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RESEARCH ARTICLE

Ethnobotany of pokot communities on bamboo species in the dryland areas of West Pokot County, Kenya

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Abstract: Communities in dryland areas of West Pokot in Kenya rely on fragile degraded ecosystems that have led to famines, low productivity and income. Although cultivating bamboo provides solutions to part of these problems, the benefits of bamboo cultivation are species and site-specific. However, no research has established the ethnobotanical knowledge of bamboo in West Pokot, making it difficult to upscale its cultivation. The study aimed at 1) determining the level of awareness of bamboo 2) the uses of bamboo 3) factors motivating and hindering its cultivation. The study adopted an analytical cross-sectional survey research design. Simple random and purposive sampling techniques were used in selecting the study site. A Systematic random sampling technique was used in selecting households to be used in establishing local knowledge through questionnaires. Data were analysed using chi-square test of fit, chi-square test of association and cochran's Q test of K-related samples. Results showed that farmer to farmer approach (38.9%) was the main source of information. Among the respondents, 70.6% of them were aware of bamboo out of which 67.6% were aware of its uses. The commonly identified uses were soil conservation (48.1%), shade provision (39.5%), fencing material (38.8%) and construction material (36.9%). The findings revealed that 74.1% of the respondents were willing to cultivate bamboo due to its environmental, economic and cultural benefits among others. However, inadequate knowledge of bamboo planting and management techniques (51.8%) is the main impeding factor to the cultivation of bamboo in the region. Therefore, forestry and agricultural extension agents in the county should sensitize and train farmers on bamboo establishment and management for farmers to realize its full potential .

Keywords: Agroforestry, carbon sequestration, forestry, multipurpose

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Introduction

Bamboo is a perennial grass belonging to the Poaceae (Gramineae) family and Bambusoideae subfamily. The plant is widely distributed with more than 1,500 species in the tropical, sub-tropical and temperate regions with an exception in Antarctica (Lobovikov *et al*., 2007; Yeasmin, 2015; Partey *et al*., 2017). Canavan *et al.* (2017) and Liu *et al*. (2018) indicated that the number and dominance of bamboo species vary among regions with China reporting over 800 species, the largest number of bamboo species with *Dendrocalamus strictus* and *Bambusa bamboos* being the dominant species. In Sub-Saharan Africa, the most common bamboo genera include *Dendrocalamus, Bambusa, Arundinaria* and *Oxythenanthera* (Partey *et al*., 2017).

In Kenya, Kenya Forestry Research Institute (KEFRI) (2019a) indicated that *Oldeania alpine* bamboo species naturally grow in mountainous regions but over 22 species introduced from China, being promoted for cultivation such as *Bambusa bamboos*, *Bambusa vulgaris*, *Dendrocalamus giganteus*, *Bambusa tulda, Dendrocalamus membranaceus* and *Dendrocalamus strictus*. The most notable environmental, health, social and economic benefits accrued from

construction materials without deforestation, enhancing sustainable fodder supply, improving site biodiversity, herbal medicine, improved food security without encroaching protected areas, job creation and improved household income (Sharm *et al*., 2017; Partey *et al*., 2017; KEFRI, 2019a). Thus, bamboo is a multipurpose crop for humans suited for different purposes in the current world facing climate change and global warming (Sharm *et al*., 2017; Xu *et al*., 2019). Different bamboo species has specific economic functions such as *Phyllostchys edulis* and *Dendrocalamus giganticus* for flooring, pulp and paper, and construction materials (Liu *et al*., 2018). Since growth characteristics and potential benefits of a bamboo species vary from region to region depending on prevailing environmental conditions, the benefits accrued from bamboo may vary from region to region (Song *et al.,* 2017).

In Kenya, dryland areas cover over 80% of the land area, and any further expansion will be detrimental to human, livestock and wildlife populations (Njoka *et al*., 2016). West Pokot County is among the 23 counties in Kenya categorized as drylands, dominated by pastoralism and agro-pastoralism (Njoka *et al.,* 2016; County Government of West Pokot, 2018). Like other drylands, West Pokot experiences economic and political marginalization with unreliable and varied rainfall ranging from 100-1200 mm annually along with soil erosion due to flash floods and hot temperatures of up to 32°C (Kyule *et al*., 2015; County Government of West Pokot, 2018). Land degradation in West Pokot County has been as a result of both anthropogenic and climate change factors. Factors such as population pressure, overgrazing, deforestation and woodland thinning, and unsustainable agricuture has accelerated drought and flood cycles in the County (Cervigni and Morris, 2016; Röhss *et al*., 2017; Peterson *et al*., 2021). These has led to soil erosion in particular gully erosion by water that has notably affected the cropping fields, grazing lands and degraded hillsides in parts of Chepareria and Kacheliba in West Pokot (Nyberg *et al*., 2015; Watene *et al*., 2021).

Cultivating bamboo in the Sub-Saharan Africa (SSA) can restore degraded lands, conserve soils, supply fodder for livestock, reduce poverty, enhance food security, increase income, reduce deforestation, increase household energy access and enhance climate change mitigation through carbon sequestration. However, there is limited research to verify the importance of bamboo cultivation as available knowledge is mostly based on intuitions of governments and development actors (Partey *et al*., 2017).

Understanding and integrating the local knowledge of bamboos in the local communities including the intrinsic and extrinsic factors in enhancing the restoration of degraded lands and innovative agricultural techniques are highly relevant (Mishra *et al*., 2014; Meijer *et al.,* 2015). This paper determined the level of awareness, uses of bamboo, willingness to cultivate bamboo, motivating factors and challenges constraining its adoption among the Pokot communities in Kenya.

Materials and methods

Study Site

The study was conducted in the drylands of West Pokot County lying between longitudes 34° 47′ and 35° 49′ East and latitude 1° and 2° north with an area of about 9,169.4 km^2. The county is mainly inhabited by the pastoralists and agro-pastoralists from the Pokot community with the Sengwer minority. The county has a human population of about 77,180, a dependency ratio of 127.89 and population density of 147 persons/ km^2 and a low literacy level of 30% compared to the national literacy level of 62% (County Government of West Pokot, 2018)

The study was mainly conducted in Masol, Sigor, Kacheliba, Kongelai and Alale found in the northern parts of the county that are mainly drylands with an altitude less than 900 m above sea level. The sites are characterized by high soil erosion due to flash floods, poor soils, low rainfalls of about 800 mm per year and high temperatures of over 32°C (Nyberg *et al*., 2015; County Government of West Pokot, 2018).

Research and Sampling Design

An analytical cross-sectional survey research design was used which involved collection of data at only specific points in time without manipulating the variable (Omair, 2015). The study adopted a multi-stage sampling technique. A simple random sampling technique was used in selecting West Pokot County among the 23 counties in the drylands. Purposive sampling technique was used to select the northern parts of the county because the region experiences harsh environmental factors including low rainfalls, poor soils and high temperature that represent real dryland. Target population was drawn from the dry-low land areas of West Pokot including Alale, Kacheliba, Kongelai, Masol and Sigor. In each area, systematic random sampling technique was used to select every 3rd household to be included in the research.

Sample Size and Data Collection

According to the 2019 housing and population census in Kenya, West Pokot County has a total of 34,213 households. Therefore, the respondent sample size was determined according to Israel (2009) (equation 1):

$$n = \frac{N}{1 + Ne^2} \quad \text{……..(1)}$$

Where;

n = the sample size;

e = margin of error = 0.05 corresponding 95% confidence level;

N is the total population = 34,213

Therefore, $n = \frac{N}{1 + Ne^2} =$

$$\frac{34213}{1 + (24213 \times 0.05^2)} = 395.4 = 396 \text{ households.}$$

Therefore, there were 396/5 = 79.2 = 80 households considered in each area.

Data collection Procedures

Data was collected using a structured questionnaire with both closed and open-ended questions. The questionnaire was administered by local field research assistants that were recruited from each respective site.

Data analysis

Data was analyzed using non-parametric tests in Statistical Package for the Social Sciences (SPSS). Chi-square test of fit was used to test significant difference in proportions of respondents on different stakeholders promoting bamboo. Chi-square test of association was used to test if there was any significant association of demographic data and source of information on bamboo, awareness of bamboo and willingness to cultivate bamboo. Cochran's Q test of K-related samples was used to test statistically significant differences in the proportion of respondents that identified uses of bamboo, factors motivating and hindering bamboo cultivation. Pairwise analysis was conducted using Cochran's Q test of 2 related samples.

Results and Discussions

Stakeholders Creating Awareness of Bamboo

Table 1 indicates that 38.9%, 2.1%, 12.6%, 3.4%, 9.9%, 5.0% and 1.7% of respondents were aware that stakeholders promoting bamboo in West Pokot County were farmers themselves (farmer to farmer), KEFRI, KFS, agricultural extension agents, environmental conservation agents and mass media among other stakeholders like NGOs (world vision), respectively.

Chi-square test of fit indicated that the frequencies of respondents on different stakeholders promoting bamboo in the West Pokot County were significantly different ($\chi^2_{(6)} = 462.932$, $P < 0.001$), with the majority of respondents (38.9%) having heard about bamboo from fellow farmers. This is an indicator that farmer to farmer extension model has been effective in the dissemination of knowledge about bamboo as an agroforestry crop. As witnessed in Zimbabwe, farmer-to-farmer extension has enabled 80.6% of farmers to adopt improved farming practices that ensure soil conservation and management (Dube, 2017). The rest of the sources of information (KEFRI, KFS, agricultural extension agents, Environmental conservation agents, mass media and others) registered least percentage of responses up to 1.7%. The study concurred with MoALF (2016) that extension service providers such as in agricultural sector have limited reach in the county due to poor road network while at the same time the county has few trained and experienced officers. This is attributed to low budgetary allocation towards hiring and support of the field activities within the county.

The Chi-square test of association indicated that respondents' gender ($\chi2(6) = 9.808$, P = 0.133), and age ($\chi2(12) = 19.054$, P = 0.087), had no significant association with stakeholders from which farmers obtain information on bamboo. However, the source of information was significantly associated with the respondent's education level ($\chi2(18) = 66.392$, P< 0.001), with majority of respondents (21.2%) with no formal education (didn't attend school) getting information from fellow farmers while the majority of respondents (4.4%) with tertiary education getting information from environmental conservation agencies.

Table 1. Stakeholders creating awareness of bamboo

Demographic characteristics			Stakeholders Promoting Bamboo Awareness and Cultivation (%)						
Education level	**Age**	**Gender**	**Farmer to farmer**	**KEF RI**	**KFS**	**Agricultural extension agents**	**Environmental conservation agents**	**Mass Media**	**Others**
Didn't attend school	<30	Male	2.0	0.0	0.0	0.0	0.0	0.0	0.0
		Female	0.8	0.0	0.3	0.0	0.0	0.0	0.0
	30-50	Male	4.2	0.0	0.8	0.0	0.0	0.3	0.0
		Female	6.0	0.0	0.5	0.0	0.0	1.0	0.0
	>50	Male	4.5	0.0	1.5	0.0	0.5	0.0	0.0
		Female	3.7	0.0	1.0	0.3	0.3	0.0	0.0
Sub-total			21.2	0	4.1	0.3	0.8	1.3	0.0
Primary education	<30	Male	0.8	0.0	0.3	0.0	0.3	0.0	0.0
		Female	1.7	0.0	0.3	0.0	0.3	0.0	0.0
	30-50	Male	2.0	0.0	0.8	0.3	1.0	0.0	0.3
		Female	1.7	0.3	1.2	0.0	0.5	0.3	0.0
	>50	Male	2.7	0.0	0.3	0.3	0.5	0.0	0.0
		Female	0.5	0.0	0.3	0.0	0.0	0.0	0.0
Sub-total			9.4	0.3	3.2	0.6	2.6	0.3	0.3
Secondary education	<30	Male	1.2	0.0	0.8	0.0	0.5	0.0	0.3
		Female	0.8	0.0	0.5	0.0	0.0	0.5	0.5
	30-50	Male	1.5	0.0	0.3	0.5	0.5	0.8	0.0
		Female	1.2	0.0	0.0	0.5	0.5	0.0	0.0
	>50	Male	0.3	0.3	0.3	0.0	0.3	0.0	0.0
		Female	0.0	0.0	0.3	0.0	0.3	0.3	0.0
Sub-total			5.0	0.3	2.2	1.0	2.1	1.6	0.8
Tertiary education	<30	Male	0.5	0.0	0.5	1.0	0.8	0.8	0.0
		Female	0.3	0.0	0.3	0.0	0.3	0.5	0.3
	30-50	Male	1.2	1.0	1.2	0.5	2.0	0.5	0.3
		Female	1.0	0.5	0.3	0.0	0.5	0.0	0.0
	>50	Male	0.3	0.0	0.8	0.0	0.8	0.0	0.0
		Female	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-total			3.3	1.5	3.1	1.5	4.4	1.8	0.6
Totals (%)			38.9	2.1	12.6	3.4	9.9	5	1.7

Awareness of Bamboo and their Uses in the Semi-Arid Regions of West Pokot County

The study found that 70.6% of respondents were aware of bamboo and can easily identify the plant without assistance from professionals, relatives or friends among others (Table 2). Comparatively, the awareness of respondents that didn't attend school, attained primary education, secondary education and tertiary education were 15.1%, 16%, 11% and 28.9%, respectively. These findings concur with Raghupathi and Raghupathi (2020) and Diaz-Quijano *et al.* (2018) that adults with the highest levels of education have better knowledge about a given practice. Male respondents aged 30-50 years with tertiary education level recorded higher awareness (8.0%) of bamboo.

Among respondents that were aware of bamboo, 67.6% of them were aware of various uses of bamboo with still majority of them (27.2%) having attained tertiary education, and 7.5% of them being male aged 30-50 years (Table 2). Uses of bamboo identified by respondents include fodder for livestock (21.7%), soil conservation and watershed management (48.1%), food for human consumption (6.3%), furniture making (35.4%), construction material (36.9%), making musical instruments (35.6%), carbon sequestration (7.8%), aesthetic (15.1%), biodiversity improvement (6.5%), shade provision (39.5%), alternative source of income (10.8%), energy provision especially for cooking (13.2%) and fencing material (38.8%), among other uses like feeding troughs, drinkers for chicken and livestock feeds (24.9%) (Table 2).

The use of bamboo for soil conservation and watershed management registered the highest response (48.1%). This is because bamboo grows rapidly, has permanent canopy and huge network of roots and rhizomes. The roots ensure soil protection by binding topsoils so as to prevent the erosion of soil along slopes, riverbanks and degraded land (Paudyal *et al*., 2022; Rathour *et al.,* 2022). Elsewhere in Ghana, bamboo species has served purpose in infrastructure development through provision of materials for making props, temporary sheds, trusses, furniture and bamboo floor among other uses (Akwada and Akinlabi, 2018a; Akwada and Akinlabi, 2018b; Gupta, 2022). The provision of these materials promotes enterpreneurship through sale of bamboo based products such as furniture which is a lucrative way of alleviating poverty (Gupta, 2022). In their review, Emamverdian *et al*. (2020) and Hossain *et al.* (2015) alludes that bamboo has a wide array of utilization ranging from construction, furniture, food and fuel to environmental application such as climate change mitigation, aesthetic role and control of soil erosion. The role of food for human consumption registered the least responses (6.3%) followed by biodiversity improvement (6.5%) an indicator that respondents had little knowledge concerning the use of bamboo for food. This implies that the majority of respondents are not aware of bamboo-producing healthy organic food being used to alleviate the challenges of food scarcity experienced in the world (Curammeng *et al.,* 2021; Hossain *et al.*, 2015).

Despite the fact that responses on biodiversity improvement witnessed in West Pokot were low, introduction of bamboo in tropical forests in Ghana has improved the biodiversity of the forest by reducing deforestation since the plant was introduced as an alternative plant (Akwada and Akinlabi, 2018b). This has offset pressure on the forest that resulted from overreliance on timber from trees thus enhancing conservation and climate change mitigation by limiting the amount of CO_2 in the atmosphere.

The Chi-square test of association indicated that awareness of bamboo was not significantly associated with gender ($\chi^2_{(1)} = 0.407$, $P< 0.408$) and age ($\chi^2_{(2)} = 0.659$, $P = 0.719$) of respondents. Contrary, awareness of bamboo was significantly associated with respondents education level ($\chi^2_{(3)} = 13.273$, $P = 0.004$) with the majority of respondents 28.9% having tertiary education while the least 11.1% had attained secondary education.

On the awareness of bamboo uses, the chi-square test of association indicated that awareness of bamboo uses among respondents had no statistically significant association with gender ($\chi^2_{(1)} = 2.631$, $P = 0.120$) and age ($\chi^2_{(2)} = 2.755$, $P = 0.252$) of respondents. However, the association of awareness of bamboo uses with respondents' education level was statistically significant ($\chi^2_{(3)} = 17.456$, $P = 0.001$), with the majority of respondents 27.2% having tertiary education while the least 10.6% had attained secondary education.

Table 2. Awareness and uses of bamboo

Respondent's demographic characteristics			Known uses of Bamboo (%)															
Education level	**Age**	**Gender**	**Aware of bamboo**	**Know bamboo uses**	**Fodder**	**Soil & water-shed management**	**food**	**Furniture making**	**Construction**	**Musical instrument**	**Carbon sequestration**	**Aesthetic**	**For biodiversity**	**Shade**	**In-come**	**Energy**	**Fencing**	**others**
Didn't attend school	<30	Male	4.0	4	1.2	2.7	0.3	3.0	2.2	3.0	1.0	1.0	0.0	3.0	1.0	0.7	3.0	1.2
		Female	1.5	1.5	0.7	1.5	0.3	1.2	0.5	1.0	0.3	0.5	0.3	1.2	0.5	0.5	1.2	0.3
	30-50	Male	5.7	5.2	2.0	4.7	0.7	5.0	2.0	4.2	1.0	1.5	1.5	3.2	1.0	0.7	3.7	0.7
		Female	2.2	2.0	0.5	1.7	0.0	0.7	1.5	1.0	0.3	0.5	0.3	2.0	0.3	0.0	1.7	1.0
	>50	Male	1.7	1.7	0.7	1.0	0.5	1.0	0.7	1.0	0.3	0.3	0.5	1.0	0.5	0.5	1.0	0.5
		Female	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-totals			15.1	14.4	5.1	11.6	1.8	10.9	6.9	10.2	2.9	3.8	2.6	10.4	3.3	2.4	10.6	3.7
Primary education	<30	Male	1.2	1.2	0.3	1.0	0.0	0.7	1.2	1.0	0.0	0.3	0.3	0.5	0.3	0.7	1.2	1.0
		Female	2.2	2.0	1.2	1.5	0.5	1.7	1.5	1.2	0.0	0.7	0.0	1.7	0.7	1.2	1.2	0.5
	30-50	Male	4.2	4.0	1.5	2.5	0.5	1.5	2.5	2.0	0.3	0.3	0.3	2.0	0.7	1.0	2.7	2.5
		Female	4.0	4.0	1.7	3.0	1.0	1.2	2.2	1.7	0.3	0.7	0.5	2.7	0.3	0.7	2.5	2.2
	>50	Male	3.7	3.5	1.5	2.2	0.5	1.2	1.7	1.2	0.0	0.0	0.0	1.7	0.0	0.7	2.2	2.0
		Female	0.7	0.7	0.5	0.7	0.0	0.5	0.5	0.5	0.0	0.3	0.3	0.5	0.5	0.0	0.5	0.3
Sub-totals			16	15.4	6.7	10.9	2.5	6.8	9.6	7.6	0.6	2.3	1.4	9.1	2.5	4.3	10.3	8.5

Secondary education	<30	Male	2.7	2.2	0.0	1.2	0.0	2.0	0.7	1.9	0.3	0.0	0.5	1.2	0.3	0.5	1.0	0.5
		Female	2.2	2.2	0.5	1.5	0.3	1.7	1.5	1.2	0.5	1.0	0.5	1.0	0.5	1.0	1.7	0.5
	30-50	Male	3.5	3.7	1.5	2.7	0.0	2.0	1.5	1.7	0.5	0.7	0.5	2.2	0.3	0.5	2.0	1.2
		Female	1.7	1.5	0.7	0.7	0.0	0.3	0.7	0.3	0.0	0.7	0.0	1.2	0.0	0.0	0.0	0.5
	>50	Male	0.5	0.5	0.0	0.0	0.0	0.3	0.0	0.3	0.3	0.0	0.0	0.2	0.0	0.0	0.0	0.0
		Female	0.5	0.5	0.0	0.0	0.3	0.5	0.5	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.3
Sub-totals			11.1	10.6	2.7	6.1	0.6	6.8	4.9	4.6	1.6	2.4	1.5	6.3	1.1	2.0	5.2	3
Tertiary education	<30	Male	2.2	1.5	0.5	1.2	0.0	0.5	0.7	0.5	0.3	1.0	0.0	0.7	0.3	0.0	0.3	0.5
		Female	1	1.0	0.5	1.0	0.0	0.5	1.0	0.3	0.0	0.5	0.0	0.5	0.3	0.3	0.7	0.3
	30-50	Male	8.0	7.5	2.0	3.2	0.3	1.5	2.7	2.5	0.5	0.7	0.0	3.5	0.3	0.7	1.0	1.7
		Female	6.0	5.5	1.5	6.4	0.3	3.5	4.7	3.5	0.7	2.2	0.0	3.0	1.0	0.7	3.5	1.2
	>50	Male	6.2	6.2	0.7	4.0	0.5	2.7	2.7	3.7	0.5	0.7	0.5	3.0	1.0	1.5	4.2	2.5
		Female	5.5	5.5	2.0	3.7	0.3	2.2	3.7	2.7	0.7	1.5	0.5	3.0	1.0	1.3	3.0	3.5
Sub-totals			28.9	27.2	7.2	19.5	1.4	10.9	15.5	13.2	2.7	6.6	1.0	13.7	3.9	4.5	12.7	9.7
Totals (%)			70.6	67.6	21.7	48.1	6.3	35.4	36.9	35.6	7.8	15.1	6.5	39.5	10.8	13.2	38.8	24.9

Table 3. Cochran's Q Pair-Wise analysis of bamboo uses

	Soil conservation	Food	Furniture making	Construction	Musical instrument	Carbon sequestration	Aesthetic	Biodiversity	Shade	income	Energy	Fencing	others
Fodder	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P = 0.002	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P =219
Soil conservation		P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P = 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001
Food			P < 0.001	P < 0.001	P < 0.001	P < 0.248	P < 0.001	P = 0.768	P < 0.001	P = 0.006	P < 0.001	P < 0.001	P < 0.001
Furniture making				P = 0.271	P =919	P < 0.001	P < 0.001	P < 0.001	P = 0.74	P < 0.001	P < 0.001	P=107	P = 0.001
Construction					P = 299	P < 0.001	P < 0.001	P < 0.001	P= 0.472	P < 0.001	P < 0.001	P =778	P < 0.001
Musical instrument						P < 0.001	P < 0.001	P < 0.001	P=092	P < 0.001	P < 0.001	P = 120	P = 0.001
Carbon sequestration							P < 0.001	P = 396	P < 0.001	P = 058	P =0.003	P < 0.001	P < 0.001
Aesthetic								P < 0.001	P < 0.001	P = 012	P=371	P < 0.001	P = 0.001
Biodiversity									P < 0.001	P = 0.006	P < 0.001	P < 0.001	P < 0.001
Shade										P < 0.001	P < 0.001	P =0.682	P < 0.001
Income											P =0.179	P < 0.001	P < 0.001
Energy												P < 0.001	P < 0.001
Fencing													P < 0.001

Cochran's Q test of K-related samples determined that there was a statistically significant difference in the proportion of respondents that identified different uses of bamboo, ($\chi^2_{(13)}$ = 8.334E2, P < 0.001). Pairwise analysis based on Cochran's Q test of 2 related samples indicated that the frequency of respondents that were aware that bamboo can be used for soil conservation (48.1%), making furniture (35.4%), construction materials (36.9%), making musical instrument (35.6%), shade provision (39.5%) and fencing material (38.8%) was significantly higher than other uses. On the other hand, respondents that identified food for human consumption (6.3%), carbon sequestration (7.8%), improving biodiversity (6.5%) and income (10.8%) as uses of bamboo were significantly lower than other uses (Table 3).

The study found no significant association between the age of respondents and bamboo uses ($\chi^2_{(2)}$ = 0.873, P = 0.781). However, bamboo uses were significantly associated with the respondent's gender ($\chi^2_{(1)}$ = 6.994, P = 0.023), as the majority of female respondents (6.4%) stated that bamboo can be used for soil conservation and watershed management while majority of male (5.0%) respondents indicated that bamboo can be used for furniture. In addition, bamboo uses were significantly associated with the respondent's education level ($\chi^2_{(3)}$ = 11.078, P< 0.001), where the majority of respondents with no education (11.6%), with primary education (10.9%) and tertiary education (19.5%) stated soil conservation and watershed management, while the majority of respondents with secondary education (6.8%) stated furniture making.

Willingness and Factors Motivating Bamboo Cultivation in West Pokot County

The study found that 74.1% of respondents were willing to plant bamboo on their farms (Table 4). Comparatively, 28.9%, 18.4%, 12.9% and 13.9% of respondents willing to plant bamboo on their farms had no formal education, attained primary, secondary and tertiary education respectively. Female respondents aged 30-50 years but never attended school had the highest frequency (7.4%) among respondents willing to plant bamboo on their farms.

Factors identified by respondents as motivating to engage in bamboo cultivation include: environmental benefits (9.1%), economic benefits (6.5%), social benefits (2.6%), cultural benefits (3.8%), easy access to planting materials including seedlings (5.0%), encouraged through training (3.8%), favourable environmental conditions in the area (3.3%), supportive legislations and policies both at county and national level (1.3%) and presence of vast land (2.2%) among other factors (0.8%) (Table 4).

Environmental benefit (9.1%) was highly recognized as the motivating factor towards planting of bamboo crop by farmers in West Pokot. This is because bamboo is characterized by fast growth with perennial rooting system that increases its ability to restore degraded land (Rathour *et al*., 2022). Some of the environmental benefits include carbon sequestration and stocking, landslide and erosion control, habitat and biodiversity conservation and groundwater recharge and purification (Yanxia and Frith, 2018; Paudyal *et al*., 2022). Elsewhere in North East India, two species of bamboo namely *Bambusa tulda* and *Dendrocalamus longispathus* were found to have above ground biomass range of 73.58 to 127 mg/ha and 115 to 150 mg/ha with carbon sequestration potential of 27.79 mg/ha/year and 15.36 mg/ha/year respectively (Devi and Singh, 2021). This is an indicator that bamboo plays a critical role in climate change mitigation thus a motivating factor towards its cultivation.

The second ranked motivating factor is the economic benefits (6.5%) of bamboo. This is realized because bamboo is fast growing and easy to manage crop through which tens of millions of people in rural communities have derived income (Kithan, 2014; Partey, 2017). Some of the economic benefits accruing from bamboo include provision of material for making props, temporary shed, trusses, furniture, income and bamboo floor among other uses (Partey *et al*., 2017; Akwada and Akinlabi, 2018a; Akwada and Akinlabi, 2018b; Abebe *et al*., 2021; Gupta, 2022). In Ethiopia, the top three economic uses of bamboo include food, musical instruments and medicine (Abebe *et al*., 2021).

The least motivating factor is supportive legislation and policies at the county and national level (1.3%). This is because majority of respondents have very little information about the policy governing bamboo

Table 4. Factors motivating the community cultivate bamboo

Respondent's demographic characteristics			Willingness to plant bamboo	Factors Motivating Respondents' Willingness to Engage in Bamboo Cultivation (%)									
Education level	Age	Gender		Environmental benefits	Economic benefits	Social benefits	Cultural benefits	Access to Seedling	Trainings' Encouragement	Favorable environment conditions	Supportive regulations/ policies	Vast land	Others
Didn't attend school	<30	Male	2.0	2.0	0.5	0.5	1.5	0.7	0.0	0.7	0.0	0.3	0.0
		Female	1.2	1.0	0.5	0.3	1.0	0.5	0.0	0.3	0.0	0.0	0.0
	30-50	Male	6.7	3.7	1.0	0.7	1.7	3.5	1.7	1.2	0.0	1.7	0.3
		Female	7.4	4.5	3.2	1.0	4.0	3.2	2.7	1.5	1.2	1.5	0.0
	>50	Male	6.4	4.0	4.2	1.7	1.5	1.7	1.2	1.5	0.0	0.7	0.3
		Female	5.2	3.5	2.0	1.5	4.0	1.0	0.7	1.7	0.0	0.3	0.0
Sub-totals			28.9	18.7	11.4	5.7	13.7	10.6	6.3	6.9	1.2	4.5	0.6
Primary education	<30	Male	1.2	1.0	0.5	0.3	0.5	0.3	0.0	0.0	0.0	0.3	0.0
		Female	2.7	1.5	2.0	0.7	1.2	0.7	0.7	0.5	0.3	0.0	0.0
	30-50	Male	5.9	3.0	2.0	2.2	1.7	1.5	0.5	1.2	0.0	0.7	0.5
		Female	4.5	2.7	1.2	1.0	2.0	1.2	0.7	1.5	0.5	0.3	0.5
	>50	Male	3.6	1.5	1.0	2.0	0.7	1.2	0.3	1.0	0.5	1.0	0.0
		Female	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0
Sub-totals			18.4	10.0	7.0	6.5	6.4	5.2	2.5	4.5	1.3	2.3	1.0
Secondary education	<30	Male	2.0	1.5	0.5	0.7	0.3	0.2	0.0	1.0	0.0	0.5	0.0
		Female	2.0	1.0	0.7	0.5	0.7	0.7	0.7	0.5	0.3	0.0	0.0
	30-50	Male	4.2	2.5	1.7	1.0	0.7	1.2	1.0	1.0	0.0	1.0	0.3
		Female	2.2	1.2	1.0	0.5	0.3	0.7	0.7	0.7	0.3	0.7	0.0
	>50	Male	0.5	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
		Female	2.0	0.7	1.0	0.3	0.3	0.3	0.0	0.3	0.0	0.3	0.0
Sub-totals			12.9	7.2	5.2	3.3	2.6	3.1	2.4	3.5	0.6	2.5	0.3
Tertiary education	<30	Male	4.2	3.0	1.7	0.7	2.0	2.0	1.5	1.0	0.5	1.0	0.5
		Female	1.0	0.7	0.5	0.5	0.5	0.3	0.3	0.3	0.0	0.3	0.0
	30-50	Male	5.7	3.7	3.5	0.7	0.5	1.5	1.2	1.2	0.5	0.3	0.3
		Female	1.5	1.2	0.3	0.0	0.3	0.7	0.5	0.3	0.3	0.3	0.0
	>50	Male	1.5	0.5	0.5	0.7	0.5	0.5	0.3	0.5	0.0	0.3	0.0
		Female	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-totals			13.9	9.1	6.5	2.6	3.8	5.0	3.8	3.3	1.3	2.2	0.8
Grant Totals (%)			74.1	45.0	30.1	18.1	26.5	23.9	15.0	18.2	4.4	11.5	2.7

Table 5. Cochran's Q Pair-Wise Analysis of motivating factors to cultivate Bamboo

	No seedlings	Lack of markets	Lack of interest	Discouraged by others	Unsupportive policies	Unfavourable environmental conditions	Poor growth characteristics	unaware of benefits	Limited land	Against culture
Inadequate knowledge	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001
No seedlings		P < 0.001	P < 0.001	P < 0.001	P < 0.001	P = 0.720	P < 0.001	P < 0.001	P < 0.001	P < 0.001
Lack of markets			P = 0.011	P < 0.001	P = 0.564	P < 0.001	P < 0.001	P = 0.021	P = 0.847	P < 0.001
Lack of interest				P < 0.001	P < 0.064	P < 0.001	P < 0.001	P = 0.833	P = 0.013	P < 0.001
Discouraged by others					P < 0.001	P < 0.001	P = 0.446	P < 0.001	P = 0.007	P = 0.002
Unsupportive policies						P < 0.001	P < 0.001	P < 0.071	P = 0.419	P < 0.001
Unfavourable environmental conditions							P < 0.001	P < 0.001	P < 0.001	P < 0.001
Poor growth characteristics								P < 0.001	P = 0.001	P = 0.011
Not aware of benefits									P = 0.025	P < 0.001
Limited land										P < 0.001

crop in Kenya. Bamboo is classified as a secondary forest product and therefore not on the priority list of crops under cultivation in agriculture and forestry sectors (Barwant, 2022). Having considered the challenges encountered in bamboo farming, a policy was formulated with the aim of developing a vibrant bamboo industry with the objective of increasing its area cover in either state or private land (Republic of Kenya, 2019).

The Chi-square test of association indicated that the willingness to cultivate bamboo was not significantly associated with respondents' gender ($\chi^2_{(1)} = 3.834$, $P < 0.050$), age ($\chi^2_{(2)} = 4.376$, $P = 0.112$) and level of education ($\chi^2_{(3)} = 4.894$, $P = 0.180$). This implies that people in West Pokot regardless of gender, age and education level are willing to cultivate bamboo in their farms.

Cochran's Q test of K-related samples determined that there was a statistically significant difference in the proportion of respondents that identified different factors motivating cultivation of bamboo on farms, ($\chi^2_{(9)} = 4.222E2$, $P < 0.001$). Post-hoc analysis based on Cochran's Q test of 2 related samples indicated that the frequency of respondents motivated to cultivate bamboo by environmental benefits of bamboo (45.0%) and economic benefits (30.1%) were significantly higher than other factors while supportive regulations/policies (4.4%) and vast land (11.5%) were significantly lower than other factors (Table 5).

The study found no significant association between motivating factors to cultivate bamboo with respondents' age ($\chi^2_{(2)} = 3.920$, $P = 0.209$). However, factors motivating bamboo cultivation were significantly associated with the respondent's gender ($\chi^2_{(1)} = 13.063$, $P = 0.043$) where most female respondents (4.5%) were motivated by environmental benefits of bamboo, while majority of male (4.2%) were motivated by economic benefits. In addition, factors motivating bamboo cultivation were significantly associated with the respondent's education level ($\chi^2_{(3)} = 19.143$, $P < 0.001$), where for example 13.7% of respondents with no education were motivated by cultural benefits while only 2.6% of respondents with secondary education were motivated by the same factor.

Challenges Hindering Bamboo Cultivation in West Pokot County

Respondents identified various challenges that hinder or may hinder cultivation of bamboo on farms, they include: inadequate knowledge on bamboo planting and management techniques (51.8%), unavailability of planting materials like seedlings (35.9%), lack and or inadequate markets for bamboo products (15.3%), lack of interest to engage in bamboo cultivation (20.7%), discouragement from other farmers (8.9%), unsupportive regulations and policies at County and national levels (16.5%), unfavourable environmental conditions in the area (37.9%), poor growth characteristics of bamboo like invasiveness (7.5%), inadequate or lack of knowledge on potential benefits of bamboo (20.1 %) and limited land (15.0%), among other factors (3.6%) (Table 6).

Lack or inadequate knowledge of propagation, setup, plantation management and harvesting techniques has posed a challenge (Barwant, 2022). Barwant (2022) states that lack of systematic documentation of natural and planted stands of bamboo harvesting and use for commercial purposes in the world has led to unavailability of such important information to the farmers. The little information that is available has been shelved rather than being disseminated to the potential audience (Nzyuko *et al*., 2021). This is because bamboo had received little attention as an agroforestry crop, thus the need to increase its public awareness and sensitization (Kinyili, 2020).

The unavailability of planting materials (seedlings) (35.9%) has caused farmers to hesitate bamboo planting on their farms. This is because in West Pokot, bamboo seedlings are inaccessible to most farmers. Kinyili (2020) recommends for provision of planting materials as a way of enhancing adoption of bamboo among farmers. The farmers also reported that the little materials that could be available is costly for them since one cutting of bamboo was selling at Kes 150 making them to opt for alternatives.

Unfavourable environmental conditions are exhibited in West Pokot County as major parts of the region including Kacheliba, Kongelai, Sigor, Alale and Masol experience arid conditions. They

Table 6. Challenges hindering bamboo cultivation

Respondent's demographic characteristics			Challenges Hindering Bamboo Cultivation (%)										
Education level	**Age**	**Gender**	**Inadequate knowledge**	**Un-availability of seedlings**	**lack of markets for products**	**Lack of interest**	**Discouraged by others**	**Un-supportive regulations/ policies**	**Unfavourable environmental conditions**	**Poor growth characteristics**	**Not aware of benefits**	**Limited land**	**Against culture**
Didn't attend school	<30	Male	2.0	0.5	0.0	1.0	0.0	0.3	0.7	0.3	1.7	0.3	0.0
		Female	1.0	0.5	0.0	0.5	0.3	0.0	1.0	0.0	0.5	0.0	0.0
	30-50	Male	4.5	2.0	1.0	2.7	0.3	1.0	3.0	0.5	2.7	1.2	0.3
		Female	5.7	4.7	1.5	3.0	2.2	1.2	4.0	1.2	3.7	1.2	0.0
	>50	Male	4.0	4.2	2.5	0.7	0.7	2.0	4.0	0.3	1.2	2.0	0.7
		Female	4.2	2.2	0.7	1.7	1.0	1.0	4.0	0.7	2.2	0.5	0.5
Sub-totals			21.4	14.1	5.7	9.6	4.5	5.5	16.7	3	12	5.2	1.5
Primary education	<30	Male	1.0	0.3	0.0	0.7	0.0	0.7	0.5	0.0	0.7	0.3	0.0
		Female	2.0	1.0	1.2	1.5	0.5	0.0	2.0	0.5	0.5	0.0	0.0
	30-50	Male	4.0	2.5	0.3	1.0	0.3	1.2	3.2	0.0	0.5	1.5	0.3
		Female	2.2	2.2	0.5	0.3	0.5	0.5	3.0	0.3	0.5	1.0	0.0
	>50	Male	2.0	2.5	0.5	1.0	0.0	1.0	2.5	0.3	0.5	0.7	0.0
		Female	0.3	0.5	0.5	0.3	0.3	0.0	0.5	0.0	0.0	0.0	0.0
Sub-totals			11.5	9	3	4.8	1.6	3.4	11.7	1.1	2.7	3.5	0.3
Secondary education	<30	Male	1.5	1.0	0.7	0.5	0.5	0.5	0.7	0.7	0.5	0.7	0.0
		Female	1.2	1.2	0.3	0.3	0.0	0.7	1.0	0.5	0.3	0.7	0.0
	30-50	Male	3.2	1.2	0.7	1.2	0.3	0.5	2.0	0.0	0.7	1.5	0.5
		Female	1.2	0.5	0.5	0.7	0.0	0.7	0.5	0.5	0.5	0.5	0.3
	>50	Male	0.3	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0
		Female	0.7	0.5	0.3	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Sub-totals			8.1	4.7	2.5	3	0.8	2.4	4.8	1.7	2	3.7	0.8
Tertiary education	<30	Male	3.5	2.2	1.3	1.3	0.7	2.5	1.5	0.7	1.7	0.3	0.3
		Female	0.7	0.7	0.7	0.5	0.5	0.5	0.7	0.0	0.5	0.3	0.0
	30-50	Male	4.2	4.2	1.5	0.7	0.5	1.2	2.0	1.0	0.5	1.5	0.7
		Female	1.2	0.5	0.3	0.3	0.3	0.7	0.0	0.0	0.7	0.0	0.0
	>50	Male	1.2	0.5	0.3	0.5	0.0	0.3	0.5	0.0	0.0	0.5	0.0
		Female	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sub-totals			10.8	8.1	4.1	3.3	2	5.2	4.7	1.7	3.4	2.6	1
Grant Totals (%)			51.8	35.9	15.3	20.7	8.9	16.5	37.9	7.5	20.1	15.0	3.6

Table 7. Cochran's Q Pair-Wise Analysis of challenges hindering bamboo cultivation

	No seedlings	Lack of markets	Lack of interest	Discouraged by others	Unsupportive policies	Unfavourable environmental conditions	Poor growth characteristics	unaware of benefits	Limited land	Against culture
Inadequate knowledge	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001	P < 0.001
No seedlings		P < 0.001	P < 0.001	P < 0.001	P < 0.001	P = 0.720	P < 0.001	P < 0.001	P < 0.001	P < 0.001
Lack of markets			P = 0.011	P < 0.001	P = 0.564	P < 0.001	P < 0.001	P = 0.021	P = 0.847	P < 0.001
Lack of interest				P < 0.001	P < 0.064	P < 0.001	P < 0.001	P = 0.833	P = 0.013	P < 0.001
Discouraged by others					P < 0.001	P < 0.001	P = 0.446	P < 0.001	P = 0.007	P = 0.002
Unsupportive policies						P < 0.001	P < 0.001	P < 0.071	P = 0.419	P < 0.001
Unfavourable environmental conditions							P < 0.001	P < 0.001	P < 0.001	P < 0.001
Poor growth characteristics								P < 0.001	P = 0.001	P = 0.011
Not aware of benefits									P = 0.025	P < 0.001
Limited land										P < 0.001

are characterized by high soil erosion, poor soils, low rainfalls of about 800 mm per year and high temperatures of over 32°C (Nyberg, *et al*., 2015; County Government of West Pokot, 2018). Due to the prevailing environment, respondents acknowledged that bamboo is a riparian vegetation which may not be a suitable crop for dry-arid zones. This has drastically killed the morale of farmers in the uptake of bamboo as an agroforestry crop that would reduce the environmental problems such as soil erosion and land degradation that are commonly experienced in the area.

Cochran's Q test of K-related samples determined that there was a statistically significant difference in the frequencies of different challenges hindering bamboo cultivation in West Pokot County ($\chi^2_{(10)}$ = 6.158E2, P< 0.001). Post-hoc analysis based on Cochran's Q test of 2 related samples indicated that the frequency of respondents hindered by inadequate knowledge on planting and management (51.8%), unavailability of seedlings (35.9%) and unfavourable environmental conditions (37.9%) were significantly higher than other factors. on the other hand, poor growth characteristics like invasiveness (7.5%) and discouragement from other farmers (8.9%) also had the least response frequencies (Table 7). This is because majority of the respondents had not interacted with bamboo and therefore could not have information on its growth characteristics and invasiveness. This implies that bamboo cultivation can be encouraged by enhancing knowledge and providing necessary planting materials materials. There were no significant associations between challenges hindering bamboo cultivation with respondent's gender ($\chi^2_{(1)}$ = 3.093, P = 0.591), age ($\chi^2_{(2)}$ = 8.940, P< 0.0132) and level of education ($\chi^2_{(3)}$ = 11.803, P = 0.091).

Conclusions

Bamboo crop grows in West Pokot County and the major stakeholders aiding in its dissemination are farmer to farmer, Kenya Forest Service and environmental conservation agents within the County. Majority of the respondents were aware of bamboo and could easily identify without the help of professionals. Various ecological and economical uses of bamboo including soil conservation and watershed management, shade provision, fencing material, construction materials, musical instrument and furniture making are highly recognized. However, using bamboo for food and biodiversity improvement are least known. Farmers regardless of their gender, age and education level are willing to plant bamboo on their farms. This is due to various environmental, economic and cultural benefits as well as encouragement through training on bamboo by agents of environmental conservation. However, the challenging factors constraining bamboo cultivation include inadequate knowledge on planting and management techniques, unavailability of seedlings and unfavourable environmental conditions that could not support growth of bamboo in the area. There is a need to further sensitize and train the community on establishment of bamboo as an agroforestry crop and its management techniques by forestry and agricultural extension agents in the county for the multiple benefits of bamboo

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