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Perception of artisans towards bamboo preservation for improved product durability in Uganda

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A R T I C L E I N F O

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A B S T R A C T

Bamboo continues to attract attention globally as a sustainable material and is used in many applications. However, the quality of bamboo products in Uganda remains poor and cannot compete in the local and international markets. Bamboo's low product quality is associated with poor raw material processing and limited preservation methods, which lead to the short service life of the products due to its susceptibility to bio-deterioration and degradation. To cope with the above, artisans in Uganda apply various preservation methods depending on their knowledge and available resources. In this paper, the authors seek to determine the methods used by the artisans to preserve bamboo, understand the background of their intention to preserve, and their perception towards bamboo preservation. The Theory of Planned Behaviour was used as the main framework to understand artisans' perceptions towards the intention to preserve bamboo. A cross-sectional survey with 186 randomly selected artisans working with bamboo was conducted across three agroecological zones presumed to be Uganda's main bamboo growing areas. The study reported 13 available bamboo species, with the artisans exploiting mainly three of these species. Most artisans (86%) were aware of the need to preserve bamboo, with 67.4% practising bamboo preservation. The artisans use different methods and chemicals for preservation, i.e. leaching (17%), smoking (14%), soaking in crude lake salt (31%), boric acid and borax solutions (20%), surface application (16%), and pressure treatment (1%). Ordinal logistic regression was used to model artisans' intention to engage in bamboo preservation. Attitude and subjective norms were the psychological factors that significantly influenced artisans' intention to preserve bamboo. Interventions that increase benefits accrued from preserved bamboo can improve artisans' attitude and subjective norms and enhance their intention to engage in bamboo preservation.

Introduction

Bamboo is an essential Non-Timber Forest Product (NTFP) resource that has been closely linked with human lives and livelihoods for a long time. Bamboo is widely distributed worldwide, mainly in tropical and subtropical areas, and provides unique ecological, economic, and cultural services (Phimmachanh et al., 2015). These services can aid in addressing some of the global challenges, such as climate change, poverty alleviation, and environmental degradation. In recent years, bamboo has become an essential part of the international sustainable development agenda, with the potential to contribute to the United Nations 2030 Sustainable Development Goals. Bamboo's important contribution to sustainable development lies in its fast growth - maturing in 3–5years with an extensive rhizomatous root system that creates new bamboo shoots and requires no replanting (Mohan et al., 2022; Song et al., 2017). Bamboo is also considered an alternative to wood in various applications such as furniture and construction (Archila et al., 2018; Chaowana, 2013; Coreeal, 2016; Ogunsanwo et al., 2015; Yadav and Mathur, 2021). However, bamboo is susceptible to biodegradation agents and can only serve in the above applications when adequately preserved. Decay fungi, bacteria, termites and beetles are some of the most significant constraints to the utilisation of bamboo and often limits its service life to 2–5 years (Kaur et al., 2016a).

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Bio-deterioration and degradation have a negative economic impact on the bamboo sector (Beaver et al., 2011). The damage caused by insects and decay fungi accounts for more than 40% loss of untreated bamboo material during use or storage (Desalegn and Tadesse, 2014). Bamboo biodegradation can lead to the collapse of structures, leading to safety challenges (Gauss et al., 2019; Liese and Tang, 2015). It is vital to understand and address the biodegradation of bamboo to enhance its usability. Studies show several preservation methods ranging from traditional to modern techniques whose efficiency varies with concentration, preservation method, and species (Kaur et al., 2016a; Kim et al., 2011; Liese and Tang, 2015; Norhisham et al., 2015). Traditional techniques have been passed down to bamboo artisans according to traditional practices (Kaur et al., 2016a). On the other hand, modern techniques employ the use of chemicals that have been scientifically verified and recommended.

Despite the growing interest in bamboo for construction and product development in Uganda, the material's low durability threatens to hamper its usability (Kaur et al., 2016a; Li and He, 2019; Yadav and Mathur, 2021). Consequently, bamboo products are of low quality (Kalanzi et al., 2017), lowering the consumers' confidence in using bamboo products and negatively affecting bamboo promotion efforts. There have been efforts to increase awareness among artisans regarding the need to preserve bamboo for increased durability in service. However, the artisans' response is generally slow, prompting concerns regarding their perceptions towards bamboo preservation. Moreover, the appropriate concentrations of the chemical formulations currently used for preservation are unclear to many artisans. Therefore, this study was conducted to 1) determine the methods used by the artisans to preserve bamboo and their perceived effectiveness and 2) understand the background of artisans' intention to preserve and their perception towards bamboo preservation as a basis for improving the durability of bamboo products.

Theoretical framework

This study uses Ajzen's Theory of Planned Behaviour (TPB) as a framework for understanding the perception of bamboo artisans toward bamboo preservation (Ajzen, 1991). The theory of planned behaviour is one of the most applied theories in studying psychological factors that influence human behaviour. The TPB has been used successfully to understand a wide variety of human behaviour, such as the intention to address post-harvest losses (Ssebaggala et al., 2017), to adopt agroforestry (Buyinza et al., 2020), or to stop illegal mining and improve water quality (Duncan et al., 2022). The foundation of the TPB is that the individual's decision to engage in specific behaviour is based on their beliefs about the behaviour and the expectation of a positive outcome. According to Ajzen (1991), the perception of the behaviour is informed by three aspects: attitude toward a behaviour, subjective norms, and perceived behavioural control. Attitude is the degree to which the execution of the behaviour is positively or negatively evaluated by an individual (Ajzen, 1991). Subjective norms refer to the extent to which one's decision to perform a behaviour is influenced by other people's views, and perceived behavioral control is the individual's perceived capability to successfully perform the behavior (Borges and Lansink, 2016). In this study's context, the intention to perform a behaviour refers to the willingness of the artisans to undertake practices that preserve bamboo. Artisans would have a higher intention to preserve bamboo if they evaluate bamboo preservation to generate positive outcomes (attitude) when they are positively influenced by the views of other people (peers or superiors) about preservation (subjective norms), and when they positively evaluate their capacity to possess resources required to carry out bamboo preservation (perceived behavioural control). Therefore, three hypotheses are derived from the theory and applied in the context of this study:

H_1 : Attitude has a positive influence on artisans' intention to preserve bamboo;.

H_2 : Subjective norm has a positive influence on artisans' intention to preserve bamboo;.

H_3 : Perceived behavioural control has a positive influence on artisans' intention to preserve bamboo.

Methodology

Study area and sampling

The study was conducted in three agroecological zones (AEZs) of Uganda, i.e., West Nile, South Western Highlands, and Lake Victoria Crescent (Fig. 1). These AEZs were selected because key informants ranked them as areas with a high concentration of bamboo artisans. The sites also have the most extensive bamboo stands, and farmers are very receptive to interventions to integrate bamboo into their agricultural landscapes.

Sample selection

Before the survey, a list of bamboo artisans was generated using key informants. Key informants included representatives of key stakeholders in Uganda's bamboo sub-sector, including Nature Uganda, Uganda Bamboo Association, Uganda Industrial Research Institute, National Forestry Authority, National Forestry Resources Research Institute, and International Bamboo and Rattan Organisation (INBAR). This list constituted a sampling frame from which respondents were selected using a simple random sampling procedure. A total of 186 respondents were selected following the procedure described by Krejcie and Morgan (1970) and interviewed using semi-structured face-to-face interviews. The semi-structured questionnaire had a set of questions to examine the perception of artisans towards bamboo preservation. These questions were measured on a 5-point Likert scale (with 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree) based on several independent variables under the three constructs of the TPB theoretical model. Two focus group discussions (FGDs) were conducted in the southwestern highlands. The FGDs aimed to generate consensus on the preservation methods in terms of the procedure followed, the concentration of chemicals used, and the duration of the preservation as conducted by artisans.

Data analysis

The information from the FGDs was refined to include as much detail as possible and ensure accurate discussion content. Data from the focus group discussions were reduced and organised into themes to describe the common methods of preservation and their efficiency as applied and perceived by the artisans, respectively. The quantitative data were analysed using SPSS statistical software version 16 to generate descriptive and inferential statistics. Descriptive statistics were obtained for all explanatory variables, including means, standard deviations, and minimum and maximum. Ordinal logistic regression was used to analyse the intention to preserve bamboo by the artisans using the TPB construct variables. The model specification is as follows:

$$In\left[\frac{P(Y)}{1-P(Y)}\right] = Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 = \mu \tag{1}$$

where Z is the logit – the log of the odds that the artisan will carry out preservation;.

β_0 is the Y-intercept;.

β_1 to $\beta_2$are coefficients (weights) attached to each of the predictors X_1 to X_3 where.

X_1 is the attitude, X_2 is the subjective norm, X_3 is the perceived behavioural control;.

μ is the error term.

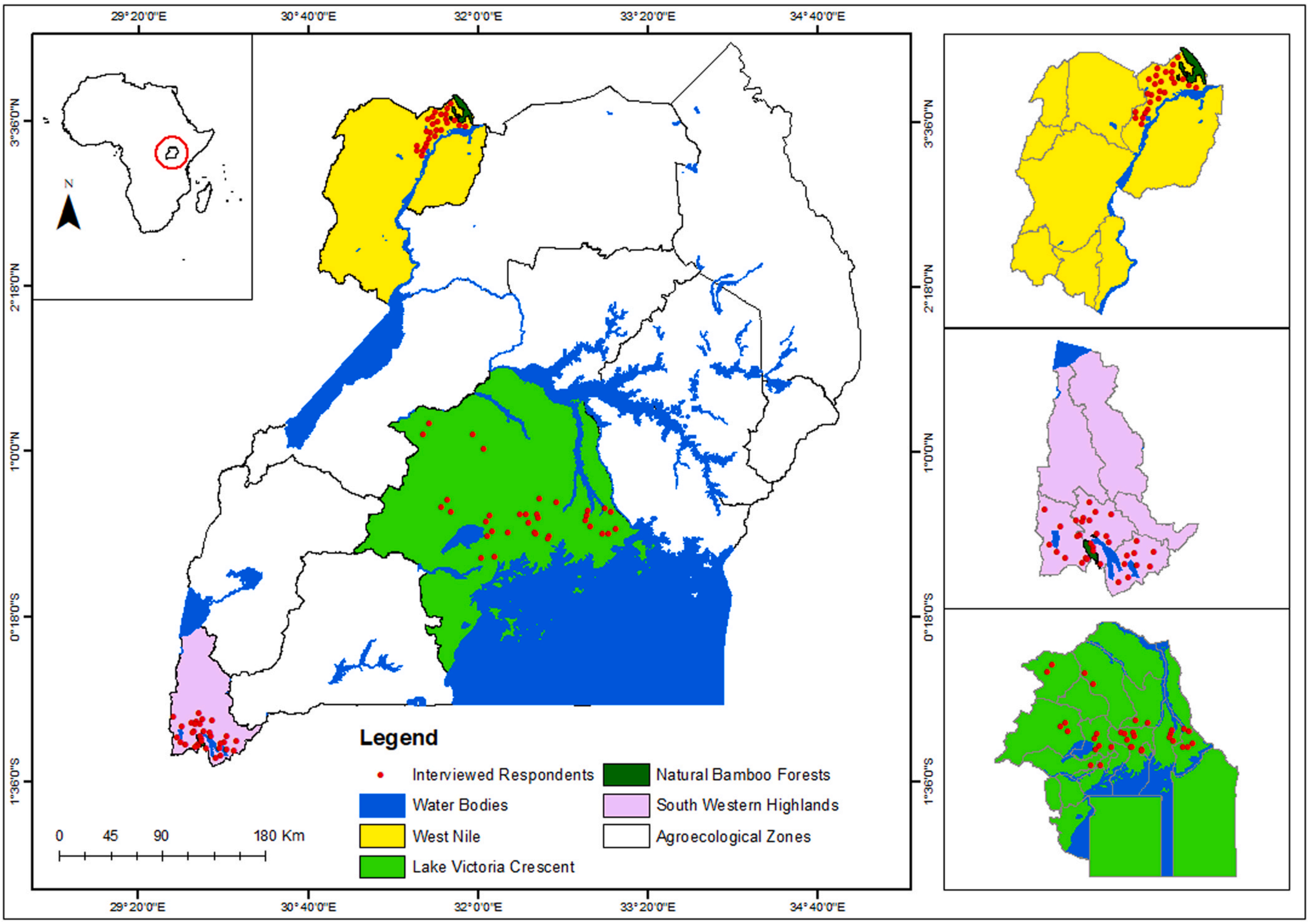


Fig. 1. Map of Uganda showing the study sites and location of the respondents.

Results and discussion

Gender and socio-economic characteristics of the artisans

Of the 186 respondents interviewed, 78% were males, and 22% were females. This could be attributed to the gender stereotyping of bamboo processing, where women are not involved in some bamboo processing activities, such as the production of bamboo baskets and trays, as the sitting positions involved are not considered descent for women in Uganda (Kalanzi et al., 2017). Bamboo processing is tedious since it involves trekking long distances to the forest to extract the bamboo, involving more men than women (Obiri et al., 2020). Over 50% of the respondents were 36–55 years old, and the majority had attained primary education, with 21% having received specialised training sessions on how to carry out preservation. Those who had received training on preservation belonged to the Kisoro bamboo weaving and handcraft association in the South Western highlands.

Species of bamboo used by artisans and their sources

Thirteen species were reported in the study, with artisans exploiting mainly *Oxytenanthera abyssinica* (A. Rich.) Munro (lowland bamboo), *Oldenia alpina* (K.Schum) (commonly known as highland bamboo) and *Bambusa vulgaris* Schrad ex. Wendl. (Fig. 2). Two species, *O. abyssinica* and *O.alpina,* are indigenous bamboo species, while *B. vulgaris* is exotic. The other exotic species were recently introduced by INBAR and have not yet matured for harvesting.

Most artisans (59%) collected bamboo from government forest reserves (Echuya central forest reserve in the South Western Highlands and Otzi central forest reserve in West Nile). About 17% of the artisans were growing bamboo on their farms, while 24% bought bamboo, most from Lake Victoria Crescent, as indicated in Fig. 3.

Preservation of bamboo by the artisans

About 86% of artisans were aware of the need to preserve bamboo against attack by biodegradation agents. Most artisans reported beetles as the main biodegradation agents affecting their bamboo products (Fig. 4). About 67.4% of the artisans preserved the bamboo culms. The bamboo artisans engaged in preservation reported several activities before preserving bamboo culms. Thirty percent of the artisans used the air drying technique to reduce the moisture of the bamboo culms for three days before preservation. Some artisans (7.4%) used the clump curing technique, where the bamboo leaves and branches were left intact on bamboo culms for a few days after harvesting to lose moisture quickly. It is essential to dry the bamboo before preservation. Studies recommend drying bamboo culms with close to 20% moisture content before preservation, and this can take 6–12 weeks when air drying bamboo (Kumar et al., 1994; Liese and Tang, 2015; Singha and Borah, 2017). This enables the preservative to be absorbed into the cell wall of the bamboo, and also, in the case of surface treatments such as painting and varnishing, the paint film layer bonds well on dry culms (Archila et al., 2018). About 63% of the artisans carrying out preservation used the punching technique to drill holes through the diaphragm at the nodes of the bamboo culms, which would otherwise serve as barriers to the movement of the preservative. Generally, the anatomy of bamboo is divided into nodes and internodes, with internodes having hollow tubes with axially oriented cells, which later converge at the node with a

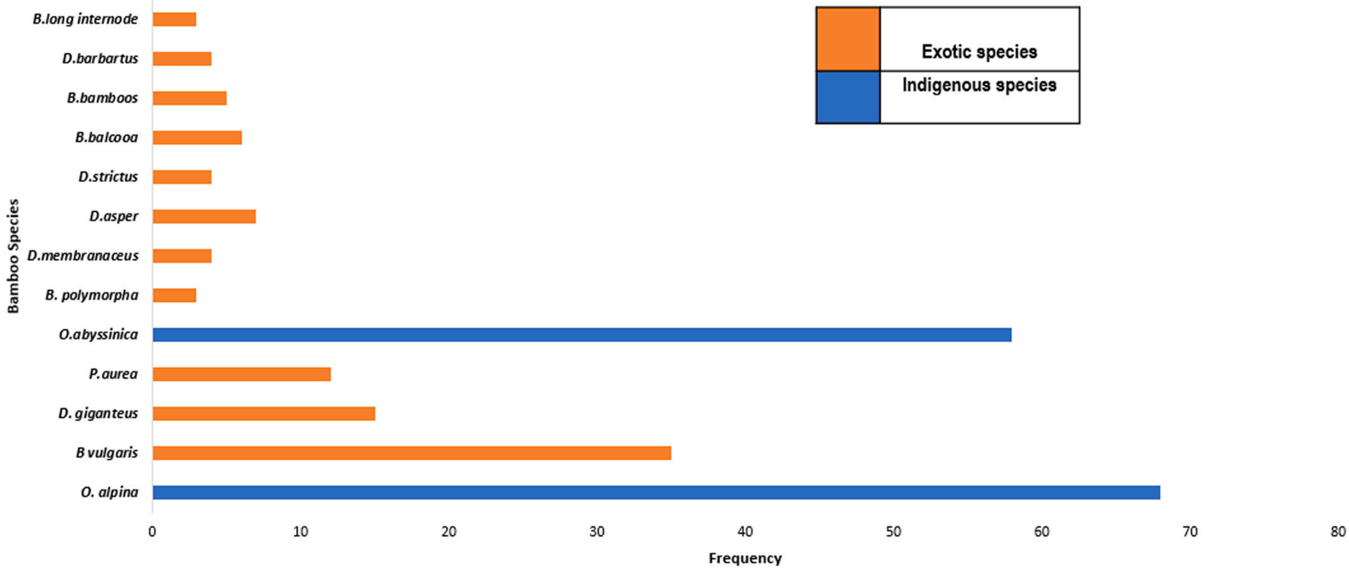


Fig. 2. Ranking of bamboo species.

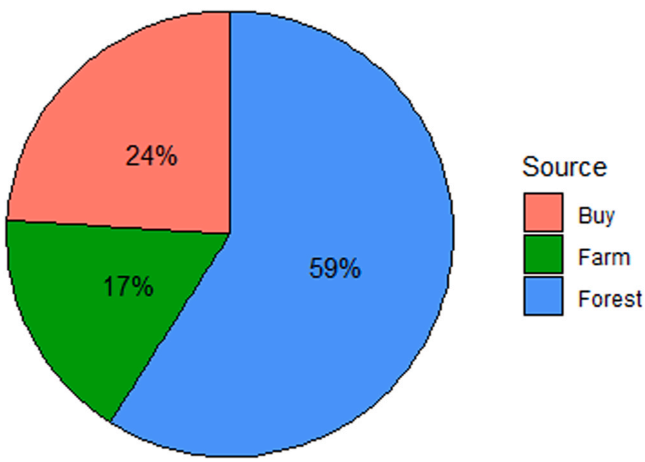


Fig. 3. Sources of bamboo used by artisans in Uganda.

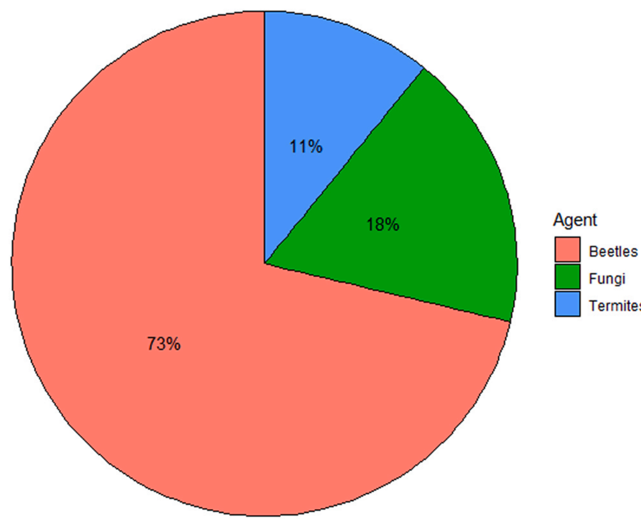
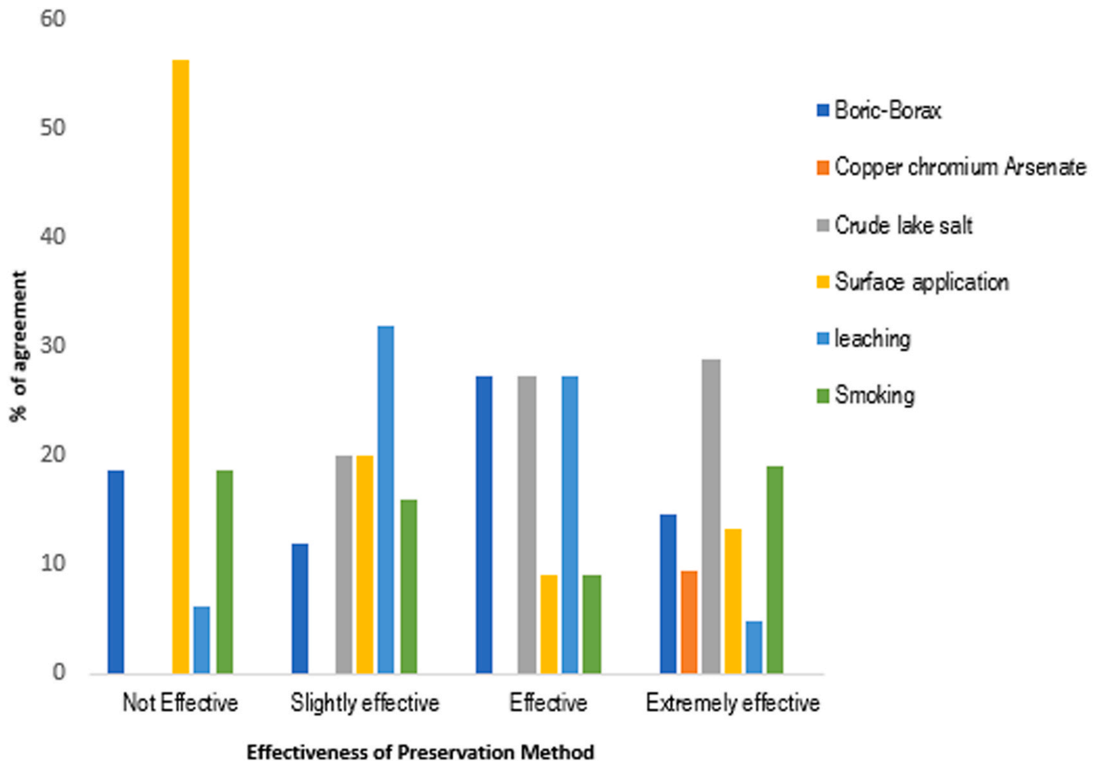


Fig. 4. Perception towards biodegradation agents negatively affecting bamboo material.

diaphragm. Such a structure limits the flow of fluids in the radial direction (Trujillo and Lopez, 2020). Punching the nodes enables the preservative to fill the internode sections and penetrate uniformly into the bamboo cells ensuring proper preservation.

Bamboo artisans' carry out several methods of preservation. Some preservation methods were adopted from the past generation, while others were learned through training targeting bamboo product development. About 17% practised leaching, 14% smoking, 31% soaked bamboo culms in crude lake salt, 20% boric acid and dinatriumtetraborat (borax) solutions, 16% used surface application and 1% pressure treatment with copper chromium arsenate (CCA). The perceived effectiveness of the different preservation methods by the artisans is illustrated in Fig. 5. Generally, the effectiveness of these methods ranged from not effective to extremely effective. Unlike CCA, artisans used different concentrations for other preservation methods, resulting in variation in their perceived effectiveness. Artisans who used CCA applied the recommended concentration by the manufacturer, which has been proven effective by other studies (Tomak and Topaloglu, 2022). However, the cost of CCA hinders most artisans from using it to preserve bamboo. In addition, CCA is reported to pose environmental and health risks to the communities, and it's banned in many countries (Kaur et al., 2016a; Lansbury and Beder, 2005). Hence artisans and industries must be discouraged from using CCA to preserve bamboo.

Leaching: According to the artisans who used this method, bamboo is harvested and left in the forest for three days. After three days, the bamboo is immersed in a stream of water for a period not exceeding a week. Some artisans, who do not live adjacent to streams, soak the bamboo culms in water in artificial ponds. However, they must ensure that they fill the pond with fresh water for each round of preservation. Weight is attached to the culms to enable them to submerge entirely in water. Afterwards, the bamboo is air dried under a shade before converting it into various products. The soaking period of one week reported in the present study is shorter than the recommended soaking duration of one month Kaur et al., (2013) and three months (Kaur et al., 2016a). Soaking bamboo in water ensures that starch, carbohydrates and other water-soluble substances are washed out of the culms. Once the starch content reduces, the possibility of beetle attack is lowered. Apart from using leaching as a preservation method, the artisans involved in basketry reported that the water kept the culms soft, improving the bamboo strips' workability. However, other factors may affect the effectiveness of this preservation method. For example, harvesting time affects the durability of bamboo. Bamboo harvested during the dry season is more susceptible to attack by bio-degradation agents because of the increased starch content. More soaking time is required to wash out the starch of the bamboo harvested during the dry season.



Category	Duration
Not effective	<1year
Slightly effective	>1 - < 2years
Effective	>2 - < 4years
Extremely effective	>4years

Fig. 5. A cross-tabulation of artisans' perceived effectiveness of different preservation methods.

Besides, the effectiveness of soaking would vary from species to species due to variations in starch content. Studies have reported a remarkable reduction in the starch content of bamboo after soaking – offering more resistance to attack by bio-degradation agents. But this resistance only lasts for a short time, meaning that water leaching, although used by many artisans for a long time, does not protect bamboo against bio-degradation agents (Kaur et al., 2016a).

Smoke treatment: This method is used by artisans, mainly producing bamboo hives, to increase the service life of the hives. After producing the hives, a fire is lit, and the hives are placed above the fire for 10–15 min. The smoke from the fire renders the hives resistant to insect attack. These findings align with Hadi et al., (2010), who reported that smoked wood was resistant to termite attack. However, for bamboo, Kaur et al., (2016b) reported eight hours of smoke treatment offered protection to *Dendrocalamus strictus* under only laboratory conditions and no protection under field conditions. Singha and Borah (2017) reported that smoke treatment did not provide resistance to *Bambusa tulda* against fungal attack.

Soaking in crude lake salt: Bamboo poles are harvested and left to dry for three days, after which they are sectioned into different sizes depending on the products produced. The cut sections are soaked in a crude lake salt solution. According to the artisans who use this method, the solution comprises 100 L of water containing 2 kg of crude lake salt, i.e., a solution of 2%. The bamboo pieces are soaked in the solution for 7–9 days. According to the artisans, this method's effectiveness varied from slightly to highly effective (Fig. 5).

Surface application of preservatives: Another preservation method included the surface application of varnish, thinner, used oil, and paint on bamboo articles. In particular, varnish comes in various colours and provides an added advantage of beautifying the articles. The effectiveness of this method, as perceived by artisans, ranged from slightly to highly effective (Fig. 5). However, studies show that surface or "paint-on" treatments in bamboo do not provide sufficient preservation against biodegradation agents, especially from decay fungi (Archila et al., 2018; Liese and Kumar, 2003).

Soaking in boric acid or borax solution

Fresh bamboo culms are harvested and dipped in a 2–6% concentration of boric/borax solution in a ratio of 1:1.5 for 7–14 days. Some artisans punched the bamboo poles' nodes to increase the preservative solutions' absorption. The boric/borax solution was either used with heat or without heat. This method is carried out mainly by artisans and companies in the Lake Victoria Crescent AEZ. This is apparent in Fig. 5 where the efficacy of boric-borax varies within 15–30% range from ineffective to extremely effective, possibly because of variation in concentration, pretreatment methods and duration of soaking. Jayanetti and Follet, (1998) reported that boric/borax solutions are ineffective against fungi and bamboo borers. There are many concentrations in different studies (Sánchez Vivas et al., 2019), implying the need to standardize these various concentrations to obtain an optimal concentration to ensure increased bamboo preservation.

Behaviour intention to carry out the preservation of bamboo

An ordinal logistic regression was carried out to understand what shapes artisans' intention to preserve bamboo. The three constructs of the TPB, namely: attitude, subjective norms and perceived behavioural control were treated as predictor variables in the model to determine the likelihood that artisans would engage in bamboo preservation. The results of the model are presented in Table 1. Results from the model

Table 1
Influence of attitude, subjective norms and perceived behavioural control on artisans' intention to preserve bamboo.

TPB Construct	Estimate	Wald	P-value
Attitude*	2.265	20.644	0.000
Subjective Norms*	1.207	7.166	0.007
Perceived Behaviour Control	0.331	1.843	0.175

* Significant at 5% p ≤ .005

indicated that attitude and subjective norms significantly influenced the intention to preserve bamboo.

Attitude had a more significant influence than subjective norms and perceived behavioural control on artisans' intention to preserve bamboo. The strong influence of attitude showed that the positive evaluation of the benefits associated with bamboo preservation was the main determinant of artisans' intention to preserve bamboo. This implies that artisans evaluated preserving bamboo as more favourable than not preserving it. Artisans' positive evaluation of bamboo preservation resulted from them realizing preserved bamboo products could be sold at a higher price than unpreserved products, consequently increasing income. Studies have demonstrated that proper bamboo preservation has more economical and sustainable benefits through increasing bamboo products' service life (Desalegn and Tadesse, 2014; Kaur et al., 2016a; Liese and Tang, 2015). This study's findings on attitude as a significant predictor of behaviour agree with other studies, e.g. Sugandini et al., (2016) who found that attitude positively influenced the adoption of natural dyes among batik artisans in Yogyakarta, Indonesia.

Furthermore, Buyinza et al., (2020) reported that the attitude of farmers strongly influenced their adoption of agroforestry in the Eastern highlands of Uganda, while Duncan et al. (2022) found that the attitude of illegal miner's significantly influenced their intention to choose an alternative job. Therefore, interventions to encourage and engage artisans to continue or start carrying out proper bamboo preservation could focus on increasing benefits from preserved bamboo by opening specialised markets for preserved products. Furthermore, for the artisans to engage in preservation, interventions should ensure access to preservatives at affordable costs.

Although the artisans' attitude had a significant influence, subjective norms from people considered important to the artisans also influenced their intention to preserve bamboo. As a part of subjective norms, the influence of fellow artisans would motivate them to engage in bamboo preservation. Most artisans work in groups and often sell their products collectively. Therefore, if there is a perceived need by some peers in the group to carry out preservation to ensure that the products produced in the group meet the same quality, other group members could easily comply. Subjective norms have taken on many variants, ranging from peer influence (Kalanzi et al., 2021) to descriptive norms where people engage in an activity because the others in the group are doing the same activity to live in harmony as a group (Anderson and Dunning, 2014). A few studies have not found subjective norms as a significant factor influencing behavioural intentions (Buyinza et al., 2020). However, many other studies also support the possibility of artisans influencing each other (subjective norms) regarding the intention to preserve bamboo. For example, a study by Ofoegbu and Ifejika Speranza, 2017 reported that peer influence significantly affected smallholder farmers' choice of sustainable forest use and management options in South Africa. Borges et al., (2019) noted that the opinion of others influences farmer's decisions. Kalanzi et al. (2021) found that peer influence significantly increased the choice probability of using the boundary planting agroforestry technology. In this study, the subjective norm was a significant factor influencing the intention to preserve bamboo because the artisans mainly work in groups, and there is a strong possibility for peer influence. This is further strengthened by the fact that for typical rural areas, people tend to rely more on each other in cliques or group to which they belong, for knowledge exchange (Zossou et al., 2019).

In this study, the perceived behaviour control had no significant influence on artisans' intention to preserve bamboo. This is in contrast to other studies that have reported perceived behavioural control as a predictor of behavioural intentions. For example, a study by Buyinza et al. (2020) found that perceived behavioural control influenced farmers' intention to integrate trees in their coffee gardens in the Mt. Elgon region of Uganda. Similarly, a study in the Eastern highlands of Uganda found that perceived behavioural control increased the choice probability of boundary planting and intercropping agroforestry technologies (Kalanzi et al., 2021). Perceived behavioural control is about individuals having a positive evaluation of their capacities to engage in a behaviour (Denkyirah et al., 2017; Van Hulst and Posthumus, 2016).

In the context of this study, artisans did not believe that they had the resources to engage in bamboo preservation. Artisans specifically mentioned the lack of access to preservatives and equipment to use while preserving.

Conclusions

The study shows that artisans in Uganda are embracing bamboo as an alternative to wood. Artisans used several methods: leaching, smoking, soaking in crude lake salt, boric acid and borax solutions, surface application, and pressure treatment to preserve their bamboo. Apart from the modern methods employing proven chemicals of known formulations such as CCA and Boric-Borax treatment, the effectiveness of the traditional preservative methods remains unclear. Much remains unclear regarding the duration of exposure to the treatment and the concentration of crude lake salt used. There is need for scientific verification of the identified traditional methods as a basis for training bamboo artisans on how to successfully execute the preservation methods to ensure improved durability of bamboo products.

This study showed how the three constructs of TPB (attitude, subjective norms, and perceived behavioural control) influence artisans' intention to engage in bamboo preservation. Attitude and subjective norms had the most significant influence on artisans' intention to engage in bamboo preservation. While this study focused on the three psychological constructs: attitude to behaviour, subjective norm, and perceived behavioural control to capture artisans' behavioural intention towards bamboo preservation, the study did not capture other factors that may influence artisans' behaviour. Further studies on the influence of other factors, such as specialised markets for preserved bamboo, economic analysis of preserved bamboo products and the role of institutions in influencing artisans' intention to preserve bamboo are necessary.

Data Availability

The data that has been used is confidential.

Declaration of Competing Interest

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

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References

Ajzen, I. (1991). The theory of planned behavior. Organizational behavior and human decision processes. 50, 179–211.

Anderson, J.E., Dunning, D., 2014. Behavioral norms: Variants and their identification. Social and Personality Psychology Compass 8 (12), 721–738.

Archila, H., Kaminski, S., Trujillo, D., Zea Escamilla, E., Harries, K.A., 2018. Bamboo reinforced concrete: a critical review. Mater. Struct./Materiaux et Construct. 51 (4). https://doi.org/10.1617/s11527-018-1228-6

Beaver, R., Sittichaya, W., Lan-yu, L., 2011. A review of the powder-post beetles of Thailand (Coleoptera: Bostrichidae). Trop. Nat. Hist. 11 (2), 135–158.

Borges, J.A.R., Domingues, C.H., de, F., Caldara, F.R., Rosa, N.P., da, Senger, I., Guidolin, D.G.F., 2019. Identifying the factors impacting on farmers' intention to adopt animal friendly practices. Prev. Vet. Med. 170 (June), 104718. https://doi.org/10.1016/j.prevetmed.2019.104718

Borges, J. A. R., & Lansink, O. A. G. J. M. (2016). Identifying psychological factors that determine cattle farmers' intention to use improved natural grassland. *Journal of Environmental Psychology*, 45(C), 89–96. https://doi.org/10.1016/j.jenvp.2015.12.001.

Buyinza, J., Nuberg, I.K., Muthuri, C.W., Denton, M.D., 2020. Psychological factors influencing farmers ' Intention to adopt agroforestry: a structural equation modeling approach psychological factors in fl uencing farmers ' intention to adopt agroforestry: a structural equation modeling approach. J. Sustain. For. 00 (00), 1–12. https://doi.org/10.1080/10549811.2020.1738948

Chaowana, P., 2013. Bamboo: an alternative raw material for wood and wood-based composites. J. Materials Sci. Res. 2 (2), 90–102. https://doi.org/10.5539/jmsr.v2n2p90

Coreeal, J., 2016. In: Harries, K., Sharma, B. (Eds.), Bamboo Design and and Construction. Nonconventional and Vernacular Construction Materials. Elsevier.

Denkyirah, E.K., Okoffo, E.D., Adu, D.T., Bosompem, O.A., 2017. What are the drivers of cocoa farmers' choice of climate change adaptation strategies in Ghana? Cogent Food Agric. 3 (1). https://doi.org/10.1080/23311932.2017.1334296

Desalegn, G., Tadesse, W., 2014. Resource communication. Resource potential of bamboo, challenges and future directions towards sustainable management and utilization in Ethiopia. For. Syst. 23 (2), 294–299.

Duncan, A.E., Vries, N., De, Nyarko, K.B., 2022. An intervention to address deteriorating water quality: An application of Ajzen ' s theory of planned behavior. Curr. Psychol. 1967–1975.

Gauss, C., Kadivar, M., Savastano, H., 2019. Effect of disodium octaborate tetrahydrate on the mechanical properties of Dendrocalamus asper bamboo treated by vacuum/pressure method. J. Wood Sci. 65 (1). https://doi.org/10.1186/s10086-019-1804-6

Hadi, Y.S., Nurhayati, T., Yamamoto, H., Kamiya, N., 2010. Smoked wood resistance against termite. J. Trop. For. Sci. 22 (2), 127–132.

Jayanetti, D.L., Follet, P.R., 1998. an Introduction (No. 15). International Network for Bamboo and Rattan. International Development Research Center, Regional Office for South Asia.

Kalanzi, F., Mwanja, C., Agaba, H., Guuroh, R.T., 2017. Potential of bamboo as a source of household income in South Western Uganda. J. Bamboo Rattan 16 (1), 33–45.

Kalanzi, F., Kyazze, F.B., Isubikalu, P., Kiyingi, I., Orikiriza, L.J.B., Okia, C., Guuroh, R.T., 2021. Influence of socio-technological factors on smallholder farmers' choices of agroforestry technologies in the eastern highlands of Uganda. Small-Scale For. 20 (4), 605–626. https://doi.org/10.1007/s11842-021-09483-8

Kaur, P., Kardam, V., Pant, K.K., Satya, S., Naik, S., 2013. Scientific investigation of traditional water leaching method for bamboo preservation. J. Am. Bamboo Soc. 26 (1), 27–32.

Kaur, P.J., Satya, S., Pant, K.K., Naik, S.N., 2016a. Eco-Friendly preservation of bamboo species: traditional to modern techniques. BioResources 11 (4), 10604–10624.

Kaur, P.J., Satya, S., Pant, K.K., Naik, S.N., Kardam, V., 2016b. Chemical characterization and decay resistance analysis of smoke-treated bamboo species. Eur. J. Wood Wood Prod. 74 (4), 625–628. https://doi.org/10.1007/s00107-016-1029-y

Kim, T., Tang, H., Liese, W., 2011. Pressure treatment of bamboo culms of three Vietnamese species with boron and CCB preservatives. J. Bamboo Rattan 10 (1&2), 63–76.

Krejcie, R.V., Morgan, D.W., 1970. Determining sample size for research activities. Educational and psychological measurement 30 (3), 607–610.

Kumar, S., Shukla, K., Dev, T., & Stinson, P. (1994). Bamboo Preservation Techniques: A Review (pp. 1–25).

Lansbury, N., Beder, S. , 2005. Treated Timber, Ticking Time-bomb The Need for a Precautionary Approach to the Use of Copper Chrome Arsenate (CCA) as a Timber Preservative. 〈https://ro.uow.edu.au/artspapers/41%0AResearch〉.

Li, W., & He, S., 2019. Research on the Utilization and Development of Bamboo Resources through Problem Analysis and Assessment. IOP Conference Series: Earth and Environmental Science, 300(5), 052028. https://doi.org/10.1088/1755–1315/300/5/052028.

Liese, W., Tang, T., 2015. Preservation and drying of bamboo. In Bamboo. Springer, Cham, pp. 257–297. https://doi.org/10.1007/978-3-319-14133-6_9

Liese, W., & Kumar, S., 2003. INBAR Technical Report: bamboo preservation compendium. (Issue 22).

Mohan, N., Dash, S.P., Mary Boby, N., Shetty, D., 2022. Study of bamboo as a building material – Construction & preservation techniques and its sustainability. Mater. Today: Proc. 60, 100–114. https://doi.org/10.1016/j.matpr.2021.12.263

Norhisham, A.R., Faizah, A., Zaidon, A., 2015. Effects of moisture content on the bamboo borer Dinoderus minutus. J. Trop. For. Sci. 27 (3), 334–341.

Obiri, B., Oduro, K., Obeng, E., Pentsil, S., Appiah-Kubi, E., 2020. Bamboo value chain study: Ghana - INBAR. Int. Bamboo Rattan Organ. 1–118 (https://www.inbar.int/resources/inbar_publications/bamboo-value-chain-study-ghana/).

Ofoegbu, C., Ifejika Speranza, C., 2017. Assessing rural peoples' intention to adopt sustainable forest use and management practices in South Africa. J. Sustain. For. 36 (7), 729–746. https://doi.org/10.1080/10549811.2017.1365612

Ogunsanwo, O.Y., Terziev, N., Panov, D., Daniel, G., 2015. Bamboo (Bambusa vulgaris Schrad.) from moist forest and derived savanna locations in South West Nigeria - Properties and gluability. BioResources 10 (2), 2823–2835. https://doi.org/10.15376/biores.10.2.2823-2835

Phimmachanh, S., Ying, Z., Beckline, M., 2015. Bamboo resources utilization: a potential source of income to support rural livelihoods. Appl. Ecol. Environ. Sci. 3 (x), 176–183. https://doi.org/10.12691/aees-3-6-3

Sánchez Vivas, L., Mullins, G., Cunningham, J.A., Mihelcic, J.R., 2019. Mechanical properties of bamboo: a research synthesis of strength values and the factors influencing them. Journal of American Bamboo Society 29, 1–21.

Singha, B.L., Borah, R.K., 2017. Traditional methods of post harvest bamboo treatment for durability enhancement. Int. J. Sci. Eng. Res. 8 (1), 518–522.

Song, Q.N., Lu, H., Liu, J., Yang, J., Yang, G.Y., Yang, Q.P., 2017. Accessing the impacts of bamboo expansion on NPP and N cycling in evergreen broadleaved forest in subtropical China. Sci. Rep. 7 (December 2016), 1–10. https://doi.org/10.1038/srep40383

Ssebaggala, G., Kibwika, P., Kyazze, F., Karubanga, G., 2017. Farmers' Perceptions of rice postharvest losses in eastern Uganda. J. Agric. Ext. 21 (2), 30–43.

Sugandini, D., Rahatmawati, I., Istanto, Y., 2016. Adoption of natural dyes for batik artisans in Yogyakarta, Indonesia. Review of Integrative Business and Economics Research 6 (1), 349–359.

Tomak, E.D., Topaloglu, E., 2022. Testing the durability of copper based preservative treated bamboos in ground - contact for six years. Cellulose 29 (12), 6925–6940. https://doi.org/10.1007/s10570-022-04699-z

Trujillo, D.J., Lopez, L., 2020. Bamboo material characterisation. In Non Conventional and Vernacular Construction Materials. Elsevier Ltd, pp. 491–520. https://doi.org/10.1016/B978-0-08-102704-2.00018-4

Van Hulst, F.J., Posthumus, H., 2016. Understanding (non-) adoption of conservation agriculture in Kenya using the reasoned action approach. Land Use Policy 56, 303–314. https://doi.org/10.1016/j.landusepol.2016.03.002

Yadav, M., Mathur, A., 2021. Bamboo as a sustainable material in the construction industry: an overview. Mater. Today: Proc. 43, 2872–2876. https://doi.org/10.1016/j.matpr.2021.01.125

Zossou, E., Arouna, A., Diagne, A., Agboh-Noameshie, R.A., 2019. Learning agriculture in rural areas: the drivers of knowledge acquisition and farming practices by rice farmers in West Africa*. J. Agric. Educ. Ext. 26 (3), 291–306. https://doi.org/10.1080/1389224X.2019.1702066