RESEARCH PAPER

Determinants of tree resource consumption around Mont Sangbé national park in western Côte d'Ivoire

Kouamé Christophe Koffi[*1], Serge Cherry Piba[1], Kouakou Hilaire Bohoussou[1],

Naomie Ouffoue[1], Alex Beda[2]

[1] *University of Man, Department of Agronomy, Forestry, and Environmental Engineering, Man, Côte d'Ivoire*

[2] *Ivorian Office of Parks and Reserves, Man, Man, Côte d'Ivoire*

ABSTRACT

Tropical forests constitute essential resources for rural communities in sub-Saharan Africa, providing food, traditional medicine, fuelwood, and income. Nonetheless, their sustainability is increasingly compromised by factors such as population growth, poverty, deforestation, and access restrictions associated with conservation policies. In the proximity of Mont Sangbé National Park in Côte d'Ivoire, food tree species play a crucial role in ensuring household food security and resilience. This research aims to investigate how household socioeconomic, demographic, and environmental characteristics influence tree resource consumption practices. Data were gathered through a survey of 120 households across three villages, with a focus on the types of species consumed, the parts utilized, and the levels of consumption. A mixed typological approach, integrating factorial analyses (PCA and MCA) and hierarchical clustering, identified three distinct household profiles based on their social integration, access to resources, and proximity to the park. Floristic analysis disclosed a notable diversity of species, predominantly dominated by the Fabaceae and Anacardiaceae families. Fruits emerged as the most consumed parts, followed by leaves and seeds, with a marked preference for versatile species such as *Parkia biglobosa* and *Adansonia digitata*. Although Pearson's correlation analysis did not disclose a significant relationship between frequency of use and intensity of consumption, multiple linear regression analysis identified key determining factors, including distance to the park, land reserves, and the possession of durable goods. These findings underscore the importance of incorporating social dimensions into sustainable forest resource management policies.

*Corresponding Author: Kouamé Christophe Koffi ✉ christophe.koffi@univ-man.edu.ci

* https://orcid.org/0009-0008-8516-1781

INTRODUCTION

Tropical forests are indispensable to the sustenance of rural communities, particularly within sub-Saharan Africa, where they provide an array of essential commodities, including food, medicinal products, fuelwood, and construction materials (Shimizu, 2006; Wunder *et al.*, 2014).

As reported by the World Bank Group (2002), over 1.6 billion individuals globally rely upon forests, encompassing 60 million people who are members of indigenous communities.

In Africa, non-timber forest products (NTFPs) are instrumental as sources of income and food security for numerous rural households (Schreckenberg, 2004). Current research signifies that forest resources continue to be pivotal to the livelihood strategies of rural populations, particularly during periods of crisis or food scarcity (Torimiro *et al.*, 2025). These resources serve both as direct consumables, such as food and traditional healthcare, and as income generators through the sale of commodities like fuelwood, charcoal, fruits, seeds, and medicinal plants.

Approximately 15 million individuals in sub-Saharan Africa depend on forest-related activities as their primary income source, alongside the substantial number of indirect employment opportunities generated in the forestry sector (Torimiro *et al.*, 2025). Nonetheless, the viability of these resources is increasingly jeopardized by factors such as population growth, enduring poverty, deforestation, climate change, and access limitations enforced by conservation policies within protected areas (Chirwa *et al.*, 2024). While such restrictions are imperative for biodiversity preservation, they may endanger the livelihoods of local communities unless alternative access or compensation mechanisms are instituted. Within this framework, it is crucial to comprehend the interactions between local populations and forest resources, specifically tree food species, to inform sustainable forest management policies that embrace more inclusive and equitable methodologies.

Around Mont Sangbé National Park (MSNP) in Côte d'Ivoire, local communities extensively depend on tree food species to enhance their diets, diversify their income streams, and fortify their resilience amidst economic and climatic variabilities. However, the intricacies surrounding these resource utilizations remain inadequately documented, particularly in relation to the socioeconomic, environmental, and demographic factors influencing consumption practices.

As access restrictions persist, it becomes imperative to understand how household characteristics influence interactions with tree resources. This understanding is vital to determine measures that advance sustainable and equitable forest management. Consequently, a fundamental question emerges: To what extent do the socioeconomic, demographic, and environmental attributes of local households affect their tree resource consumption practices in a context of restrictive conservation? Addressing this inquiry is essential to achieve equilibrium between the preservation of forest ecosystems and the fulfillment of the foundational needs of local populations, as well as for the development of public policies that endorse integrated and participatory management of natural resources.

The primary objective of this study is to examine the interrelations between the socioeconomic and environmental profiles of households residing near Mont Sangbé National Park (MSNP) and their tree resource consumption practices. Specifically, the study aims to delineate the socioeconomic, demographic, and environmental conditions of households surrounding the MSNP, identify the most prevalently consumed tree food species and their respective components, evaluate the levels of household consumption of these resources, and ultimately analyze the socioeconomic and environmental factors that shape these consumption practices.

MATERIALS AND METHODS

Study area

The research was undertaken from February to April 2022 in three villages adjacent to the MSNP: Toulô, Sorotonan, and Kokialo (Fig. 1). Situated in the western region of Côte d'Ivoire, the MSNP was initially designated as a protected forest before its reclassification as a national park in 1976. The park spans an area of 95,000 acres and is geographically located between longitudes 73° and 75° east and latitudes 32° and 35° north. Encompassing the departments of Biankouma, Touba, and Séguéla,

the park is characterized by a diverse array of ecosystems, including savannahs, gallery forests, and semi-deciduous rainforests. It supports a rich floristic diversity, featuring species such as *Aubrevillea kerstingii*, *Khaya grandifoliola*, *Pseudospondias microcarpa*, *Hallea stipulosa*, *Nauclea zanthoxylon*, and *Raphia sudanica* (Poilecot, 2001). The climate of the region is typified by an annual average of 70 to 100 days of rainfall, with an average temperature of 25°C and a relative humidity of approximately 75% (Ndabalishye, 1995; Poilecot, 2001).
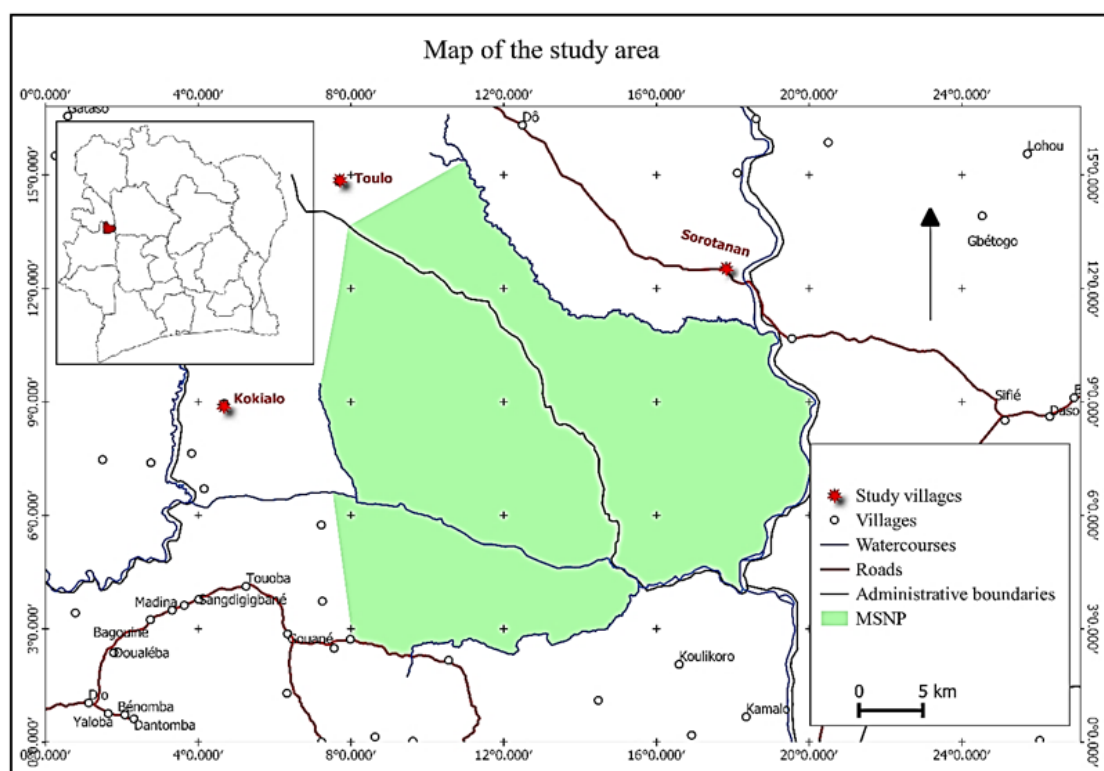

Fig. 1. Location map of the study area

Data collection

A survey was conducted involving 120 households, distributed equally across three villages. The heads of these households or their spouses engaged in semi-structured interviews, which were facilitated by ecologists from the Ivorian Office of Parks and Reserves (OIPR). These ecologists also provided assistance with translating and identifying botanical species in both local languages and scientific nomenclature. All participants were farmers, and informed consent was obtained prior to conducting

each interview. The primary focus of the data collection was on tree species utilized for food. For each species identified, households were allocated a consumption score based on a frequency scale from 1 to 3, where 1 denotes rare consumption, 2 denotes moderate consumption, and 3 denotes frequent consumption. Respondents were also asked to specify which parts of the tree were consumed. Species identification adhered to the Flora of Arbonier (2009) and Hawthorne (2006). The collected data were processed and analyzed using R software, version 4.2.0.

Ecological determinants and the socioeconomic status of households

The analysis incorporated a variety of environmental factors, including the distance to the national park, which signifies the proximity of households to forest resources, and the availability of land reserves, indicative of areas of old fallow land. The assessment of socioeconomic characteristics encompassed variables such as the age and educational attainment of the household head, alongside their affiliation with various associations (Esperon-Rodriguez *et al.*, 2025; Olunga, 2013). The evaluation of housing structure employed indicators such as the type of roofing materials, either metal or straw, and the wall materials, either concrete or mud, each serving as a reflection of living standards. Additionally, the ownership of assets such as automobiles, motorcycles, bicycles, and televisions was considered to comprehend the impact of mobility and material comfort on reliance upon tree resources for consumption (Rao and Min, 2018). This comprehensive approach facilitated an exploration of the ecological and socioeconomic factors that govern the utilization of tree resources for consumption.

Statistical analysis

Approach for formulating household typologies

To delineate the socioeconomic profiles of households situated in proximity to the national park, a mixed typological approach was implemented, integrating factorial analysis methodologies on both quantitative and qualitative datasets, followed by hierarchical classification (Eshetae *et al.*, 2024; Husson *et al.*, 2010). Initially, quantitative variables present in the database—such as household size, distance to the national park, age of the household head, cultivated area, and land reserve in the form of old fallow land—were subjected to Principal Component Analysis (PCA).

This procedure aimed to reduce the dimensionality of the numerical data while preserving the majority of its variability. Simultaneously, qualitative variables (including education level, types of building materials, household equipment, and association affiliations) were incorporated into a Multiple Correspondence Analysis (MCA) (Greenacre, 2017). This integration facilitated the exploration of relational structures among the modalities, projecting the households into a factorial space composed exclusively of categorical variables. The coordinates derived from both the PCA and the MCA (factorial axes selected based on cumulative inertia percentages and quality of representation) were thereafter consolidated to form a comprehensive matrix of individuals. This matrix served as the basis for a Hierarchical Classification of Principal Components (HPC) using Ward's method (Husson *et al.*, 2010). The objective was to cluster households according to their multivariate similarities, considering their socioeconomic structure, level of amenities, access to the park, and land resources. This integrated approach facilitated the development of a robust and interpretable typology of households, thereby enhancing the analysis of the dynamics between local populations and the arboreal resources of the national park.

Correlation of Pearson

This research investigates the association between the quantity of households consuming a particular tree species and the aggregate level of consumption of that species. To achieve this, the study utilized the Pearson's correlation coefficient, which is a statistical approach designed to evaluate the strength and direction of the linear relationship between two quantitative variables (Artusi *et al.*, 2002). The objective was to ascertain whether tree species preferred by a larger number of households also demonstrate elevated levels of consumption. The fundamental hypothesis of this analysis suggests that the popularity of a tree species (as evidenced by the number of households consuming it) could be positively correlated with the intensity of its utilization. A positive and statistically significant correlation would substantiate the concept that certain tree species are crucial to local food practices, influencing both the frequency and volume of consumption. Consequently, this analysis augments our comprehension of the dynamics of tree resource

use and aids in identifying the most strategic species to ensure food security within local communities.

Multiple linear regression

A multiple linear regression analysis, as per the methodology outlined by Deressa *et al.* (2009), was undertaken to ascertain the determinants influencing household consumption of tree resources in the area surrounding Mount Sangbé National Park. The dependent variable, indicative of the consumption level of tree resources, was modelled utilizing a spectrum of explanatory variables, encompassing ecological factors and the socioeconomic conditions of the households. To optimize the selection of explanatory variables for the regression model, an automated statistical procedure termed the stepwise selection method (Anderson and Burnham, 2004) was employed. This method encompasses both progressive inclusion (forward selection) and successive elimination (backward elimination) of variables, meticulously assessing the statistical significance of each variable's impact on the overall model quality at every juncture.

The objective was to maintain only those variables that bore significant explanatory power concerning the dependent variable. Specifically, the algorithm scrutinizes the addition or exclusion of each variable based on criteria such as the *p*-value and the Akaike Information Criterion (AIC) (Zuur *et al.*, 2007). Retention is limited to those variables whose inclusion markedly enhances the performance of the model. This methodology not only mitigates issues of overparameterization but also aids in the development of a more parsimonious model, while optimizing its explanatory efficacy. Through the automation of the selection process, the stepwise method ensures impartiality in the identification of the most pertinent variables for modelling tree resource consumption.

RESULTS

The socioeconomic characteristics of households surrounding MSNP

Factorial analysis (Fig. 2) demonstrates that the initial two dimensions explain 35% and 19.1% of the

total inertia, respectively, culminating in an aggregate 54.1% of the variability. This substantial proportion substantiates the representation of the two-dimensional factor space as an accurate depiction of household profile structuration. The projection of individuals onto this plane distinctly classifies three groups, each characterized by unique socioeconomic and spatial attributes, which disclose contrasting dynamics of social integration, resource accessibility, and proximity to the park. The first group (Cluster 1), comprising 43.4% of the sample, is typified by large households (frequently with 10 or more members) characterized by low literacy levels, residing in precarious housing (constructed with mud walls and straw roofs), possessing few or no amenities, exhibiting limited associative integration, and being situated proximate to the park (within 4.1 km). This proximity predisposes them to a heightened risk of resource extraction.

Fig. 2. Profile typologies reflecting the dynamics of tree resource consumption

The second group (Cluster 2), encompassing 33.6% of households, is typified by an average size (5 to 9 members) and is distinguished by primary education levels, varied housing conditions, moderate amenities, and an intermediate land reserve. The third group (Cluster 3), representing 23.0% of households, encompasses smaller domestic units (6 or fewer members) that are better educated (ranging from high primary to secondary education), well-equipped (with amenities such as a TV, motorbike, or even a car), possess a significant land reserve, and are located at a greater distance from the park (at least 8 km). This cluster exemplifies a more advantageous socioeconomic status.

Diversity and composition of tree species consumed for food by local households

The study area demonstrates a significant degree of plant biodiversity, with a total of 27 species distributed across 23 genera within 18 botanical families, notably featuring tree species utilized for nutritional purposes (Fig. 3). Predominantly, the Fabaceae and Anacardiaceae families are the most frequently observed, each encompassing four species, whereas the Apocynaceae family includes three species. Together, the Fabaceae and Anacardiaceae families contribute approximately 14.8% of the species total, while the Apocynaceae accounts for about 11.1%. The remaining families are each represented by a singular species, illustrating an extensive yet not excessively redundant range of taxonomic diversity.
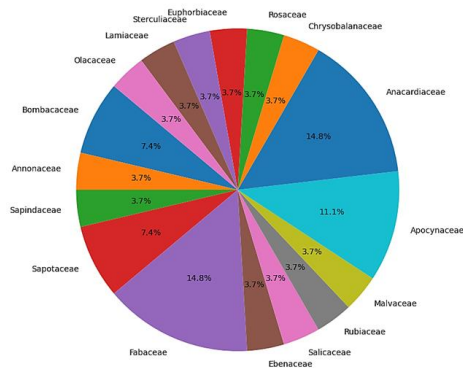

Fig. 3. Taxonomic composition of edible tree species

Patterns and practices of tree species consumption among rural households

The utilization of tree resources by households in the vicinity of Mont Sangbé National Park reveals a profound dependence on particular tree species, primarily for their fruits, leaves, and seeds (Fig. 4). Fruits represent the most extensively consumed category, with approximately 62% of households partaking in their use. Predominant species include *Parkia biglobosa* (utilized by 109 households), *Adansonia digitata* (78 households), and *Saba senegalensis* (50 households), attributable to their plentiful availability. Leaves, notably those from the baobab (*Adansonia digitata*), are extensively

employed, with approximately 19% of households utilizing them predominantly for sauce preparation. Seeds primarily originate from *Parkia biglobosa* (109 households) and *Ricinodendron heudelotii* (12 households), serving as flavoring agents. This distribution pattern highlights a preference for versatile and well-regarded species. Furthermore, thirteen species were employed by a limited number of households (ranging from 1 to 3), which may indicate restricted local availability or a lesser degree of cultural importance.
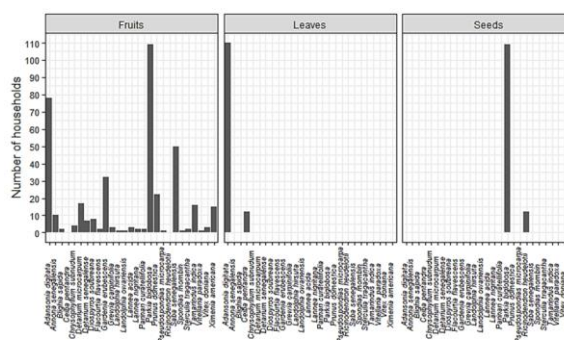
Fig. 4. Household consumption patterns of tree species around MSNP

Quantifying the consumption intensity of forest tree resources

Fig. 5 presents a comprehensive visualization of household consumption preferences for various tree parts (fruits, leaves, seeds) surrounding Mont Sangbé National Park, categorizing them into three consumption levels: low, medium, and high. An examination of the figure reveals that the majority of species are consumed at a low level, including popular varieties such as *Parkia biglobosa* and *Adansonia digitata*, which suggests widespread, albeit not particularly intensive, consumption. Certain species display a medium level of consumption, indicating regular usage that is not predominant; for instance, *Adansonia digitata* is utilized for its leaves (9 households) and fruits (36), while *Parkia biglobosa* is consumed for its fruits (46) and seeds (55). Other species, including *Ximenia americana* (2), *Ceiba pentandra* (3), and *Gardenia erubescens* (2), also demonstrate medium consumption levels for their fruits or leaves. In contrast, only a few species attain

high consumption levels, indicating a strong preference among some households for multipurpose species such as *Parkia biglobosa* (seeds: 24 households; fruits: 8) and *Adansonia digitata* (leaves: 6). Fruits emerge as the most commonly consumed part, albeit chiefly at a low level, while leaves show a more balanced distribution across consumption levels, with *Adansonia digitata* reaching a high level. Seeds, particularly those from *Parkia biglobosa*, exhibit significant consumption, occasionally high, due to their use as a local condiment (soumbala). Statistical analysis indicates that the number of households utilizing a species does not correlate with the consumption level (r = 0.0379; *p* = 0.8186), suggesting that the popularity of a species, as measured by the number of households, does not necessarily equate to more intensive consumption. This absence of a statistically significant linear relationship implies that other factors may exert a greater influence on consumption levels.

Fig. 5. Household consumption intensity of tree parts around MSNP

Factors and determinants of household tree resource consumption

The assessment of the regression model demonstrates a relatively strong explanatory capacity (Table 1). The coefficient of determination (R^2 = 0.5557) signifies that the model accounts for approximately 55.57% of the observed variability in consumption. This extent of performance implies that more than half of the variations in the dependent variable can be attributed to the explanatory variables integrated within the model, indicating a reliable fit. Additionally, the statistical significance of the model is corroborated by

an overall *p*-value of less than 0.001, indicating a highly significant relationship between explanatory variables and consumption. The residual standard error, calculated at 2.658, suggests a moderate dispersion of the observed values around the predicted values, indicating an acceptable level of model accuracy.

The analysis of the linear regression model investigating the factors affecting tree resource consumption around Mount Sangbé National Park (Table 1) uncovers several significant determinants. The model comprises five explanatory variables: distance to the forest, land reserves, and ownership of a metal roof, a motorcycle, and a television. The intercept of the model, estimated at 13.02, represents the average expected tree resource consumption in the absence of any explanatory variables. Among the most influential factors, the distance to the forest exhibits a pronounced negative effect (β = -0.87, *p* < 0.001), indicating that households located further from the park tend to consume fewer tree resources. This observation suggests a strong reliance of households proximate to the park on accessible tree resources, particularly for food, thereby emphasizing the vital role of the park's proximity in ensuring local food security.

Additional socioeconomic variables also influence tree resource consumption. Land reserves display a moderate positive effect (β = 0.10, *p* = 0.0315), implying that old fallow land functions as a supplementary source of tree resources. Conversely, ownership of a motorcycle (β = -3.99, *p* < 0.001) and a television (β = -1.66, *p* = 0.0163) is associated with a significant reduction in tree resource consumption. These findings can be construed as indicators of a lifestyle shift: households possessing these commodities appear less dependent on tree resources for their consumption, likely due to enhanced access to alternative sources. Consequently, the model underscores a dynamic of socioeconomic transition, wherein the ownership of household equipment acts as a factor contributing to the gradual reduction in tree resource consumption.

Table 1. Determinants of tree resource consumption around MSNP: insights from a multiple linear regression model

Variables	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	13.01845	0.90464	14.391	< 2e-16	***
Distance from the MSNP	-0.86603	0.12312	-7.034	1.50e-10	***
Land reserve	0.10282	0.04723	2.177	0.0315	*
Metal roof	1.21095	0.63368	1.911	0.0985	.
Owning motorcycle	-3.99305	0.56593	-7.056	1.34e-10	***
Owning TV	-1.66253	0.68200	-2.438	0.0163	*
Signif. codes	: 0 '***	' 0.001 '**	' 0.01 '	*' 0.05 '	.' 0.1 ' ' 1

Residual standard error: 2.658 on 116 degrees of freedom
Multiple R-squared: 0.5557,   Adjusted R-squared: 0.5323
F-statistic: 19.43 on 5 and 116 DF, *p*-value: 5.169e-14

DISCUSSION

The findings of this study underscore the pronounced socioeconomic diversity among households residing in proximity to Mont Sangbé National Park, which considerably influences their patterns of tree resource consumption. Factorial analysis has identified three distinct groups, exhibiting clear gradients of vulnerability, resource access, and socioeconomic transition. This segmentation is congruent with other research conducted in sub-Saharan Africa, where variables such as proximity to forests, household size, and education level are principal determinants of reliance on natural resources (Maja and Ayano, 2021). The first group, consisting of large households with low literacy levels situated near the park, exhibits a high dependence on tree resources. This corresponds with well-documented dynamics in the literature, suggesting that the most vulnerable populations—often marginalized from formal economic channels—resort to natural resources for their livelihoods (Angelsen *et al.*, 2014; Shackleton *et al.*, 2001). The geographical proximity to the park presents both opportunities and pressures on local ecosystems. Although the diversity of consumed species is relatively high, it is predominantly characterized by a few key species, including *Parkia biglobosa* and *Adansonia digitata*, which are valued for their versatility and nutritional benefits. This preference for multipurpose species mirrors trends observed in other West African contexts, where food trees play an essential role in the food security of rural households (Lykke *et al.*, 2004). Overall consumption intensity remains low, influenced by factors such as seasonal availability, access constraints, and cultural practices.

The absence of a correlation between the frequency of a species' use and its consumption levels indicates that other variables, particularly economic and logistical factors, significantly influence actual consumption volumes. Analysis of the determinants of consumption underscores the pivotal role of distance from the park as a critical factor; households located at a greater distance from the park tend to utilize fewer forest resources. This finding is consistent with observations in other protected areas in Africa, where physical accessibility significantly affects resource exploitation (Pouliot *et al.*, 2012). Additionally, the ownership of durable goods, such as televisions and motorcycles, correlates with a diminished dependence on natural resources, reflecting a shift towards lifestyles that are less reliant on them, as noted in the studies of Cavendish (2000) and Babulo *et al.* (2009). Furthermore, the presence of land reserves, particularly old fallow land, appears to enhance access to alternative resources, thereby alleviating direct pressure on protected forests. This observation resonates with the conclusions of Maja and Ayano (2021), which emphasize the role of agricultural land in bolstering household resilience to environmental constraints.

CONCLUSION

This investigation underscores the complex interaction between household socioeconomic attributes and the practices of forest resource consumption in proximity to Mont Sangbé National Park. Utilizing factorial analysis, three distinct household typologies were discerned, exhibiting diverse dynamics concerning resource access, economic vulnerability, and proximity to the park.

These typologies influence not only the diversity of tree species utilized but also the intensity and modalities of their exploitation. The findings suggest that while certain species, such as *Parkia biglobosa* and *Adansonia digitata*, are broadly recognized and used, their consumption typically remains moderate. This implies a cautious or limited approach to the exploitation of available resources. Furthermore, the lack of correlation between usage frequency and consumption levels highlights the importance of contextual factors, including accessibility, cultural preferences, and livelihood strategies. The regression model identifies critical determinants of consumption, such as distance from the park, land availability, and ownership of durable goods, all of which suggest a gradual transition towards lifestyles less dependent on forest resources. These findings highlight the imperative for the differentiated and equitable management of natural resources that considers the social and economic realities of local communities. Ultimately, this research emphasizes the necessity for conservation policies that surpass the rigid protection of ecosystems to also consider the needs and paths of local populations. An integrated approach is essential for reconciling ecological sustainability with social justice in protected areas of West Africa.

ACKNOWLEDGEMENTS

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