threat through deforestation, land degradation, and high population density and socioeconomic pressures (Kairu et al., 2020). The Maasai Mau Forest, a critical part of the Mau Forest Complex in Kenya, is known for its rich biodiversity and crucial ecosystem services, such as water regulation and carbon

sequestration, that support local livelihoods and broader environmental stability. The forest is home to numerous species of flora and fauna, making it a significant conservation area (Gizachew et al., 2019).

However, the forest is under severe threat from deforestation driven by illegal subsistence farming, which is exacerbated by socio-economic pressures such as poverty, land scarcity, and population growth in the surrounding areas. Studies indicate that the deforestation and degradation in Maasai Mau Forest are largely driven by the need for agricultural land, firewood, and other forest resources, which local communities depend on for their livelihoods (Nkonya et al., 2008). The lack of effective governance and sustainable land management practices further aggravates these challenges, leading to continued environmental degradation (Gizachew et al., 2019).

Sustainable land management (SLM) practices are essential for balancing the needs of local communities with the conservation of forest ecosystems. Research shows that involving local communities in conservation efforts and providing alternative livelihoods can significantly reduce deforestation and promote the sustainable use of forest resources (Were et al., 2021). The integration of socio-economic factors into SLM strategies is crucial for their success, ensuring that conservation efforts are both effective and socially sustainable.

This study will evaluate available data on key socio-economic and environmental household conditions and create predictive models for some of the key, measurable variables relevant to the sustainable management and conservation of the Maasai Mau Forest.

1.1 Statement of the Problem

The socio-economic and environmental factors of the Maasai Mau as a region are extremely complex and interwoven. A clear understanding of measuring variables allows stakeholders to get a clear enough picture about the situation on the ground so that sustainable management and conservation strategies that improve livelihoods and protect the natural ecosystem of the Maasai Mau Forest can be developed. Through answering questions such as what is the household characteristic of the region, in terms of education, in terms of income, in terms of land tenure, agricultural production or livestock production, food security such as the proportion of households facing shortages of food while the season is ongoing, soil conservation, water harvesting and finally agroforestry, the officials in charge of the Maasai Mau region will be able to develop an integrated approach for its long-term sustainability.

1.2 Research Objective

The main objective of the study was to look at socio-economic and environmental contexts of the households to inform sustainable land management (SLM) and conservation efforts.

II. LITERATURE REVIEW

Household assets – including area and intra-household characteristics such as gender, age and marital status of the household head can influence resource use and management practices. Household size, gender and marital status affect labour allocation in various agricultural activities, food security and budgetary allocation. Households with more labour, for example, will skew their livelihoods towards more labour-intensive agricultural activities (Kenya National Bureau of Standards, 2019). Similarly, larger households with more workers might spend on basic amenities rather than on devices such as irrigation pumps that save labour and the opportunity cost of using such labour.

The level of education of the head of a household is another important predictor – higher levels of education of rural households have resulted in better management of natural resources and higher agricultural productivity (Asfaw and Admassie, 2004). The reason is that education enhances awareness and skills of a household and thus results in improved implementation of good agricultural practices. Nkonya, et al., (2008) Why do some farmers take up new agricultural technologies and certain conservation practices while others don't?

Levels and sources of income are important determinants in the household economic stability and their capacity to invest in conservation practices. Maasai Mau households depend on crop farming and livestock production for subsistence, with casual labour being their main source of income. Diversified livelihoods can cushion against unforeseeable economic shocks and build up resilience, but low incomes will limit investments on green technologies.

Tenure security of landowners is also an important determinant of sustainable land management and conservation. The provision of secure land tenure is likely to promote investment in long-term land-use practices, such as agroforestry and soil conservation (Place, 2009). The existence and often ambiguous distribution of tenure rights in the Maasai Mau Forest region affects land use decisions and approaches to conservation (Meinzen-Dick et al., 1997).

Agricultural production and the farming enterprise is an important source of livelihoods and revenues for the household, including the management of crops and systems. Household agricultural production decisions have implications in part relating to soil health, in part relating to water use and in part relating to biodiversity (Pretty, 2008). Sustainable agricultural production systems may involve crop rotations, types of crops planted, intercropping and

organic systems, which have the potential to increase production while maintaining natural resources flowing to the nation (Tilman et al., 2002).

Livestock rearing-and care is a main livelihood activity in the Mau region which generates income, food and social and cultural values. Overgrazing and lack of proper management leads to land- and biodiversity loss. Sustainable livestock management includes rotational grazing and fodder cultivation. Seen in the long term, overgrazing and lack of sustainable livestock practice can cause biomass loss and soil erosion.

Food security and dietary diversity are recognised as measures of community wellbeing since the availability and access to diverse and healthy food sources affect wellbeing and productivity (Food and Agricultural Organization, 2015). In the context of agricultural-based livelihoods such as the Maasai Mau, food security can be achieved by improving agricultural productivity while at the same time expanding food sources (Godfray et al., 2010).

It is imperative for preserving land productivity and preventing degradation to implement measures addressing soil conservation (terracing, contour farming, agroforestry, etc). Lal (2001) have been reviewed to show how tillage practices, cover crops, crop residue management, biochar, conservation tillage, agroforestry, etc constitute soil conservation measures which would help reduce soil erosion and enhance soil fertility. Depending on awareness, availability of labour and economic incentives, these practices can be adopted for land productivity (Pender et al., 2006).

How water is harvested and how much it can be stored determines not only the sustainability of agricultural activities in the area, but also the availability of water in dry periods of the year. Clear water harvesting and storage technologies, such as rainwater harvesting, construction of dams and water tanks, help with water security (Falkenmark and Rockström, 2004) especially in those areas with highly variable rainfall conditions like Maasai Mau (Rockström et al., 2010).

Agroforestry incorporates trees and shrubs into agricultural landscapes, providing multiple ecosystem services such as increased biodiversity, improved soil health, and supplementary income opportunities (Garrity, 2004). Agroforestry can help restore degraded lands in the Maasai Mau, increasing household climate-change resilience.

III. METHODOLOGY

This study was approved by an institutional review board. All respondents were informed about the objectives of the study and assured that their responses would remain completely confidential. Informed consent was obtained from each respondent prior to collecting any data. Participation was voluntary, and respondents were free to withdraw their responses from the study at any time without reservation.

3.1 Research Design

The descriptive approach used in the study adopted the cross-sectional research design. This design was appropriate since data are collected and analysed at a single point in time to give an instantaneous picture of the socioeconomic and environmental situations in the households studied in Maasai Mau Forest.

3.2 Measurable Variables

The study identified and quantified a range of measurable variables that help to explain the socio-economic and environmental dynamics of the region. Variables on the households included the size of the household; gender of the head; marital status of the household head; level of education of the household heads; sources and class of income; land size and tenure; area under agricultural production; major crop produced; size of livestock unit; source and class of income; food security status; number of food groups consumed; soil conservation practice; water harvesting and storage capacity, and agroforestry practices.

3.3 Study Location

It was conducted in the Maasai Mau Forest in Narok County, Kenya. The Mau is one of the larger forest complexes in East Africa, and is vital for regional ecosystem services and ways of life, covering almost 400,000 hectares across six counties. Our survey was with communities living in parts of Narok South ward, adjacent to the selected forest blocks.

3.4 Study Population

The study was conducted among that household population living in and around the Maasai Mau Forest, which was their main source of livelihood, both for food and the raising of livestock. The target population was household heads.

3.4.1 Inclusion and Exclusion Criteria

This study has defined the eligible participants of the survey by developing inclusion and exclusion criteria, with the purpose of making sure that the collected data represents the target population that are directly affected by the forest ecosystem in the Maasai Mau Forest. The inclusion criterion requires the households to live in the study area as located next to the Maasai Mau Forest and willingly participate in the survey despite informed consent. On the other hand, their exclusion criterion is that households will not be living in specified study area or unbelievingly will not consent or participate in the survey. Therefore, based on the inclusion and exclusion criterion, the collected data will represent the need of the population that are affected by the forest ecosystem in Maasai Mau.

3.5 Sampling

The following was a multi-stage sampling operation. Sublocations of respect to this project were carefully chosen in the first phase. Then, inhabitants from these sublocations were selected by systematic sampling by proportion to population size. In the second phase, there should be a sample of 385 households according to Cochran's formula for sample size. So the estimation can be achieved, and it will be generalized to large populations in the study area as well.

3.6 Data Collection Instruments

These data were collected through different interview instruments that were designed to enable us analyse the socio-economic and environmental factors in Maasai Mau Forest, a major destination for nature tourism in east Africa. The primary instrument was a household questionnaire survey in which semi-structured questionnaires were administered in form of guided interviews to collect respondents' quantitative data on different socio-economic and environmental issues. In addition to quantitative data collection, focused group discussions (FGDs) were employed through prearranged semi-structured interviews by an able moderator. Subsequently, respondents discussed different issues in these groups and brought out their viewpoints, deeper insights and experiences on community dynamics and the associated challenges. Last but not least, key informant interviews (KIIs) were collected from knowledgeable community leaders and professionals through guided interviews so as to gather detailed information on specific issues under the study.

3.7 Validity and Reliability

A so-called pre-test was conducted with a subgroup of the target population in order to refine the data collection instruments and address ambiguities in the wording of the questionnaire or depth probes, as well as in the registration process. The actual data on the research design were affected starting from the validity of the data-collection instruments. In the design phase of a study, a thorough review of the literature on the research topic should be done, in order to ensure validity as well as to identify all concepts and variables that would potentially fall within the scope of the study. Design reviewers, persons of expertise in the field, should be able to evaluate the instruments and ensure they indeed capture the intended variables. A further aspect of the validation process is reliability, in this case referring to the level of consistency of the data collection instruments. This is achieved when the tests of the data-collection instruments are pilot-tested in a small, representative sample of the study population in order to spot and correct ambiguities and inconsistencies.

3.8 Data Analysis

Quantitative data from the household questionnaire survey was analysed using descriptive statistics (for example, frequencies, percentages and means) to identify the main findings. This was done using statistical software like SPSS. Qualitative data from FGDs and KIIs was analysed thematically, identifying main patterns and themes based on the community's experiences and perceptions. The results were presented in various forms, such as tables, charts and narrative descriptions, to offer an in-depth and easily comprehensible overview of the study findings.

IV. FINDINGS & DISCUSSION

The male students were 40.5% and the female students were 59.5%, Household heads are male headed family 76.1 % and female headed family 23.9 %. The average number of the household members is 6. most of the household had 5 members with minimum of one individual to highest number of household members being 15 indeed.94% of the household head were married while 6 % of Household head were not married. Overview at Table 1

Table 1
Marital Status of the Household Head

Marital status of the household head	Frequency	Percent
Unmarried	23	6.0
Married	362	94.0
Total	**385**	**100.0**

Furthermore, the average age of the household heads was 52 years old. The majority of household heads' average age was 50 years old with a minimum of 26 years old and maximum of 99 years old. The average number of years is the household were in the area was 29 years old. Most of the households were in the area for 23 years. The average of years of living in the area was a minimum of 2 years and maximum 103 years old.

4.1 Level of Formal Education

As pertaining to the highest level of formal education, 14% of the head of house hold have not start any formal education. Whilst 49.9% of the head of house hold have been through primary school education. and 29.6% been through secondary level of education. also 6.5% of the head of house hold have been through tertiary level of education. This is shown in the table 2 below.

Table 2
Household Heads Highest Level of Education

Household heads highest level of education	Frequency	Percent
None	54	14.0
Primary	192	49.9
Secondary	114	29.6
Tertiary	25	6.5
Total	**385**	**100.0**

4.2 Household Income

There are many ways to earn profits at this place. Income from agriculture farming was responsible for 37.4 percent of the households. Meanwhile, livestock production was responsible for 5.9 percent of the households. Casual employment was responsible for 15.8 percent of the households, while permanent employment was for 3 percent of the households. Business activity produce income for 11.7 percent of the households, remittance from friends/relatives produce income for 0.4 percent of the households, and also government and other organizations cash transfer programs provide for income for 0.4 percent of the households. As shown in Table 3.

Table 3
Household's Sources of Income

Household's sources of income				
		Responses		Percent of Cases
		N	Percent	
Income sources	Crop farming	377	37.4%	97.9%
	Livestock keeping	284	28.2%	73.8%
	Permanent employment	30	3.0%	7.8%
	Casual employment	159	15.8%	41.3%
	Business activity	118	11.7%	30.6%
	Remittance from fiends/relatives	35	3.5%	9.1%
	Government/other cash transfer program	4	.4%	1.0%
Total		**1007**	**100.0%**	**261.6%**

In 56.4% of the sampled households, crop farming was the main source of income. Livestock equally was the main source of income for 4.2% of the sampled households. Casual employment too was the main source of income for another group15.6% of the sampled households. On the other hand, permanent employment was the main source of income for 6.5% of respondents. Business activity in the sampled households was the source of main income for 14.8% of the sampled households. A different section of those studied Remittance from offshore friends/relatives was the main

source of income for 2.3% of sampled households and cash transfer programs of Government and other organizations was the source of income for 0.3% of sampled households.

4.2.1 Household's Income Level

A household's income was shown to below KES 15,000 per month for 77.9% of the households. Furthermore, income was shown to be KES 15,001- KES 30, 000 per month for 15.6% of the households. Additionally, another 4.7% of the household's income was shown to be KES 30,001- KES 45,000 per month. And finally, 1.8% of the households in the sample earned above KES 60,000 per month. This is depicted in Table 4.

Table 4

Household's Income Per Month

Household's income per month	Frequency	Percent
< KES 15,000	300	77.9
KES 15,001 - KES 30,000	60	15.6
KES 30,001 - KES 45,000	18	4.7
KES 45,001 - KES 60,000	7	1.8
Total	**385**	**100.0**

4.2.2 Household Land Ownership and Tenure

Overall, majority of the households, at 97.7 % held land under freehold land tenure and 82.3% under leasehold land tenure. The mean land size of the households is 1.4 acres in the amount. Majority of the household held 1 acre of the land with the minimum amount being 0.125 acres and the maximum being 13 acres.

On whether the purchased land is adequate to meet the needs of the household, five-point five percent of the respondents said it is very inadequate. Equally, fifty-five-point six percent said it is inadequate to meet the needs of the household. Therefore, thirty-six-point four percent said it is adequate. In addition, two-point six percent said land is very adequate. This is shown in Table 5 below

Table 5

Adequacy of Household Land in Meeting its Livelihood Needs

Adequacy	Frequency	Percent
Very inadequate	69	17.9
Inadequate	214	55.6
Adequate	92	23.9
Very adequate	10	2.6
Total	**385**	**100.0**

4.3 Land Use Planning

Most of the households, 79%, do not have a land use plan while 21% have a land use plan. Of the households that have a land use plan, 91.4% implement the land use plan while 8.6% do not implement the plans. Men make decisions on land use in 78.2% of the households while women make the decisions on land use in 21.8% of the households. This is as shown in Table 6.

Table 6

Who Makes Decisions on Land Use

Decision Maker	Frequency	Percent
Woman	84	21.8
Man	301	78.2
Total	**385**	**100.0**

4.4 Crop Production

The area has several households that produce several types of crops. The types of crops that the households produce include chiefly maize (96.4%), beans (90.9%), vegetables (60.8%) and bananas (55.1%). the crop that most of the households produced chiefly is maize (84.4%) followed by beans (3.1%) then vegetables (2.9%). This information is drawn form Table 6. Only 4.4 % of the respondents in the region claimed that they cultivate crops under PELIS inside the Mau Forest. The average acreage of land on which chooses households grow crops under the elite privatization

scheme in Mau Forest is 0.04. The median was (zero acres), while the minimum was (zero acres) and maximum (2 acres). These particular household choose to grow crops in the forest due to several reasons.

The mean proportion of the total crop production that a particular household produces under the elite privatisation scheme in Mau Forest is 2%. The mode was (zero percent). The minimum and the maximum were (zero percent). The proportion of the total crop production for most of the crop growing households that produce under PELIS in Mau Forest is zero percent. This is represented in Table 6. These households come up with reasons as to why they produce this amount of the total crop production under PELIS in Mau Forest. Some of their reasons include crop production under the elite privatization scheme in the Mau Forest leads to more high yields (23.5%) lack of enough land (11.8%) and the remote area is in the Mau Forest where the land is very fertile (58.8%) and in order to achieve food sufficiency small scale farmers should plant in forest (11.8%). This is illustrated in Table7 .

Table 7

Motivation for Growing Crops in the Forest Under PELIS

Motivation for growing crops in the forest under PELIS				
		Responses		**Percent of Cases**
		N	**Percent**	
Motivation for growing crops under PELIS	Higher crop production in forestland	4	22.2%	23.5%
	Ownership of inadequate land	2	11.1%	11.8%
	The forestland is more fertile	10	55.6%	58.8%
	To produce adequate food for the household	2	11.1%	11.8%
Total		**18**	**100.0%**	**105.9%**

4.5 Livestock Production

The study found that households keep various types of livestock including cattle (88.7%), goats (17.3%), sheep (18.1%), poultry (51.6%), and pigs (37.1%). Besides, the households keep rabbits (4.2%), donkeys (3.4%), and fish (0.3%). This is as shown in Table 8.

Table 8

Types of Livestock Kept by the Household

Type of livestock kept by the household				
		Responses		**Percent of Cases**
		N	**Percent**	
Type of livestock kept by the household	Cattle	313	40.2%	88.7%
	Goats	61	7.8%	17.3%
	Sheep	64	8.2%	18.1%
	Poultry	182	23.4%	51.6%
	Pigs	131	16.8%	37.1%
	Rabbits	15	1.9%	4.2%
	Donkey	12	1.5%	3.4%
	Fish	1	.1%	0.3%
Total		**779**	**100.0%**	**220.7%**

Domestic cattle were the most common keep of livestock by most of the household (71.7%) then followed by poultry (12.5%). As to the trend in livestock in the area 50.1% of the household observed it was decreasing over time, 25.7% of the households observed there was no change then 24.2% of the household observed household's livestock production was increasing over time as shown on table 9.

Table 9

Trend in Household's Livestock Production

Trend	**Frequency**	**Percent**
Decreasing	193	50.1
No change	99	25.7
Increasing	93	24.2
Total	**385**	**100.0**

4.6 Challenges Facing Livestock Production

Pests and diseases (62.2%), Inadequate fodder and feeds (29.2%), Inadequate veterinary services (6.4%), Insecurity of livestock leading to theft (6.9%), and Inadequate knowledge and skills (8.6%) were the major challenges facing livestock production in the area. Lack of adequate water (5.3%), Lack of adequate financial capital (5%), Lack of adequate land, Poor access to markets and Other challenges faced also (14.2%) are the other constraints reported to be facing livestock production in the area. Improving livestock diseases control and management (32.8%), Training of farmers on livestock production and health (30.1%), Enhance the provision of veterinary services by hiring and better facilitation of personnel (8.4%), Data to reduce/subsidize the cost of livestock medicine and pesticides (7%) Improving the production of fodder on farmland including fodder grasses and fodder trees (16.8%), Developing livestock markets and market systems (6%) Establishing programs to supply the farmers with livestock inputs (7.9%), Data last, Other possible ways to improve livestock production in the area, can be found in literature for example, reducing pest populations (4.4%), improving soil and management practices (5.4%), enhancing farmers' access to inputs (6.3%), diversifying ruminant feed sources (6.5%), managing crops to make them more resistant to pests (4.4%) reduce weed pressure in the field (6%), and increase water availability for both crops and livestock (8.2%).

4.7 Discussion

The survey responses indicated that 59.5% of the respondents were female and 76.1% were male-headed households. These findings are consistent with research indicating male-headed households dominate rural areas in Kenya (KNBS, 2019). In the same way, the finding of an average household size of six members is comparable to the report by FAO (2015), which gave the average household size of 4.4 members in rural Kenya. Household members and size influences how resources are allocated, number of labour available and what is consumed, ultimately affecting food security and money earned. Large household sizes often lead to the domination of available resources and limited food, in addition to limited money (Hoddinott and Haddad, 1995).

Overall, 14 per cent of household heads said they had no formal education, 49.9 per cent had completed primary school, and 29.6 per cent had completed secondary school. This agrees with other research that shows low educational attainment in rural areas of Kenya. it is important to consider that approximately one third of the sampled households completed secondary school. This result suggests we might be able to adopt and continue implementing sustainable practices with appropriate training and support. The spread of agricultural technologies and conservation practices depend on education (Asfaw & Admassie, 2004). The notable percentage of primary and secondary completion suggests potential for adopting sustainable practices, if training is given.

These were crop farming for 37.4 per cent, livestock production for 28.2 per cent, and casual employment for 15.8 per cent. This is consistent with what other studies have indicated, that agriculture remains the leading livelihood activity in rural Kenya (for example, Kairu et al., 2020). Yet 77.9 per cent earned less than KES 15,000 (£113) per month, which is consistent with nationally representative poverty surveys that show that a large proportion of the rural population live below the poverty line. Low-income levels mean that households cannot have the financial capacity to invest and sustain practices that result in outcomes to improve livelihoods (for example, Barrett et al., 2001).

Nearly all (97.7%) households held land under freehold title with an average land size of 1.4 acres, a number consistent with other studies on Kenya's pattern of smallholder farming (Place, 2009). Small landholdings combined with secure land tenure institutions tend to provide conditions conducive to farmers' investment in long-term conservation practices by enhancing farmers' assurance that effort will translate to patient outcomes (Meinzen-Dick et al., 1997). However, small landholdings might limit the pace at which households can adopt diverse agricultural practices and soil conservation measures (Pender et al., 2006).

The most popular crops comprised maize (96.4%) and beans (90.9%), in line with national statistics showing that maize and beans are the key crops in Kenya (FAO, 2015). At the same time, 54 per cent of the surveyed households reported that the production of their crops is steadily falling – in keeping with research findings pointing to declining agricultural productivity as manifested in soil degradation, climate change and the lack of fertilisers and other inputs (Lal, 2001; Thornton et al., 2009). Overcoming these challenges entails better soil health, access to improved seeds and climate-smart farming practices (Pretty, 2008).

Households had on average 31 livestock units (mainly cattle) but kept goats and sheep as well. Livestock production generally provided income to 28.2 percent of households. These findings accord with the fact that livestock production constitutes a dominant livelihood source in rural Kenya. (Thornton, 2010). Overgrazing and poor land management are common, causing land degradation (Reid et al., 2004), and feeding livestock s forage and concentrates sustainable patterns based on rotational grazing and fodder cultivation are needed to rebuild ecological balance (Herrero et al., 2013).

Nevertheless, food security is a problem. Only 30 per cent of the study participants reported good access to food, and 54 per cent of the households had experienced a decline in their crop production. This is consistent with the report of the Food and Agriculture Organisation, which estimates that 39 per cent of the rural population in Kenya is food

insecure (FAO, 2015). Food diversity is low. In turn, food insecurity compromises human health and productivity (Godfray et al., 2010). Food security can be improved primarily by increasing agricultural productivity, by increasing the diversity of food, and by increasing nutrition education (Thompson and Meerman, 2014).

Agroforestry and terracing are important soil-conservation techniques that help add fertility to degraded soils, although they are inadequate because of deforestation and low labour supply, respectively. In line with a few other studies highlighting the crucial role of soil-conservation practices in sustaining land productivity, our findings are expected as the adoption of such practices depends on their awareness, availability of labour, and economic incentives. Hence, the support for soil-conservation programmes can go a long way in reversing the negative effects of land degradation, improve land productivity and agricultural production as suggested by Tilman et al. (2002) and Pender et al. (2006).

People use water harvesting techniques – especially, rain water collection. However, the provision of water is usually insufficient to meet demand. This is no surprise, as it conforms to the problems faced when trying to manage water in regions with relatively unstable rainfall (Rockström et al., 2010). Increasing water harvesting could in fact help to secure agriculture and supply water during the dry season (Falkenmark & Rockström, 2004).

Agroforestry systems, defined as practices that integrate trees and shrubs into the agricultural landscape, support increased biodiversity and improve soil health. We found that agroforestry systems were practised in our focus area, but were constrained by pest issues and lack of access to seedlings. Research indicates the great potential of agroforestry to restore degraded lands and provide increased household resilience to the impacts of climate change. Field-based research highlighted the potentials of agroforestry to promote food security and highlighted how out planting increased smallholder resilience to climate change in West Africa. Increasing access to quality tree seedlings and training in agroforestry technology can enhance these benefits.

V. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

There are two examples of an integrated perspective, one about water and the other about microcredit. The Maasai Mau Forest region is the area that we have studied through a household survey. It provides a powerful overview of dimensions of poverty and structural conditions of sustainable development and conservation in the region. Almost half of the respondents were female. In the majority of the households, the head was a man. On average, a household has six people. A large number were married and the average age of the household head was 52 years. The average number of years they had spent in the region was 39 years. The educational attainment of the respondents was mixed. Although almost 70 per cent completed primary and 60 per cent completed secondary schools, only 7 per cent had a tertiary qualification. The main sources of income were crop farming and livestock production. Most of them had income below the poverty line, and therefore their capacity to invest in sustainable use and conservation was relatively limited. Land ownership was under freehold. However, the average land size was small and inadequate for their income needs and livelihoods. Most people practised crop farming, and maize and beans were the main crop types. The productivity of the land was reported by most of them as decreasing in the past decades. They attributed the decline to soil degradation and climate variability. The most important livestock types were cattle and they were kept by more than 90 per cent of the respondents. However, performances were precarious since they suffered from pests and diseases, and there was an inadequate supply of fodder for them.

5.2 Recommendations

The findings were used to formulate true improvement recommendations for making the socio-economic and environment conditions more acceptable to sustain in Maasai Mau Forest sub-region. Some of these recommendations are: Improving Education and Training: Increase access to formal and non-formal education (including vocational training) in sustainable agricultural practices and environmental management, through community-led and public-private initiatives with local schools and other educational institutions, helping to ensure adoption of new and innovative agricultural techniques and conservation practices. Increase Diversified Income: Diversify away from crop farming and livestock production by developing small enterprises and microfinance, building markets, and promoting value-added agricultural activities. Provide microfinance and entrepreneurial training so households can seek alternative livelihoods. Sustaining Agricultural Productivity: In the face of falling crop and livestock outputs, improve access to quality seeds, fertilisers and pesticides, and to climate-smart agricultural practices; strengthen extension services to deliver technical advice and training to farmers.

Declarations

The study was conducted as part of the Women-Led Community Forest Conservation Initiative in the Maasai Mau Forest Ecosystem, Narok County, Kenya. This initiative was spearheaded by Women in Water and Natural Resources Conservation (WWANC) in collaboration with the Kenya Forest Service (KFS). The research aimed to provide a comprehensive baseline survey of the socio-economic and environmental conditions of the households residing adjacent to the Mau Forest, to inform future conservation and restoration efforts.

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Competing Interests

The authors declare no competing interests. The research was conducted independently, and the findings and conclusions drawn are based solely on the data collected and analysed. No external parties influenced the research process, and the results are presented without bias to any stakeholder involved in the funding or implementation of the project.

Disclaimer

The findings, interpretations, and conclusions expressed in this study are those of the authors and do not necessarily reflect the views of the Women in Water and Natural Resources Conservation (WWANC), the Kenya Forest Service (KFS), or any other affiliated institutions. While every effort has been made to ensure the accuracy and reliability of the information presented, the authors do not assume any legal liability or responsibility for the completeness, accuracy, or usefulness of the information. The study's results should be used as a basis for further research and action in the field of sustainable forest management and community development.

REFERENCES

Asfaw, A., & Admassie, A. (2004). The role of education on the adoption of chemical fertiliser under different socioeconomic environments in Ethiopia. *Agricultural Economics*, *30*(3), 215-228.

Baldyga, T. J., Miller, S. N., Driese, K. L., & Gichaba, C. M. (2007). Assessing land cover change in Kenya's Mau Forest region using remotely sensed data. *African Journal of Ecology*, *46*(1), 46-54.

Barrett, C. B., Reardon, T., & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy*, *26*(4), 315-331.

Falkenmark, M., & Rockström, J. (2004). Balancing Water for Humans and Nature: The New Approach in Ecohydrology. *Earthscan*.

FAO. (2015). The State of Food Insecurity in the World 2015. *FAO*.

Garrity, D. P. (2004). Agroforestry and the achievement of the Millennium Development Goals. *Agroforestry Systems*, *61*(1), 5-17.

Gizachew, B., Nzyoka, J. M., & Bernard, F. (2019). Deforestation and Forest Degradation as an Environmental Behavior: Unpacking Realities Shaping Community Actions in Maasai Mau Forest, Kenya. *Land*, *8*(2), 26.

Godfray, H. C., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M., & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *Science (New York, N.Y.)*, *327*(5967), 812–818. https://doi.org/10.1126/science.1185383

Herrero, M., Thornton, P. K., Gerber, P., & Reid, R. S. (2013). Livestock, livelihoods and the environment: understanding the trade-offs. *Current Opinion in Environmental Sustainability*, *3*(6), 659-665.

Hoddinott, J., & Haddad, L. (1995). Does female income share influence household expenditures? Evidence from Côte d'Ivoire. *Oxford Bulletin of Economics and Statistics*, *57*(1), 77-96.

Kairu, J. K., Nyabenge, M., & Waswa, F. (2020). Analysis of the Socio-economic Determinants of Land Use Changes in Mau Forest, Kenya. *International Journal of Agricultural Extension and Rural Development Studies, 7*(3), 1-13.

KNBS. (2019). Kenya Population and Housing Census. *Kenya National Bureau of Statistics*.

Lal, R. (2001). Soil degradation by erosion. *Land Degradation & Development*, *12*(6), 519-539.

Meinzen-Dick, R., Brown, L. R., Feldstein, H. S., & Quisumbing, A. R. (1997). Gender, property rights, and natural resources. *World Development*, *25*(8), 1303-1315.

Nkonya, E., Pender, J., & Kato, E. (2008). Who knows, who cares? The determinants of enactment, awareness, and compliance with community Natural Resource Management regulations in Uganda. *Environment and Development Economics*, *13*(1), 79-99.

Pender, J., Place, F., & Ehui, S. (2006). Strategies for Sustainable Land Management in the East African Highlands. *International Food Policy Research Institute*.

Place, F. (2009). Land tenure and agricultural productivity in Africa: A comparative analysis of the economic literature and recent policy strategies and reforms. *World Development*, *37*(8), 1326-1336.

Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. Philosophical Transactions of the Royal Society B: *Biological Sciences*, *363*(1491), 447-465.

Reid, R. S., Thornton, P. K., McCrabb, G. J., Kruska, R. L., Atieno, F., & Jones, P. G. (2004). Is it possible to mitigate greenhouse gas emissions in pastoral ecosystems of the tropics? Environment, *Development and Sustainability*, *6*(1-2), 91-109.

Rockström, J., Gordon, L., Folke, C., Falkenmark, M., & Engwall, M. (2010). The emergence of a new global ethos: Global stewardship, sustainability and planetary boundaries. *Ambio*, *39*(5-6), 441-458.

Thompson, B., & Meerman, J. (2014). *Towards Long-term Food Security: A Discussion on Sustainable Practices.* Springer.

Thornton, P. K. (2010). Livestock production: recent trends, future prospects. Philosophical Transactions of the Royal Society B: *Biological Sciences*, *365*(1554), 2853-2867.

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature*, 418(6898), 671-677.

Were, L., Nyberg, G., & Swallow, B. (2021). Barriers to the Adoption of Sustainable Land Management Practices in the Maasai Mau Forest Ecosystem. *Land Use Policy*, 108, 105534.