Blueprint Academic Publishers

Journal of Aquatic and Terrestrial Ecosystems
3(2)
Received: April 15, 2025
Accepted: May 28, 2025
Published: June 9, 2025

Livelihood Dynamics from Bamboo Utilization and Commercialization in Busia and Elgeyo Marakwet Counties, Kenya

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Abstract

Bamboo has the potential to enhance the livelihoods of smallholder farmers, generate employment and promote community development. Despite government and institutional initiatives aimed at promoting bamboo utilization in Kenya, its full potential remains underexploited. This study investigated the livelihood factors influencing bamboo utilization and commercialization in selected regions, aimed at identifying support strategies to maximize its benefits within local communities. The study employed descriptive research design. Using the 2019 Kenya Population and Housing Census data, the study targeted 32,213 and 27,029 households in Butula and Keiyo South respectively. The household sample of 398 was calculated using Taro Yamane's (1967) formula, with 205 households (51.3%) drawn from Butula Sub County and 193 households (48.7%) from Keiyo South Sub County. Simple random sampling was used to select households in various villages. Data was coded into SPSS and analysed using descriptive and inferential statistics. Results indicated high awareness of bamboo benefits among respondents (91.2% in Busia and 92.7% in Elgeyo Marakwet), with 87.3% and 37.8% actively utilizing bamboo within their households, respectively. Gender, age, education level, household size, and land ownership significantly influenced bamboo utilization ($p < .001$). ANOVA results showed that bamboo utilization was significantly influenced by adoption ($F = 42.816$, $p < .001$), livelihood dynamics ($F = 57.675$, $p < .001$), and gender ($F = 7.321$, $p = .001$) however, socio-cultural factors did not significantly affect utilization ($p = .189$). Further, commercialization was more prevalent in Busia (39.5%) than Elgeyo Marakwet (2.6%). ANOVA results indicated that bamboo selling was significantly influenced by adoption ($F = 7.655$, $p = .001$), livelihood dynamics ($F = 4.911$, $p = .003$) and socio-cultural factors ($F = 8.801$, $p < .001$), but not by gender ($p = .249$). In conclusion, bamboo adoption and utilization are shaped by socio-economic, gender, and cultural factors, but it remains promising due to its economic and ecological potential. Targeted awareness and financial support are recommended to promote its broader adoption and commercialization.

Keywords: Bamboo, utilization, commercialization, Elgeyo Marakwet, Busia, livelihoods

Journal ISSN: 2960-1118

Issue DOI: https://doi.org/10.69897/jatems.v3i1

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Funding: The author received no financial support for the research, authorship and/or publication of this article.

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials or upon reasonable request.

Competing interests: The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Introduction

Bamboo is a widely distributed grass in the tropical, subtropical and temperate climatic domains. It taxonomically belongs to the subfamily Bambusoideae of the grass family Poaceae (Scurlock *et al.*, 2000), having about 90 genera and 1,500 species in the world (Desalegn & Tadesse, 2014; Clark *et al.*, 2015). It covers a total area of 35.04 million ha worldwide with 4.65 million ha, 24.88 million ha, 5.39 million ha and 1.25 million ha, in Africa, Asia, South America, North and Central America respectively (FAO, 2020). This contributes to approximately 1% of global forest area (Lobovikov *et al.*, 2007; FAO, 2020).

The total area under bamboo has increased by almost 50 percent between 1990 and 2020 (FAO, 2020). Its popularity has increased over the past few decades, partly due to the belief that some varieties are "wonder plants" or "miracle crops," meaning they are particularly useful for addressing contemporary environmental, social, and economic demands (Hoogendoorn & Benton 2014; Liese & Köhl, 2015).

Africa has 12.3% of the global bamboo resources and contributes 7.3% of the total bamboo species (Bahru & Ding, 2021). It is host to 115 bamboo species from 48 of the continent's countries (FAO, 2020). In Africa, Ethiopia, Kenya and Uganda possess most of the bamboo resources, with Ethiopia contributing the highest amount (Kelbessa *et al.*, 2000; Lobovikov *et al.*, 2005; FAO, 2020). These countries all play a pivotal role in promoting bamboo value chains for the socio-economic and environmental benefit of Eastern Africa (Pinimidzai *et al.*, 2022). Yet, despite the long history of the utilization of bamboo across the continent, the potential of this green economic resource remains largely unexploited (Pinimidzai *et al.*, 2022).

The bamboo value chain enterprises are most advanced and complex in China and the most under-developed in Africa with limited processing (Tambe *et al.*, 2020). In many African countries, bamboo is not well developed because of unclear governance whereby bamboo falls between the agricultural and forestry sector; as well as inadequate training on how to well manage it both in

the forest and farmlands (Buckingham *et al*., 2011). Among various other bottlenecks, low-value products and a lack of capacity to adhere to international standards have resulted in the region's exclusion from a global export trade in bamboo products currently valued at over United States Dollar (USD) 1.8 billion (Pinimidzai *et al*., 2022). The population growth with increasing economic development and energy needs has resulted to depletion of other forest resources leading to bamboo forests being considered for commercial exploitation to replicate their uses in Asian countries (Muchiri & Muga, 2013). Building capacity at the local, village, and family levels is essential to improve bamboo management and utilization practices (Boissière *et al*., 2020).

In Kenya, the dominant species of bamboo is *Yushania alpina (K. Schumach)*, and it is found mainly in Mount Elgon, Mount Kenya, Cherangany Hills, Mau Forest and the Aberdare Range (National Bamboo Policy, 2022; Ongugo *et al*., 2000). It is the only species native to Kenya, and covers approximately 150,000 ha growing in pure or mixed stands in montane forest of Kenya (Kigomo, 2007). They are locally known as *Mirangi* (Kikuyu), *Techani* (Pokot), *Tegek* (Kipsigis), *Tekek* (Sebei), *Modi* (Luo) and *Mianzi* (Kiswahili) occurring between 2290 and 3360 m above sea level (Ongugo *et al*., 2000). They cover a total of 342.01 km^2, 259.66 km^2, 81.80 km^2, 301.96 km^2 and 500.38 km^2 respectively (Zhao *et al*., 2018). However, most of these plantations have been cleared to allow for farming and production of commercial exotic tree species in gazetted forests (Ongugo *et al*.,2000; Kibwage *et al*., 2008). The Kenya Parliament in September 2020 classified bamboo as a cash crop and recorded it as the 16th scheduled cash crop in the country (National Bamboo Policy, 2022). This classification was done to accelerate commercialization of bamboo.

The studies on *Bambusa vulgaris* and *Dendrocalamus giganteus* in Nyanza province have shown that bamboo can be grown by farmers and produce better returns compared to tobacco growing (Kibwage *et al*., 2008). Bamboo shoots from *Bambusa vulgaris*, *Yushania alpine* and *Dedrocalamus giganteus* are potential food sources (Karanja *et al*., 2015). Results showed that these types of bamboo that grow well in Kenya and are wealthy in critical major-nutrients are comparable to edible varieties grown in countries such as China and India (Karanja *et al*., 2015). The bamboo sector in Kenya is still at a nascent stage and, to encourage investment and the growth of the sector, there is a need for strategies that would encourage private land owners to engage in bamboo agro-forestry to boost the resource base and, possibly, tax exemptions for bamboo products similar to those applicable to other products on the market (Pinimidzai *et al*., 2022).

The propagation of the native *Y. alpina* has proven challenging, resulting in its inadequate domestication within the suitable environments (John *et al*., 2022). This necessitated the introduction of exotic species. Research to introduce and validate suitability of different types of bamboo to Kenya's agro-ecological conditions started in 1986 (KEFRI, 2008). Twenty-two bamboo species were introduced from Asia among which 12 were found to be suitable for different agro-ecological zones in Kenya include: *Bambusa brandisii, Bambusa vulgaris var. vulgaris, Bambusa vulgaris var. vittata, Bambusa bambos, Bambusa tulda, Dendrocalamus membranaceus, Dendrocalamus strictus, Dendrocalamus asper, Dendrocalamus hamiltonii, Gigantochloa aspera, Oxytenanthera abyssinica* and *Thyrsostachys siamensis* (National Bamboo Policy, 2022).

It is evident that bamboo is an important component of the rural farming system and plays an important role in rural economics to sustain the livelihoods of

local communities (Paudyal *et al*., 2022). Commercial bamboo forestry has the potential to promote sustainable development, provide alternatives to timber products, sequester carbon and restore degraded lands (Buckingham *et al*., 2011). Expanding bamboo plantations can be one of the cheapest ways of reversing land degradation and is appropriate for meeting global restoration goals (Paudyal *et al*., 2022). This is because bamboos have also proven to have an ecological function of soil and water conservation, especially in the water towers (Zhou *et al*., 2005).

Bamboo is a key component in lifting rural people out of poverty by providing job opportunities (Mishra, 2015; Chen *et al*., 2017). Due to its versatile application and rapid re-growth, bamboo provides materials for household use, construction, and industries (Kaur *et al*., 2016; Sofiana *et al*., 2017), which is an alternative material to wood products facing immense environmental concerns. Bamboo weaving for example, is a good income-earning opportunity for disadvantaged groups (Das, 2017). Bamboo industries have developed rapidly in recent years and contributed more than USD 60 billion annually in 2017 (INBAR, 2019). These industries can further contribute to green growth strategies nationally and globally (FAO, 2007; INBAR, 2019).

In Kenya, a verbal proclamation "banning" harvesting of Bamboo from natural forests was issued by the late former President Daniel Arap Moi in 1986 (Ongugo *et al.,* 2000; KEFRI, 2008). This resulted in non-availability of Bamboo resources for value-addition and processing, and contributed to under-development of the Bamboo sector in Kenya. The "ban", was intended to protect the Bamboo resources from over exploitation (National Bamboo Policy, 2022). Key challenges in bamboo development are in the demand-side and there is a need to create new markets for bamboo by promoting industries that support both job creation and increase in farmer incomes (Tambe *et al*., 2020) that will result in further replacement of timber-based products hence less deforestation and further reduced GHG emissions.

Despite bamboo's vast potential for socio-economic and environmental benefits, its value chain in Africa, particularly in Kenya, remains largely underexploited due to various challenges. This study, therefore, seeks to investigate the livelihood dynamics in the utilization and commercialization of bamboo among households in Busia and Elgeyo Marakwet Counties, Kenya, to inform strategies for unlocking the full potential of the bamboo sector for sustainable development.

Methodology

Study areas

Butula Sub County

Butula Sub- County (Figure 1) is one of the sub counties located in the lower region of Busia County. It borders Siaya County and Kakamega County. It has 6 wards namely: Marachi West, Marachi North, Marachi Central, Kingandole and Elugulu wards. Economically, it's one of the best revenue generation areas with Bumala market as one of the biggest markets in Busia County hence has a lot of potential in economic development. The main economic activities include trading, farming both crop (with sugarcane as the main cash crop) and livestock farming.

Most parts of Busia County fall within the Lake Victoria Basin. The altitude is undulating and rises from about 1,130 metres (m) above sea level at the shores of Lake Victoria to a maximum of about 1,500 metres (m) in the Samia and North Teso Hills. The central part of the county, especially Butula and Nambale sub-counties, are occupied by a peneplain

marked by low flat divides of approximately uniform height, often capped by lateritic and a shallowly incised swampy drainage system.

The mean temperatures in the County are about 21-27°c whereas the annual rainfall is about 750-2000mm. The temperature is fairly warm through the year. The precipitation is consistent throughout the year, although the first half of the year known as first season (January-June) receives a slightly greater amount of precipitation than in the second season (July-December). The dry season with scattered rains falls from December to February. Intense precipitation and heat stress are both hazards that contribute to agricultural risk in the county throughout the year, whereas dry spells are more an issue in the second season.

Whereas most parts of Busia County have sandy loam soils, dark clay soils cover the northern and central parts of the county inclusive of Butula and Nambale sub counties. Other soil types are sandy clays and clays.

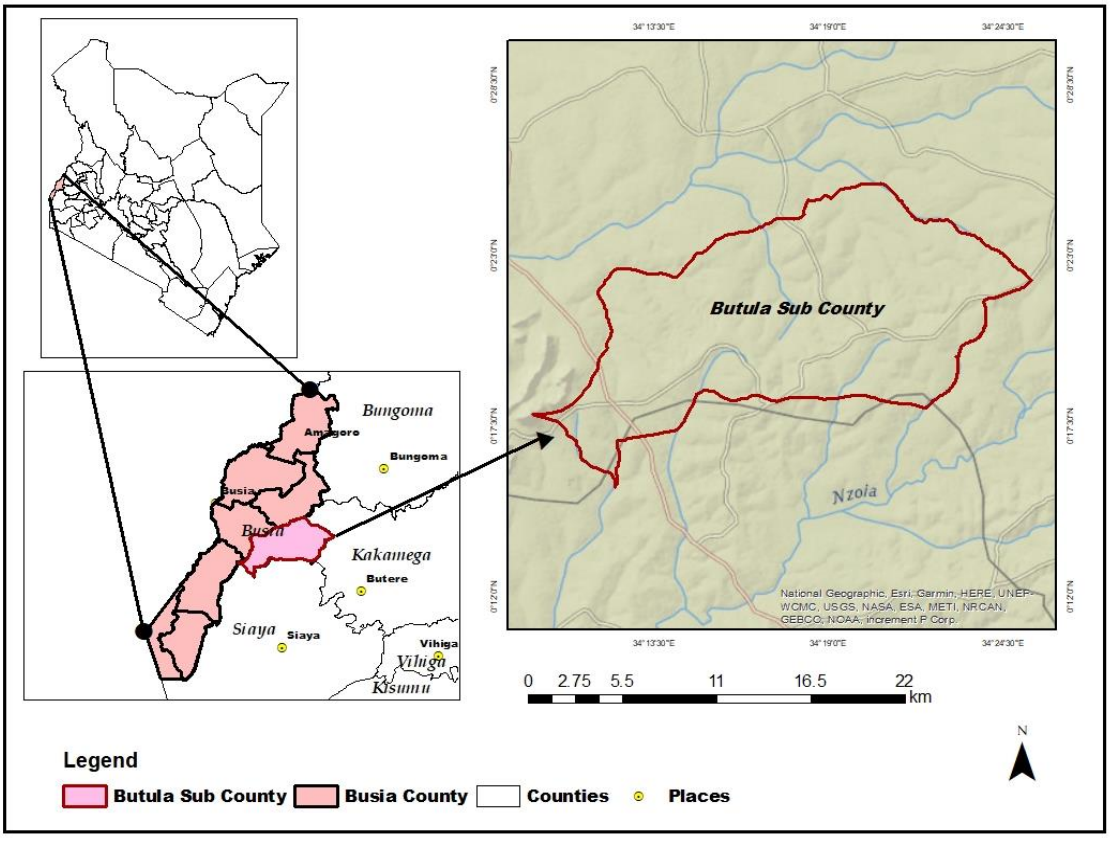

Figure 1: Map of Butula Sub County

Elgeyo ecosystem

Elgeyo ecosystem is part of the Rift valley and Lake Victoria Drainage basin largely situated in Elgeyo Marakwet County and a small section stretches to Uasin Gishu County. Geographically positioned between 35° 20'' and 35° 45'' East Longitude and 0° 10'' and 0° 20'' North latitude (Figure 2). In the year 2019, the Elgeyo water catchment ecosystem covered about 108,367 ha comprising a gazetted forest (25,400 ha) and the buffer zone (82,967ha). The State Forest includes Kessup, Kaptagat, Sabor, Penon, and Kipkabus forest blocks (Figure 6). Commercial exotic forest covers forty percent of the state forest, while native forest covers approximately 38%, and open

grassland and bushland cover 22%. The bigger section of the ecosystem falls in high altitude agro-ecological zone with a moderately cool climate. While a small section falls within the great rift valley escarpment with a moderately dry and hot climate. The area has high agricultural potential endowed with volcanic soils that has encourage crop production. Seventy-two percent (72%) of the population in the water tower practice farming as source of livelihood (KWTA, 2020b).

The locals also keep livestock as source of food and household income. Livestock kept are mainly cattle, sheep, goats and donkeys. Seventy percent (70%) of the households practice free range grazing where most livestock graze and live inside the forest (KWTA, 2020b)

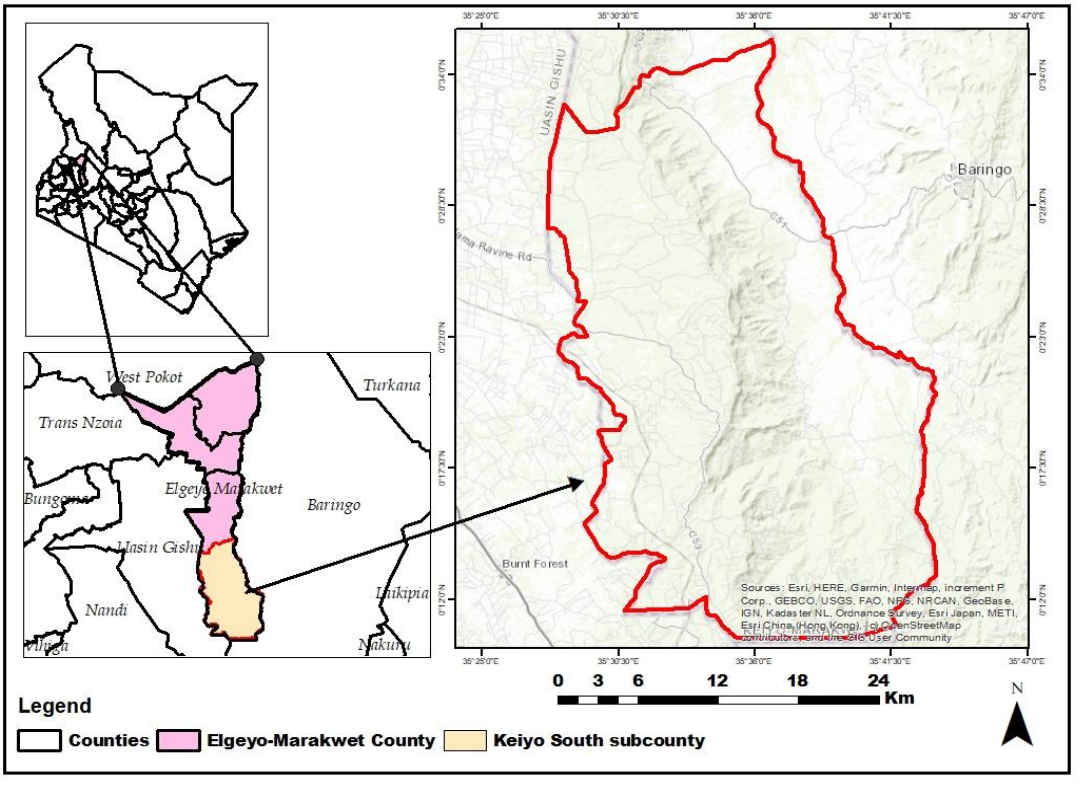

Figure 2: Map of Elgeyo Ecosystem

Research Design

This study adopted by the descriptive design research that describes the characteristics of the population, sample or phenomenon studied (Matanda, 2022, p. 63). This study employed mixed methods research design where both qualitative and quantitative research methods were employed for data collection. Both components utilized a combination of literature survey, household surveys, Focused Group Discussions (FGDs), Key Informant Interviews (KII) and participant observations.

Target population and sampling frame

The study targeted the population living within Butula Sub County in Busia County and Keiyo South Sub County in Elgeyo Marakwet County. These sub-counties were purposively sampled as the study sites due to the specific government, non-governmental and community

initiatives implemented within these areas. The study sampled proportionately from these sub-counties. The study targeted households as the major unit of analysis due to their role in establishment and utilization of bamboo resources.

Sampling procedures and sample selection

Purposive sampling (Obilor, 2023) was used to select key respondents who have knowledge and insights on establishment, management and use of bamboo in the study area. These respondents were drawn from the Kenya Forest Service (KFS), Kenya Water Towers Agency (KWTA), *Kenya Forestry Research Institute (KEFRI), County Government of Busia and Elgeyo Marakwet,* International Bamboo and Rattan Organization (INBAR), Local administration, Eco-green Foundation-Busia, Community Forest Associations (CFAs), Water Resource Users Association (WRUAs) amongst other relevant authorities.

Simple random sampling techniques were employed in all the villages to identify households for the questionnaire survey. The population within the village were obtained from the 2019 Kenya Population and Housing Census data (KNBS, 2019) and annual population projections as per County Integrated Development Plan (CIDP) 2023-2027 for Busia and Elgeyo Marakwet Counties.

Sample size determination

Households in the two sub-counties were sampled using random sampling approach. Taro Yamane's (1967) formula was used to calculate the household sample size for the study. Conferring to population census of 2019, there were 32,213 and 27,029 households in Butula and Keiyo South respectively. CIDP reports (Busia CIDP, 2023-2027; EMC CIDP, 2023-2027) projects the households to be 35,092 and 33,281 by 2025 in Butula and Keiyo South respectively.

The formula used to get the sample size is given as:

$n = N / (1 + N(e^2))$

Where:

- n is the sample size
- N is the population size
- e= significance level (0.05)

The sampled population was a total of 398 households in both sub-counties. A total of 205 (51.3%) and 193 (48.7%) households were sampled from Butula and Keiyo South sub- counties respectively.

Data collection involved both primary and secondary sources aligned with the study objectives. Primary data was gathered through household surveys, key informant interviews, focus group discussions, and direct observation. Observations captured real-life practices and interactions around bamboo use, supported by photographic documentation. Secondary data was sourced from existing literature, government offices, and online databases to complement field data.

Data analysis

Qualitative data from key informant interviews, FGDs, observations, and household surveys were analyzed using SPSS Version 23 and Excel. Descriptive statistics such as frequencies, percentages, and means were used alongside inferential tools including Chi-square tests to assess relationships between categorical variables and bamboo utilization and commercialization. Univariate ANOVA tested the significance of continuous variables in relation to the same, while Pearson correlation (r) at a 0.05 significance level was used to determine associations between study variables. Findings were presented in tables and graphs.

Results

Demographic Characteristics

The household respondents from Busia and Elgeyo Marakwet were asked about certain demographic information that included gender, age, education level, occupation, household size, total area of land owned and the crops grown. The findings are summarized in Table 1 below.

Table 1: Demographic Characteristics of the respondents

Characteristic	Category	Busia (n=205)	%	Elgeyo Marakwet (n=193)	%	Total (N=398)	%
Gender	Male	116	56.6	77	39.9	193	48.5
	Female	89	43.4	116	60.1	205	51.5
Age (Years)	18–25	8	3.9	14	7.3	22	5.5
	26–35	9	4.4	18	9.3	27	6.8
	36–45	44	21.5	40	20.7	84	21.1
	46–55	62	30.2	69	35.8	131	32.9
	>56	82	40.0	52	26.9	134	33.7
	Mean Age (Years)	-	39.8	-	36.6	-	-
	Std. Dev.	-	11.07	-	11.18	-	-
Education Level	No formal education	62	30.2	20	10.4	82	20.6
	Primary	85	41.5	66	34.2	151	37.9
	Secondary	41	20.0	93	48.2	134	33.7
	Tertiary	17	8.3	14	7.3	31	7.8
Occupation	Farmer	180	87.8	171	88.6	351	88.2
	Trader	17	8.3	21	10.9	38	9.5
	Employed	8	3.9	1	0.5	9	2.3
Household Size	1–3	32	15.6	4	2.1	36	9.0
	4–6	66	32.2	90	46.6	156	39.2
	7–9	80	39.0	95	49.2	175	44.0
	10+	27	13.2	4	2.1	28	7.8
	Mean Size	-	4.4	-	4.91	-	-
	Std. Dev.	-	1.91	-	1.58	-	-
Land Size (Acres)	<0.5	40	19.5	27	14.0	67	16.8
	0.5–1	72	35.1	21	10.9	93	23.4
	1–1.5	32	15.6	27	14.0	59	14.8
	1.5–2	3	1.5	24	12.4	27	6.8
	>2	58	28.3	94	48.7	152	38.2
	Mean Land Size (Acres)	-	1.84	-	2.71	-	-
	Std. Dev.	-	1.50	-	1.50	-	-

The results from Table 1 shows that in Busia, there were more males (56.6%) than females (43.4%) while in Elgeyo Marakwet, there were more female (51.5%) than male (48.5%). From the results, it illustrates that cumulatively,

slightly more than half (51.5%) of the respondents from both counties were female while the male contributed 48.5% of the respondents.

As far as age of the respondents was concerned Table 1 majority of the respondents from Busia at 40.0% were aged over 56 years whereas the lowest were those between 18 and 25 at 3.9%. In Elgeyo Marakwet the highest number of the respondents were aged between 46 and 55 at 35.8% and the lowest were those between 18 and 25 years at 7.3%. Cumulatively, majority at 33.7% of the respondents from both counties were aged 56 years and above and the lowest were those of 18-25 years at 5.5%. While there seems to be a slightly younger respondent pool from Elgeyo Marakwet than in Busia, majority of the respondents were middle aged to older people.

The results from Table 1 shows that in Busia, more respondents at 41.5% had primary education while in Elgeyo Marakwet, more respondents at 48.2% had secondary education. Notably, Busia had a higher percentage (41.5%) of the respondents with no formal education. In both counties, the least number of respondents had tertiary education at 8.3% and 7.3% in Busia and Elgeyo Marakwet counties respectively. The results show that majority of the respondents from Busia and Elgeyo Marakwet were farmers at 87.8% and 88.6% respectively. There was a slightly higher number of traders in Elgeyo Marakwet (10.9%) than those in Busia who were 8.3% of the respondents. On average, only 9.5% of the respondents from the two counties were traders and a paltry 2.3% were employed.

The result from Table 1 shows that majority at 39.0% of the respondents in Busia and 49.2% in Elgeyo Marakwet had household sizes of between 4 and 9. The lowest number of household size in Busia was household sizes of more than 10 people whereas in Elgeyo Marakwet, households between 1 and 3 people as well as those above 10 people each contributed 2.1%.

The results from Table 1 illustrate that the average land sizes were higher in Elgeyo Marakwet (2.71 acres) compared to 1.84 acres in Busia. Comparatively the majority of the respondents in Busia at 54.6% owned less than 1 acre of land while in Elgeyo Marakwet, majority at 75.1% owned more than 1acre land. This implies that respondents from Busia owned less land area than those from Elgeyo Marakwet. Notably, the majority (45.7%) of the respondents in Elgeyo Marakwet owned land sizes above 2 acres.

Livelihood dynamics in the utilization and commercialization of bamboo in the two selected counties

This section presents findings on how various livelihood factors influence the adoption, utilization, and commercialization of bamboo in Busia and Elgeyo Marakwet counties.

Uptake of Bamboo Enterprise in Busia and Elgeyo Marakwet Counties

The first factor influencing uptake of bamboo enterprise in farmlands within the study areas was awareness levels of Bamboo as a crop and its use. The results presented in Table 2 shows high awareness levels of Bamboo as a crop and its usage at a majority of 91.2% and 92.7 % in Busia and Elgeyo Marakwet counties respectively. There seems to be no marked difference in the awareness levels between the two counties.

The second factor measuring uptake of bamboo enterprise in farmlands within the study areas was whether bamboo had been planted. The findings indicate that bamboo planting is higher in Busia County than in Elgeyo Marakwet. 75.6% of the respondents from Busia indicated that they had planted bamboo in their farms while 33.2 % in Elgeyo Marakwet said they had planted bamboo in their farms.

Table 2: Uptake of Bamboo Enterprise in Busia and Elgeyo Marakwet Counties

Indicator	Category	Busia (%)	Elgeyo Marakwet (%)
Awareness of Bamboo	Aware	91.2	92.7
	Not Aware	8.8	7.3
Bamboo Planting	Planted	75.6	33.2
	Not Planted	24.4	66.8
Acreage Under Bamboo	< 0.5 acres	78.7	92.1
	0.5–1 acre	16.1	7.8
	>1 acre	5.1	0
	Total planted	70.8	29.2
Years in Bamboo Farming	<1 year	17.1	20.2
	1–5 years	45.9	19.8
	6–10 years	33.2	55.9
	>10 years	3.9	4.1

On acreage under bamboo in Busia and Elgeyo Marakwet County, results in Table 2 indicates that more farmers (70.8%) in Busia had planted bamboo compared to those in Elgeyo Marakwet (29.2%). In Busia, majority at 78.7% had planted bamboo on less than 0.5 acres with only 16.1% planting bamboo on between 0.5 to 1 acre and 5.1% in 1 acre or more. On the other hand, In Elgeyo Marakwet, majority at 92.1% had planted it on less than 0.5 acres with only 7.8% planting bamboo on acreage between 0.5 to 1 acre and none in 1 acre or more.

The third factor measuring uptake of bamboo enterprise in farmlands within the study areas was the period those who had farmed bamboo had been involved in farming the crop. Table 2 results from shows that in Busia, majority at 45.9% had been involved in Bamboo farming for between 1 and 5 years while in Elgeyo Marakwet, majority at 20.2% had only farmed Bamboo for less than 1 year. Generally, the least number of farmers at 3.9% and 4.1% in Busia and Elgeyo Marakwet had planted bamboo for over ten years. It can thus be implied that bamboo planting is still at infancy in both counties even though farmers in Busia County have taken up on the same compared to their counterparts in Elgeyo Marakwet.

Statistical Association Between Household Characteristics and Bamboo Adoption

To evaluate the relationship between household characteristics and bamboo adoption, Chi-square tests assessing the statistical association between selected household characteristics was conducted at a 95% confidence level ($p < 0.05$). The findings are presented in Table 3 below.

From the results shown in Table 3, some of the categorical variables had significant results of <0.05 and significant Pearson Chi-square results while others did not. The data included test statistics (Pearson Chi-square, Likelihood Ratio) and significance levels for four variables: age, level of education, household size, and total land owned. All the variables were tested to see if there is a significant association between each factor and bamboo adoption in the two counties.

In Busia and Elgeyo Marakwet, there was a significant association (Chi-square = 38.213, p = .000) and (Chi-square = 42.133, p = .000) between age and the level of adoption respectively.

Table 3: Chi-square test for adoption against selected variables

		Busia			
Category	Statistic	Value	Sig	Value	Sig
Age	Pearson Chi-square	38.213	.000	42.133	.000
	Likelihood ratio	13.900		12.109	
	N of Valid Cases	398		398	
Level of education	Pearson Chi-square	19.564[a]	.000	45.182[a]	.341
	Likelihood ratio	31.099		12.866	
	N of Valid Cases	398		398	
Household Size	Pearson Chi-square	41.867[a]	.000	34.988[a]	.821
	Likelihood ratio	61.432		17.001	
	N of Valid Cases	398		398	
Total area of land owned	Pearson Chi-square	23.908[a]	.000	43.102[a]	.000
	Likelihood ratio	38.611		12.901	
	N of Valid Cases	398		398	

The confidence interval is 0.05

There was also a significant association between the level of education within the household and bamboo adoption of (Chi-square = 19.564, p = .000) in Busia. However, education did not have a significant influence (Chi-square = 45.182, p = .341) on bamboo adoption in Elgeyo Marakwet. In both counties, land size had a significant influence on bamboo adoption of (Chi-square = 23.908, p = .000) and (Chi-square = 43.102, p = .000). in Busia and Elgeyo Marakwet respectively. On the contrary, the household size in Busia had a significant influence (Chi-square = 41.867, p = .000) on bamboo adoption whereas it did not significantly affect adoption in Elgeyo Marakwet (Chi-square = 34.988, p = .821). These findings indicate that, those who were older, more educated, larger in household sizes and had more land were more inclined to adopt bamboo farming. The same significant result applied to Elgeyo Marakwet households in so far as age and total area of land owned and as such, older and with more land in Elgeyo Marakwet were more inclined to adopt bamboo farming. In contrast, the same did not apply to Elgeyo Marakwet in terms of level of education and household size.

Utilization of Bamboo

To assess how household's, engage with bamboo as a resource, this subsection presents findings on its use across Busia and Elgeyo Marakwet counties. Figures 1 and 2 illustrate the extent of bamboo utilization and the specific purposes for which it is applied within households.

Based on results from Figure 1, bamboo was used in most household in Busia (87.3%) while it was largely not used in households in Elgeyo Marakwet (62.2%). This data indicates that bamboo usage has been embraced in households in Busia and not in Elgeyo Marakwet.

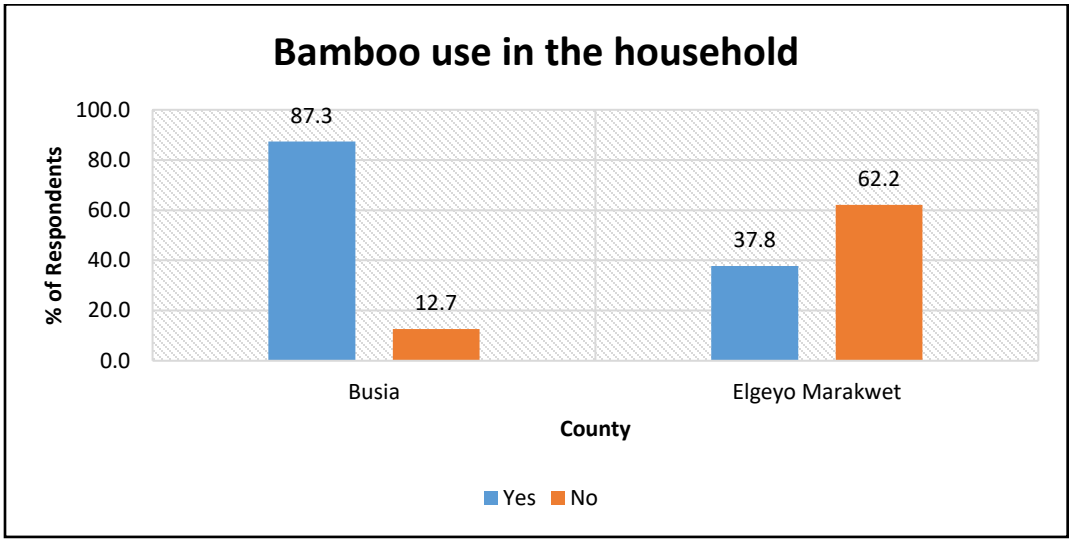

Figure 1: Utilization of Bamboo

The results from Figure 2 shows that in Busia, bamboo is mostly used for fuelwood (51.2%) and fencing (48.3%). Others include baskets (20.5%), furniture (16.6%) and the least was their usage as manure (2%) and as food (1.0%). In Elgeyo Marakwet bamboo is mostly used for catchment protection (37.8%), fuelwood (35.2%) for fencing (29.5%) and construction (14.5%). Evidently, the usage of bamboo and bamboo products in households within Busia is higher and varied compared to Elgeyo Marakwet whose utilizations are limited and to a smaller extent.

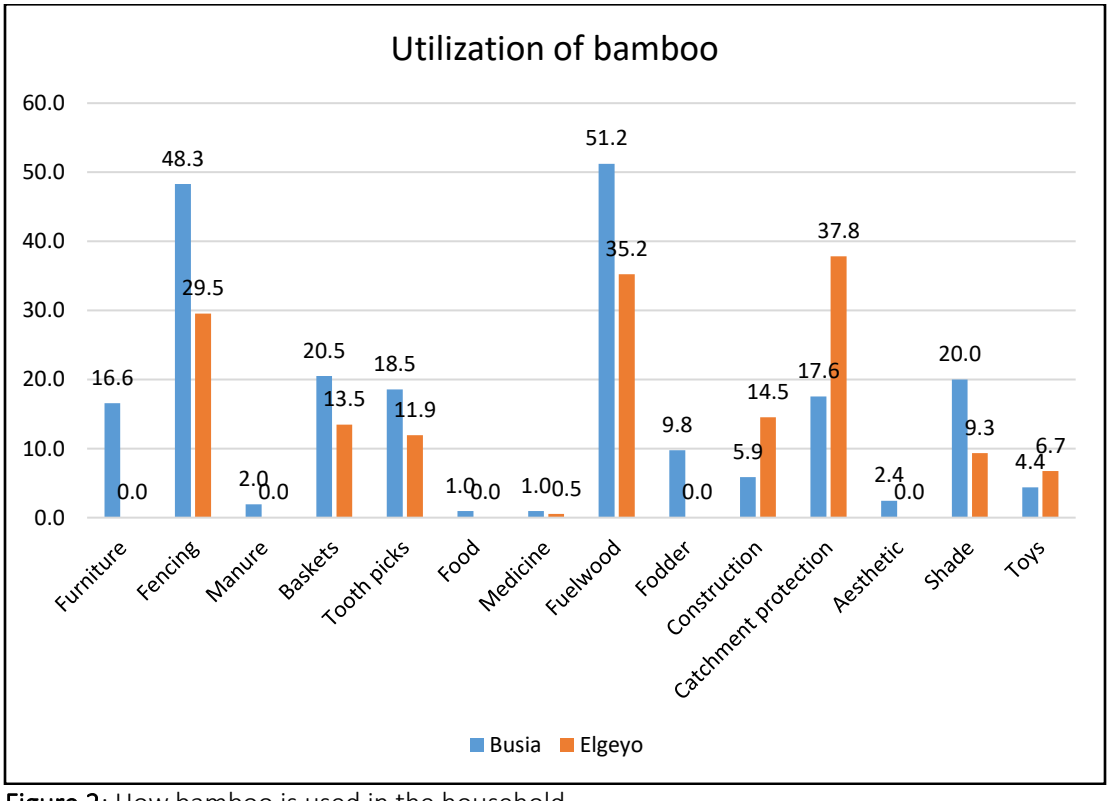

Figure 2: How bamboo is used in the household

Statistical Association Between Household Characteristics and Bamboo Utilization

To assess the extent to which socio-demographic variables influence bamboo utilization, Table 4 presents Chi-square test results for gender, age, education level, household size and total land owned. The analysis, conducted at a 95% confidence level, reveals that all tested variables showed statistically significant associations with bamboo use ($p < 0.05$).

Table 4: Chi-square Test for utilization against selected variables

Category	Statistics	Value	df	Sig
Gender	Pearson Chi-square	14.897	1	.000
	Likelihood ratio	12.121	1	
	N of Valid Cases	398	1	
Age	Pearson Chi-square	29.604[a]	4	.000
	Likelihood ratio	34.098	4	
	N of Valid Cases	398	1	
Level of education	Pearson Chi-square	71.122 [a]	3	.000
	Likelihood ratio	65.111	3	
	N of Valid Cases	398	1	
Household Size	Pearson Chi-square	59.802 [a]	3	.000
	Likelihood ratio	27.096	3	
	N of Valid Cases	398	1	
Total area of land owned	Pearson Chi-square	23.188 [a]	4	.000
	Likelihood ratio	23.176	4	
	N of Valid Cases	398	1	

The confidence interval is 0.05

From the results shown in Table 4 all the categorical variables have a significance of <0.05 and significant Chi-square results. Gender had a significant influence on utilization of bamboo of (chi-square 14.897, p = .000), age of (chi-square = 29.604, p = .000), level of education of (chi-square = 71.122, p = .000), household size of (chi-square = 59.802, p = .000) and total land owned at (chi-square = 23.188, p = .000).

The findings indicate that there is a significant difference in the distribution of gender (male and female), age, level of education, household size and total area owned on the utilization and commercialization of bamboo in Busia and Elgeyo Marakwet. All the categorical variables aforementioned had a significant influence on the level of use and sale of bamboo and its associated products.

Influence of Adoption, Livelihood and Gender Dynamics on Bamboo Utilization

To assess how adoption of bamboo, household livelihood factors, gender, and socio-cultural dynamics influence bamboo use, an ANOVA test was conducted. Table 5 presents the results.

The findings shown on Table 5, shows that the data is statistically significant ($p < .001$), meaning that the independent variables collectively have a significant influence on bamboo use within households. Approximately 71.8% of the variance in household bamboo use ($R^2 = .718$) indicates a strong correlation between the variables. The adoption of bamboo was highly significant with a value (p = .000) with an F-value of 42.816 to indicate that utilization of bamboo within a household was influenced by the rate of adoption.

Table 5: ANOVA testing variables against utilization of Bamboo

Dependent Variable: Bamboo use within the household

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	76.120[a]	13	4.906	71.398	.000
Intercept	179.258	1	179.258	2641.492	.000
Bamboo use and Adoption of Bamboo via planting	5.811	2	2.906	42.816	.000
Bamboo use and Livelihood dynamics	8.0086	2	3.783	57.675	.000
Bamboo use and Gender dynamics	.994	2	.567	7.321	.001
Bamboo use and social-cultural factors	.316	2	.159	3.396	.189
Error	25.041	369	.072		
Total	813.109	398			
Corrected Total	89.775	382			

a. R Squared = .718 (Adjusted R Squared = .712)

Changes in livelihood dynamics within a household in terms of income also indicated a significant value of (p = .000, F = 57.675) towards utilization. Gender was also another significant factor (p = .001, F = 7.321) on utilization. However, socio-cultural factors on bamboo did not have statistically significant influence (p = .189) on utilization of bamboo within a household.

Commercialization of Bamboo

To assess the income potential of bamboo as a resource, commercialization aspects were analyzed. Respondents were asked whether they sold any bamboo or bamboo -based products within their household. The results are as presented on Figure 2.

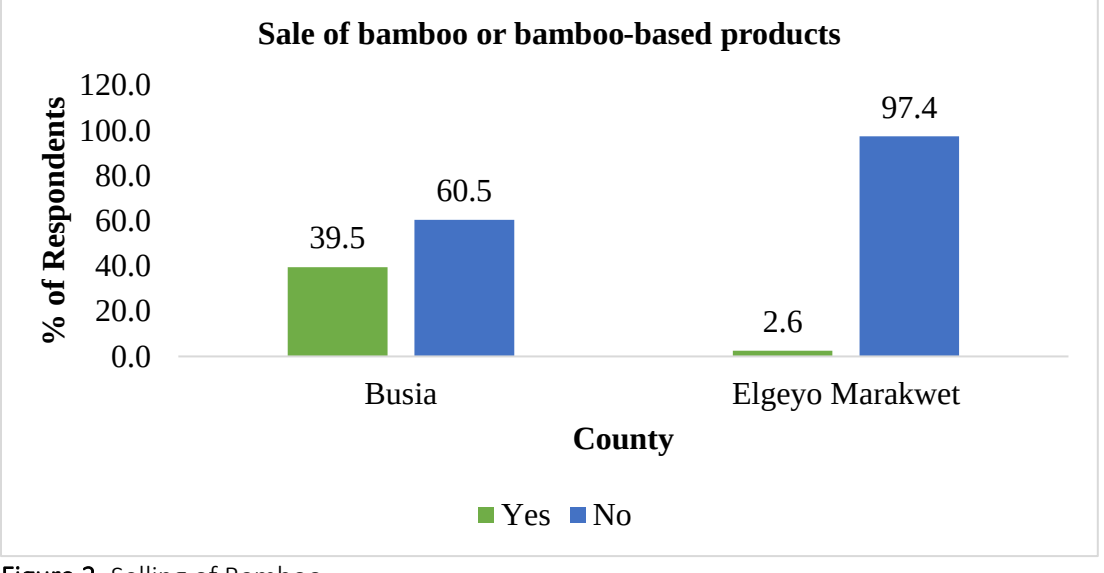

Figure 2: Selling of Bamboo

Based on the results from Figure 12, 39.5% of the respondent's sold bamboo in Busia while an insignificant 2.6% of the respondents in Elgeyo Marakwet was involved in selling of bamboo. This implies that there was a bit of commercialization of bamboo in Busia as opposed to Elgeyo Marakwet where it was almost non-existent.

Types of bamboo products sold and their markets in Busia and Elgeyo Marakwet

The Figure 3 below shows different uses of bamboo in different household in Busia and Elgeyo Marakwet Counties.

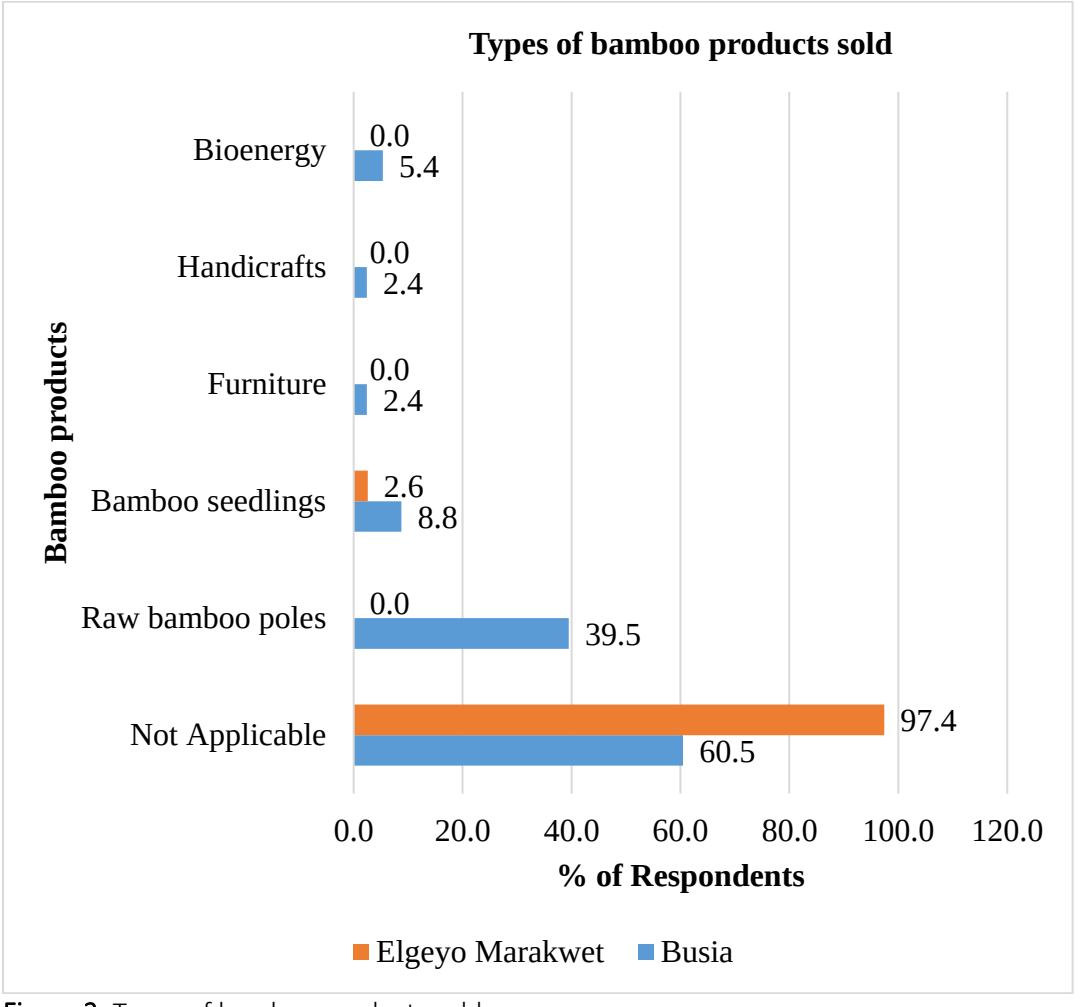

Figure 3: Types of bamboo products sold

In Busia, 39.5 % of the respondents sold raw bamboo poles, 8.8% sold bamboo seedlings while others sold bamboo seedlings (8.8%), bio-energy (5.4%) and 2.4% for both furniture and handicrafts. Only 2.6% of the respondents sold bamboo seedlings in Elgeyo Marakwet. There were no other bamboo products sold in the county.

Bamboo markets in Busia and Elgeyo Marakwet

The respondents were asked to indicate markets where they sell Bamboo. Figure 4 illustrates their summarized responses.

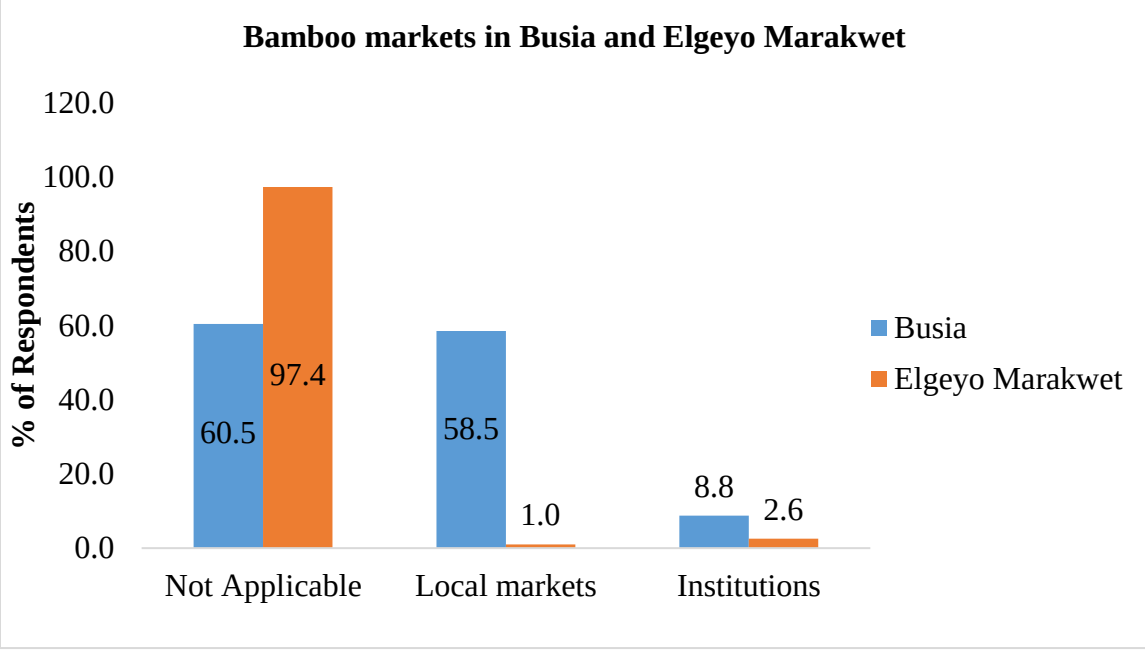

Figure 4: Bamboo markets in Busia and Elgeyo Marakwet

Figure 4 illustrates that the local market is the major market (58.5%) for bamboo products sold in Busia. Institutions comprise of 8.8% and 2.6% for Busia and Elgeyo Marakwet County respectively.

Factors Influencing Commercialization of Bamboo

To evaluate the effect of selected variables on bamboo commercialization, an ANOVA test was conducted. Table 6 presents the statistical results.

Table 6: ANOVA testing variables against commercialization of Bamboo

Dependent Variable: Selling Bamboo					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16.118[a]	13	1.754	10.189	.000
Intercept	388.712	1	366.491	2790.113	.000
Bamboo selling and adoption of bamboo	1.675	2	.991	7.655	.001
Bamboo selling and Livelihood dynamics	1.312	2	.689	4.911	.003
Bamboo selling and gender dynamics	.412	2	.209	1.371	.249
Bamboo selling and social-cultural factors	2.208	2	1.133	8.801	.000
Error	46.544	369	.129		
Total	1314.010	398			
Corrected Total	62.099	382			

a. R Squared = .282 (Adjusted R Squared = .216)

The results from Table 6 shows that bamboo commercialization was significantly associated with adoption of bamboo (p=.001); livelihood dynamics (p = .003); social cultural factors (p = .000), but not significantly associated with gender dynamics (p = .249). Thus, socio-cultural furthers significantly affects adoption of bamboo as well as the resulting sale of the same. In addition, livelihood dynamics also influence the adoption and commercialization of bamboo. However, gender dynamics had no significant influence on commercialization of bamboo in Busia and Elgeyo Marakwet. The p-value for the overall model is < .001, indicating that the independent variables collectively significantly predict adoption and selling of bamboo. The adjusted R^2 results of .216 shows that on 21.6% of the measures in adoption of bamboo, livelihood dynamics and social cultural factors had a positive effect on commercialization of bamboo.

Discussion

Utilization of Bamboo

The results indicate that there was awareness of what bamboo is together with its potential uses. In Busia, bamboo is locally known as "*Lidaiya"* or "*Madaiya"* in plural, whereas in Elgeyo Marakwet, it is known as "*Tekat"* or "*Tekik"* in plural. Despite the knowledge of what bamboo is and what it does, there was an increased adoption of bamboo within farmlands in Busia than in Elgeyo Marakwet. 75.6% of farmers in Busia had planted bamboo compared to 33.2% in Elgeyo Marakwet. This means that Busia County had both the awareness and the decision to use the lessons learnt by planting bamboo while Elgeyo Marakwet households had the awareness but had not made the decision to establish bamboo within their farms. In addition, most farmers had established bamboo on a very small piece of land. 82% of all the farmers who had planted bamboo had established it on less than 0.5 acres of land. This could be attributed to small land sizes owned within the counties that has to accommodate other household land uses. Average land sizes in Busia is 2 hectares whereas in Elgeyo Marakwet is 7.0 hectares (KNBS, 2019a). Kumar et al. (2011) concluded that land size substantially influences bamboo planting density, with bigger landholdings facilitating more widespread bamboo stands that fulfill many functions, including erosion management, timber production, and fodder provision. Smaller landowners frequently choose reduced planting rates because of limited land availability.

In terms of utilization, bamboo products in various forms were used within a substantial number of households in Busia compared to Elgeyo Marakwet. However, bamboo usage is still limited in both counties. Products used within the households were mostly furniture, spoons, cups, table mats, trays, baskets and tooth picks. Tooth picks were not locally made but bought from supermarkets. These were however in very few households. In rare instances, the bamboo furniture such as chairs and tables were made within homesteads of farmers who had planted bamboo and had been trained on artistry using bamboo.

The culms were mostly used for building small structures especially granaries in Elgeyo Marakwet and grass thatched mud houses in Busia. The bamboo served as the structure in place to hold the shape of the mud together for the houses (Isukuru *et al*., 2023). The respondents also indicated that they were used as kingposts whenever cedar or any other appropriate wood that served the same purpose was missing. The culms were also used for fencing homesteads as well as animal sheds.

Plate 1: Bamboo products produced in Busia

The respondents indicated that fences made with bamboo are long lasting and one does not have to repair them for a long time unlike those made from timber or posts from other wood species which rot over time.Other studies have also stated that bamboo culms have been regarded for generations as a cost-effective, ecological choice for housing and construction due to their strength, elasticity, and versatility (Akoto *et al*., 2017; Sailo *et al*., 2025). The results are consistent with local literature from Kenya that shows that bamboo utilization is largely constricted to domestic usage like making tea picking baskets, fencing, energy feedstock, furniture making coupled with construction of food storage structures (Katumbi *et al*., 2017) and that their use for construction is still at its infancy (Ochieng *et al*., 2022) and therefore their minimal usage.

Bamboo handling requires expertise for good quality products to be produced. An artisan can destroy the culms or reduce the quality of the final product if not trained on production of bamboo products. The culms have been noted to offer a sound alternative to timber wood as they are in their cutting very economical in terms of overcutting capacity (Liese & Kumar, 2003; Wang *et al*., 2009). Bamboo however requires a treatment process to ensure the durability of the construction being done. Unfortunately, the technical expertise to enable utilization of bamboo for construction is very minimal within the counties.

Bamboo was also used as fuel wood in many households. The respondents indicated that it burns with ease especially when dry and therefore saves a lot of cooking time. The women also indicated that they produce a lot of heat and do not produce smoke when burning. This therefore ensures protection from diseases such as Chronic Obstructive Pulmonary Disease (COPD) associated with inhalation of smoke over a long period of time (Van Gemert *et al*., 2015). The findings also indicate poor sensitization about the quality of bamboo products for cooking as compared to other sources of wood fuel. Bamboo has somehow been neglected as a source of bio-fuel and is thus largely underutilized within many households (Engler *et al*., 2012; Katumbi *et al*., 2017) as is the case with the two study sites. Bamboo with a calorific value of 19.8 MJ/kg, is highly energized and this value is higher than most of the other conventional energy sources within the wood family like willow, eucalyptus and hybrid popular (INBAR, 2015, 2018). In addition to its use as fuel and charcoal, ash from burnt bamboo is used as vegetables tenderizer for vegetables commonly known as "*msherekha*" in Busia.

Findings from the study also ascertained the production of briquettes and bio-char in Busia albeit in very small quantities. Butula Cooperative society was the only entity in Busia producing and selling these products at the time of the study. The briquettes were sold in supermarkets and local trading centres especially during market days. The members of the Cooperative Society were supported through the Dutch Sino Project. The members however cited inadequate access to markets for the products therefore hampering their production. The ripple effect to this is that the farmers could not continue supplying the bamboo culms to the factory as the demand would be low.

Plate 2: Bamboo briquettes produced by Butula Bamboo Farmer's Cooperative

From the FGDs, some of the discussions centered on the fact that in Busia and Elgeyo Marakwet, bamboo is used as source of fodder for animals during harsh climate because bamboo rarely dries in harsh temperatures. Bamboo has resilience in highly deteriorated conditions, necessitating low nutritional input (Sailo *et al*., 2025). Moreover, bamboo leaves offer cheap and more quality food and fodder that can be used within the agricultural space in a more meaningful way (Mulatu *et al*., 2022).

In agriculture, they are used for vining plants such as peas, beans and passion fruits. Other farmers with bamboo in their farms use the leaf litter as manure and they indicated an increased soil fertility. Maina, Ochola & Mwaniki, (2021) indicated that the significant attribute of bamboo is leaf shedding, which enhances soil fertility by forming a dense humus layer which serves as an indigenous soil management strategy. The respondents mentioned that they intercrop bamboo with other low cover crops and they achieved good harvests.

In Busia, a few families used bamboo shoots as food especially those that had the right species for consumption within their farms. The bamboo species whose shoots were commonly used as food in Busia was *Dendrocalamus asper*. The shoots are boiled and eaten as an accompaniment with other foods or eaten as a snack. The shoots can also be dried and crashed to a powder that can be used to make nutritious porridge. Other studies indicate that the shoots can be consumed in raw, canned, boiled, marinated, fermented, frozen, liquid, and medicinal forms for food, medicine, and both traditional and modern drinks (Endalamaw *et al*., 2013; Mekonnen *et al*., 2014; Guadie *et al*., 2019; Abebe *et al*., 2021).

Young bamboo shoots are noted for their high protein, fiber, carbohydrate, and mineral content, while being low in fat and sugars, and have been consumed as a vegetable for an extended period in numerous Asian countries (Nirmala *et al*.,2011; Karanja *et al*., 2015) that make up for dietary deficiencies of nutrients in many diets (Mekuriaw *et al*., 2011; Yigardu *et al*., 2019; Abebe *et al*., 2021) The farmer who used the bamboo shoots for food however noted that consumption of the shoots will jeopardize the number of culms growing to maturity. In the long run it will affect the income generated from the sale of the culms. Other studies have iterated on the same (John *et al*., 2022; Oriwo *et al*., 2022). In the interviews, most of the respondents noted that bamboos situated along riverbanks offer shade and therefore regulated temperature. They indicated that water fetched from rivers, streams and springs surrounded by bamboo is very clean and cool and one can drink at the source. They believed that bamboo purifies the water. In Elgeyo Marakwet, bamboo growing naturally in the forests and along rivers flowing through farmlands were perceived to control soil erosion and protect the water catchments from drying up. Research findings have concluded that bamboo is rapidly becoming a viable solution for the rehabilitation and conservation of water catchments, degraded riverbanks, and other riparian areas (Nadir *et al*., 2024). This is consistent with other studies that stated that bamboo's extensive fibrous root systems, dense canopy, and green cover boost soil stabilization, mitigate soil erosion, and improve moisture retention (Lin *et al*., 2017; Sawarkar *et al*., 2020).

Plate 3: Bamboo planted on a riverine

Bamboo-derived nanoparticles for various applications such as in water purification (Isikuru *et al*., 2023), has the ability to tolerate and remediate soil contaminated with toxic heavy metals, making them suitable for phytoremediation in contaminated sites (Wang *et al*., 2020a; Wang *et al*., 2020b), remove heavy metals, such as lead and cadmium, from contaminated soil (Zhou *et*

al., 2018) and polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) (Chen *et al*., 2019). This explains the reason why most respondents felt that they fetch clean water from spring heads covered by bamboo.

Commercialization of Bamboo

In general, on average majority (78.9%) of the respondents were not selling bamboo or bamboo-related products. The result resonates with FGD responses that showed that while planting of bamboo was present; its commercialization was low mostly due to lack of markets and an inadequate knowledge on bamboo commercialization. On average, the most sold products were raw bamboo culms and bamboo seedlings. The culms were mostly bought by local artisans who used them to produce furniture and other handicrafts. This agrees with other findings that state that bamboo culms have been extensively used in economic artifacts such as handicraft, making of chopsticks, blinders, mats, carpets, and furniture (Melorose *et al*., 2015a). It is proposed that developing Small Scale Enterprises (SSEs) could be a way to boost rural economies through increase in the financial benefits from bamboo resources, while creating incentives for improving the management of the bamboo plantations (Boissière *et al.*, 2020; Lamsal *et al*., 2017).

Bamboo seedlings where mostly sold to government and non-governmental institutions undertaking tree planting activities within the two counties. Some of the institutions where KFS, KEFRI, KWTA, WRA, County Government of Busia, INBAR and Eco-Green CBO in Busia whereas in Elgeyo Marakwet, KFS, KEFRI, WRA, County Government of Elgeyo Marakwet, WWF, Kipchoge Foundation, World Vision amongst others. Farmers adopting bamboo as a crop also offered a demand for the seedlings.

This scenario depicts that bamboo commercialization is still relatively low within the two ecosystems, due to low variety of products being sold as well as inadequate market opportunities for the farmers. In order to increase production of various bamboo products, there is need to promote the growth of bamboo SSEs, by ensuring clarity on how to obtain land use rights over existing bamboo forests, access to funding, markets linkages, business training, and low-cost innovations (Boissière *et al*, 2020). The ripple effect will be the increased adoption of bamboo farming since there will be a ready market for the culms.

Conclusion

Bamboo plays a variety of socio-economic, ecological, and traditional roles in the community. It was one of the components of agricultural tasks and practices for some households and supplements their sources of income. It provided material for house and fence construction, furniture, wood fuel, toys and musical instruments. It is also used as a source of food, medicine, and fodder as well as for soil and water conservation. Despite the existence of considerable knowledge on bamboo and its numerous purposes in both Busia and Elgeyo Marakwet, there are clear differences in adoption and utilization. In Busia, there is more bamboo growing and diverse applications including housing, fencing, fuel, food, and even small-scale production of bamboo products such as briquettes, furniture and handicrafts. Conversely, in Elgeyo Marakwet, awareness exists but limited land availability and technological knowledge prevent significant bamboo farming and application. Although bamboo's natural resilience, ecological benefits in water conservation and soil erosion control, and adaptability for both domestic and agricultural uses confirms its value, its full potential remains untapped in the country,

especially in efforts towards using it for construction and commercialization. Improved technical training, market access, and increased awareness could assist bamboo's contributions to sustainable livelihoods and environmental management in the country.

Recommendation

Bamboo utilization and commercialization is still at infancy in Kenya. This study recommends extensive undertaking of awareness initiatives, community outreaches and experimental programs such as establishment of more bamboo cooperatives and demonstration sites that can highlight its advantages. Substantial investments in training, supply chain establishment, collaborations with local suppliers, and a robust logistics network are needed to realize the economic benefits of bamboo. Partnerships with NGOs can augment the awareness creation therefore expanding the reach to more households and communities.

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