European Journal of Agriculture and Food Sciences
Vol 7 | Issue 4 | July 2025
ISSN 2684-1827

RESEARCH ARTICLE

Relationship between the Availability of Non-Timber Forest Products (NTFPs) and Distance to the Forest Edge around Kavonge and Museve Hilltop Forests in Kitui, Kenya

Vandi Alex Saffa*, Festus Mbatha Mutiso, and Kiruki Harun Mutuma

ABSTRACT

Distance to the forest edge in NTFPs collection was one of the key factors affecting the NTFPs availability and consumptions in the study area. This study established the relationship between the availability of NTFPs and the distance to the forest from households in Kitui County. The specific study objective was to establish the relationship between the availability of NTFPs and distance to the forest edge. Datasets were collected by employing structured questionnaires, key informant interviews, and focus group discussions to know the types of NTFPs, quantities, and distance of collection from households. These were used to collect primary data from the two selected villages through a purposive sampling method. The Yamane formula was used to choose a sample size of 120 respondents for the purpose of this study. The study employed the purposive sampling technique to choose villages that were within a 5-km radius of the hilltop forests. Additionally, a systematic parallel transect line design of one km by one km was used to identify household points for data collection. The data were analyzed using descriptive statistics, Kendall tau b-correlation, and linear regressions. The results summarized the following types of NTFPs (wild fruits 67.7%, wild vegetables 51.7%, medicinal plants 62%, wild mushrooms 80%, fuel wood 64%, and charcoal 77% collected in Kavonge and Museve hilltop forests. The Kendall tau b correlation result indicates a downward trend statistically significant (tau b -0.709, $p = 0.000$), signifying a consistent decrease in the amount of NTFPs collected over the years. The results found that there was a significant relationship ($p = 0.000$, $R^2 = 0.797$) between the distance covered to the forest edge and the amount of NTFPs collected from the forests. The results concluded that the trends in NTFPs availability have been reducing gradually in the past 30 years and that distance was among the key factors affecting NTFPs availability and consumption in the study area. Based on the distance effects on NTFPs collection, it is essential to advocate for strict community bylaws that encourage responsible NTFPs collections, management, and forest preservation of endangered NTFPs species.

Keywords: Forest edge, Kavonge forest, Museve forest, NTFPs.

Submitted: July 18, 2024

Published: July 11, 2025

10.24018/ejfood.2024.7.4.843

Department of Environmental Sciences and Land Resources Management, School of Agriculture, Environment, Water and Natural Resources, South Eastern Kenya University, Kenya.

Corresponding Author:
e-mail: vandialexsaffa123@gmail.com

1. Introduction

The forest ecosystem relies heavily on Non-Timber Forest Products (NTFPs), which support wildlife habitat conservation, soil conservation, macroclimate maintenance, and landscape maintenance [1], [2]. During changes in agricultural systems, which are a crucial component of communities residing close to forests, NTFPs provide a supportive role in livelihood and socioeconomic security [3]–[5]. Zaman *et al*. [6] reported that respondents at forest walking distance around forest edge communities collected NTFPs due to poverty, income generation, and personal interest in the area. His statistical findings also indicated that forest products like fruits, mushrooms, vegetables, and

medicinal plants are being extracted from the forests by the host communities.

Numerous essential ecosystem services help to regulate climate and provide food, medicines, biomass, water, habitats, forest species, and pollination [7]. Studies conducted by Suleiman *et al*. [8] found that communities close distance to Falgore Game forest often depend on the forest for medicinal herbs, fodder, fruit nuts, and firewood for household use and income generation. Furthermore, the distance to the nearest market from the respondent's home influenced the collection of NTFPS, which are primarily gathered for commercial purposes. They also reported that NTFPs extractions can be altered through the distance in kilometers (km) between the household and the forest. The longer the distance from home to forest the less likely the NTFPs can be extracted from the reserve.

Based on research findings by Maua and Harrison [9], 90% of the heads of the household extract NTFPs at a close distance, indicating how important the forest is to the nearest households. Similarly, Rahman *et al*. [10] reported that distances between home and forest have a negative effect on income from NTFPs. They also reported that the quantity of NTFPs collected declines with increasing distance between households and forests. Statistical analysis showed negative relationships to forest distance for NTFPs collections, while positive relationships exist between the amount of NTFPs collected and the time spent on NTFP collection. Additionally, Mujawamariya and Karimov [11] confirmed that communities near the forest normally rely on NTFPs than others residing far away from the forest who would have more challenges obtaining NTFPs because of high transportation expenses.

In order to ensure long-term sustainable forest management and conservation, it is crucial to comprehend the factors that influence the amount of NTFPs collected by households in relation to distance to the forest boundary [12], [13]. This knowledge can help planning, policy creation, and sustainable management practices in order to provide initiatives to lessen reliance on forests [14], [15]. An understanding of the level of NTFPs utilization and the relationship between the amount collected and the distance from households to the forest can help researchers, policymakers, and practitioners initiate actions to diversify households' livelihood portfolios. This promotes sustainable resource utilization in order to foster a balance between households close to the forest and those at a far distance from the forest [15], [16].

In the context of Kavonge and Museve hilltop forests in Kenya, understanding the relationship between the availability of NTFPs and the distance to the forest edge is crucial. These forests are vital resources for the surrounding communities, providing a range of NTFPs that support their livelihoods. However, the availability of these products can vary significantly with distance from the forest edge due to factors such as resource depletion near the edge, varying forest density, and differences in species distribution. In light of this, our study aimed at establishing the relationship between the amounts of NTFPs collected by households and the distance to the forest edge of Kavonge and Museve hilltop forests in Kitui county. The study was guided by the following three questions: (1) What types of NTFPs are collected in Kavonge and Museve hilltop forests? (2) What is the level of NTFPs collection in the last 30 years? (3) What is the relationship between availability of NTFPs and distance from the forest edge?

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in the local communities living around Kavonge and Museve hilltop forests in Kitui County. These hilltop forests are fragments located between latitude 1° 19′ 59″ S and longitude 38° 2′ 59″ E. Both are dry land forests covering an area of 436 ha [17]. The two hilltop forests are made of rock outcrops that rise above the normally low-lying sedimentary plains [18], [19]. Typically, there are two distinct rainy seasons every year-the long and the short rain seasons with an average annual rainfall of 750 mm to 1150 mm distributed in both rainy seasons. Its long rains seasons begin in late March until May, while the short rains season starts at the end of October till December. The temperature ranges from a minimum of 15.7 °C to a maximum of 27.1 °C annually. It varies throughout; during the day, the normal temperature is around 23 °C, and at night, it is around 17 °C. The dry season starts in July to August [20], [21]. The primary economic activities around these forests include raising livestock, growing crops, hunting, trading on traditional medicine, timber, firewood, building poles, and charcoal burning. The location of the two forests is shown in Fig. 1.

2.2. Data Collection

The study utilized both primary and secondary datasets. Key informant interviews, Focus group discussions, household survey questionnaires, and direct field observations were the methods used to gather the primary data. The relevant books, journals, and published papers in the field of study were used to gather the secondary data. This additional information was meant to identify knowledge gaps and assess earlier research in the field of study. A reconnaissance survey was carried out to obtain a fundamental understanding of the study area, pre-test research instruments, identify stakeholders, and give the researcher a clear general picture of the socio-economic activities, ethnicity, population size, and settlement patterns of the study area. The study area was purposively selected based on their closeness to the forest, while systematic sampling was used along transect lines 1 km apart and up to a 5 km distance from the forest edge for household selection. 5 km distance was considered the maximum distance from the forest edge where one can make trips to the forest to collect NTFPs (Fig. 2). In total, 120 households were sampled from the two hilltop forests using the Yamane formula [22].

2.3. Data Analysis

Data on the types of NTFPs collected were analyzed using percentages, frequencies, and tables. Interview data on the amount of NTFPs collected and distance from the forest were compared by use of linear regression to determine if there are positive relationships. The Kendall's

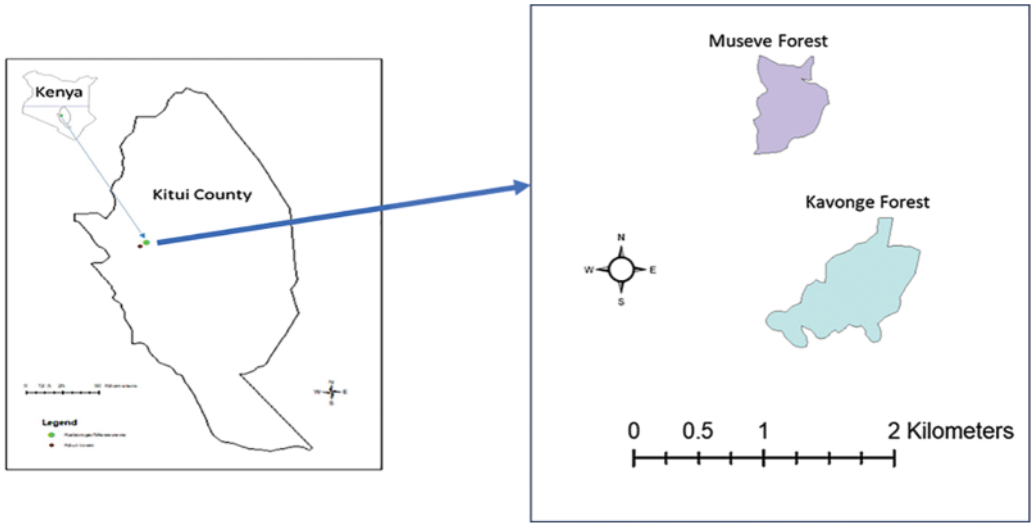

Fig. 1. Location of the Kavonge and Museve hilltop forests within Kitui County in Kenya.

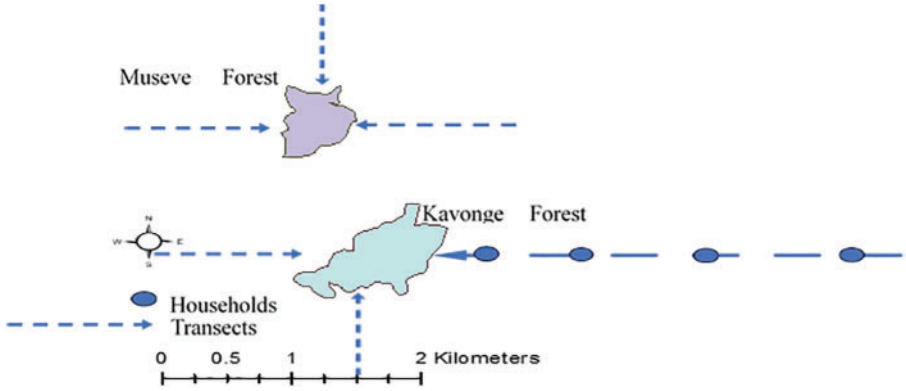

Fig. 2. Sampling design.

TABLE I: Types of NTFPs Collected

Types of NTFPs collected	% Response (n)
Wild fruits	66.7%
Wild vegetables	51.7%
Medicinal plants	62.0%
Wild mushrooms	80.0%
Fuel wood	64.0%
Charcoal	77.0%

TABLE II: Kendall Tau b Correlation on the Trends in the Amount of NTFPs Collected (kgs) for the Past 30 Years

		Year	Amount of NTFPs
Kendall's tau-b			−0.709**
	Sig. (1-tailed)	.	0.000
	N	30	30

Note: ** means the correlation is significant at the 0.05% level (1-tailed).

tau b correlation coefficient was used to determine the trends of NTFPs availability around the Kavonge and Museve hilltops forests for the past 30 years (1993–2023).

3. Results

3.1. *Types of NTFPS Collected*

The results indicate that different types of NTFPs were harvested in Kavonge and Museve hilltop forests by respondents. These included wild fruits, wild vegetables, medicinal plants, wild mushrooms, fuel wood, and charcoal (Table I).

3.2. *Trends of NTFPS Available in Kavonge and Museve Hilltop Forests in the Past 30 Years*

The Kendall tau b correlation results indicate an inverse strong negative correlation between the amount of NTFPs and time (years), which was statistically significant (tau b −0.709, p = 0.000). The negative value of tau b indicates a downward trend, signifying a consistent decrease in the amount of NTFPs collected over the years, as shown in Table II and Fig. 3.

3.3. *The Relationship between the Availability of NTFPS and the Distance to the Forest Edge*

The linear regression results found out that there was a significance relationship (p = 0.000, R^2 = 0.797, β = −893) between distance covered to the forest edge and the amount of NTFPs collected from Kavonge and Museve hilltop forests Table III and Fig. 4.

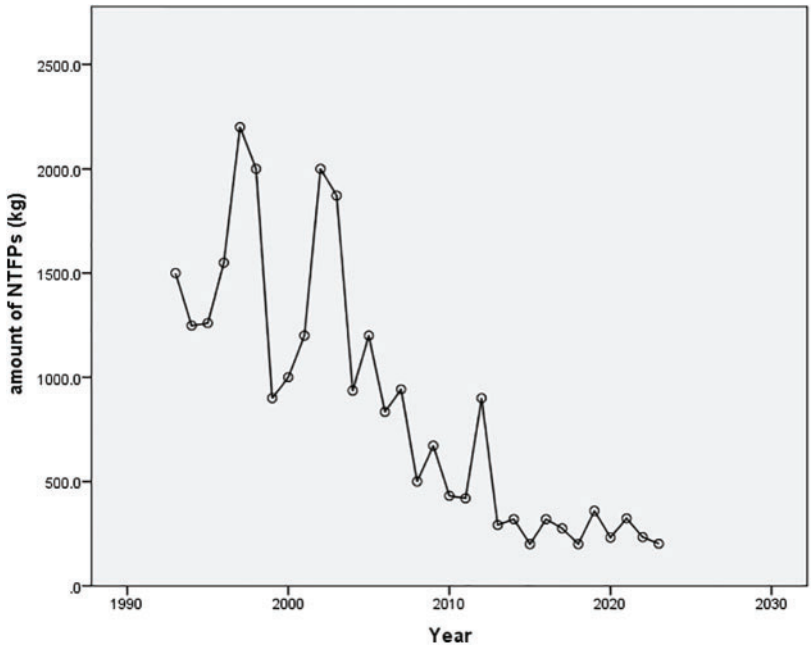

Fig. 3. Trends of the amount of NTFPs collected from Kavonge and Museve hilltops forests for the past 30 years.

TABLE III: Linear Regression Analysis on Availability of NTFPs and Distance to the Forest Edge

Model		Co-efficient				
		Unstandardized coefficients		Standardized coefficients		
		B	Std. Error	Beta	t	Sig
1	(Constant)	4.956	0.232	–	21.367	0.000
	Distance km	−0.004	0.000	−0.893	−9.293	0.000

Note: a. Dependent Variable: Amount of NTFPs.

4. Discussion

4.1. NTFPs Collected in Kavonge and Museve Hilltop Forests

The Kavonge and Museve hilltop forest edge communities rely on Non-Timber Forest Products (NTFPs) as essential resources, offering various benefits such as food, medicine, and energy. Utilizing NTFPs like wild fruits, wild vegetables, medicinal plants, wild mushrooms, fuel wood, and charcoal plays an essential function in the traditions and livelihoods of these communities. This analysis explores the percentages of collection and usage of these NTFPs, highlighting their significance and identifying potential areas for policy intervention and sustainable management. According to the findings, the respondents from the hilltop forests of Kavonge and Museve gathered a total of 6 distinct types of Non-Timber Forest Products (NTFPs). Among the NTFPS were charcoal, mushrooms, wild fruits, wild vegetables, fuel wood, and medicinal plants. These NTFPs were useful for producing income in addition to being consumed. Wild fruits are a vital source of nutrition and food security for forest-edge communities. The relatively high percentage indicates a strong reliance on wild fruits as part of the local diet. The collection of wild fruits helps diversify food sources and contributes to dietary health. It also offers potential economic benefits if surplus fruits are sold in local markets. The high percentage may be due to the presence of a variety of fruit species in the forest, the traditional understanding of fruit collection, and the seasonal abundance, all of which could contribute to the high collection rate. Ruffo *et al*. [23] found out that wild fruits of *Adansonia digitata* and *Ximenia caffra* contain higher vitamin C content than mango (*Mangifera indica*) or orange (*Citrus sinensis*).

Wild vegetables are another important food source, providing essential vitamins and minerals. The percentage reflects a moderate reliance on these resources. Its reliance supports food diversity and nutrition. However, it also indicates the need for sustainable harvesting practices to avoid overexploitation. The potential reasons for harvesting are the seasonal availability of vegetables, cultural preferences, and the presence of specific edible plant species that influence the collection rate. According to research by Mvungi [24], wild vegetables save the lives of thousands of impoverished people who reside in forest edge communities of Iringa, Dodoma, Singida, and Morogoro in Tanzania.

The medicinal plants play a crucial role in primary healthcare for forest edge communities. The high percentage highlights the importance of traditional medicine to forest edge communities of Kavonge and Museve hilltop forest areas. The use of medicinal plants underscores the need for conservation efforts to ensure these resources remain available. It also suggests the potential for developing sustainable medicinal plant markets. The rich traditional knowledge of herbal medicine, limited resources for modern healthcare, and the availability of diverse medicinal species in the forest contribute to it high usage in the study area. Mann *et al*. [25] reported that traditional medicines will continue to be a major source of healthcare for the majority of rural communities in developing countries.

In relation to NTFPs collections, the most often harvested was wild mushrooms used by respondents. Wild mushrooms are highly valued for their nutritional and

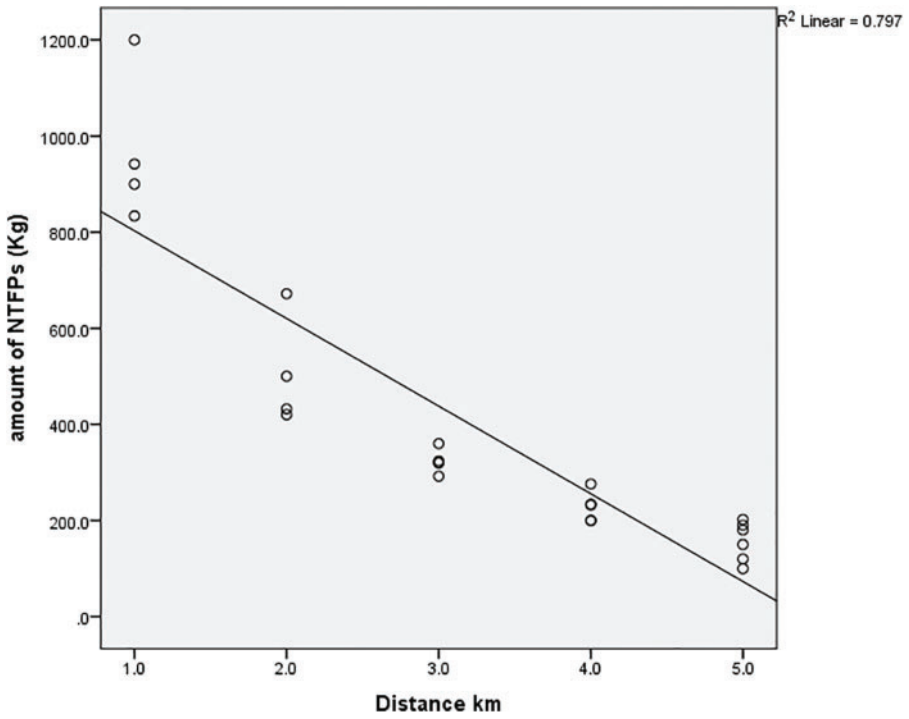

Fig. 4. Relationship between the amount of NTFPs and the distance to the forest edge.

culinary properties. Their high percentage in the collection indicates significant reliance on the resource by the locals in Kavonge and Museve hilltop forest areas. The high usage rate calls for careful management to prevent the depletion of mushroom populations. The abundance of mushroom species, favorable climatic conditions for mushroom growth, and cultural preferences for mushroom consumption drive this high collection rate in the study area. A similar study conducted in Western Kenya by Nandi and Palapala [26] reported that wild mushrooms are frequently used as a food source for nutritional needs, therapeutic uses, and life-span extension.

Fuel wood is a primary energy source used for cooking and heating by forest edge communities of Kavonge and Museve hilltop forests area. The high percentage reflects the substantial dependence of the households on this resource. This high reliance on traditional use of fuel wood contributes greatly to forest dependence in the study area, and this also poses challenges for forest conservation, as unsustainable fuel wood collection can lead to deforestation. It emphasizes the need for alternative energy sources and sustainable harvesting practices. The finding also reported that charcoal is another popular energy source, often used for cooking and heating around the Kavonge and Museve hilltop forest area. This high percentage of the collection indicates their strong reliance on charcoal production and use by these communities. The economic benefits include high energy efficiency, income generation from sales, and cultural practices that also influence the high usage rate. The result from this finding implies that the extensive use of charcoal raises concerns about forest degradation and carbon emissions. It highlights the need for sustainable charcoal production methods and alternative energy options for households around these forests. The result of this study agreed with Marry *et al*. [27], who reported that 72% of urban and 98% of rural families in sub-Saharan Africa get their energy from fuelwood. They further reported that charcoal dependence among Kenyans living in urban areas has increased by 64% over the last two decades.

4.2. Trends of NTFPS Available in Kavonge and Museve Hilltop Forests in the Past Last 30 Years

The correlation between the availability of NTFPs and the distance from the forest border is inconsistent with Maua and Harrison [9] who reported that 90% of the heads of the household extracts NTFPs at a close distance, indicating how important the forest was to the nearest households. Also, the results are in agreement with the widely accepted ecological premise that gradients in environmental variables, including distance from forest borders, frequently alter the ecological composition of forests, including the abundance of various NTFP-bearing species [28]. For the local communities reliant on these resources, the spatial distribution of NTFPs, as modified by proximity to the forest edge, has significant ramifications. NTFPs are easier to reach for those who live closer to the forest border by accessing dependable sources of income, food security, and livelihood.

The Kendall tau b correlation coefficient shows that the amount of NTFPs has been gradually decreasing in the last 30 years around the Kavonge and Museve hilltop forest areas. The continuous decline in NTFPs availability is probably caused by unpredictable rainfall and high-temperature intensity during the flowering seasons of NTFP species. Other factors causing the decline in NTFPs are population increase and their use of limited NTFP resources, economic and policy change, increase in commercialization of NTFPs, and increased knowledge on the value of NTFPs in present days as compared to the past decades. These results are in line with the findings of Shackleton and Shackleton [29], who found that people

are now more aware of how important NTFPs are to their livelihoods. For instance, wild foods significantly boost food security and nutrition, especially for the impoverished in rural areas. Moreover, a study by Hamza *et al*. [30] discovered that 80% of the nearby populations in the Migori Forest area gathered honey, wild fruits, and vegetables from the forest to assist in meeting their nutritional needs.

4.3. The Relationship between the Availability of NTFPS and the Distance to the Forest Edge

The results signify that the distance to the forest edge is inversely proportional to the quantity of available NTFPs collected by the household heads. The R-squared value indicates that approximately 79.7% of the variance in the amount of NTFPs collected is explained by the various distances covered in km from the regression model. This finding reported that a strong relationship exists between the distance to the forest and the amount of NTFPs collected, as a high proportion of the variability in the amount of NTFPs collected is accounted for by the model. The p-value indicates that the results are statistically significant, which means that there is strong evidence against the null hypothesis (which states that there is no effect or no relationship).

The regression coefficient (β) indicates the nature and magnitude of the relationship between the distance to NTFPs collection and the amount of NTFPs collected. The negative sign of the coefficient showed that there is an inverse relationship between the distance to NTFPs collection and the amount of NTFPs collected. As the distance to the forest increases by one unit, the amount of NTFPs is expected to decrease in units, holding all other factors constant. The absolute value of the coefficient represents the amount of change in the available NTFPs to a one-unit change in the distance to the forest.

The negative slope means an increase in distance by one leads to a decrease in the amount of NTFPs in the study area. It was observed that there are variations in quantities of NTFPs collected between household heads living within a distance of 1 km–3 km and those living within a distance of 4 km to 5 km away from the forest. The results are in agreement with Suleiman *et al*. [8], who expressed the expectation that the actual distance, expressed in km, between the home of the household heads and the forest, will have an impact on the number of NTFPs collected. Additionally, this suggests that the longer the distance of the household home from the forest, the less likely it is for NTFPs collection from the forest.

The results of this study clearly showed an inverse relationship between NTFPs availability and families' distance from the forest edge. Particularly, those who lived closer to the forest border discovered that NTFPs were noticeably more readily available and collected many times than those living a bit far from the forest. This is consistent with a study by Mujawamariya and Karimov [11], who observed that residents in the forest reserve had a greater reliance on forest resources compared to those living far from the forest. The study also agreed with Rahman *et al*. [10], who reported that increasing distance between households and forests negatively influenced available NTFPs and household income from NTFPs.

5. Conclusion and Recommendation

5.1. Conclusion

The percentages reflect a significant reliance on NTFPs for various needs, highlighting their critical role in the livelihoods of forest edge communities. Furthermore, promoting alternative energy sources and sustainable harvesting techniques can help balance the use of NTFPs with the need to preserve forest ecosystems.

The results indicated that a statistically significant relationship exists between the availability of NTFPs and the distance to the forest edge from households. The distance to the forest edge from the household head residence was among the key factors affecting the NTFPs availability and consumption in the study area. It was concluded that the longer the distance of the household home from the forest, the fewer NTFPs were collected from the hilltop forests. The trends in these NTFPs availability were clear from the findings that it has been gradually reducing in the past 30 years. The delicate social structure of the people living close to the Kavonge and Museve hilltops forest is significantly impacted by the decreasing supply in NTFPs. The study also concludes that the communities have developed a strong, mutually beneficial connection with NTFPs and have relied on them as the foundation of their way of life for many years. The strands of this link span a variety of aspects of everyday life, including nutrition, diversified sources of income, conventional medicine, and the preservation of cultural customs.

5.2. Actions and Recommendations

1. *Sustainable Management Practices:* Implement sustainable harvesting practices to ensure that NTFPs can regenerate and remain available for future generations.
2. *Conservation Efforts:* Strengthen conservation efforts to protect forests and their resources. This may involve creating protected areas, enforcing anti-deforestation laws, and promoting reforestation.
3. *Policy Interventions:* Develop and implement policies aimed at reducing deforestation, controlling overharvesting, and mitigating the impacts of climate change on forest ecosystems.
4. *Community Involvement:* Engage local communities in sustainable management practices and conservation efforts, as they often rely on NTFPs for their livelihoods.
5. *Further Research:* Conduct detailed research to identify specific drivers of the decline in NTFPs and to develop targeted strategies for addressing these issues.

Acknowledgment

My appreciation and sincere gratitude goes to the Program for the Protection of Forestry (PAPFoR), Conservation Society of Sierra Leone (CSSL), Birdlife International, and Royal Society for the Protection of Birds (RSPB) for providing the funds which give me the opportunity to pursue my postgraduate studies in Climate Change and Agroforestry.

I wish to also thank the Ministry of Environment and Climate Change in Sierra Leone, especially Mrs. Kate M. B. Garnet, the Director of Forestry Sierra Leone, and the entire Forestry staff of the Ministry, for giving me this kind opportunity of leaving my duty station to pursue my Master of Science degree study in Kenya.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

References

[1] Talukdar NR, Choudhury P, Barbhuiya RA, Singh B. Importance of non-timber forest products (NTFPs) in rural livelihood: a study in Patharia Hills Reserve Forest, Northeast India. *Trees, Forests People*. 2021;3:100042. doi: 10.1016/j.tfp.2020.100042.

[2] Gurung LJ, Miller KK, Venn S, Bryan BA. Climate change adaptation for managing non-timber forest products in the Nepalese Himalaya. *Sci Total Environ*. 2021;796:148853.

[3] Shanker, *et al.* Livelihood gains and ecological costs of NTFP dependence: assessing the roles of dependence, ecological knowledge and market structure in three contrasting human and ecological settings in South India Germany. 2004.

[4] Magry MA, Cahill D, Rookes J, Narula SA. An integrated value chain analysis of non-timber forest products: a case of Jharkhand state of India. *Small-Scale For*. 2022:1–25.

[5] Yadav S, Bhattacharya P, Areendran G, Sahana M, Raj K, Sajjad H. Predicting impact of climate change on geographical distribution of major NTFP species in the Central India Region. *Model Earth Syst Environ*. 2022;8(1):449–68. doi: 10.1007/s40808-020-01074-4.

[6] Zaman M, Jabeen A, Shabbir R. Collection of Non Timber Forest Products (NTFPs) and their contribution to sustainable rural livelihoods in selected areas around Ayubia National Park, Pakistan. *Role Non Timber For Prod Livelihood*. 2023:1–24.

[7] Geijzendorffer IR, Cohen SE, Cord AF, Cramer W, Guerra C, Martín LB. Ecosystem services in global sustainability policies. *Environ Sci Policy*. 2017;74:40–8.

[8] Suleiman MS, Wasonga VO, Mbau JS, Suleiman A, Elhadi YA. Non-timber forest products and their contribution to households' income around Falgore Game Reserve in Kano, Nigeria. *Ecol Processes*. 2017;6(1):23. doi: 10.1186/s13717-017-0090-8.

[9] Maua JO, Harrison M. Species diversity and utilization of non-timber forest products (NTFPs) by households adjacent to South Nandi Forest, Kenya. 2018b. pp. 16.

[10] Rahman MH, Roy B, Islam MS. Contribution of non-timber forest products to the livelihoods of the forest-dependent communities around the Khadimnagar national park in Northeastern Bangladesh. *Reg Sustainability*. 2021;2:280–95.

[11] Mujawamariya G, Karimov AA. Importance of socioeconomic factors in the collection of NTFPs: the case of gum Arabic in Kenya. *For Pol Econ*. 2014;42:24–9.

[12] Gunatilake H. The role of rural development in protecting tropical rainforests: evidence from Sri Lanka. *J Environ Manage*. 1998;53(3):273–92.

[13] Hegde R, Enters T. Forest products and household economy: a case study from Mudumalai Wildlife Sanctuary, Southern India. *Environ Conserv*. 2000;27(3):250–9.

[14] Babulo B, Muys B, Nega F, Tollens E, Nyssen J, Deckers J, *et al.* Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. *Agric Syst*. 2008;98(2):147–55.

[15] Dagm F, Wubalem T, Abdella G. Economic contribution to local livelihoods and households dependency on dry land forest products in Hammer District, Southeastern Ethiopia. *Int J For Res*. 2016;11:1–11.

[16] Baiyegunhi LJS, Oppong BB, Senyolo MG. Socio-economic factors influencing mopane worm (Imbrasia belina) harvesting in Limpopo Province, South Africa. *J For Res*. 2016;27(2):443–52.

[17] KFS. National forest resource mapping and capacity development for the Republic of Kenya. In *Forest Preservation Programme, Report No. KEF09/11494/01*. Nairobi: Kenya Forest Service, 2013.

[18] MENR BTC. *Kitui District Forestry Master Plan*. Nairobi: Government Printer; 1994.

[19] MoA. *Farm Management Handbook of Kenya Vol. II – Part C Natural Conditions and Farm Management Information*. East Kenya (Eastern and Coast provinces), Nairobi; 1983.

[20] Jaetzold R, Schmidt H, Hornetz B, Shisanya C. *Farm Management Handbook of Kenya, Vol II. Natural Conditions and Farm Management Information. Part C. East Kenya*. Nairobi, Kenya: Ministry of Agriculture; 2006.

[21] Corbett JD. Classifying maize production zones in Kenya through multivariate cluster analysis. In *Maize Technology Development and Transfer: A GIS Application for Research Planning in Kenya*. Hassan RM Ed. Wallingford: CAB International, 1998, pp. 15–25.

[22] Yamane T. *Statistics: An Introductory Analysis*. New York: Harper & Row; 1967. Temu RPC, Andrew SM. Endemism of plants in Uluguru Mountains. *For Ecol Manage*. 2008;255(7):2858–69.

[23] Ruffo CK, Birnie A, Tengnäs B. *Edible Wild Plants of Tanzania*. Nairobi, Kenya: Regional Land Management Unit, SIDA; 2002, pp. 766.

[24] Mvungi E. Iringa residents are living on wild vegetables. In *Mtanzania (A Tanzanian) Newspaper P1*; 2001 Jun 21.

[25] Mann A, Amupitan JO, Oyewale AO, Okogun JI, Ibrahim K, Oladosu P, *et al.* Evaluation of in vitro antimycobacterial activity of Nigerian plants used for treatment of respiratory diseases. *Afr J Biotechnol*. 2008;7(11):1630–6.

[26] Nandi OMJ, Palapala VA. Social-cultural uses of wild wood ear mushrooms of Western Kenya. 2009. Available from: http://erepo.usiu.ac.ke/11732/5865.

[27] Mary N, Nancy K, Cristel M, Miyuki I, Henry N, Jacob K, *et al.* Charcoal production and strategies to enhance its sustainability in Kenya. *Dev Pract*. 2013;23(3):359–71. doi: 10.1080/09614524.2013.780529.

[28] Turner W. Free and open-access satellite data are key to biodiversity conservation. *Biol Conserv*. 2015;173:173–6.

[29] Shackleton C, Shackleton S. The importance of non-timber forest products in rural livelihood security and as safety nets: a review of evidence from South Africa. *J Sci 100 South Afr*. 2004;658–64.

[30] Hamza KFS, Njogoya J, Msalilwa U, Kitula RA. Contribution of medicinal plants to the health of communities living around Mgori forest in Singida. *Tanz J Tazanian Assoc For*. 2004;10:72–9.