*Original Research Article*

Influence of Economic Incentives on Endau Dryland Forest Conservation Practices

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ABSTRACT

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| Forest degradation remains a pressing environmental concern in Kenya, particularly within buffer zones where community livelihoods intersect with conservation efforts. This study investigates how economic benefits derived from forest-related activities influence forest cover change in the Endau Forest. The primary objective was to assess whether perceived and actual economic gains from sustainable practices affect community participation in forest conservation. A descriptive survey design was employed, involving 298 randomly selected households from communities around Endau Forest. Data were collected using structured questionnaires and supplemented by semi-structured interviews with six key informants, including two forest conservators, two foresters, local leaders, and a ranger. Descriptive statistics, correlation, and regression analyses were used to examine the relationship between economic incentives and forest cover dynamics. Results showed that activities such as charcoal production and firewood collection were perceived as major drivers of forest degradation. However, communities also recognised the potential of sustainable practices, such as ecotourism and farm forestry, to offer viable economic alternatives. A strong positive correlation (*r* = 0.860, *p* = 0.001) and a statistically significant regression coefficient (*β* = 0.210, *p* = 0.028) indicated that economic incentives positively influence conservation behaviour. The findings highlight the importance of integrating economic development with forest conservation strategies. Policy interventions that promote alternative livelihoods could enhance sustainable forest management in buffer zones. |

***Keywords:***Forest conservation, economic benefits, buffer zones, Endau Forest, sustainable livelihoods, deforestation, *Dryland Forest, Economic incentives.*

1. INTRODUCTION

Dryland forests are vital ecosystems that cover approximately 27% of the Earth's forested area. Dryland forests provide environmental services such as carbon sequestration and biodiversity conservation. Dryland forests are a source of livelihood that supports approximately two billion people in the world [1]. Despite their importance, these ecosystems are increasingly threatened by human activities like agricultural expansion, logging, and overgrazing, as well as by the impacts of climate change. Globally, the degradation of dryland forests contributes to rising carbon emissions, exacerbates desertification, and diminishes biodiversity [2]. According to FAO 2020, all types of forests constitute 31% of the total land in the world. Studies by FAO have shown that the forest cover has been decreasing at alarming rates. The first Forest Research Assessment (FRA) was done in 1948. In 1948, FRA indicated that 66% of the world was forested. In 2020, only 30.8% (4.06 billion hectares) of the world was forested. Therefore, more than half of the area that was occupied by the forest in 1948 has been deforested [1]. More than half of the forests have been deforested in seven decades. Despite extensive research on tropical rainforests, there is a significant gap in the literature concerning the spatiotemporal dynamics of dryland forests, particularly in understanding the specific patterns and drivers of change over extended periods. Addressing these knowledge gaps is crucial for developing effective conservation strategies that are tailored to the unique challenges faced by dryland forests.

African forests account for only 16% (636 million hectares) of the world's forests [1]. The African forest cover is almost half the world's average. However, Africa experienced significant deforestation, losing 3.9 million hectares annually between 2010 and 2020 [1]. Forest services such as food, fibre, medicinal, pharmaceutical plants, timber, and biofuel production will be affected if deforestation continues [3]. In Africa, dryland forests are especially vulnerable due to rapid population growth, poverty, and a heavy reliance on natural resources for livelihoods [4]. Dryland forests that are found in regions such as the Sahel, in the Horn of Africa, and Southern Africa, are under immense pressure from agricultural expansion, charcoal production, and unsustainable land-use practices [5]. While there is growing research on the drivers of deforestation in Africa, regional studies often cover short periods. The specific impacts of economic activities on forest cover remain underexplored. The intersection of economic factors with forest cover change is particularly critical, as economic pressures frequently lead to the conversion of forested land into agricultural land or the extraction of forest resources for income generation.

In East Africa, dryland forests are facing significant threats due to economic, environmental, and social pressures [6]. These forests are crucial for the ecological balance and the livelihoods of local communities, yet they have experienced notable degradation over the past four decades [6]. However, the literature on forest cover change in East Africa often lacks a comprehensive analysis of the spatial and temporal dynamics specific to dryland forests, which are distinct from other forest types in the region. Moreover, there is limited literature on how members of Participatory Forest Management (PFM), which is used to mitigate forest degradation in dryland forest areas, benefits directly.

Economic activities in forest are widely recognised as major drivers of deforestation and forest degradation, yet the specific impacts of these activities on dryland forests are less understood, particularly on a global scale [7]. According to [1], Africa had the highest rate of deforestation per year between 2010 and 2020, at 3.9 million hectares per year. In countries like Sudan, dryland forest cover decreased due to anthropogenic activities [8]. While there is substantial literature on the economic drivers of deforestation, such as agricultural expansion and logging, much of this research has focused on humid tropical forests, where the dynamics may differ from those in dryland regions. In Africa, economic factors like the demand for charcoal and agricultural land have been identified as key contributors to forest loss [9], but the nuanced relationships between these factors and forest cover change require further exploration. In East Africa, the interplay between economic drives of deforestation is critical but under-researched. This study aims to fill this gap by examining how economic activities, such as agricultural expansion and charcoal production, have influenced dryland forest cover in the region, offering insights into balancing economic development with sustainable forest management.

2. material and methods

This research used a descriptive survey design. The research design enabled the researcher to conduct and write coherent research, serving as a master plan [10]. The study's research design incorporated a positivist philosophy, employed survey methods for data collection, and adopted a cross-sectional time horizon.



**Figure 1: Endau Forest (Study Area)**

This research was conducted in the Mutitu Sub-County in Kitui County. The forest is located on Endau Hill, with several peaks ranging between 814 M and 1400 M above sea level. The sampling frame was derived from households within the buffer zone, which was divided into four administrative sublocations. To ensure fair representation, proportionate sampling was used, distributing the sample size among these sublocations according to their respective population sizes. This approach guaranteed that each sublocation was adequately represented in the study. This paper used a sample size of 298, which was calculated using the Yamane formula. From 2020 household. Proportionate distribution was used for fair representation [10]. The highest number of respondents came from Ndetani 121 (40.6%), reflecting its population size. While some imbalance did exist, all sub-locations were reasonably represented, followed by Yiuku 73 (24.49%), Katumbi 53 (17.78%), and the lowest from Kathua 51 (17.11%), which enhanced the validity of the data and reduced location bias.

3. results and discussion

**3.1 RESULTS**

***3.1.1 Economic Causes of Forest Cover Change***

Most of the respondents (72.5%) agreed that charcoal production was the major contributor to deforestation, while 13.8% remained neutral and 13.8% disagreed. Firewood collection contributed to the reduction of forest cover. A total of 69.8% of respondents agreed, indicating that firewood collection remains a significant contributor to forest degradation. However, 16.1% remained neutral, and 14.0% disagreed. The results indicate that agricultural expansion is one of the key drivers of forest cover change in the Endau, especially in the buffer zones. A total of 69.1% of respondents agreed, while 14.4% remained neutral and 16.5% disagreed.

The results noted that the grazing livestock in the forest contributes to the degradation of the forest, with 72.5% of respondents agreeing, while 14.8% remained neutral, and 12.7% disagreed. Economic hardships led many households to rely on forest resources for survival. A total of 68.5% of respondents agreed, while 19.8% were neutral and 11.7% disagreed. The demand for timber and wood products was also identified as a key factor influencing deforestation. A total of 69.8% of respondents agreed, while 18.5% remained neutral and 11.7% disagreed. Market demand for agricultural products encouraged deforestation for farming activities. A total of 68.5% of respondents agreed, while 15.4% remained neutral and 16.1% disagreed.

**3.1.1 Charcoal burning**

Most of the households in Endau buffer zone communities rely heavily on forest-based activities to supplement their income, particularly during periods of economic stress or environmental hardship. Charcoal production emerged as the most dominant livelihood activity and a major contributor to forest degradation. The availability of county-issued licenses permitting charcoal production for domestic use has created a regulatory loophole. These permits are frequently exploited by commercial traders, leading to large-scale and often unregulated deforestation. As one community leader explained:

*“Charcoal production remains a major livelihood, making it difficult to control deforestation. Since the county government gives licenses to produce charcoal for local use, traders take advantage of this situation and do mass production of charcoal.”*

A forest officer added:

“*When there is drought for a long time, the residents have no other economic activities, hence they produce charcoal and graze livestock in the forest.”*

The profitability of charcoal, especially when combined with limited oversight, incentivises overharvesting and undermines conservation regulations. Similarly, small-scale agriculture is practised in parts of the buffer zone, with trees often cleared to expand farmland. This is especially problematic in areas with insecure land tenure, where forest boundaries are poorly defined or contested.

#### **3.1.2 Illegal Logging and Commercial Interests**

Illegal logging, though officially banned, remains widespread in parts of Endau Forest. The practice continues due to its high profitability and protection by influential actors. A conservation officer observed:

“*Illegal logging remains lucrative, making it difficult to convince people to stop. Most of the people who participate in illegal logging are either politicians or well-connected people.”*

The value of some indigenous trees is very high, incentivising some business people to cut down the trees and sell even without a permit, even among those who are aware of the ecological consequences. While forest patrols and enforcement exist, they are often undermined by a lack of sufficient human resources, political interference and budgetary constraints.

Other forms of commercial use, such as livestock grazing, further complicate forest management. Despite recommendations from the National Environment Management Authority (NEMA) to limit grazing, allowances are made for residents to pay nominal fees for grazing rights. However, these permissions are often expanded informally. A conservation officer explained:

*“The residents pay Ksh 100 per month to graze cows in the forest. Also, those who wish to graze sheep pay Ksh 40 per month to be allowed.”*

While intended to regulate access, these small fees are rarely enforced in practice and often encourage rather than limit unsustainable grazing practices. There are only four KFS rangers to guard the whole forest, hence little reinforcement.

Further, Payments for Ecosystem Services (PES) were mentioned as a potential motivator for community-level conservation. These financial incentives reward individuals or groups who actively protect forest resources. However, their current scale and outreach remain limited. As noted in the results, while these positive alternatives show promise, they remain insufficient to outweigh the high financial appeal of charcoal production and illegal logging.

Based on the Pearson correlation analysis between Economic Benefits and Dryland Forest Cover Change, the findings indicate a strong positive relationship, with a correlation coefficient of 0.860. This relationship is statistically significant (*p* = 0.01), implying that the association is highly unlikely to have occurred by chance.

**3.2 Discussion**

Charcoal production remains a critical driver of deforestation in the Endau region. More than two-thirds of respondents reported that residents frequently cut down trees to produce charcoal, especially during periods of drought when alternative income sources are limited. Charcoal serves as a primary source of income for many rural households; however, its production often involves unsustainable harvesting practices that accelerate forest degradation. Boscow [11] highlights similar patterns in dryland regions, where charcoal production significantly contributes to forest loss. Introducing alternative energy sources, such as briquettes, along with afforestation programs, could help reduce dependency on charcoal.

Firewood collection also contributes to forest cover change, although some respondents perceived its impact as less severe. Selling firewood for income gradually depletes tree cover, particularly in areas where other energy sources are unavailable. Mbuvi [12] notes that firewood remains the main cooking fuel in many rural communities, and without viable alternatives, this reliance is likely to persist. Even limited tree-cutting in dryland forests can have serious long-term ecological consequences, necessitating the development of sustainable energy solutions and community education on forest conservation.

Livestock grazing emerged as another significant factor affecting forest ecosystems. Respondents reported grazing their animals in the forest during dry seasons, especially during prolonged droughts. Community members are permitted to graze livestock in forest areas under certain conditions, such as during emergencies or with payment. However, studies by Gebregergs et al. (2019) [13] show that overgrazing leads to soil compaction, hinders forest regeneration, and contributes to deforestation. Implementing controlled grazing systems, such as designated zones and rotational grazing practices, may mitigate these effects and enhance forest sustainability.

Agricultural expansion was widely cited as a contributor to forest clearance, driven by high market demand and the pursuit of economic gains. Respondents acknowledged that both commercial and subsistence farming contribute to deforestation, as forested land is often cleared to increase crop production. Sedano et al. (2022) [14] argue that without sustainable land management, farming activities pose a substantial threat to forest ecosystems. These findings concur with Doggart *et al*. (2020) [15] who found that agriculture is the most dominant economic factor that led to deforestation. Promoting conservation farming, offering incentives for agroforestry, and enforcing land-use regulations could help reduce agriculturally driven deforestation and protect forest resources.

Economic vulnerability plays a central role in driving forest degradation. Households facing financial hardship often turn to logging, charcoal production, and firewood collection to meet their basic needs. These unsustainable practices result in the continued loss of forest cover. Fagariba et al. (2018) [16] identify poverty as a key driver of environmental degradation in forest-dependent communities. Addressing this issue requires the implementation of alternative livelihood programs and the promotion of community-based forest management to balance economic needs with environmental protection.

Timber harvesting for construction and commercial use also contributes significantly to forest loss. As the population grows, the demand for forest products increases, consistent with the forest transition theory. Petersen et al. (2021) [17] report that unsustainable logging, coupled with weak enforcement of forestry regulations, exacerbates deforestation. Strengthening regulatory frameworks and promoting tree-planting initiatives could help mitigate the negative impacts of timber extraction.

The cumulative findings indicate that multiple economic activities, charcoal production, firewood collection, agricultural expansion, livestock grazing, and timber harvesting, are collectively responsible for forest degradation in the region. These pressures are primarily driven by economic necessity, market demand, and limited livelihood alternatives. These results are consistent with Ranjan *et al*. (2025) [18] Who found that forest cover change was caused by economic drivers such as agriculture, grazing, and timber harvesting. The high level of agreement among respondents reinforces the urgency of addressing the economic drivers of deforestation through integrated forest conservation strategies.

The result suggests that as economic benefits derived from forest conservation increase, there is a corresponding positive impact on dryland forest cover. In practical terms, this means that communities that perceive or receive tangible economic incentives, such as income from ecotourism, sustainable logging, agroforestry, or payments for ecosystem services, are more likely to engage in practices that protect and restore forest cover.

These findings align with Waisse *et al*. (2023) [19] who posit the importance of integrating livelihood support mechanisms into forest conservation strategies. For instance, economic viability has been shown to play a key role in influencing community attitudes and behaviours towards environmental stewardship. When communities benefit economically from conservation initiatives, they are more motivated to participate in sustainable land management practices.

This strong correlation reinforces the need for policy frameworks that link conservation efforts with economic empowerment, particularly in dryland regions where forest-dependent communities face economic hardship. Programs that enhance access to credit, promote value-added forest products, and ensure equitable benefit-sharing can help reduce deforestation pressures and support long-term ecological sustainability. A Pearson correlation coefficient of 0.860, statistically significant at the 0.001 level, indicates a strong positive relationship between economic incentives and forest conservation. This suggests that when communities derive financial benefits from sustainable forest practices, they are more likely to engage in conservation activities. Matta and Alavalapati (2016) [20] support this view, arguing that economic incentives enhance local participation in environmental protection programs. Opportunities such as ecotourism, agroforestry, and sustainable logging not only improve livelihoods but also promote long-term forest health.

The findings also point to the importance of incorporating livelihood improvement initiatives into conservation strategies. Programs such as payment for ecosystem services (PES), community forestry enterprises, and equitable access to forest resources have been shown to reduce pressure on forests. Marnelly et al. (2023) [21] emphasise that enhancing credit access and promoting sustainable economic activities can shift community dependence away from forest exploitation. Kiria and Onundo (2022) [22] further assert that financial incentives are vital for encouraging responsible forest stewardship. Integrating economic benefits with conservation policies is therefore essential for achieving lasting sustainability in dryland forest ecosystems.

4. Conclusion

Economic factors also emerged as a critical theme influencing forest cover change. Respondents identified activities such as charcoal production and firewood collection as major contributors to forest degradation. Conversely, they recognised that forests provide essential economic benefits, incentivising communities to engage in sustainable practices. The perceptions indicated that when communities perceive economic advantages connected to forest conservation, they are more likely to support and participate in initiatives that protect forest resources. There were perceptions indicating a significant relationship (correlation *r* = 0.860, *p* = 0.0001 between economic benefits derived from sustainable practices and forest conservation. The regression result was at *β* = 0.210; *p* = 0.028. The mean score of 3.92 for the perception that charcoal production contributes to forest degradation reflects the prevailing economic dependencies threatening forests. Respondents strongly recognised the potential of alternative economic incentives, such as ecotourism and farm forestry, in mitigating deforestation, signaling a need for policies integrating economic viability with conservation efforts.

We suggest that community forests should come up with alternative economic activities that can discourage them from using the forest products to allow it to regenerate naturally. We also suggest that the introduction of modern technologies that will reduce the use of firewood and charcoal enable the community forest to reduce the over-reliance on forest products.

Ethical approval

This study was approved by the Chuka University Ethics Committee. Informed consent was obtained from all participants. Author(s) hereby declare that NO generative AI technologies were used when writing this research paper.

Definitions, Acronyms, Abbreviations

**CFA** Community Forest Association

**PFM** Participatory Forest Management

**Buffer Zones:** The area approximately five kilometres from the forest boundary.

**Community Forest**: The people who live within a five-kilometre radius around the forest boundary. They form the forest buffer zone and are interested in the forest.

**Deforestation:** The conversion of forests to other land uses.

**Dryland Areas:** The areas that receive very little rainfall throughout the year, and very little crop farming is done due to aridity. Dryland areas are places where the ratio of annual precipitation and mean annual potential evapotranspiration is less than 0.65.

**Dryland Forests:**Forests found in areas with low precipitation and high evaporation (dryland). These trees should cover more than half a hectare.

**Sustainable Forest Management (SFM):** It is the approach aimed at ensuring that forest ecosystems are managed in a way that maintains their biodiversity, productivity, regeneration capacity, and vitality, while also meeting social, economic, and ecological needs.

**Sustainable Forest Practices (SFP):** These are specific actions used by individuals or communities to achieve sustainability in forest management. The practices that will enable the farm forest to continue thriving.

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