




Unlocking pathways to livelihood improvement through valuation of ecosystem services in Kakamega Forest, Kenya

Erick O. Osewe^{a,c,*} , Bogdan Popa^a, Harald Vacik^c , Joram K. Kagombe^b, Ibrahim Osewe^a , Ioan Vasile Abrudan^a

^a Faculty of Silviculture and Forest Engineering, Transilvania University of Brasov, Sirul Beethoven 1, 500123 Brasov, Romania

^b Kenya Forestry Research Institute, P.O. Box 20412-00200 Nairobi, Kenya

^c Institute of Silviculture, University of Natural Resources and Life Sciences, Peter-4 Jordan-Strasse 82, A-1190 Vienna, Austria

ARTICLE INFO

Keywords:

Ecosystem Services
Economic Valuation
Payment for Ecosystems
Livelihoods
Forest Dependency and Kakamega Forest
Ecosystem

ABSTRACT

Overdependence on tropical forest ecosystems in the Global South continues to drive deforestation and environmental degradation. The non-conformity of ecosystem service (ES) values with conventional economic models limits effective resource management policies. ES valuation provides comparable metrics for the economic inclusion of natural capital in decision-making for livelihood improvement. This research assessed how forest dependent communities derive economic and cultural value from Kakamega Forest Ecosystem (KFE) in Kenya by (i) identifying the most frequently used forest products, (ii) evaluating the contribution of foraged forest products to local livelihoods, and (iii) determining their perceptions and willingness to pay (WTP) for cultural ES. This research used survey methods to collect primary data by distributing mixed-format questionnaires to 631 households across five sub-counties bordering KFE. Statistical analyses of collected data were conducted in R studio. Firewood at 49% was the most frequently used forest product of the total foraged products. The total annual monetary valuation for tangible ES was US\$ 283,362, which comprised vines (*Mondia whitei*) at US\$ 74,786, firewood at US\$ 73,513, fruits (*Persea americana*) at US\$ 72,860, medicinal plants US\$ 39,320, timber US\$ 12,801, and mushrooms (*Auricularia auricula-judae*) at US\$ 8015. For the intangible ES, 93% of the respondents had WTP within the price range of US\$ 0.55 to US\$ 2.17 with an average of 70% positive perceptions expressed for cultural ES at forest sacred groves. The findings on both economic and cultural dependencies on KFE enabled Payment for Ecosystem Services (PES) scenarios in livelihood improvement. This research recommends PES schemes and socially inclusive interventions for sustainable forest management.

1. Introduction

Tropical forest ecosystems have critical ecological functions for the maintenance of global biodiversity (Pillay et al., 2022) and provide essential ecosystem services (ES): forest products like wood or environmental services, such as climate regulation through carbon sequestration (Psistaki et al., 2024). Communities adjacent to tropical forests often directly rely on the provisioning ES – wood-based products, namely wood fuel, timber, and non-timber products which include water supply for sustenance of daily needs (Dawson et al. 2021). Within tropical regions in Southeast Asia, South America and Africa, the ES associated with forest biodiversity are often jeopardized for short-term gains like timber extraction and conversion of forest land for agriculture, overlooking their long-term negative impacts on forest ecosystems

and the effect on global climate conditions (Artaxo et al. 2022). Although conservation efforts at international levels often advocate for the protection of unique and endangered species (Betts et al. 2020), the demand for forest products to cater for immediate needs is prioritized by communities at local levels (Haji et al., 2021).

In Africa, socio-economic dynamics related to household income levels among forest fringe communities have been cited as a precursor to the increasing rate of forest resource extraction for subsistence (Nugroho et al. 2022), and commercial purposes (Chama et al. 2023a). For instance, Lepetu et al. (2009) established that the level of forest dependence in Botswana among the rural communities was associated with household incomes. In Ethiopia's Tigray region, livelihood assets associated with household economic activities substantially impacted reliance on forest resources (Babulo et al. 2008). Furthermore,

* Corresponding author.

E-mail address: erick.osewe@unitbv.ro (E.O. Osewe).

<https://doi.org/10.1016/j.tfp.2025.101031>

Available online 28 September 2025

2666-7193/© 2025 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY-NC license (<http://creativecommons.org/licenses/by-nc/4.0/>).

international market demand for timber and wood products has also influenced harvesting rates at household levels in Côte d'Ivoire and Cameroon due to the existing financial incentives for forest products (Ngaba et al. 2023). In Gabon, the demand for wood products within the European markets resulted in increased timber production (Terheggen 2011). Similarly, in the Democratic Republic of Congo (Butsic et al. 2015), various forms of timber extraction have been exacerbated to fulfil the market demand for wood and timber for export.

Regionally, continued deforestation in East Africa (Osewe et al. 2024), has been linked to land use changes often from the conversion of forests land to agricultural land. In Kenya, these changes are more pronounced and visible along the boundaries and edges of tropical forest ecosystems (Osewe et al., 2022). Studies on forest ecosystems covering Central, Eastern and Western Kenya have confirmed the nexus between forest dependency and the need for rural communities to produce food through various forms of subsistence agricultural practices such as shift cultivation (Chhetri et al., 2023). For instance, Jebiwott et al. (2023) highlighted small-scale agriculture, population pressure and political interference as key drivers of deforestation in the Mau Forest complex. Similarly, Kocemba et al. (2025) linked the decline in woodlands and indigenous forest cover in Mt. Elgon region to the increased pressure on remaining forest fragments because of lowered slope stability and less arable land in the region. While other studies on forest dependency emphasized conservation to avert irreplaceable biodiversity loss (Jago et al. 2024), community centred approaches through payment for ecosystem services (PES) schemes were cited as an effective long-term solution for sustainable forest management (Osewe et al., 2023).

Communities in Western Kenya relying on Kakamega National Forest Reserve are organized in forest user groups and formally recognized as Community-Based Forest Associations (CFAs) under the forest conservation and management Act of 2016 (Republic of Kenya, 2016). These CFAs work together on utilizing and conserving forest resources through initiatives that improve their livelihoods, such as silk farming, and offering ecotourism services as tour guides. Further, Frank et al. (2017) also highlighted the positive outcomes associated with community-centred participatory forest management (PFM) in Mida Creek, Kenya and linked their economic empowerment with collective resource ownership attitudes of forest-dependent communities through CFAs. Moreover, Tsingalia (2020a) emphasizes the effectiveness of joint forest management through CFAs and the government towards identifying the needs of indigenous people and developing conservation policies that recognise the role of forest resources in their livelihoods. Similarly, Musyoki et al. (2013) determined that households with CFA memberships in central Kenya were more likely to contribute towards forest resource stewardship through PFM compared to non-CFA affiliated households.

While the focal theme of most ES valuation studies typically refer to tangible forest products and associate their value with livelihoods of forest dependent communities, this often leaves a gap in understanding the contribution of intangible ES, particularly those with cultural values (Gogo et al. 2022). For instance, Osewe et al. (2024) established that cultural ES were the least assessed compared to other categories of ES in East Africa, with spiritual services being the lowest ranked among services such as ecotourism and cultural practices. The Tiriki sacred groves of Hamisi sub-county in KFE hold spiritual and religious significance for rite of passage rituals amongst Tiriki people of the luhya community in Western Kenya (Kassily et al., 2009). These sacred groves are not just expressions of identity or tradition; they also serve as social anchors that influence how communities relate to and conserve forest ecosystems. In many contexts, sacred groves and spiritual rituals are linked with forest ecosystems function as informal conservation mechanisms (Fernandes et al. 2022; Khunweechuay et al., 2022). Therefore, a comprehensive economic assessment of ES, which includes aspects of spiritual services related to the Tiriki sacred groves in KFE, would offer valuable insights to key actors of a potential inclusive PES schemes that incorporates the values which societies associate with tangible and intangible ES.

Previous studies have highlighted the rate of dependency by forest fringe communities to the ES (Waruingi et al., 2021), and the impact of CFAs on forest user group attitudes towards conservation through PES schemes (Nyongesa et al. 2016). Research has also associated forest dependency with provisioning ES and their rate of supply as a factor that determines the extent of utility (Maithya et al., 2022). Similar studies have elaborated on the ES prioritized by the forest fringe communities (Diafas et al., 2017), and assessed their willingness to pay (WTP) for maintenance of forest resources with regards to regulating and supporting ES (Waruingi et al. 2023). However, few studies have provided comparable metrics for the inclusion of both tangible and intangible ES in conventional economic models. Moreover, Osewe et al. (2024) also cited the gap in assessment of intangible ES and recommended the inclusion of values like cultural services in ES valuations. Therefore, a holistic assessment would provide a crucial context for understanding the contribution of ES to the livelihoods of forest fringe communities around KFE.

The aim of this research is to assess how forest dependent communities derive economic and cultural value from Kakamega Forest Ecosystem (KFE) in Kenya by (i) identifying the most frequently used forest products, (ii) evaluating the contribution of foraged forest products to local livelihoods, and (iii) determining their perceptions and willingness to pay (WTP) for cultural ES. While numerous studies highlighted the benefits of engaging with local communities to identify their priorities in ES utility (Ali et al. 2025; Pradhan et al. 2023), forest conservation and management of natural resources (Ombogoh et al., 2022), this research used survey methods to collect primary data by disseminating questionnaires to households spread out across five different sub-counties amongst the forest fringe communities bordering KFE. A data frame was created for analysis based on the socio-economic information provided by respondents to provide context for the forest resource value chain and the socio-cultural impact on their livelihoods. Further, this research aimed at using comparative economic metrics drawn from the ES valuation to contextualise their contribution to livelihoods and provide proper PES scheme scenarios for livelihood improvement and sustainable forest management.

2. Materials and methods

2.1. Study area and context

Kakamega National Forest Reserve (Fig. 1) is an important forest ecosystem because of its immense direct and indirect ecosystem benefits to the livelihoods of the surrounding communities (Osewe et al., 2022). Within the context of this study, surveyed households were spread out along the forest edge covering the sub-counties of Lurambi, Shinyalu, Navakholo and Malava. The selected sub-counties had approximately 90 % geographic coverage of the forest ecosystem to the western side of Kakamega County. The remaining 10 %, located at the southern tip, was covered by questionnaires administered in Vihiga County (Hamisi sub-county). Furthermore, the eastern forest edge defined the outermost boundary for Kakamega County extending to Nandi County.

2.2. Questionnaire design

Four hour focus group workshops with at least five CFAs leaders were held in each of the five selected sub-counties before distributing questionnaires. These interactive sessions were conducted to identify preferences for ES. The four sub-counties of Lurambi, Shinyalu, Navakholo, and Malava, showed a preference in utility for tangible ES related to forest products like firewood, fruits (*Persea americana*), vines (*Mondia whitei*), timber, medicinal plants (*Azadirachta indica*) and other categories like wild wood ear mushrooms (*Auricularia auricula-judae*). Consequently, the respondents were issued questionnaires focusing on the type, amount and use of the of tangible forest products (Appendix A, Table AII). The remaining sub-county (Hamisi sub-county) exhibited a

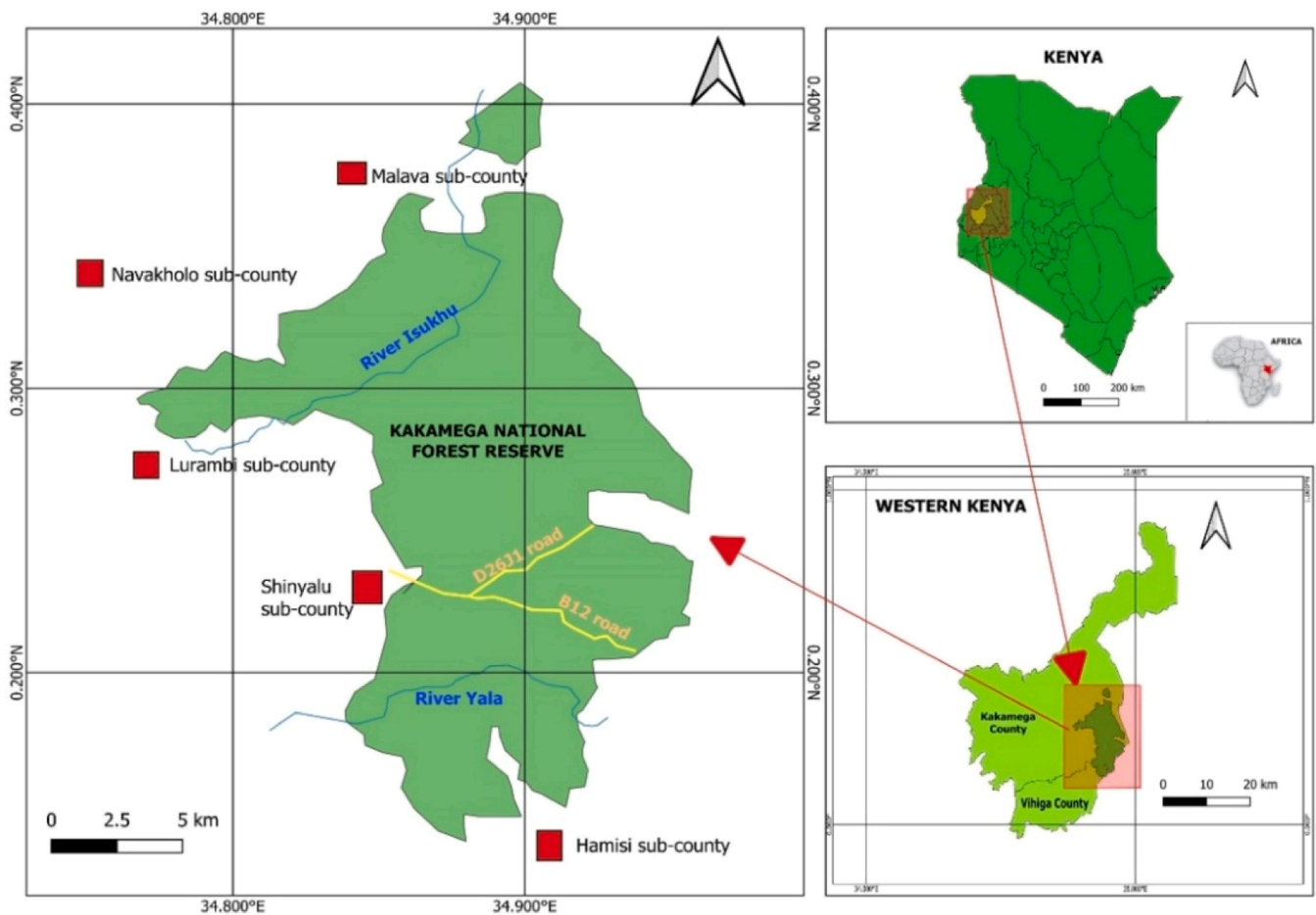


Fig. 1. Surveyed sub-counties bordering Kakamega national forest reserve.

preference in utility for intangible ES, particularly cultural and spiritual services associated with the Tiriki sacred groves, known by the locals as “*Ikavakava shrines*” (Sharma et al., 2022). These spiritual associations with KFE were uniquely concentrated in Hamisi sub-county based on focus groups, and the other four sub-counties did not report similar traditions during preliminary focus group consultations.

Respondents were issued questionnaires addressing these cultural values considering their perceptions, attitudes and WTP for cultural services from Tiriki sacred groves (Appendix A, Table AIII). While the cultural ES assessment was specific to Hamisi sub-county, it provides insight into the broader role of sacred groves in shaping forest community relationships within the greater KFE. Moreover, Kambona et al. (2016) reported less ecological disturbance and extraction of tangible forest products by communities around Tiriki sacred groves compared to other communities without sacred associations to KFE. Similarly, Shoddo (2022) established a link between the conservation practices with minimal extraction and sacred forest culture amongst the

communities of Gudo Forest in Ethiopia.

2.3. Data collection

The field data were collected in five sub-counties located at the western and southern borders of KFE with a total population of 656, 578 and a total number of 172,288 households according to the 2019 Kenya Population and Housing Census (Kenya National Bureau of Statistics (KNBS), 2019). Kakamega Forest lies in two different counties i.e., Kakamega county and Vihiga county and its boundaries overlap with adjacent targeted sub-counties (Table 1). Sample size determination, considered parameters such as (i) statistical confidence level, (ii) margin of error, and (iii) questionnaire design.

A stratified sampling technique was used, with sub-counties as strata (Alzahrani et al., 2025), and interval number between households (Table 1). The sample size was established for each sub county using a 95 % confidence level and 5 % margin of error (Ummel et al. 2024). For

Table 1
Survey sample size for each administrative unit bordering KFE.

Sub-counties where Kakamega Forest Ecosystem lies	Population of Sub- Counties	Targeted sample size with confidence level 95 %, Margin of error 5 %, population proportion of 50 %.	Increased sample size for strata (Hn)	Number of Households per Sub- County (HH)	Interval Number for household survey along road/ street/ pathways $interval(i)=(HH)/(Hn)$
Lurambi Sub-County	160,229	94	154	52,015	337
Shinyalu Sub-County	159,475	93	153	39,589	258
Malava Sub-County	115,354	68	112	26,049	232
Navakholo Sub-County	116,851	68	112	27,671	247
Hamisi Sub-County	104,669	61	100	26,964	269
Total number of Targeted households for survey			631		

better representativeness of each stratum, the sample size was increased while preserving the proportionality and stratified structure of the sample to have a minimum of 100 respondents in each stratum. Households for survey were selected depending on interval number established in Table 1. The questionnaire was applied to the adult in the household who was to celebrate his/her birthday first.

2.4. Data processing

The primary data consisted of five datasets collected from the sub-counties bordering KFE: four addressing the use of tangible forest products and one addressing the cultural values of Tiriki sacred groves. This research combined the four datasets from Lurambi, Shinyalu, Navakholo, and Malava into a single numerical column dataset for descriptive statistical analysis in R-Studio.

Using this combined dataset, the sum of responses regarding forest product preferences was weighted and aggregated into percentages to identify the most used forest products. Statistical approaches for multiple survey responses were used to weigh and adjust potential biases (Arnab 2023). An analysis of the frequency distribution per sub-county was conducted to show an overview of forest product utility by local communities, inferring preferences for firewood, fruits (*Persea americana*), vines (*Mondia whitei*), timber, medicinal plants (*Azadirachta indica*), and wild wood ear mushrooms (*Auricularia auricula-judae*). Given that some respondents provided multiple entries, a Pearson's Chi-squared test (Apolo et al. 2016) was conducted to assess any statistically significant association between sub-counties and the most used forest products.

Based on similar statistical approaches for sums of weighted stratified datasets (Orlov et al., 2014), the numerically coded responses were summarised and grouped by the quantity of forest products collected in kilograms (kg) per month. The aggregated sums of weighted averages were based on medians of ranges per category of collected forest products: (i) under 20 kg, (ii) 21 to 50 kg, (iii) 51 to 80 kg, (iv) 81 to 110 kg, and (v) over 111 kg (Appendix A, Table AII). To evaluate the contribution of collected forest products to local livelihoods, their direct economic gains were estimated using the weighted average amount of forest products collected per year (12 months) multiplied by their respective market prices (Appendix A, Table AI). An analysis of variance (ANOVA) test (Ostertagová et al., 2013), was conducted to identify any statistical differences in the mean quantity of forest products collected across three categories: (i) occupation or work status, (ii) main use of forest products, and (iii) gender, which have been identified by similar studies to influence the collection (Kimanzu et al. 2021), and foraging of forest products (Bohnett et al. 2023).

For the assessment of cultural values, data was extrapolated from survey responses capturing demographic attitudes and perceptions associated with cultural ES, specifically spiritual services in the Tiriki sacred groves of Hamisi sub-county. Using stated preference approaches, such as contingent valuation methods (Cheng et al. 2019), the willingness to pay (WTP) was analysed by amount in price ranges as an indicator of economic value in a hypothetical scenario where entrance to sacred shrines was fee-based. An ANOVA test was conducted to identify any statistical differences in the distribution of WTP across key drivers of cultural shifts, such as (i) religion and (ii) level of education (Son et al., 2023). Gender was excluded from the analysis because, culturally, only male respondents were permitted to provide feedback on the questionnaire regarding the Tiriki sacred groves (Ouma et al., 2015). Additionally, respondents' perspectives were analysed based on their experiences at Tiriki sacred shrines to provide context for their perceptions of the socio-cultural significance of sacred shrines to livelihoods. Finally, this research drafted economic perspectives based on the ES valuation results to suggest proper PES scheme scenarios for livelihood improvement in KFE.

3. Results and discussions

3.1. Analysis of forest product use per sub-county

Firewood was the most used forest product locally as detailed in Fig. 2. Similar studies have highlighted the high dependence of rural households in Kenya on wood fuel and charcoal as their primary source of fuel (Sola et al., 2020) for cooking, water heating and housewarming. Osewe et al. (2024) attributed this overreliance to the easy access to firewood for nearby communities, and socio-economic factors such as poverty. Other studies have also highlighted limited access to electricity in rural areas (Sawe 2012), the inaccessibility and cost of acquiring liquefied petroleum gas (LPGs) as determinants to the overreliance in firewood as a main energy source (Sola et al. 2019).

Variations in usage for the other forest products were influenced by household needs and preferences. Market-related factors and environmental influences also contributed towards these variations (Hlangwani et al., 2023). For instance, Murimi et al. (2024), highlighted the significance of value addition interventions for products such as fruits (*Persea americana*), which played a key role in market robustness by driving their usage rates in Kakamega County. Moreover, McMullin (2016) also outlined the ecological suitability of KFE which supported optimal growing conditions for various products throughout the year. Moreover, these environmental conditions favoured consistent harvesting for forest products like fruits and vines (Mohammed et al. 2020).

The roots of vines (*Mondia whitei*) which are commonly known as "mukombero" by the local communities, were mainly used for recreational and medicinal purposes. For instance, Mabonga et al. (2022) concluded that *Mondia whitei* boosted testosterone levels and showed great potential for treatment of erectile dysfunction in males. *Mondia whitei* has a wide range of other applications in alleviating stomach pains, fever, stress, and as an aphrodisiac (Aremu et al. 2011a). Traditional uses have also been documented (Chokwe et al., 2021), among forest communities in Southern African countries of Zimbabwe, Malawi and South Africa where it was extensively used for treatment of allergies, malaria fever, intestinal worms and skin diseases. Odugbemi et al. (2008) also showed its efficacy in malaria therapy treatment amongst the Okadigbo in Nigeria. *Mondia whitei* stands out as both a culturally rooted and economically valuable forest product, reflecting its broad significance in the local forest value chain. These diverse applications contributed towards the rate of utility in KFE comparable to the other forest products.

Medicinal plants (e.g. *Azadirachta indica*), locally known as 'mwarubaini' have been used to alleviate common treatable illnesses alongside modern medicine from hospitals (Wanzala et al., 2019). Traditional medicine is perceived to be more accessible and cost-effective, especially in rural areas where access to modern medicine and primary preventative care clinics is limited (Gakuya et al. 2020). The traditional practices involving the use of medicinal plants in KFE were also intertwined with cultural inclinations and socio-economic perceptions (Muthee et al. 2011). Similarly, Njoroge et al. (2007) showed that the peri-urban population in Thika town preferred using herbal medicine over modern treatments for common illnesses like diarrhoea. They perceived traditional medicines to have comparable efficacy to modern medicine and to be less expensive. Njoroge et al. (2006) also noted the preferential uptake of traditional medicine by farmers in ethnoveterinary practices for livestock in Central Kenya. Other studies have highlighted deterrent factors, such as the high costs associated with conventional modern veterinary drugs (Githiori et al. 2002), which drive farmers to seek less expensive traditional alternatives with comparable efficacy.

Timber had the lowest usage rates in three of the sub-counties because commercial logging in the tropical forests of Western Kenya is highly restricted for ecological reasons (Tsingalia, 2020b). In some cases, it is totally prohibited such as by the 2018 logging moratorium of the Kenyan government (Bartlett et al. 2024). Additionally, technical and financial reasons contribute to the low usage rates (Langat et al.

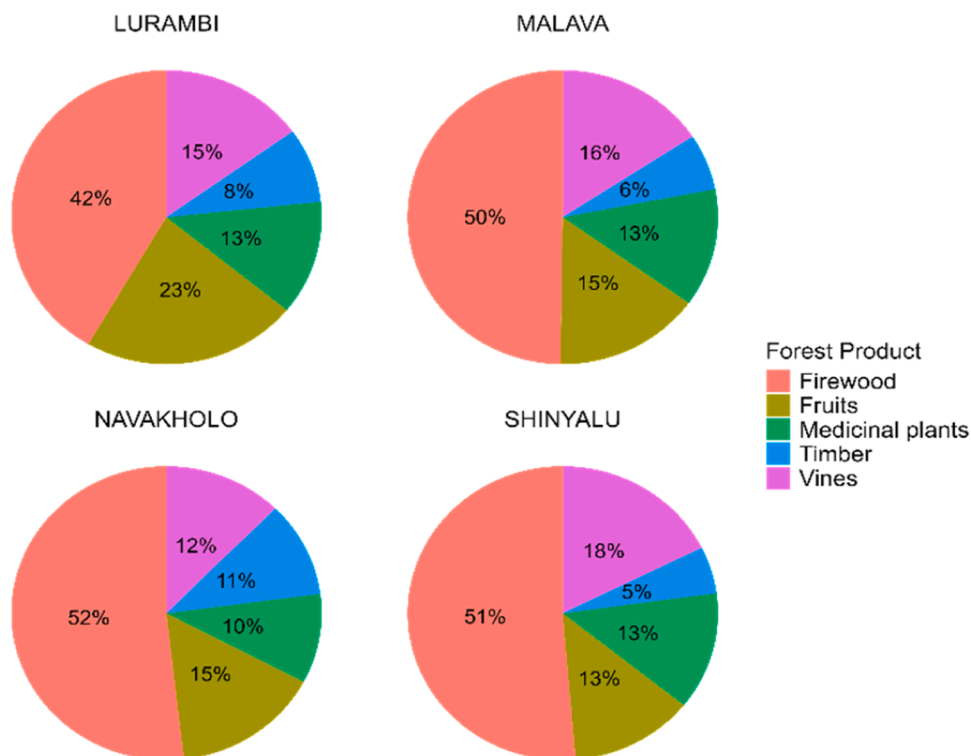


Fig. 2. Distribution of the most used forest products per sub-county.

2022). Efficient timber harvesting requires access to power saws, elaborate transportation systems, and a profitable value chain (Cheboiwo, 2016), which many farmers in rural communities lack. Without full control over the value chain for sawn timber, these activities are predominantly left to established logging companies, estimated at 27 in the western region (Muthike, 2017), with even fewer operating in Kakamega County.

Although variations in the percentage of forest product usage were observed in Fig. 2, the chi-square test p-value of 0.3836 indicated that the usage of forest products was not dependent on the sub-county. The findings suggest that socio-cultural factors (Ndung'u et al. 2023) influenced the priorities of forest fringe communities in forest product utility and therefore were not significantly different across the sub-counties. In addition, Adwar et al. (2023) highlighted other common drivers influencing forest dependency among rural communities, such as household

income, family size, proximity to forest ecosystems, and access to alternative energy sources.

3.2. Evaluation of collected forest products

Firewood was the most collected forest product by dry weight per month, as detailed in Table 2. This was attributed to its essential role as a primary fuel source for local communities (Ministry of Energy 2022). Mbaka et al. (2019) concluded that the household preference for wood fuel in rural areas in Kenya was due to factors such as low-income levels, education levels, limited access to cleaner energy sources, and high upfront costs for LPGs and subsequent refilling (Matthews, 2014). These findings correlate with the distribution in Fig. 2, which demonstrated a collective preference for firewood across all four counties, implying a heavy reliance on forest resources to meet basic household energy needs

Table 2 Summary of the average amount of forest products collected monthly in Kakamega county.

Forest products	Estimated weighted average (kg) of forest products collected per month in Kakamega County				Total collected per month/ forest product (kg)	Percentage share (%) / forest product collected	Estimated annual (12 months) monetary valuation = {product(kg) × Unit price KES/kg according to Appendix A (Table AI)}
	Lurambi sub-county	Malava sub-county	Navakholo sub-county	Shinyalu sub-county			
Firewood	1299	3712	3696	3929	12,636	37.2 %	9552,816
Fruits (<i>Persea americana</i>)	997	1331	1628	1304	5260	15.5 %	9468,000
Vines (<i>Mondia whitei</i>)	625	1824	1339	1611	5399	15.9 %	9718,200
Timber (sawn)	1364	1446	1980	755	5545	16.3 %	1663,500
Medicinal Plants (<i>Azadirachta indica</i>)	464	1118	984	1692	4258	12.5 %	5109,600
Other categories i.e., wild wood ear mushrooms (<i>Auricularia auricula-judae</i>)	116	96	626	30	868	2.6 %	1041,600
Total (kg) collected per month/Sub-County	4865	9527	10,253	9321	33,966	∑ KES 36,553,716	
Annual total (kg) estimate /sub-county	58,380	114,324	123,036	111,852	407,592		
Percentage share (%) /sub-county	14 %	28 %	31 %	27 %			

around KFE. Similar findings have been recorded in other studies, showing an overreliance on forest ecosystems for wood fuel in South America (Thiffault 2023), Sub Saharan Africa (Njenga et al., 2023) and Southeast Asia (Sasaki et al. 2009).

Timber was the second most collected product by dry weight, due to its heavier mass compared to other forest products, even though its frequency was lower, as shown in Fig. 2 (Lovrić et al. 2020). This was also due to the main use of timber as the primary material for construction in rural areas (KNBS, 2022). As for the fruits (*Persea americana*) and vines (*Mondia whitei*), the amount collected suggested that they served an essential nutritional and specialized function, as in the case of vines, being commonly used as aphrodisiacs (Oketch 2012). Medicinal plants and other categories (wild ear mushrooms) were the least collected by dry weight, indicating they were less in demand with specialized use and had limited availability (Kaigongi et al. 2023). Other studies also established that many medicinal plants were endangered species (Ojunga et al. 2023a), and the unregulated foraging was a driver towards their continuous depletion.

In terms of forest product collection by dry weight per sub-county, Navakholo and Shinyalu had a higher reliance on forest products because they are predominantly rural areas (Kambona et al., 2006). This contrasts with the lower dependence observed in Lurambi, a more urbanized sub-county that hosts the county capital of Kakamega Town (Lloydjones et al., 2014). Malava, despite urban influences due to its proximity to Kakamega town and good road infrastructure, showed notable dependence on forest products because of its rural outskirts. The amount of timber and firewood collected in sub-counties Navakholo and Malava was attributed to the heavy reliance exacerbated by the accessibility to forest resources by surrounding rural communities (Okumu et al., 2020). Table 2 reflected variations in resource availability, community priorities, and the influence of local economic activities for forest resource users.

The total annual monetary valuation for all the collected forest products was estimated at KES 36.5 million (US\$ 283,362). The highest monetary valuation was for vines at KES 9.7 million (US\$ 74,786), which was due to the niche market demand driven by the robust trading in major cities like Nairobi, Kisumu and Mombasa where it had high fetching value (Osano 2019). Additionally, Tendwa et al. (2024) related the extraction and foraging of vines with cultural practices amongst the Luhya community and perception of improved fertility associated with the vines. Other forest products had comparatively lower valuation, namely medicinal plants, which was due to the limited availability of certain endangered plant species (Ojunga et al. 2023b). The low volume of timber was associated with harvesting when needed for construction (Cheboiwo et al., 2019a), and the short shelf life of mushrooms led to lower market prices, which further declined with storage length (Onyango, 2016). These results suggest a higher demand for vines, firewood, and fruits compared to other forest products like medicinal plants, timber, and mushrooms.

The economic valuation was based on surveyed market prices per kilogram in Appendix A (Table A1). While the prices used reflect market rates during the survey period, they may vary due to seasonality, supply fluctuations, and market distance. Therefore, conservative price

estimates were used, and annual values were calculated using 12 month extrapolations from weighted monthly averages (Table 2).

3.2.1. Average quantity of forest products collected by occupation or work category

The self-employed category (45 %) had the highest share of total products collected in Table 3. This category earned additional income from the sale of forest products, which supplemented their household earnings (Nerfa et al., 2020). Farmers were second, because of their involvement in agricultural activities through programs like the Plantation Establishment and Livelihood Improvement Scheme (PELIS) (Humphrey, 2016), and their high reliance on forest resources to meet their livelihood needs. Similar studies have also highlighted the nexus between the reliance on forest ecosystems (Newton 2022), and agricultural production along forest edges (Mahmoudi et al. 2023).

The collection by the retired group was influenced by their reduced physical capability due to advanced age (Göbel et al., 2012), while civil servants, given their stable income from formal employment, were less dependent on forest resources for daily needs (Khan et al., 2020). Respondents who did not identify with the social categories collected negligible amounts of forest products at 1 %. Moreover, the ANOVA p-value of 0.222 indicated no significant difference in the mean quantity of forest products collected between different occupation or work categories.

3.2.2. Average quantity of forest products collected depending on the main use

68 % of the total forest products collected (Table 4) were for household use, which implied a high reliance and dependency on the forest resources to meet daily livelihood needs. Moreover, large quantities of firewood, fruits, vines and medicinal forest products were collected for household use, which are typically associated with immediate needs of forest fringe communities (Chama et al. 2023b).

Commercial uses were related to large amounts of timber, firewood and fruits which were primarily collected for sale. Minimal amounts of forest products were collected for mixed use purposes which were either commercial or subsistence. Furthermore, the ANOVA p-value of 0.415 indicated no significant difference in the mean quantity of forest products based on their main uses. Factors such as data structure, distribution, and sensitivity within-group variability within large categories, like household use, contributed towards the p-value.

3.2.3. Average quantity of forest products collected depending on gender

Women collected 66 % of the total forest products, as shown in Table 5. This is due to the gender roles assigned by local communities in Kakamega County (Rhodah et al., 2016). The findings reflect that women are more engaged in gathering and foraging forest resources mainly for household needs. In contrast, men are involved in different economic activities, including agriculture, formal employment, and skilled trades. For instance, Sylvester et al. (2016) also highlighted apparent biases between the genders and roles assigned in forest foraging in Costa Rica amongst the Bribri indigenous communities. Similarly, Kiptot et al. (2012) demonstrated the disparities in roles

Table 3
Summary of forest products collected per category of occupation or work.

Category of occupation or work	Estimated weighted average (kg) of forest products collected per month in Kakamega County per category of occupation or work						Percentage share (%) of forest product/ occupation or work
	Firewood	Fruits	Vines	Timber	Medicinal	Other	
Farmers	5955	1965	2392	2166	1688	323	43 %
Civil servants	772	640	700	358	414	76	9 %
Retired	312	10	191	222	106	0	2 %
Self-employed	5440	2590	2080	2799	2050	358	45 %
None of the above apply	156	56	36	0	0	111	1 %

Table 4
Summary of the average amount of forest products collected depending on main use.

Main use of forest products	Estimated weighted average (kg) of forest products collected per month in Kakamega County per category of main usage						Percentage share (%) of forest product/ category of main use
	Firewood	Fruits	Vines	Timber	Medicinal	Other	
Commercial use	3008	1698	1391	2860	1059	81	30 %
Subsistence use	9364	3517	3897	2397	3163	720	68 %
Mixed use	262	46	111	288	36	66	2 %

Table 5
Summary of the average amount of forest products collected depending on gender.

Gender	Estimated weighted average (kg) of forest products collected per month in Kakamega County depending on gender						Percentage share (%) of forest product/ depending on gender
	Firewood	Fruits	Vines	Timber	Medicinal	Other	
Male	4436	1778	1316	1258	1997	438	33 %
Female	8190	3482	4084	4286	2260	363	66 %
Other	0	0	0	0	0	66	0.2 %
Non-declaring	10	0	0	0	0	0	0.8 %

dictated by cultural norms in different African countries while reviewing the participation of women in forest conservation and management.

Respondents who identified as “other” or non-declaring accounted for 1 % of the total forest product collected, which implied their limited involvement in foraging activities. Additionally, the ANOVA p-value of 0.023 indicated a significant difference in the mean quantity of forest products collected between the different genders.

3.3. Evaluation of the cultural ES for Tiriki sacred groves

Most of the respondents (39 %) showed WTP given a hypothetical scenario of entrance fees within the price range of KES 76 (0.55US\$) to KES 150 (1.09US\$) as detailed in Fig. 3. This implied that the majority had an appreciation of perceived values associated with Tiriki sacred groves. Pedroso et al. (2019) reported similar findings while assessing WTP for cultural services, i.e. ecotourism, and established that the WTP was heavily influenced by the socio-economic status of the respondents in the Mara basin. Additionally, other studies also outlined factors like level of education and awareness (Acharya et al., 2021b), cultural attachment and identity (Konu et al., 2024), to have influence on

respondents WTP for cultural ES.

A sharp decrease was observed for the high price ranges beyond KES 300 (2.17US\$) because only a few of the respondents perceived high economic value for the spiritual services. Acey et al. (2019) similarly revealed that positive perceptions and income levels influenced the WTP for improved sanitation amongst low-income households in Kenyan cities. Additionally, Misra (2008) outlined that respondents WTP for improved essential services dropped beyond an affordable price range because their WTP was pegged at the median household income. Therefore, household income levels heavily influenced the respondents WTP as it determined the amount of disposable income they would hypothetically spend on cultural ES. 93 % of the respondents demonstrated WTP for spiritual services at Tiriki sacred groves within the price range of KES 76 (0.55US\$) to KES 300 (2.17US\$). Horowitz et al. (2003) had similar findings and attributed the effect of respondent’s WTP beyond their income level as a reflection of a higher value associated with an ES service.

3.3.1. Key drivers of respondents’ attitudes towards cultural ES

83 % of the respondents were identified with a form religion, which

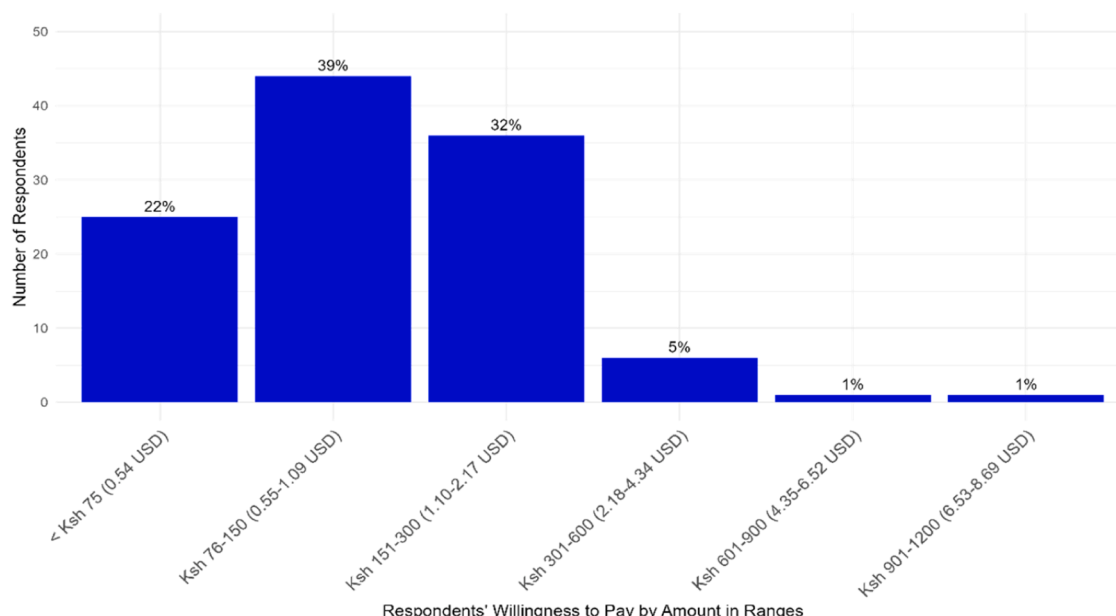


Fig. 3. Distribution of respondents WTP if the entrance to sacred groves was fee based.

suggested a dominant presence of a belief system in a spiritual context or deity shown in Fig. 4. Such religious affiliations have been identified as key drivers that shape perspectives and reinforce appreciation for cultural ES associated with spirituality (Ives et al., 2024). Lusambili et al. (2022) provided an aetiology which showed a permanence of religion and adoption of evangelism in Kakamega County since the late 1970s. Further, Iyer et al. (2020) highlighted that the social interactions which were intertwined with ethnic practices avoided the competition for religious superiority. Instead, the belief systems merged and formed a hybrid keeping the indigenous language and culture while professing doctrines of Christianity.

Additionally, the ANOVA p-value of 0.5152 indicated that religious identities amongst respondents did not significantly influence their WTP for cultural ES. The findings suggested that the large percentage of religious affiliation had no significant bearing on the respondent's perception of ES values associated with Tiriki sacred groves. Respondents therefore did not interpret cultural practices and religious affiliation as mutually exclusive. Similarly, Thelma and Chitondo (2023), while assessing the intersection of culture and religion, reported that many of the respondents in Zambia simultaneously identified with a form of religion as well as other cultural practices and beliefs.

This prevailing attachment to cultural practices specific to Tiriki sacred groves amongst the luhya community in Hamisi sub-county is best demonstrated by male initiation ceremonies (Ouma et al., 2015), which only take place at the "Ikavakava scared shrines". The follow-up rites for the initiates are also conducted exclusively within the sacred groves (Duncan 2021) to allow for intercession with the ancestral spirits while initiates learn life skills from the teachings of the elders (Were et al., 2024). The rite of passage is done physically through circumcision (Odoyo et al. 2021), and then accompanied by traditional practices to signify transition from boyhood to manhood.

In terms of literacy levels, 93 % of the respondents had basic education at primary and high school level up to university. This implied a high literacy level amongst the respondents, reflecting a greater exposure to concepts and ideas related to the appreciation of values associated with cultural ES. In Ethiopia, Wassihun et al. (2021) established that education with regards to the literacy levels of the respondents impacted their WTP for the conservation of cultural ES derived from Altash National Park. The high literacy levels from basic to tertiary level of education influenced the level of the respondents' awareness (Arif et al., 2022) in terms of the population appreciating the existence of intangible ES benefits and having a comprehension of bequest value to their livelihoods.

3.3.2. Perspectives on experiences at tiriki sacred groves

Although perspectives vary depending on personal preferences and experiences, the distribution in Fig. 5 offered insights into the felt benefits resulting from the respondents' interaction with sacred groves capturing the wider range of values attributed to the sacred groves

(Nche et al., 2024). The first questionnaire prompt had a majority of respondents who affirmed feeling a sense of peace and tranquillity while visiting the sacred groves. Michael et al (2021) in an exploratory study of healing shrines in Africa similarly highlighted the effect of personal fixations in levels of satisfaction with regards to calm and tranquil experiences while visiting sacred shrines.

Most respondents reported experiencing physical sensations during their visits, suggesting that visits to the sacred groves induced diverse physical experiences (Herzog et al. 2013). Yaden et al. (2022) similarly showed that feelings of physical sensations varied and influenced the spirituality of devotees. Moreover, the high percentage of respondents having spiritual experiences while visiting the sacred groves underscored its spiritual significance. Other studies have demonstrated that the physical presence at religious places, such as sacred shrines, churches, mosques, and temples, enhances feelings of spirituality (Al-Musawi et al., 2021) and closeness to a deity or belief system (Cooper et al. 2021).

The majority of the respondents also reported that the sacred groves enhanced their religious life and deepened their spiritual and religious practices, demonstrating that the sacred groves played a key role as spiritual conduits for many believers. Collins et al. (2015) highlighted the intersection of religiosity among tourists who experienced a spiritual connection while visiting sacred places like the Vatican City, implying that they associated certain spiritual values with sacred sites of worship (Shinde 2021). On average, 70 % of the respondents had positive perceptions of the Tiriki sacred groves and recommended visits. Despite variations in perspectives and experiences, respondents showed a high regard for cultural ecosystem services and the spiritual services associated with the Tiriki sacred groves.

3.4. PES scenario for livelihood improvement and sustainable forest management in KFE

Key stakeholders in a PES scheme include: (i) beneficiaries, such as forest fringe communities around KFE through their CFAs, (ii) intermediaries like the Kenya Forest Service (KFS) and the Kenya Forestry Research Institute (KEFRI), and (iii) buyers, including the Kakamega County Government, NGOs like Biovision Africa Trust, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), and the World Bank's Global Biodiversity Framework Fund. In the short and medium term, CFAs would receive direct payments to reduce their dependence on tangible ecosystem services (ES) like wood fuel, which is linked to household income and the ability to afford alternative energy sources.

Monitoring and assessment of PES schemes, based on established indicators, would be conducted by KFS and KEFRI, leveraging their forestry expertise. A co-payment structure with in-kind transactions, providing farmers with subsidies and extension services based on successful programs, like PELIS, could alleviate poverty and improve livelihoods in KFE. In the long term, CFAs are expected to develop

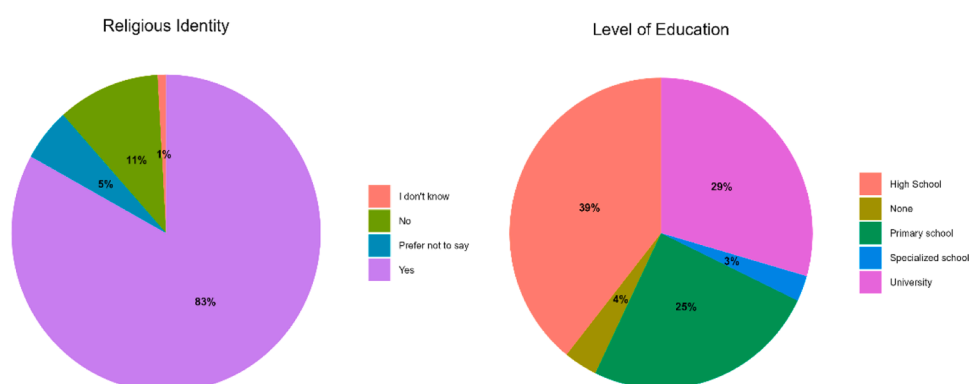


Fig. 4. Distribution of respondents by the factors influencing attitudes towards cultural ES.

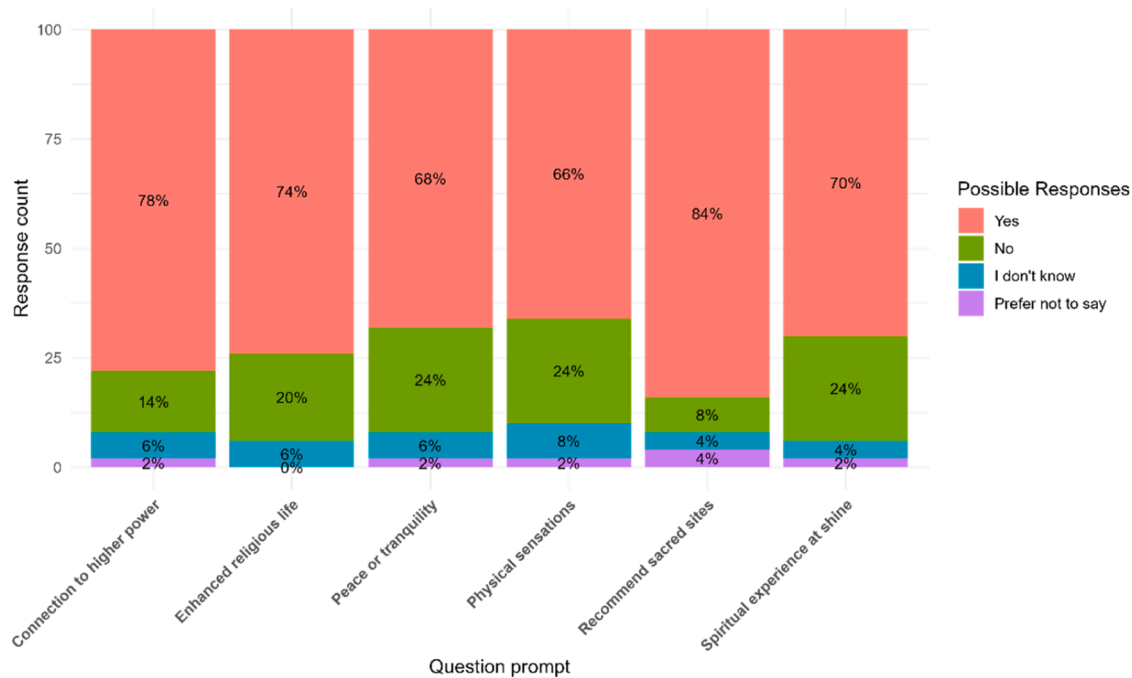


Fig. 5. Distribution of respondents' perspectives on their experiences at Tiriki sacred groves.

sustainable businesses, such as beekeeping, mushroom farming, and butterfly farming, using capital from PES scheme payments to prevent a return to resource extraction once PES payments end.

4. Conclusion

This research found that forest fringe communities exhibited a strong preference and heavy reliance on tangible ES compared to intangible ES. The monetary valuation of foraged forest products ranked firewood, vines, and timber highest, each contributing an average of US\$73,720 per annum to the livelihoods of communities around KFE. Future valuation approaches should integrate variability, seasonal variations and market demand shifts into pricing models and policy projections. Diverse needs and preferences were identified within socio-demographic categories, such as occupation, primary use of forest products, and gender. Civil servants could afford alternative energy sources, unlike farmers who relied directly on foraged products like firewood for household use. A substantial proportion of foraged products were used for subsistence. Gender disparities were evident, with women more involved than men in foraging forest products. To bridge gender disparities, this research recommends inclusive decision making platforms that actively engage marginalized groups like the women from low income households to support community led value addition for products like vines, mushrooms, and medicinal plants. Forest policies that guarantee inclusivity in decision making frameworks for low income groups could improve livelihoods.

In terms of valuation for intangible ES, income disparity and perceptions influenced the acceptable price ranges within the WTP hypothetical scenario for the "ikavakava" sacred groves in Hamisi sub-county. Religious affiliation and education levels positively influenced respondents' attitudes and perceptions towards cultural ES and their WTP for spiritual services. The values attributed to the sacred groves were not mutually exclusive with modern religious beliefs, which were dominant among respondents. This research explored socio-cultural dynamics in the valuation of cultural ES, assisting practitioners in contextualising preferences and attitudes and establishing a common base for interpreting intangible ES. The findings highlighted the importance of cultural contexts in forest policy and PES frameworks. Therefore, this

research recommends that future forest policies on PES schemes could include frameworks addressing the immediate economic needs of communities and involve multiple stakeholders to achieve sustained positive impacts on rural livelihoods. Further studies integrating both tangible and intangible ES for a comprehensive approach to forest management are needed to inform holistic and equitable forest management strategies.

CRedit authorship contribution statement

Erick O. Osewe: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Bogdan Popa:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Investigation, Formal analysis. **Harald Vacik:** Writing – review & editing, Validation, Software, Resources, Methodology, Formal analysis. **Joram K. Kagombe:** Writing – review & editing, Validation, Supervision, Resources. **Ibrahim Osewe:** Writing – review & editing, Visualization, Resources, Investigation, Data curation. **Ioan Vasile Abrudan:** Writing – review & editing, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We acknowledge the support provided by the Kenya Forestry Research Institute through collaboration agreement REF: KEFRI/56/04/VOL.1(111) with Transilvania University of Braşov. This research was approved by the Kenya Forest Service REF: RESEA/1/KFS/VOL.VI (124) and the Kenya National Commission for Science, Technology, and Innovation (NACOSTI) under license number NACOSTI/P/23/25591. This research was funded by grant from Transilvania University of

Brasov, DGRIAE-111284/IN1/1/EC/03.09.2021.

Appendix A

Table AI,AII,AIII

Table AI

Indicative prices for collected forest products in KFE.

Monetary valuation per unit price of dry weight for collected forest products *Prices provided are not static but subject to market fluctuations, seasonal variations in resource availability		
Forest Product	Indicative prices: Kenya Shillings (KES) per kilogram (kg)	Literature source
Firewood	KES 63 per kg	(KNBS, 2024)
Fruits (<i>Persea americana</i>)	KES 150 per kg	(Nyakang'i et al. 2023)
Vines (<i>Mondia whitei</i>)	KES 150 per kg	(Aremu et al. 2011b; John Shilita 2021)
Timber (sawn)	KES 25 per kg	(Cheboiwo et al., 2019)
Medicinal Plants (<i>Azadirachta indica</i>)	KES 100 per kg	(Omara 2020)
Other categories like wild wood ear mushrooms (<i>Auricularia auricula-judae</i>)	KES 1000 per kg	(Richard Maosi 2021)

Table AII

A summary of household questionnaires for collected forest products in KFE.

QUESTIONS	POSSIBLE RESPONSES					
	a	b	c	d	e	f
Gender	Female	Male	Other	I rather not say		
occupation or work	Farmer	Civil servant	Retired	Self-employment		
How often do you use forest products	Daily	Weekly	Monthly	At least once in within 12 months (a year)	Never	
What Forest products do you use most frequently?	Firewood	Fruits (<i>Persea americana</i>)	Vines (<i>Mondia whitei</i>)	Timber	Medicinal plants (<i>Azadirachta indica</i>)	Others (mushrooms) (<i>Auricularia auricula-judae</i>)
Quantity of forest product used in kilograms	Under 20kg	21 kg to 50 kg	51 kg to 80 kg	81 kg to110 kg	Over 111kg	
Main use for forest products?	To sell and make profit (commercial)	For household use (subsistence)	Mixed use Both Commercial and subsistence			

Table AIII

A summary of household questionnaires for Tiriki sacred groves.

QUESTIONS	POSSIBLE RESPONSES					
	a	b	c	d	e	f
Gender	Female	Male	Other	I rather not say		
Education level	None	Primary school	Secondary school	Education level	None	
Religious affiliation	Yes	No	I don't know.	Prefer not to say.		
Would you be willing to pay if entrance was fee based?	Yes	No	I don't know.	Prefer not to say.		
If the entrance was fee based, how much would you be willing to pay?	less than Ksh 75 (0.54US\$)	Ksh 76 (0.55US\$) to Ksh 150 (1.09US\$)	Ksh 151 (1.10US\$) to Ksh 300 (2.17US\$)	Ksh 301 (2.18US\$) to Ksh 600 (4.34US\$)	Ksh 601 (4.35US\$) to Ksh 900 (6.52US\$)	Ksh 901 (6.53US\$) to Ksh 1200 (8.69US\$)
Peace or tranquillity at the sacred groves?	Yes	No	I don't know.	Prefer not to say.		
Physical sensations such as tingling at sacred groves?	Yes	No	I don't know.	Prefer not to say.		
Spiritual experience at sacred groves?	Yes	No	I don't know.	Prefer not to say.		
Enhanced spiritual or religious life?	Yes	No	I don't know.	Prefer not to say.		
Connection to a higher power?	Yes	No	I don't know.	Prefer not to say.		

(continued on next page)

Table AIII (continued)

QUESTIONS	POSSIBLE RESPONSES					
	a	b	c	d	e	f
Recommend visits to sacred groves?	Yes	No	I don't know.	Prefer not to say.		

Data availability

Data will be made available on request.

References

- Acey, Charisma, Kisiangani, Joyce, Ronoh, Patrick, Delaire, Caroline, Makena, Evelyn, Norman, Guy, Levine, David, Khush, Ranjiv, Peletz, Rachel, 2019. Cross-Subsidies for Improved Sanitation in Low Income Settlements: assessing the Willingness to Pay of Water Utility Customers in Kenyan Cities. *World Dev.* 115 (March), 160–177. <https://doi.org/10.1016/j.worlddev.2018.11.006>.
- Acharya, Ram Prasad, Maraseni, Tek Narayan, Cockfield, Geoff, 2021. Estimating the Willingness to Pay for Regulating and Cultural Ecosystem Services from Forested Siwalik Landscapes: perspectives of Disaggregated Users. *Ann. For. Sci.* 78 (2), 51. <https://doi.org/10.1007/s13595-021-01046-3>.
- Adwar, Benard Ogwen, Ogada, Maurice Juma, Masila, Christopher, 2023. Drivers of Community Participation in Participatory Forest Management: An Evidence of Koderia Forest in Kenya. *East Afr. J. Forest. Agroforest.* 6 (1), 254–261. <https://doi.org/10.37284/eajfa.6.1.1410>.
- Al-Musawi, Mahmood H, Al-Mumar, Mohammad H, Nasar, Zuhair A, 2021. The Role of Religious Monuments in Restructuring the Movement Systems in the Wadi Al-Salam Cemetery. *IOP Conf. Series.* 1067 (1), 012040. <https://doi.org/10.1088/1757-899X/1067/1/012040>.
- Ali, Fatima Salaheldin Mohamad, Sommer, Jan Henning, Borgemeister, Christian, Biber-Freudenberger, Lisa, 2025. Participatory and Non-Participatory Forest Ecosystem Services Valuation in Sub-Saharan Africa: a Systematic Literature Review. *Discov. Sustainabil.* 6 (1), 199. <https://doi.org/10.1007/s43621-025-00907-5>.
- Alzahran, Mohammed R., Almohaimeed, Mohammed, 2025. A Novel Approach for Estimation Population Mean with Dual Use of in Stratified Random Sampling. *Alexandria Eng. J.* 119 (April), 64–72. <https://doi.org/10.1016/j.aej.2025.01.057>.
- Apolo, Andrea B., Lindenberger, Liza, Shih, Joanna H., Mena, Esther, Kim, Joseph W., Park, Jong C., Alikhani, Anna, et al., 2016. Prospective Study Evaluating Na¹⁸F PET/CT in Predicting Clinical Outcomes and Survival in Advanced Prostate Cancer. *J. Nuclear Med.* 57 (6), 886–892. <https://doi.org/10.2967/jnumed.115.166512>.
- Aremu, A.O., Cheesman, L., Finnie, J.F., Van Staden, J., 2011a. *Mondia Whitei* (Apocynaceae): a Review of Its Biological Activities, Conservation Strategies and Economic Potential. *South Afr. J. Botany* 77 (4), 960–971. <https://doi.org/10.1016/j.sajb.2011.06.010>.
- Mondia Whitei (Apocynaceae): a Review of Its Biological Activities, Conservation Strategies and Economic Potential. *South Afr. J. Botany* 77 (4), 2011, 960–971. <https://doi.org/10.1016/j.sajb.2011.06.010>.
- Arif, Muhammad, Changxiao, Li, 2022. Impacts of Environmental Literacy on Ecological Networks in the Three Gorges Reservoir, China. *Ecol. Indic.* 145 (December), 109571. <https://doi.org/10.1016/j.ecolind.2022.109571>.
- Arnab, Raghunath., 2023. A Note on Randomized Response Technique for Multiple Sensitive Attribute from Complex Surveys. *Communicat. Statist. - Theory Meth.* 52 (1), 94–103. <https://doi.org/10.1080/03610926.2021.1910301>.
- Artaxo, Paulo, Hans, Christen, Hansson, Luiz, Machado, Augusto T., Rizzo, Luciana V., 2022. Tropical Forests Are Crucial in Regulating the Climate on Earth. *Plos Clim.* 1 (8), e0000054. <https://doi.org/10.1371/journal.pclm.0000054>.
- Babulo, Bedru, Muys, Bart, Nega, Fredu, Tollens, Eric, Nyssen, Jan, Deckers, Jozef, Mathijs, Erik, 2008. Household Livelihood Strategies and Forest Dependence in the Highlands of Tigray, Northern Ethiopia. *Agric. Syst.* 98 (2), 147–155. <https://doi.org/10.1016/j.agsy.2008.06.001>.
- Bartlett, Anne, Alix-García, Jennifer, Abarca, Alejandro, Walker, Sarah, Hoek, Jamon Van Den, Murillo-Sandoval, Paulo, Friedrich, Hannah K, 2024. The Unintended Consequences of Production Bans: the Case of the 2018 Kenya Logging Moratorium. *Environment. Res. Lett.* 19 (9), 094007. <https://doi.org/10.1088/1748-9326/ad661c>.
- Betts, Jessica, Young, Richard P., Hilton-Taylor, Craig, Hoffmann, Michael, Rodríguez, Jon Paul, Stuart, Simon N., Milner-Gulland, E.J., 2020. A Framework for Evaluating the Impact of the IUCN Red List of Threatened Species. *Conservat. Biol.* 34 (3), 632–643. <https://doi.org/10.1111/cobi.13454>.
- Bohnett, Eve, Lamichhane, Sanju, Liu, Yanjing Tracy, Yabiku, Scott, Singh Dahal, Digambar, Mammo, Siraj, Fandjinou, Kossi, Ahmad, Bilal, An, Li, 2023. The Implications of Community Forest Income on Social and Environmental Sustainability. *Sustainability* 15 (8), 6603. <https://doi.org/10.3390/su15086603>.
- Butsic, Van, Baumann, Matthias, Shortland, Anja, Walker, Sarah, Kuemmerle, Tobias, 2015. Conservation and Conflict in the Democratic Republic of Congo: the Impacts of Warfare, Mining, and Protected Areas on Deforestation. *Biol. Conserv.* 191 (November), 266–273. <https://doi.org/10.1016/j.biocon.2015.06.037>.
- Chama, Eyasu, Shibru, Simon, Gebre, Tizazu, Demissew, Sebsebe, Woldu, Zerihun, 2023a. Forest Products Monetary Contribution to Households' Income: a Means to Improve the Livelihood of a Low-Income Rural Community in South Ethiopia. *Heliyon* 9 (11), e21553. <https://doi.org/10.1016/j.heliyon.2023.e21553>.
- Forest Products Monetary Contribution to Households' Income: a Means to Improve the Livelihood of a Low-Income Rural Community in South Ethiopia. *Heliyon* 9 (11), 2023, e21553. <https://doi.org/10.1016/j.heliyon.2023.e21553>.
- Cheboiwo, Joshua Kiplongei, Muga, Meshack, Kiprop, Jonah, 2019. Economic Analysis of Forest Landscape Restoration Options in Kenya. <https://www.researchgate.net/publication/332671599>.
- Cheboiwo, J.K., 2016. Private Forestry Sector in Kenya: status and Potential. www.aforum.org.
- Cheng, Xin, Van Damme, Sylvie, Li, Luyuan, Uyttenhove, Pieter, 2019. Evaluation of Cultural Ecosystem Services: a Review of Methods. *Ecosyst. Serv.* 37 (June), 100925. <https://doi.org/10.1016/j.ecoser.2019.100925>.
- Chhetri, Ram, Yokying, Phanwin, Smith, Alexander, Hoek, Jamon Van Den, Hurni, Kaspar, Saksena, Sumeet, Fox, Jefferson, 2023. Forest, Agriculture, and Migration: contemplating the Future of Forestry and Agriculture in the Middle-Hills of Nepal. *J. Peasant Stud.* 50 (1), 411–433. <https://doi.org/10.1080/03066150.2021.1978983>.
- Chokwe, Ramakwala Christinah, Dube, Simiso, Nindi, Mathew Muzi, 2021. Development of a Quantitative Method for Analysis of Compounds Found in Mondia Whitei Using HPLC-DAD. *Processes* 9 (11), 1864. <https://doi.org/10.3390/pr9111864>.
- Collins-Kreiner, Noga, Wall, Geoffrey, 2015. Tourism and Religion: spiritual Journeys and Their Consequences. *The Changing World Religion Map.* Springer Netherlands, Dordrecht, pp. 689–707. https://doi.org/10.1007/978-94-017-9376-6_34.
- Cooper, Anthony-Paul, Laato, Samuli, Nenonen, Suvi, Pope, Nicolas, Tjiharuka, David, Sutinen, Erkki, 2021. The Reconfiguration of Social, Digital and Physical Presence: from Online Church to Church Online. *HTS Teol. Stud. /Theologic. Stud.* 77 (3). <https://doi.org/10.4102/hts.v77i3.6286>.
- Dawson, Neil M., Coolsaet, Brendan, Sterling, Eleanor J., Loveridge, Robin, Nicole, D., Gross-Camp, Supin Wongbusarakum, Sangha, Kamaljit K., et al., 2021. The Role of Indigenous Peoples and Local Communities in Effective and Equitable Conservation. *Ecology Soc.* 26 (3), art19. <https://doi.org/10.5751/ES-12625-260319>.
- Diafas, Iason, Barkmann, Jan, Mburu, John, 2017. Measurement of bequest value using a non-monetary payment in a choice experiment—the case of improving forest ecosystem services for the benefit of local communities in rural Kenya. *Ecologic. Econom.* 140, 157–165. <https://doi.org/10.1016/j.ecolecon.2017.05.006>.
- Duncan, Mukhwana M., 2021. The Indomitable Women Position in Traditional Circumcision Ceremony as a Rite of Passage among the Abanyala of Kakamega. *J. Afric. Interdisciplin. Stud* 5. <http://cedred.org/jais/index.php/issues>.
- Fernandes, Lucas Mazzero, Visscher, Anna Maria, Couto, Hilton Thadeu Zarato do, Marcusso, Gabriel Mendes, Righi, Ciro Abud, 2022. Indigenous Agriculture at the Beginning of the Twenty-First Century: the Guarani Mbyás Minority Conserves Ethnobotanical and Agrobiodiversity within the Remnants of the Brazilian Atlantic Forest. *Agroforestry Syst.* 96 (8), 1211–1224. <https://doi.org/10.1007/s10457-022-00780-5>.
- Frank, Céline, Kairo, James G., Bosire, Jared O., Mohamed, Mohamed O.S., Dahdouh-Guebas, Farid, Koedam, Nico, 2017. Involvement, Knowledge and Perception in a Natural Reserve under Participatory Management: mida Creek, Kenya. *Ocean Coast. Manag.* 142 (June), 28–36. <https://doi.org/10.1016/j.ocecoaman.2017.03.009>.
- Göbel, Christian, Zwick, Thomas, 2012. Age and Productivity: sector Differences. *Economist* 160 (1), 35–57. <https://doi.org/10.1007/s10645-011-9173-6>.
- Gakuya, Daniel Waweru, Okumu, Mitchel Otieno, Kiama, Stephen Gitahi, Mbaria, James Mucunu, Gathumbi, Peter Karuri, Mathiu, Peter Mbaabu, Nguta, Joseph Mwanzia, 2020. Traditional Medicine in Kenya: past and Current Status, Challenges, and the Way Forward. *Scientif. Afric.* 8 (July), e00360. <https://doi.org/10.1016/j.sciaf.2020.e00360>.
- Githiori, John B., Höglund, Johan, Waller, Peter J., Baker, R.Leyden, 2002. Anthelmintic Activity of Preparations Derived from Myrsine Africana and Rapanea Melanophloeos against the Nematode Parasite, Haemonchus Contortus, of Sheep. *J. Ethnopharmacol.* 80 (2–3), 187–191. [https://doi.org/10.1016/S0378-8741\(02\)00030-2](https://doi.org/10.1016/S0378-8741(02)00030-2).
- Gogo, Adol F.C., Masaki, Emily, 2022. Sustainability of Cultural Tourism in East African Community. *Advances in Science, Technology and Innovation.* Springer Nature, pp. 187–194. https://doi.org/10.1007/978-3-031-07819-4_16.
- Haji, Latif, Naser Valizadeh, and Dariush Hayati. 2021. "The Role of Local Communities in Sustainable Land and Forest Management." In, 473–503. https://doi.org/10.1007/978-3-030-56542-8_20.
- Herzog, Thomas R., Gray, Lauren E., Dunville, Amy M., Hicks, Angela M., Gilson, Emily A., 2013. Preference and Tranquility for Houses of Worship. *Environ. Behav.* 45 (4), 504–525. <https://doi.org/10.1177/0013916511410422>.
- Hlangwani, Edwin, Hal, Penny Hiwilepo-van, Moganedi, Kgabo L.M., Dlamini, Bhikisiza C., 2023. The Future of African Wild Fruits – a Drive towards Responsible Production

- and Consumption of the Marula Fruit. *Front. Sustain. Food Syst.* 7 (December). <https://doi.org/10.3389/fsufs.2023.1294437>.
- Horowitz, John K., McConnell, K.E., 2003. Willingness to Accept, Willingness to Pay and the Income Effect. *J. Econ. Behav. Organ.* 51 (4), 537–545. [https://doi.org/10.1016/S0167-2681\(02\)00216-0](https://doi.org/10.1016/S0167-2681(02)00216-0).
- Humphrey, Agevi., 2016. PELIS Forestry Programme as a Strategy for Increasing Forest Cover and Improving Community Livelihoods: case of Malava Forest, Western Kenya. *Am. J. Agric. Forest.* 4 (5), 128. <https://doi.org/10.11648/j.ajaf.20160405.13>.
- Ives, Christopher, Kidwell, Jeremy, Anderson, Christopher, Arias-Arévalo, Paola, Gould, Rachelle, Kenter, Jasper, Murali, Ranjini, 2024. The Role of Religion in Shaping the Values of Nature. *Ecol. Soc.* 29 (2), art10. <https://doi.org/10.5751/ES-15004-290210>.
- Iyer, Sriya, Weeks, Melvyn, 2020. Social Interactions, Ethnicity, Religion, and Fertility in Kenya. *J. Demogr. Econ.* 86 (3), 329–365. <https://doi.org/10.1017/dem.2020.6>.
- Jago, S., Elliott, K.F.V.A., Tovar, C., Soto Gomez, M., Starnes, T., Abebe, W., Alexander, C., et al., 2024. Adapting Wild Biodiversity Conservation Approaches to Conserve Agrobiodiversity. *Nat. Sustain.* 7 (11), 1385–1394. <https://doi.org/10.1038/s41893-024-01427-2>.
- Jebiwott, Alice, Ogendi, George Morara, Kazaba, Paul Kaseya, Alo, Abiodun Akintunde, 2023. An Assessment of the Process and Impacts of Evictions on Livelihoods in Mau Forest, Kenya. The Palgrave Handbook of Global Social Change. Springer International Publishing, Cham, pp. 1–22. https://doi.org/10.1007/978-3-030-87624-1_354-1.
- Kaigongi, Magrate M., Lukhoba, Catherine W., Musila, Fredrick M., Taylor, Malcolm, Mbugua, Regina W., Githiomi, Joseph, Yenesew, Abiy, Makunga, Nokwanda P., 2023. A Versatile Untargeted Metabolomics-Driven Technology for Rapid Phytochemical Profiling of Stem Barks of Zanthoxylum Species with Antioxidant and Antimicrobial Activities. *Advanc. Tradition. Med.* 23 (3), 929–945. <https://doi.org/10.1007/s13596-022-00676-w>.
- Kambona Ouma, O., Stadel, C., 2006. Kakamega Forest, Ecotourism and Rural Livelihoods: linkages and Interactions for the Kakamega Forest Region, Western Kenya. *Sustainable Tourism II*. WIT Press, Southampton, UK, pp. 149–158. <https://doi.org/10.2495/ST060141>.
- Kambona Ouma, Oscar, Stadel, Christoph, Okalo, Benjamin, 2016. *Social Science and Indigenous Ecological Knowledge in Kakamega Forest, Western Kenya*. Res. Eco. Mont. 8 (1).
- Kassilly, Fredrick Nyongesa, Tsingalia, Harrison Mugatsia, 2009. Persistence and Loss of Cultural Values of Tiriki Sacred Groves in Hamisi District, Kenya: implications For Management (RH: cultural Values of Tiriki Sacred Groves). *J. Hum. Ecol.* 27 (2), 137–141. <https://doi.org/10.31901/24566608.2009/27.02.07>.
- Kenya National Bureau of Statistics (KNBS), 2024. Leading Economic Indicators Inflation Rate Lower Income Upper Income Kenya Inflation Rate. <https://www.knbs.or.ke/reports/leading-economic-indicator-february-2024/>.
- Kenya National Bureau of Statistics. 2019. "VOLUME IV KPHC 2019, Distribution of Population by Socio-Economic Characteristics."
- Kenya Population and Housing Census Analytical Report on Housing Conditions and Amenities. Nairobi. <https://www.knbs.or.ke/>.
- Khan Arfin, Mohammed A.S., and Md.Shamim Reza Saimun. 2020. "Forest Dependency: status, Assessment Tools, and Influencing Factors." In, 1–10. https://doi.org/10.1007/978-3-319-71065-5_24-1.
- Khunweechuay, Narumol, Roongtawanreongsri, Saowalak, Hatta, Krongchai, 2022. Cultural Forest Ecosystem Services of the Maniq Indigenous People in Southern Thailand. *Hum. Ecol.* 50 (3), 559–576. <https://doi.org/10.1007/s10745-022-00315-7>.
- Kimanzu, Ngolia, Schulte-Herbrüggen, Björn, Clendenning, Jessica, Chiwona-Karlton, Linley, Krogsgeng, Kyla, Petrokofsky, Gillian, 2021. What Is the Evidence Base Linking Gender with Access to Forests and Use of Forest Resources for Food Security in Low- and Middle-Income Countries? A Systematic Evidence Map. *Forests* 12 (8), 1096. <https://doi.org/10.3390/f12081096>.
- Kiptot, Evelynne, Franzel, Steven, 2012. Gender and Agroforestry in Africa: a Review of Women's Participation. *Agroforestry Syst.* 84 (1), 35–58. <https://doi.org/10.1007/s10457-011-9419-y>.
- Kocemba, Michèle von, Strobelt, Simon, Mande, Manasseh, Conrad, Olaf, Schickhoff, Udo, 2025. The Key Issue Is a Land Question.' – Five Decades of Forest Cover Change in the Mount Elgon Protected Area System, Uganda. *J. Mt. Sci.* 22 (3), 776–799. <https://doi.org/10.1007/s11629-024-8986-0>.
- Konu, Henna, Leino, Pinja, Tyrväinen, Liisa, 2024. Tourism Firms' Attitudes and Willingness to Contribute to Payments for Ecosystem Services in Tourism. *Tourism Recreat. Res.* (February), 1–15. <https://doi.org/10.1080/02508281.2024.2312349>.
- Langat, David Kipkirui, Kisiwa, Abdalla Kiteo, Leley, Nereoh Chelimo, Kagombe, Joram Kimenju, Cheboiwo, Joshua Kiplongi, 2022. Can Small-Holder Trees Supplement the Public Plantations in the Wood Market? The Case of Kenya's Logging Moratorium. *Open J. Forest.* 12 (03), 337–349. <https://doi.org/10.4236/ojfor.2022.123018>.
- Lepetu, J., Nair, P.K., 2009. *Forest Dependency and Its Implication for Protected Areas Management: a Case Study From Kasane Forest Reserve, Botswana*. *Int. J. Environ. Res* 3 (4), 525–536.
- Lloyd-Jones, Tony, Rakodi, Carole, 2014. *Urban Livelihoods*. Routledge. <https://doi.org/10.4324/9781849773805>.
- Lovrić, Marko, Da Re, Riccardo, Vidale, Enrico, Prokofieva, Irina, Wong, Jennifer, Pettenella, Davide, Verkerk, Pieter Johannes, Mavsar, Robert, 2020. Non-Wood Forest Products in Europe – A Quantitative Overview. *Forest Policy Econ.* 116 (July), 102175. <https://doi.org/10.1016/j.forpol.2020.102175>.
- Lusambili, Kizito Muchanga, Okoth, Pontian Godfrey, 2022. Evaluating Opportunities for Evangelisation in the Historical Development of the Catholic Diocese of Kakamega since 1978. *Res. J. Advanc. Humanit.* 3 (3), 59–77. <https://doi.org/10.58256/rjah.v3i3.878>.
- Mabonga *Bett, C., -Linge, K., 2022. SACUTE EFFECTS OF MONDIA WHITEI 'MUKOMBERO' ON TESTOSTERONE HORMONE IN MALE WINSTER ALBINO RATS. October. www.qjoest.com.
- Mahmoudi, Beytollah, Ng, Eric, Mafi-Gholami, Davood, Eshaghi, Fatemeh, 2023. Forest Dwellers' Dependence on Forest Resources in Semi-Arid Environments. *Sustainability* 15 (3), 2689. <https://doi.org/10.3390/su15032689>.
- Maithya, Joseph K., Ming'ate, Felix L.M., Letema, Sammy C., 2022. The Impact of Wetland Utilisation on Provisioning Ecosystem Services in Nyando Wetland, Kenya. *J. Environment. Assess. Policy Manag.* 24 (01). <https://doi.org/10.1142/S146433322500235>.
- Maosi, Richard, 2021. My Sweet Products from Mushrooms. How Mushroom Is Making Kakamega Farmer Thrive. *Nation Media Group*. August 14, 2021. <https://nation.africa/kenya/business/seeds-of-gold/my-sweet-products-from-mushrooms-3510874>.
- Matthews, William G., 2014. Opportunities and Challenges for Petroleum and LPG Markets in Sub-Saharan Africa. *Energy Policy.* 64 (January), 78–86. <https://doi.org/10.1016/j.enpol.2013.07.092>.
- Mbaka, Charity Kageni, Gikonyo, Joseph, Kisaka, Oscar Masika, 2019. Households' Energy Preference and Consumption Intensity in Kenya. *Energy Sustain. Soc.* 9 (1), 20. <https://doi.org/10.1186/s13705-019-0201-8>.
- McMullin, S., Ngethe, E., Gachui, A., Njogu, K., Jamnadass, R., 2016. Fruit Tree Portfolios For Improved Diets and Nutrition in Kakamega County, Kenya. *World Agroforestry Centre (ICRAF), Nairobi*. www.innerpath.com.au/loquat.
- Michael, Matthew, Habila, Umar, Danfulani, Dadem, 2021. In: Michael, Matthew, Danfulani, Umar Habila Dadem (Eds.), *African Healing Shrines and Cultural Psychologies*. Fortress Press. <https://doi.org/10.2307/j.ctv1v08zmg>. Edited by.
- Ministry of Energy, Republic of Kenya, 2022. BEHAVIOUR CHANGE AND COMMUNICATION STRATEGY FOR PROMOTING CLEAN COOKING IN KENYA. Nairobi. <https://www.energy.go.ke/>.
- Misra, Smita., 2008. Willingness of Households to Pay for Improved Services and Affordability RURAL WATER SUPPLY IN INDIA Policy Paper Extracted from the World Bank Study on Review of Effectiveness of Rural Water Supply Schemes in India. <http://documents.worldbank.org/curated/en/439161468034759169/Willin-gness-of-households-to-pay-for-improved-services-and-affordability>.
- Mohammed, Hemin Nuraddin, Beeram, Eswari, Divya, B.J., Pallavi, C., Demir, H., Demir, B.B., Polley, Tapasi, et al., 2020. In: Mastanjevic, Dr.Kristina (Ed.), *Avocado and Its By-Products: Natural Sources of Nutrients, Phytochemical Compounds and Functional Properties*. Book Publisher International (a part of SCIENCEDOMAIN International). <https://doi.org/10.9734/bpi/crafs/v1>. Edited by.
- Murimi, M., Cheloti, M., Wekesa, I., Onyuka, A., 2024. Sectoral Value Chain Mapping in Kakamega County. *Kenya Earth Envi Sci Res. Rev.* 7 (2), 1–12.
- Musyoki, Josephine Kamene, Mugwe, Jayne, Mutundo, Kennedy, Muchiri, Mbae, 2013. Determinants of Household Decision to Join Community Forest Associations: a Case Study of Kenya. *ISRN Forest.* 2013 (January), 1–10. <https://doi.org/10.1155/2013/902325>.
- Muthee, J.K., Gakuya, D.W., Mbaria, J.M., Kareru, P.G., Mulei, C.M., Njonge, F.K., 2011. Ethnobotanical Study of Anthelmintic and Other Medicinal Plants Traditionally Used in Loitokitok District of Kenya. *J. Ethnopharmacol.* 135 (1), 15–21. <https://doi.org/10.1016/j.jep.2011.02.005>.
- Muthike, George, Githiomi, Joseph, 2017. Review of the Wood Industry in Kenya; Technology Development, Challenges and Opportunities. *International J. Res. Stud. Agricultur. Sci.* 3 (10). <https://doi.org/10.20431/2454-6224.0310005>.
- Nche, George C., Michael, Benson Ogar, 2024. Perspectives on African Indigenous Religion and the Natural Environment: beings, Interconnectedness, Communities and Knowledge Systems. *Phronimon* (April). <https://doi.org/10.25159/2413-3086/14621>.
- Ndung'u, Simon, Ogemah, Vitalis, Thiga, Moses, Wandahwa, Philip, 2023. Adoption of Agroforestry as a Climate Smart Agriculture Practice among Smallholder Farmers in Kakamega County, Kenya. *Afric. J. Empiric. Res.* 4 (2), 1157–1173. <https://doi.org/10.51867/ajernet.4.2.118>.
- Nerfa, Lauren, Rhemtulla, Jeanine M., Zerriffi, Hisham, 2020. Forest Dependence Is More than Forest Income: development of a New Index of Forest Product Collection and Livelihood Resources. *World Dev.* 125 (January), 104689. <https://doi.org/10.1016/j.worlddev.2019.104689>.
- Newton, P., Castle, S.E., Kinzer, A.T., Miller, D.C., Oldekop, J.A., Linhares-Juvenal, T., Pina, L., Madrid, M., de Lamo Rodriguez, J., 2022. The Number of Forest- and Tree-Proximate People. *FAO*. <https://doi.org/10.4060/cc2544en>.
- Ngaba, Mbezele Junior Yannick, Michel-Cédric, Yonga Emagueu, Benenuegne, Marc Clément, Kobla, Anne Stéphanie, Simon, Njal Njock, 2023. Challenges of Wood Transformation Industry in Cameroon: a Holistic Overview. *OALib* 10 (11), 1–20. <https://doi.org/10.4236/oalib.1110855>.
- Njenga, Mary, Sears, Robin R, Mendum, Ruth, 2023. Sustainable Woodfuel Systems: a Theory of Change for Sub-Saharan Africa. *Environment. Res. Communicat.* 5 (5), 051003. <https://doi.org/10.1088/2515-7620/acd0f3>.
- Njoroge, Grace N., Bussmann, Rainer W., 2006. Herbal Usage and Informant Consensus in Ethnoveterinary Management of Cattle Diseases among the Kikuyus (Central Kenya). *J. Ethnopharmacol.* 108 (3), 332–339. <https://doi.org/10.1016/j.jep.2006.05.031>.
- Njoroge, Grace Njeri, Kibunga, Joan Wanjiku, 2007. Herbal Medicine Acceptance, Sources and Utilization for Diarrhoea Management in a Cosmopolitan Urban Area (Thika, Kenya). *Afr. J. Ecol.* 45 (s1), 65–70. <https://doi.org/10.1111/j.1365-2028.2007.00740.x>.
- Nugroho, Eko, Ihle, Rico, Heijman, Wim, Oosting, Simon J., 2022. The Contribution of Forest Extraction to Income Diversification and Poverty Alleviation for Indonesian

- Smallholder Cattle Breeders. *Small-Scale Forest*. 21 (3), 417–435. <https://doi.org/10.1007/s11842-022-09504-0>.
- Nyakang' I, Clinton O, Ebere, Rebecca, Marete, Eunice, Arimi, Joshua M., 2023. Avocado Production in Kenya in Relation to the World, Avocado by-Products (Seeds and Peels) Functionality and Utilization in Food Products. *Appl. Food Res.* 3 (1), 100275. <https://doi.org/10.1016/j.afres.2023.100275>.
- Nyongesa, J.M., Bett, H.K., Lagat, J.K., Ayuya, O.I., 2016. Estimating Farmers' Stated Willingness to Accept Pay for Ecosystem Services: case of Lake Naivasha Watershed Payment for Ecosystem Services Scheme-Kenya. *Ecol. Proc.* 5 (1), 15. <https://doi.org/10.1186/s13717-016-0059-z>.
- Odoyo-June, Elijah, Davis, Stephanie, Owuor, Nandi, Laube, Catey, Wambua, Jonesmus, Musingila, Paul, Young, Peter W., et al., 2021. Prevalence of Male Circumcision in Four Culturally Non-Circumcising Counties in Western Kenya after 10 Years of Program Implementation from 2008 to 2019. *Plos One*. 16 (7), e0254140. <https://doi.org/10.1371/journal.pone.0254140>.
- Oudubemi, T.O., Akinsulire, O.R., Aibinu, I.E., Fabeku, P.O., 2008. Medicinal Plants Useful For Malaria Therapy In Okeigbo, Ondo State, Southwest Nigeria. *African J. Tradition., Complement. Alternat. Med.* 4 (2). <https://doi.org/10.4314/ajtcam.v4i2.31207>.
- Ojunga, S.O., Langat, D.K., Owange, K., Otuoma, J., Ayaga, G., Muskiton, K.C., Wanyiri, M., Isack, M., 2023. Medicinal Plants and Their Economic Value in Kakamega Forest Ecosystem: a Case Study of Sustainable Land/Forest Project in Western Kenya. *J. Medicin. Herbs Ethnomed.* (April), 18–25. <https://doi.org/10.25081/jmhe.2023.v9.8193>.
- Oketch-Rabah, Hellen A., 2012. *Mondia Whitei*, a Medicinal Plant from Africa with Aphrodisiac and Antidepressant Properties: a Review. *J. Diet. Suppl.* 9 (4), 272–284. <https://doi.org/10.3109/19390211.2012.726704>.
- Okumu, Boscow, Muchapondwa, Edwin, 2020. Welfare and Forest Cover Impacts of Incentive Based Conservation: evidence from Kenyan Community Forest Associations. *World Dev.* 129 (May), 104890. <https://doi.org/10.1016/j.worlddev.2020.104890>.
- Omara, Timothy., 2020. Antimalarial Plants Used across Kenyan Communities. *Eviden.-Based Complement. Alternat. Med.* 2020 (1). <https://doi.org/10.1155/2020/4538602>.
- Ombogoh, Douglas B., Mwangi, Esther, Larson, Anne M., 2022. Community Participation in Forest and Water Management Planning in Kenya: challenges and Opportunities. *Forest., Trees. Livelihood.* 31 (2), 104–122. <https://doi.org/10.1080/14728028.2022.2059790>.
- Onyango, B.O., 2016. Molecular Characterization of Wood Ear Mushrooms [Auricularia Sp.] from Kakamega Forest in Western Kenya. *Curr. Res. Environment. Appl. Mycol.* 6 (1), 51–60. <https://doi.org/10.5943/cream/6/1/6>.
- Orlov, Mikhail, Mirkin, Boris, 2014. A Concept of Multicriteria Stratification: a Definition and Solution. *Procedia Comput. Sci.* 31, 273–280. <https://doi.org/10.1016/j.procs.2014.05.269>.
- Osano, Hezron Mogaka, 2019. Global Expansion of SMEs: role of Global Market Strategy for Kenyan SMEs. *J. Innovat. Entrepreneur.* 8 (1), 13. <https://doi.org/10.1186/s13731-019-0109-8>.
- Osewe, Erick O., Daniel Niță, Mihai, Vasile Abrudan, Ioan, 2022. Assessing the Fragmentation, Canopy Loss and Spatial Distribution of Forest Cover in Kakamega National Forest Reserve, Western Kenya. *Forests* 13 (12). <https://doi.org/10.3390/f13122127>.
- Osewe, I., Osewe, E.O., Popa, B., 2023. Interconnection Between Ecosystem Services and Local Communities: knowledge Gap Identification in the Area of Kakamega Forest. *Bulletin of the Transilvania University of Brasov. Series II: Forestry • Wood Industry • Agricultural Food Engineering*, pp. 37–68. <https://doi.org/10.31926/but.fwiafe.2023.16.65.2.3>.
- Osewe, Erick O., Popa, Bogdan, Vacic, Harald, Osewe, Ibrahim, Vasile Abrudan, Ioan, 2024. Review of Forest Ecosystem Services Evaluation Studies in East Africa. *Front. Ecol. Evol.* 12 (July). <https://doi.org/10.3389/fevo.2024.1385351>.
- Ostertagová, Eva, Ostertag, Oskar, 2013. Methodology and Application of One-way ANOVA. *Am. J. Mechanic. Eng.* 1 (7), 256–261. <https://doi.org/10.12691/ajme-1-7-21>.
- Ouma, O.K., Stadel, C., Okalo, B., 2015. Social science and indigenous ecological knowledge in Kakamega Forest, Western Kenya. *Eco. Mont J. Protect Moun. Areas Res.* 8 (1), 29–38. <https://doi.org/10.1553/eco.mont-8-1s29>.
- Ouma, Oscar Kambona, Stadel, Christoph, Okalo, Benjamin, 2015. Social Science and Indigenous Ecological Knowledge in Kakamega Forest, Western Kenya. *Eco.Mont. (J. Protected Mount. Areas Res.)* 8 (1), 29–38. <https://doi.org/10.1553/eco.mont-8-1s29>.
- Pedroso, Rui, Kung'u, James Biu, 2019. Tourists' Willingness to Pay for Upstream Restoration and Conservation Measures. *J. Sustain. Tour.* 27 (8), 1107–1124. <https://doi.org/10.1080/09669582.2019.1593991>.
- Pillay, Rajeev, Venter, Michelle, Aragon-Osejo, Jose, González-del-Pliego, Pamela, Hansen, Andrew J, Watson, James EM, Venter, Oscar, 2022. Tropical Forests Are Home to over Half of the World's Vertebrate Species. *Front. Ecol. Environ.* 20 (1), 10–15. <https://doi.org/10.1002/fee.2420>.
- Pradhan, Aditya, Khaling, Sarala, 2023. Community Priorities, Values, and Perceptions Associated with Ecosystem Services Provided by the Socio-Ecological Landscapes of Darjeeling-Sikkim Himalaya. *Reg. Environ. Change.* 23 (1), 36. <https://doi.org/10.1007/s10113-023-02028-z>.
- Pstistaki, Kyriaki, Tsantopoulos, Georgios, Paschalidou, Anastasia K., 2024. An Overview of the Role of Forests in Climate Change Mitigation. *Sustainability* 16 (14), 6089. <https://doi.org/10.3390/su16146089>.
- Republic of Kenya, 2016. Forest Conservation and Management Act. *Forest Conservat. Manag. Act.* 155 (34), 677–736. <http://www.ilo.org/dyn/travail/docs/505/EmploymentAct2007.pdf>.
- Rhodah, Ms.Esilaba Ong'awa, Grace, Mrs Sitoki Mauti, Jahonga, Wilberforce Manoah, 2016. Opportunities And Constraints for Development Funds Access Towards Empowerment of Women in Africa: a Case Study of Kakamega County. *IOSR J. Econ. Fin.* 07 (04), 57–59. <https://doi.org/10.9790/5933-0704035759>.
- Sasaki, Nophea, Knorr, Wolfgang, Foster, David R., Etoh, Hiroko, Ninomiya, Hiroshi, Chay, Sengtha, Kim, Sophanarith, Sun, Sengxi, 2009. Woody Biomass and Bioenergy Potentials in Southeast Asia between 1990 and 2020. *Appl. Energy.* 86 (November), S140–S150. <https://doi.org/10.1016/j.apenergy.2009.04.015>.
- Sawe, Estomih N., 2012. Sustainable Charcoal and Firewood Production and Use in Africa. *Bioenergy For Sustainable Development in Africa*. Springer Netherlands, Dordrecht, pp. 75–80. https://doi.org/10.1007/978-94-007-2181-4_7.
- Sharma, Sheenu, Hussain, Sabir, Singh, Narain, Singh, Anand Narain, 2022. Evaluation Methods for Cultural Ecosystem Services: a Systematic Review. *Proceed. Int. Acad. Ecol. Environment. Sci.* 2022. www.iaees.org/Article.
- Shilitsa, John, 2021. Farmers Turn 'Mukombero' Wild Plant Into a Cash Crop. *The Standard Media Group*. August 12, 2021. <https://www.standardmedia.co.ke/counties/article/2001408735/turning-mukombero-into-a-cash-crop>.
- Shinde, Kiran., 2021. Sacred Sites, Rituals, and Performances in the Ecosystem of Religious Tourism. *Religions* 12 (7), 523. <https://doi.org/10.3390/rel12070523>.
- Shoddo, Getaneh Haile, 2022. The Contribution of Gudo Forest Conservation Culture Is Key to Biodiversity Conservation the Case of Sheka Zone, Southwest Ethiopia. *Land. Use Policy.* 113 (February), 105872. <https://doi.org/10.1016/j.landusepol.2021.105872>.
- Sola, Phiso, Schure, Jolien, Eba'a Atyi, Richard, Gumbo, Davison, Okeyo, Irene, 2019. Politiques et Pratiques En Matière de Bois-Énergie Dans Certains Pays d'Afrique Subsaharienne – Un Examen Critique. *Bois. Forest. Des. Tropique.* 340 (May). <https://doi.org/10.19182/bft2019.340.a31690>.
- Sola, P., Bourne, M., Okeyo, I., Njenga, M., 2020. Governance of Woodfuel Value Chains in Kenya: an Analysis of Policies, Legislative Frameworks and Institutional Mechanism. *Center for International Forestry Research (CIFOR)*. <https://doi.org/10.17528/cifor/007890>.
- Son, Jaewon, Saha, Somidh, 2023. Public Perceptions and Willingness to Pay for Cultural Ecosystem Services from Urban Forests. *Sci. Talk.* 8 (December), 100253. <https://doi.org/10.1016/j.sctalk.2023.100253>.
- Sylvester, O., García Segura, A., Davidson-Hunt, I., 2016. Complex Relationships among Gender and Forest Food Harvesting: insights from the Bribrí Indigenous Territory, Costa Rica. *Int. Forest. Rev.* 18 (2), 247–260. <https://doi.org/10.1505/146554816819254290>.
- Tendwa, Maureen Bilinga, Morris, Aqeel, Opuwari, Chinyerum Silvia, Leisegang, Kristian, Finelli, Renata, Zenoaga-Barbăroşie, Cătălina, Henkel, Ralf, 2024. Aqueous Extractions of *Mondia Whitei* Root Improve Human Sperm Function in Vitro. *South Afric. J. Botany.* 171 (August), 77–84. <https://doi.org/10.1016/j.sajb.2024.05.055>.
- Terheggen, Anne., 2011. The Tropical Timber Industry in Gabon: a Forward Linkages Approach to Industrialisation. www.cssr.uct.ac.za/prism/projects/mmpc.
- Thelma, Chanda Chansa, Chitondo, Lufeyo, 2023. Exploring the Interplay Between Culture and Religion in African Countries: a Case of Lusaka District, Zambia. *Int. Res. J. Moderniz. Eng. Technol. Sci.* (December). <https://doi.org/10.56726/IRJMETS46879>.
- Thiffault, E., Gianvenuti, A., Zuzhang, X., Walter, S., 2023. The Role of Wood Residues in the Transition to Sustainable Bioenergy. *FAO*. <https://doi.org/10.4060/cc3826en>.
- Tsingalia, H.M. 2020a. "Kakamega Tropical Forest: island in a Human-Dominated Landscape." In, 1–11. https://doi.org/10.1007/978-3-319-71065-5_109-1.
- . 2020b. "Kakamega Tropical Forest: island in a Human-Dominated Landscape." In, 1–11. https://doi.org/10.1007/978-3-319-71065-5_109-1.
- Ummel, Kevin, Poblete-Cazenave, Miguel, Akkiraju, Karthik, Graetz, Nick, Ashman, Hero, Kingdon, Cora, Tenorio, Steven Herrera, Singhal, Aaryaman Sunny, Cohen, Daniel Aldana, Rao, Narasimha D., 2024. Multidimensional Well-Being of US Households at a Fine Spatial Scale Using Fused Household Surveys. *Sci. Data.* 11 (1), 142. <https://doi.org/10.1038/s41597-023-02788-7>.
- Wanzala, Maximila N., Were, Vincent, Oloo, J.A., Nguka, Gordon, 2019. Assessing Capacity and Performance of Health Systems Using Principal Component Analysis: results from Cross Sectional Survey in Kakamega County, Western Kenya. *J. Health, Med. Nurs.* February. <https://doi.org/10.7176/JHNM/59-03>.
- Waruingi, Esther, Mbeche, Robert, Ateka, Josiah, 2021. Determinants of Forest Dependent Household's Participation in Payment for Ecosystem Services: evidence from Plantation Establishment Livelihood Improvement Scheme (PELIS) in Kenya. *Glob. Ecol. Conservat.* 26 (April), e01514. <https://doi.org/10.1016/j.gecco.2021.e01514>.
- Waruingi, Esther, Ateka, Josiah, Mbeche, Robert, Herrmann, Raoul, 2023. Understanding the Nexus between Forest Dependence and Willingness to Pay for Forest Conservation: case of Forest Dependent Households in Kenya. *Forestry Econom. Rev.* 5 (1), 23–43. <https://doi.org/10.1108/FER-02-2022-0003>.
- Wassihun, Agerie Nega, Feleke, Fikeremariam Birara, Bayeh, Gebrehiwot Abebe, Nega, Yitayew Maledo, 2021. Smallholder Households' Willingness to Pay for Conservation of Ecosystem Services of Altash National Park of Ethiopia. *Int. J. Geohierit. Park.* 9 (4), 405–414. <https://doi.org/10.1016/j.ijgeop.2021.11.002>.
- Were, Lilian, Kassilly, Janet, Ahaya, Ochieng Lukes, 2024. The Indigenous Abaluhya Worldview in Communicating Conservation of Kakamega Forest, Kenya. *Afric. J. Empiric. Res.* 5 (3), 94–106. <https://doi.org/10.51867/ajernet.5.3.9>.
- Yaden, David B., Newberg, Andrew, 2022. *The Varieties of Spiritual Experience*. Oxford University Press, New York. <https://doi.org/10.1093/oso/9780190665678.001.0001>.