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Research Article

Socio-economic utilisation Of Upas Tree (*Antiaris toxicaria* Lesch): A case study Of Mabira Central Forest Reserve, Uganda

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Article Info

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Abstract

Antiaris toxicaria Lesch (upas tree) is a monoecious and medicinal tree species belonging to the Moraceae family and is known for its medicinal value, plywood, and veneer. The tree has been over-utilized, leading to degradation, over-exploitation, and a decrease in population size. The study aims to assess the socio-economic factors associated with the utilization of *Antiaris toxicaria* Lesch in Mabira Central Forest Reserve. A cross-sectional research design was conducted using a semi-structured questionnaire and participant observation guide from 410 randomly selected households across 10 villages. A total of 10 key informant interviews were also conducted among persons who were knowledgeable persons about the upas tree and Mabira Central Forest service. Descriptive statistics and inferential statistics (chi-square tests) were used for analysis. Results indicate eight primary uses of the tree, with timber (42.1%) and medicinal (23.6%) uses being the most common while firewood (0.9%) and fertilization (2.3%) ranked least. Significant factors influencing utilization of upas trees included residence duration (p=0.001), occupation (p=0.002), and household income (p=0.028). The National Forestry Authority and local government should work hand in hand with local communities to protect Mabira Central Forest Reserve and promote upas tree domestication. The study recommends conservation awareness among communities living in the vicinity and inclusive policies for sustainable use of upas trees.

Keywords: *Antiaris toxicaria*, forest conservation, Mabira Central Forest Reserve, socio-economic factors

1 Introduction

Despite its toxic nature, *Antiaris toxicaria* Lesch (Upas tree) has been a part of traditional livelihoods in various communities in Uganda and beyond. The tree is termed an "industrial forest plant" and is known for its commercial rather than subsistence use (Umdale et al., 2020). Upas tree is used in traditional medicine, as proven by numerous phytochemical analyses of its latex, confirming the presence of many active chemical compounds, including Antiarin (Subiono et al., 2017). Furthermore, qualitative phytochemical studies presented the existence of alkaloids, phenols, glycosides, anthraquinone, protein, amino acids, flavonoids, phytosterols, and saponins that were reported to cure different ailments. Upas tree has several medicinal applications in traditional systems across various cultures.

The different parts of the tree were found important in treating various ailments and used for other cultural values. For example, leaves, seeds, and bark are used as an astringent and febrifuge, while seeds are used as anti-dysenteric. The bark is used as an anodyne and vermifuge to treat hepatitis and mental illnesses (Ugwoke et al., 2017).

In some countries, the tree is known to treat cancer due to medicinal properties found in the components of its sap. For example, scientific studies conducted in the East African region revealed that *Antiaris toxicaria* Lesch can be used to treat tuberculosis (Obakiro et al., 2020). In Uganda, the tree is known to treat headaches and weakness in pregnancy (Tumuhe et al., 2018). However, the tree species was not only found useful in providing medicine but also in other uses. In Kerala-India, the bark of the tree was found essential in making a type of bark cloth called Maravuri among the Muthuvan people and other uses are plywood and veneer (Umdale et al., 2020). In essence, this makes the upas tree of great cultural significance and essential for the preservation of cultural practices.

Traditional medicine use is common among the old people in Sub-Saharan Africa as a result of cultural identity and traditions passed on. The use of medicinal plants in sub-Saharan Africa is linked to several socioeconomic characteristics, including age, wealth, marital status, and educational attainment. In a study done in Moroto district, Uganda, older adults, married people, and those who live far from contemporary medical facilities are more likely to use medicinal herbs (Logiel et al., 2021). A socio-economic baseline study conducted on six (6) Central Forest Reserves (CFR) in Uganda unveiled a significant increase in households (31.3%) living adjacent to CFR including Mabira Central Forest Reserve. This high population increases the chances for excessive extraction of forest resources like firewood, charcoal, poles, timber, and herbal medicine for personal use or commercial purposes (Ministry of Water and Environment, 2017). Mabira Central Forest Reserve (Mabira CFR) is facing increasing demand and the surrounding high population exerts pressure in the struggle for livelihood improvement. A forest reserve is home to many trees important to the surrounding communities, who mostly harvest these plants for their livelihood support.

Socioeconomic status of *Antiaris toxicaria* Lesch provides a clear understanding of interconnected reasons for its utilisation. On the other hand, *Antiaris toxicaria* Lesch is known to have a poor regeneration rate and hence a threatened species (Mirgal et al, 2016) and this could lead to its extinction if conservation efforts are not undertaken. A few studies on the upas tree exist and especially its socioeconomic utilization in nearby communities of Mabira CFR. The present study was undertaken to understand the socioeconomic utilisation of *Antiaris toxicaria* Lesch in the communities of Wakisi and Najjembe sub-counties around Mabira CFR, Uganda, and justify its conservation.

2 Methods and Materials

2.1 Description of the study area

Mabira CFR covers an area of 29,974 hectares. It is located in Mukono, Buikwe, and Kayunga districts, counties such as Buikwe, Nakifuma, Mukono and Ntenjeru, and sub-counties such as Wakisi, Nagojje, Najjembe, Kimenyedde, Nama and Kangulumira of Kayunga district. Geographically, Mabira CFR is located between latitudes 000 22' and 000 35' N and longitudes $30^0 56'$ and $33^0 02' E$.

The management and control of Mabira Central Forest Reserve (Mabira CFR) is vested in the National Forestry Authority (NFA) under the National Forestry and Tree Planting Act, 2003 (Ministry of Water and Environment, 2020) (Figure 1).

2.2 Research design and sample size

Buikwe district holds a total of 97,833 households. Najjembe Division has a total of 8,007 households, while Wakisi has 9,256 households (Uganda Bureau of Statistics (UBOS), 2014). Najjembe and Wakisi were purposively selected from Buikwe District because they were close to the forest reserve and held the forest's largest part. From a total number of 17,263 households in the two divisions, the sample size was estimated using Yamane's formula

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

where n stands for sample size, N for population size, and e for level of significance (5%).

Additionally, to account for non-response, 5% of the households that were obtained were added. The study employed a cross-sectional research design and 410 households were randomly sampled from the two divisions. Ten villages were purposively chosen from the divisions based on their proximity to Mabira CFR (Wakisi division-four villages and Najjembe-six villages). Fewer villages were selected from Wakisi because some of the villages that bordered the forest were inhabited by temporary workers for sugar and tea industries, who were constantly coming and going from different districts of Uganda and were not knowledgeable about the utilization of forest resources in the study area. The respondents were mainly farmers, non-farmers, and traditional healers across all the villages.

2.3 Sampling procedure and data collection

Ten (10) villages were purposively selected from the study area, as they were the closest to the forest reserve. The villages are Ssese, Dangala, Lugala, Kinoni, Buwola, and Kitoola from the Najjembe Division and Nakalanga, Wabusanke, Bugule, and Nnkonko from the Wakisi Division. Two hundred and forty-six (246) households were randomly selected from Najjembe, while one hundred and sixty-four (164) were randomly selected from Wakisi. Respondents were selected randomly from the register shared by the chairperson of the village ensuring that every household had an equal chance of being selected and avoiding bias. A semi-structured questionnaire was used to obtain primary data, and the interviews were conducted face-to-face with the respondents who were willing to participate in the study. The questionnaire had four (4) sections, the first section had the introduction and consent part and socio-demographic factors, the second section comprised questions on the collection and utilisation of *Antiaris toxicaria* Lesch, the third section was on

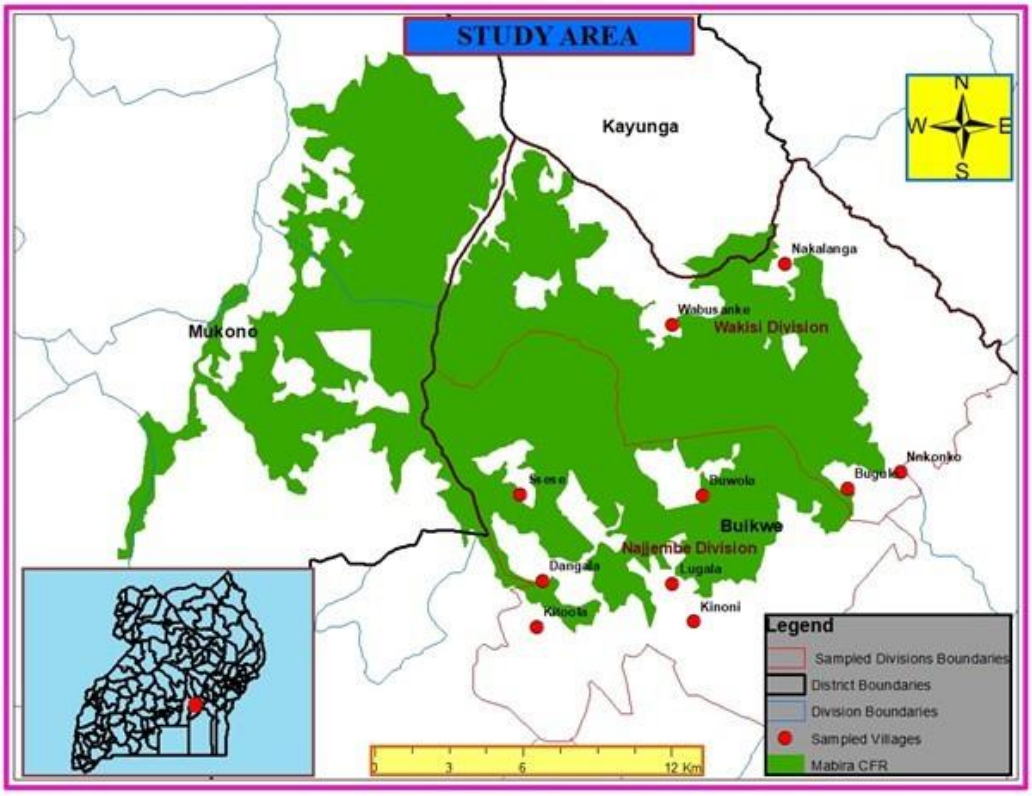

Figure 1: Map of the study area showing the location of Mabira CFR, the study divisions and villages

disturbance factors, and the last section was made up observation checklist. A key informant guide was designed, and interviews were conducted with ten (10) persons who were knowledgeable about the upas tree and Mabira Central Forest reserve.

2.4 Data analysis

The collected data were zanalyzed by Statistical Package for Social Sciences (IBM SPSS, version 29.0). Chi-Square (x^2) was used to test the significance of the association between the utilisation of *Antiaris toxicaria* Lesch and socio-economic factors, while type I and type II errors were controlled by using a 5% level of significance. Other results were transformed into frequencies and percentages, and presented in tables or chart form.

2.5 Ethical consideration

The Director of Research and Graduate Training at Kyambogo University provided us with a letter of recommendation before starting the data collection process. The letter requesting authorization to conduct the research project was delivered to the National Forestry Authority (NFA) and the local government authorities in the study area and permission was granted. Moreover, consent was sought from participants, and their involvement was entirely voluntary. Participants were free to withdraw from the study at any stage without giving any reason and without there being any negative consequences. Before participation in the study, the participants were informed of the objectives of the study and were made to understand their responses would be kept strictly confidential and only used for the research. Participant names were not linked with the research materials, and we would not be identified anywhere in the report. Each participant was required to sign a written informed consent form before taking part in the study.

3 Results

3.1 Socio-demographic characteristics of participants

The present research study assessed the association between the socio-demographic characteristics of the survey participants and the use of A. toxicaria Lesch (Upas tree). The majority of household heads (65.1%) who participated in the survey were males, while 34.9% were females. A significant number of participants (64.4%) were between 18 and 43 years old, while 35.6% were aged 44 years and above. The majority of households were farmers (82.4%) who mainly survived on subsistence farming.

Employed household heads (formally employed or self-employed in activities other than farming) constituted 15.4%, while those without formal jobs were 2.2%. There were relatively few employment opportunities in the study area while farming was the main occu-

pation. In terms of education levels, about 64.1% of participants received formal education (primary, secondary education, tertiary education), while the remaining 35.9% did not receive formal education. The marital status of most participants (75.1%) was married, while 21.5% were single and 3.4% were widows. Many of the households (55.6%) had only one to four people, 30.7% had five to eight people, and 13.7% had nine or more people living together. Most households (85.3%) earned less than 200,000 Ugandan shillings (Ugx) per month which is equivalent to 55dollars, followed by those who earned 201,000 and 500,000 Ugx (13.2%), and those who made 501,000 or more (1.5%). Generally, most households in the research area were low-income earners and relied on subsistence farming.

3.2 Collection and local utilisation of A. toxicaria Lesch

The results indicated that 66.7% of the households in the research area utilized *Antiaris toxicaria* Lesch in various ways. The remaining proportion of participants included households that did not use the tree resource and those who denied providing information for private reasons. The households which were collecting and utilizing the upas tree for both economic and cultural reasons.

A key informant (chairperson of one of the villages) noted that upas tree is greatly harvested by locals in this area as he narrated:

> . . . .upas tree is a key resource in this village and it is collected and utilized to produce timber later various types of furniture are made depending on the client's needs and preferences. It should be noted that the collection of upas trees is not authorized and locals stealthily go to harvest from the forest reserve unnoticed.

The collection and utilization of the upas tree are detailed in Fig. 2.

The two plates illustrate the collection and use of *Antiaris toxicaria* Lesch in the study area. The plate (a) shows a young tree of *Antiaris toxicaria* Lesch in Mabira CFR after cutting, while plate (b) displays timber of upas tree found in some households in Buwola village, close to the forest.

3.3 Ethnobotanical uses of A. toxicaria Lesch

Eight local uses of *Antiaris toxicaria* Lesch were identified, and the majority used the tree for medicinal purposes and timber (Fig. 2). Participants revealed more than fifteen diseases that were treated by A. toxicaria Lesch. Most reported diseases include headache (2.1%), mental illness (0.5%), weakness in pregnancy (0.7%), yellow fever (0.9%), skin diseases such as rash (2.8%), wounds (1.4%), cough (5.5%), ulcers (1.5%), Ekigalanga (1.3%), stomach complications such as parasitic worms (4%), diabetes (0.5%), blood pressure (0.9%), Enoga (0.5%), and poultry diseases (1%). The main tree parts used in disease treatment were stem (34.9%), bark (28.3%), and leaves (36.8%).

A key informant who identified himself as a traditional healer noted that upas tree is a great traditional medicine and as he narrated:

> . . . .upas tree is greatly used by locals and it is known to treat skin diseases, wounds, and many parasitic diseases and so the plant but he hinted that it must be used with the guidance of a knowledgeable person because it is toxic when used in high dosages.

The tree species were reported to contribute to households' livelihood improvement through income generation from commercialization (18.5%), medicinal use (25%), and bark cloth (Embugo , 4.2%). Other use of upas trees in the study area included; fencing materials, firewood, food from edible fruits, and making bark cloth and bee hives. The results showed that the use of A. toxicaria Lesch for medicinal purposes was reported among traditional healers (69.2%), farmers (25.3%), and non-farmers (5.5%).

A key informant (traditional chief) noted that the upas tree is used for cultural practices and as he narrated:

> . . . We make bark cloth from upas tree and this bark cloth is used as a burial shroud and ceremonial garment that chiefs put on during Buganda cultural ceremonies. Also, traditional dances make different outfits from bark cloth for entertainment purposes.

Association between age and local utilisation of A. toxicaria Lesch This section examines the association between the age of participants and the use of A. toxicaria Lesch. The association between age and utilization of the tree species was not significant (chi-square (x^2)) p=0.065). The percentage frequency of usage of upas tree was high among middle age groups, 31-43 years (85.7%) followed by 44-56 years (50%) in this study area (Fig. 3).

Association between the level of education and utilisation of A. toxicaria Lesch The utilisation of upas tree increased with a decrease in education level. Results indicated a higher utilization among participants with a low level of education (Fig. 4). There was no significant association between the level of education and the use of the tree (x^2, $p = 0.615$.)

3.4 Association between Residence duration and utilisation of A. toxicaria Lesch

The longer the residence in the study the more the person was knowledgeable about the utilisation of upas tree. Results on the association between the duration of residence of participants and the use of A. toxicaria Lesch were found significant (x^2), $p = 0.000$. The lowest utilization was among people who resided in the study area for a

(a) (a)

(b) (b)

Figure 2: A. toxicaria Lesch after cutting (a) and timber of a mature A. toxicaria Lesch (b)

short period of time (0-5 years) and highest in those who resided in the area for the longest time (18 years and above).

3.5 Association between household size and the utilisation of A. toxicaria Lesch

The utilisation of upas tree was evaluated with household size in the area and the average household size was 5 persons per household in this study area. The results indicate that the use of the tree resource increased with a decrease in household size. The majority (55.6%) of the households had one to four persons living together as a family. Chi-square (x^2) test results showed a p=0.371 meaning the association was not significant.

3.6 Association between occupation and the utilisation of A. toxicaria Lesch

The results indicated that the majority of the participants were farmers (mainly subsistence farmers) and a few were in formal employment. Association between the participants' occupations and the use of A. toxicaria Lesch was established with Chi-square (x^2) p=0.002, hence a significant association.

3.7 Association between household monthly income and the utilisation of A. toxicaria Lesch

The association between the family's monthly income and the utilization of the Upas tree was determined. A high utilization was observed in the low-income household category that earned an average of 150,000Ugx (the equivalent of 40dollars) every month (Fig. 5). The Chi-square test (x^2) results p=0.028 indicated a significant association between households' monthly income and utilization of upas tree.

4 Discussion

4.1 Collection and local utilisation of A. toxicaria Lesch

The utilisation of A. toxicaria Lesch was high and this could be because the plant has multiple uses to the community living around the forested reserve. The results of this study were related to the findings of Ministry of Water and Environment (2017), who found high utilization (66%) of the Prunus africana (Hook. F) Kalkman among communities living close to Nandi forests. Similarly, Andriamparany et al. (2014) discovered that Ficus lutea, Euphorbia tirucalli L., and Acacia bellula Drake had a high utilization rate of 82% in Madagascar by the communities. The high utilization of tree species climaxes into over-exploitation. Upas tree appears on the International Union for the Conservation of Nature (IUCN) Red List as Least Concern, its population size is declining in some areas due to over-exploitation and loss or degradation of habitats (Ugwoke et al., 2017). This denotes that the tree species could experience unsustainable harvesting pressure due to its multifunctional value. The collection/gathering of the forest resources is mainly enhanced by how vital they are for livelihoods of the communities living around them.

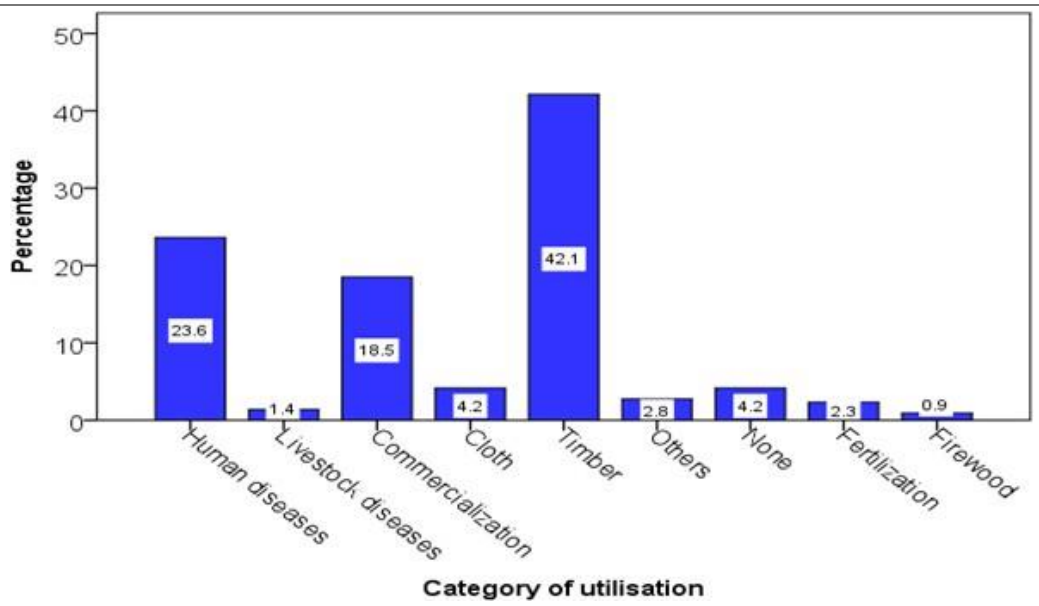

Figure 3: Ethnobotanical uses of A. toxicaria Lesch

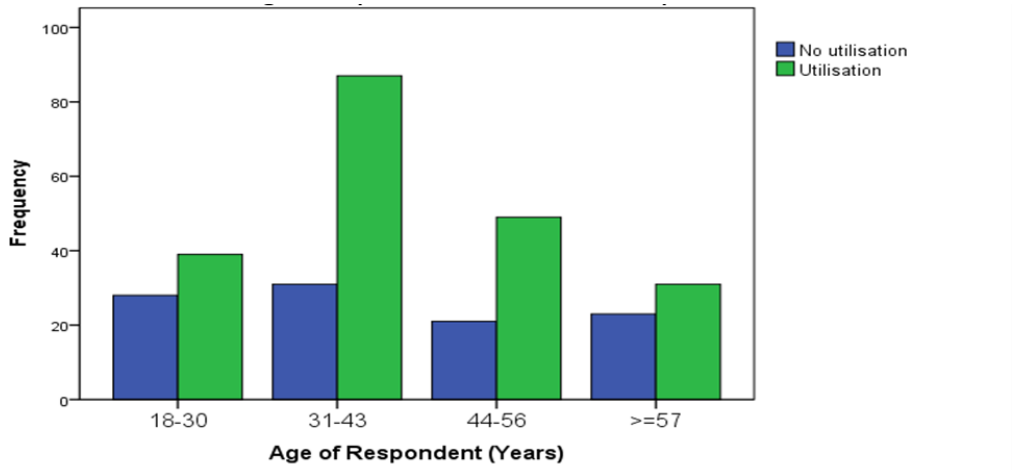

Figure 4: Association between the age of participants and utilisation of A. toxicaria Lesch

4.2 Ethnobotanical uses of A. toxicaria Lesch

People of different cultures/regions use upas trees for various purposes. It is found to be widely distributed around the world but is predominant in South and Southeast Asia countries like Indonesia, India, and the Philippines and widespread in tropical and subtropical regions like Central, West, and East Africa. In Uganda, it is found in forested regions, including the Mabira Central Forest Reserve. The various ethnobotanical uses of A. toxicaria Lesch include; traditional medicine for both human and livestock diseases, cultural significance, and timber. Several scholars point out the use of the upas tree for medicine values Andriamparany et al. (2014), Tumuhe et al. (2018), and Ugwoke et al. (2017) and this relates to the results of this study. Other uses of *Antiaris toxicaria* Lesch namely; food, making bee hives, and firewood by the local communities spell out its multiple uses by the communities. In southwestern Ethiopia, A. toxicaria is of great economic importance through the provision of quality timber and sustains the livelihoods of local communities in the vicinity (Seid et al., 2020).

The various ethnobotanical uses of upas trees could lead to accelerated population decline Mabira CFR. In a related study in Niger, it was found that woody tree species with high ethnobotanical use values were the most preferred by local communities (Abdourhamane et al., 2015). The high use-value of tree species could lead to its over-exploitation and hence extinction of species that have a poor regeneration rate like A. toxicaria (Mirgal et al., 2016). The bark of A. toxicaria Lesch was important in making bark cloth and in the central region of Uganda called Buganda, this is of great cultural significance. The bark cloth is used as a burial shroud and its fabric is worn by men and women at cultural gatherings. In a related study, it was found that bark products of A. toxicaria Lesch and Ficus natalensis were used for shoe making (foot-wear industry) as a substitute for leather Emmanuelle et al. (2024). Other products from the bark cloth include; royal and spiritual attire and several art crafts for domestic use. Similarly, in India, the bark cloth from A. toxicaria

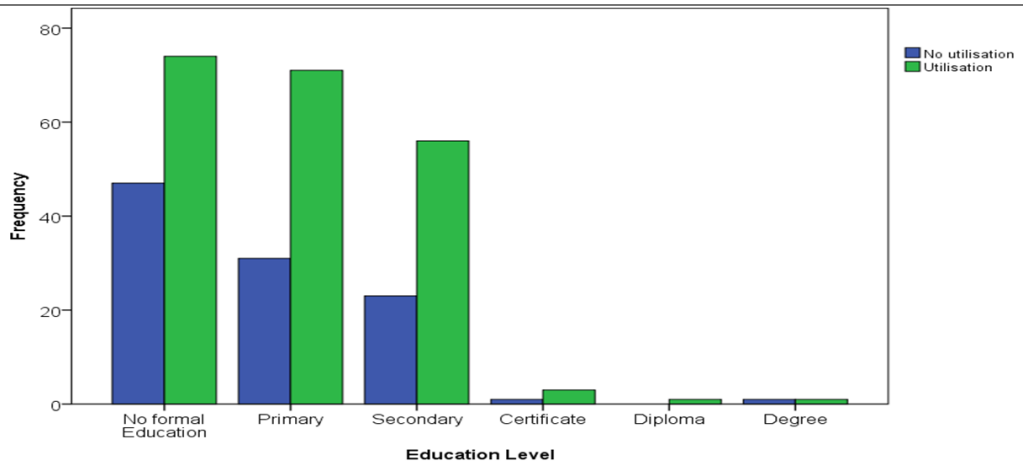

Figure 5: Association between level of education and utilisation of A. toxicaria Lesch

Lesch was found to make Maravuri amongst the Muthuvan tribe in Kerala (Umdale et al., 2020). The Maravuri was commonly used for clothing, bedspread, and ceremonial garments.

The multiple uses and wild collection of *Antiaris toxicaria* Lesch are closely associated with that of P. Africana and in both tree species, the bark is extracted except for different uses (Koros et al., 2016). Unskilled tree bark extraction can damage the plant leading to high mortality rates of the tree species. This calls for educating local harvesters in sustainable techniques and conservation of species.

4.3 Association between age and local utilisation of A. toxicaria Lesch

There was no statistically significant association between age and the use of upas trees. These findings are related to those of a study in Uganda by Bari et al. (2017) where the use of Afzelia africana Sm. had no significant difference in age. In another study in Benin, it was also found that the relationship between the use of African rosewood (a medicinal plant) and the participants' age was insignificant (Ouinsavi et al., 2021). This provides a new insight that age distribution does not influence the utilization of the forest tree resource. This could suggest that the use of *Antiaris toxicaria* Lesch does not differ meaningfully across age groups.

4.4 Association between the level of education and utilisation of A. toxicaria Lesch

Moreover, the results showed no significant association between the level of education and the utilisation of A. toxicaria Lesch. The results of this study relate to the findings of Bari et al. (2017), who found no significant association between education level and the utilisation of Afzelia africana Sm. However, there was high utilization of upas trees in respondents with low education and this relates to another study where utilisation of medicinal plants was higher in persons with low education levels (Corroto et al., 2022). The higher utilization of upas in respondents of low education could be linked to cultural transmission or accessibility or affordability that could relate to its use.

4.5 Association between Residence duration and utilisation of A. toxicaria Lesch

There was a statistically significant association between residence duration and the utilisation of *Antiaris toxicaria* Lesch. This means that residents who have lived in an area longer are more likely to utilize local resources. This may imply that long-term residency fosters deeper Indigenous ecological knowledge, highlighting the critical role of local experience and familiarity in sustaining ethnobotanical practices. The findings of this study are consistent with the findings of Wayland and Walker (2014), who stated that a longer stay in forested environments is positively associated with both greater knowledge and increased use of medicinal plants. This can be explained by the fact that people living in the same locality over time tend to rely on low-cost or free resources for basic needs, especially in rural or low-income settings, and adapt their lifestyles and knowledge systems to maximize the use of the ecological services available in their environment. Moreover, they are more familiar with plant availability, locations, and seasonal cycles.

4.6 Association between household size and utilisation of A. toxicaria Lesch

Household structure influences patterns of ethnobotanical resource use, and it should be taken into account when planning for sustainable forest management. The highest utilization of A. toxicaria Lesch is among the smallest household size class, indicating that smaller households may experience greater per capita dependence on natural resources, possibly due to limited shared labor capacity. In addition, results indicate that there is no statistically significant association between household size and the utilisation of the tree. The average household size of 5 persons from this study relates to

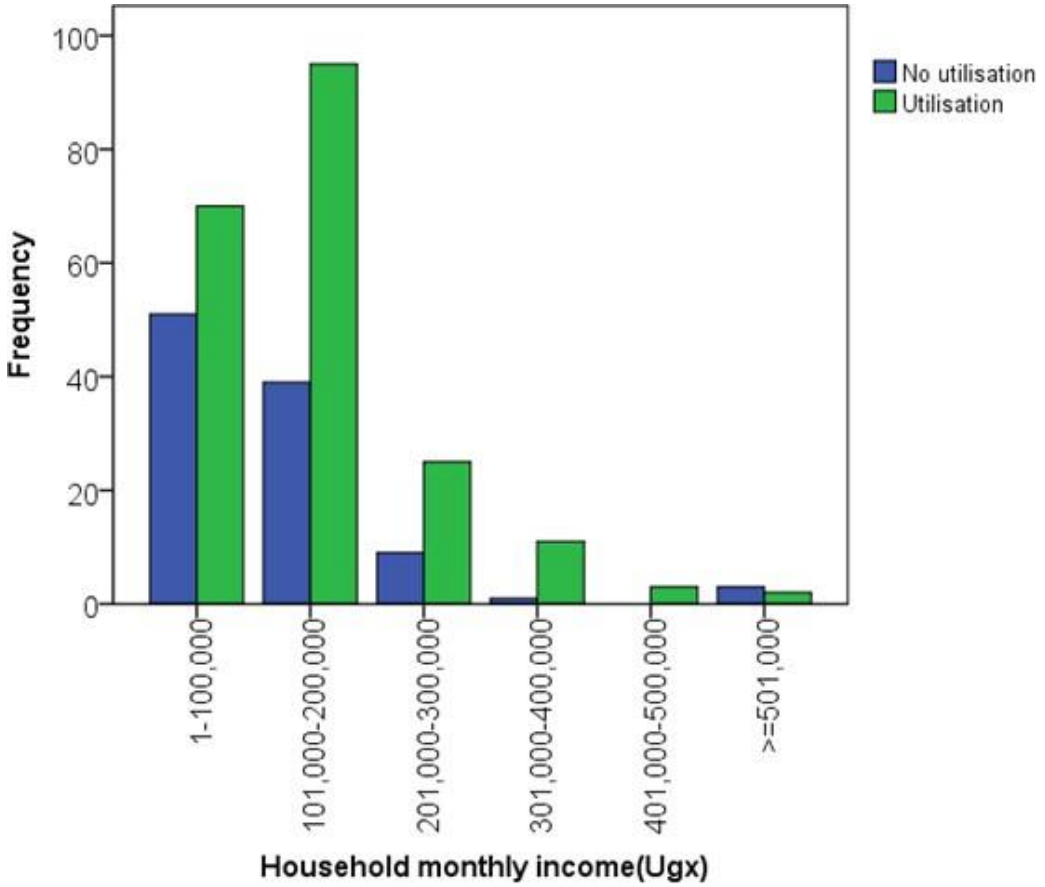

Figure 6: Association between monthly income and utilisation of A. toxicaria Lesch

the national average household size of 4.7 persons (Ministry of Water and Environment, 2017). There was no statistically significant association between household size and the utilisation of *Antiaris toxicaria* Lesch could mean that household size does not meaningfully influence how local communities utilise this tree. However, the findings of this study are not consistent with the results of Andriamparany et al. (2014) and Bari et al. (2017) in a related study where family size was significantly associated with the utilisation of medicinal plants. Similarly, a significant association was found between the utilisation of Pterocarpus erinaceus Poir and household size (Ouinsavi et al., 2021). This high dependency of households could be that the forest resources are easily accessible and available for livelihood improvement.

4.7 Association between the occupation and utilisation of A. toxicaria Lesch

Most of the participants who used upas trees were in the category of farmers and showed a significant association between the occupation of participants and the utilisation of the tree resource. This demonstrates that occupational roles influence how people interact with and rely on local plant resources. This suggests that occupation like subsistence farming strongly influences reliance on forest resources, indicating that farmers possess practical ecological knowledge and depend on multifunctional species like A. toxicaria Lesch for meeting both household and agricultural needs. The findings of Ouinsavi et al. (2021) on the socioeconomic use of Pterocarpus erinaceus Poir also indicate that farmers were the majority of the users. The same study indicates that the way people use a plant species depends not only on who they are but also on which plant species it is and the cultural or ecological context.

4.8 Association between household monthly income and utilisation of A. toxicaria Lesch

The high utilisation of A. toxicaria Lesch amongst low-income households in this study could imply more reliance on freely accessible plant species to meet essential needs, which highlights the tree's role as a socio-ecological safety net in the study area. A significant association was found between household monthly income and use of the tree species, suggesting that access, frequency, or a need to use forest resources within households are shaped by income levels, indicating that economic capability has a direct impact on dependency on natural resources. A report indicates that households living around Mabiria CFR earn income from forest resources and many resources in poor Uganda earn a livelihood from them (Ministry of Water and Environment, 2017). It implies that forest resources supply low-cost resources for household income generation hence increasing dependence. There is a need for targeted conservation strategies that take into consideration income disparities.

5 Conclusion

A. toxicaria Lesch is a multipurpose tree species mainly used for medicinal, timber, bark cloth, and ecological and cultural importance. The multiple uses of this tree render it a highly threatened species and hence needs targeted conservation strategies. High utilisation of Upas tree was mainly among farmers, low monthly income households, households who have stayed longer in the area, and low-educated groups. Alternative sources of livelihood need to be supported to offset the temptation for households to engage in the overwhelming extraction of upas tree species. National Forest Authority and local government should work hand in hand with local communities to protect Mabira CFR and promote the upas tree's domestication. Integrating local ecological knowledge into forest resource management and conservation policies is crucial for the tree's importance to low-income, long-settled, and farming communities. Promote conservation awareness among locals living in the vicinity and have inclusive policies for the sustainable use of upas trees.

Ethics approval and consent to participate

Permission to conduct this study was sought from relevant administrative authorities in the Buikwe district (study area). Consent to participate in the study was also sought from participants at the household level.

Consent for publication

The authors declare that this manuscript has not been published, or accepted for publication, or is under editorial review for publication elsewhere, and thus consent to publish this manuscript with the Food Security Journal.

Availability of supporting data

The datasets used in this study are available from the corresponding author on reasonable time requests.

Competing interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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