SOCIO-ECONOMIC UTILISATION AND MACROPROPAGATION OF UPAS TREE, *Antiaris toxicaria* Lesch: A CASE STUDY OF MABIRA CENTRAL FOREST RESERVE, UGANDA

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A DISSERTATION SUBMITTED TO THE DIRECTORATE OF RESEARCH AND GRADUATE TRAINING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF SCIENCE IN CONSERVATION AND NATURAL RESOURCES MANAGEMENT OF KYAMBOGO UNIVERSITY

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DECLARATION

I, **Emmanuel NTAWUBIZIGIRA**, declare that this dissertation is my original work and has never been presented for a degree in any other University

………………………………. ……………………………

Signature Date

DEDICATION

Firstly, this Thesis is dedicated to Almighty God who despite various challenges, protected and strengthened me up to the success of this work. Secondly, it is dedicated to my parents (Mrs Françine MUKASHYAKA and the late Sylvestre SABOKUNKIZA), my siblings, and my friends.

APPROVAL

This Dissertation entitled "**Socio-economic utilisation and macropropagation of Upas tree *(Antiaris toxicaria* Lesch)"** has been under the supervision and submitted to the Directorate of Research and Graduate Training, Kyambogo University, with the approval of the following supervisors:

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LIST OF ABBREVIATIONS/ACRONYMS

CFR: Central Forest Reserve

COVID-19: Coronavirus Disease 2019

CRD: Completely Randomized Design

CSRD: Cross-Sectional Research Design

DRC: Democratic Republic of Congo

EAC: East African Community

IAA: Indole Acetic Acid

IBA: Indole Butyric Acid

IUCEA: Inter-University Council for East Africa

IUCN: International Union for Conservation of the Nature

KFW: Kreditanstalt Für Wiederaufbau

GIS: Geographic Information System

Ha: Hectare

Lesch: Leschenault

MUARIK: Makerere University Agricultural Research Institute, Kabanyolo

MWE: Ministry of Water and Environment

NAA: Naphthalene Acetic Acid

NFA: National Forestry Authority

NTFPs: Non-Timber Forest Products

PGR: Plant Growth Hormone

RH: Rooting Hormone

RS: Remote Sensing

SPSS: Statistical Package for Social Sciences

USA: United States of America

ABSTRACT

Upas tree (*Antiaris toxicaria* Lesch) is a monoecious and medicinal tree species belonging to the Moraceae family. In various countries, the tree is known for its medicine, plywood, and veneer. In some countries, over-exploitation, degradation of habitats, and environmental challenges have been decreasing its population size. Various socio-economic and disturbance factors are negatively affecting the seedling regeneration of Upas tree in Mabira Central Forest Reserve. The present research contributes to its sustainable utilization, increase in propagation, conservation, and livelihood improvement. The main objective of this research study was to assess the socio-economic utilization of Upas tree and establish macropropagation as an alternative strategy for its regeneration and conservation. The present study employed a Cross-Sectional Research Design and a factorial experiment by using a Completely Randomized Design with 2 factors, notably cutting media and plant growth hormone treatment. A semi-structured questionnaire, supplemented by the researcher's participant observations was used during data collection. Purposive selection of 2 divisions of Buikwe district, 10 villages from the Divisions, and a random selection of 410 households were done. A total of 160 cuttings of Upas tree were collected from Mabira Central Forest Reserve and planted into 4 different cutting media, each with 40 cuttings with a half treated with a rooting hormone. The experiment was done with 2 treatments. IBM SPSS software was employed, while χ^2 and descriptive statistics were used for data analysis. Residence duration (*p-value*: 0.000), Occupation (*p-value*: 0.002), and household monthly income (*p-value*: 0.028) were significantly associated with the utilization of the multipurpose tree (all *p-values*<5%). Illegal tree cutting (28.8% at SD: 3.328) was the highest affecting and the most worrying disturbance factor of the tree's regeneration. The best cutting medium was the forest top soil, while rooting hormone had no effect on the rooting system of the cuttings. The overall survival, sprouting, and rooting of cuttings of the macropropagation experiment was 15 %, 3.75 %, and 0 % respectively. There is a possibility of macro propagation of the tree if the experiment is improved, primarily by increasing stimulation of root formation. The cutting media: only forest topsoil and a combination of forest topsoil, sand, charcoal dust, and saw dust should be preferred for the subsequent experiments. Further socio-economic and propagation studies are needed for other important medicinal trees of the forest. It is recommended that cuttings should be treated with different rooting hormones at various concentrations and planted directly. There is a need to study other propagation techniques on the tree. National Forest Authority should put more effort into the management of the Mabira forest reserve through its protection, promotion of the tree's domestication, and restoration of the forest, mainly focusing on the conservation of important tree species like the *A.toxicaria* Lesch.

Keywords: Socio-economic, *Antiaris toxicaria* Lesch, Utilisation, Disturbance factor, Mabira Central Forest Reserve, Conservation, and Macropropagation.

CHAPTER ONE

INTRODUCTION

1.1. Background

Upas tree (*Antiaris toxicaria* Lesch) is a monoecious and medicinal tree species belonging to the Moraceae family. It flowers from October to June according to the ecological range of different countries. It can grow to 25-40 m and/or more in height with a large trunk within 20 years. It is with an excellent self-pruning ability. The tree fruits are hairy and either orange or dark red, while its sap contains poisonous chemicals. It has broad, recalcitrant seeds of approximately 10 mm in length. Desiccation affects the germinability of the tree seeds (Bai *et al.*, 2011). *A.toxicaria* Lesch is a tree with oblong, oval, obtuse, or acute cordate leaves which are hairy with teeth-like extensions on both sides when young. Its leaves have a simple peduncle and the tree has one-seeded and drupe fruits (Porchselvi & Muthulakshmi, 2018).

Upas tree (*Antiaris toxicaria* Lesch) is a fast-growing tall tree. Its fruits are mainly dispersed by birds, bats, monkeys, and antelopes. During its season, *Antiaris toxicaria* Lesch produces large amounts of seeds that are easily collected from the ground. However, they lose their viability fast (Orwa *et al.*, 2009).

Upas tree (*Antiaris toxicaria* Lesch) is generally distributed in various habitats, from wet evergreen forest to dry wooded grassland. Though the International Union for the Conservation of Nature (IUCN) Red List assesses it 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).

A.toxicaria Lesch is an endemic tree species in some areas of the World such as Kalimantan (Indonesia) and some tropical countries on the Asian continent. The tree is used in traditional medicine, and its latex's phytochemical analysis confirmed the presence of some active chemicals, such as some types of Antiarin (cardenolide), and many more active chemical compounds. Cardenolide (toxicarioside) was found within the latex of the bark, seed, and stem of the tree and the chemical can be used to treat or prevent cancer. Toxicarioside is a toxic chemical that is found in the sap of the tree. In ancient times, the sap was sprayed on an arrowhead/tip due to its poisonous activity (Subiono *et al.*, 2017).

Medicinally, Upas tree leaves, seeds, and bark are used as an astringent (contraction of skin cells i.e. wound contraction), and febrifuge (reduces fever), while seeds alone are used as anti-dysenteric. The bark is used as an anodyne (pain-killing drug), and vermifuge (destroys parasitic worms), to treat hepatitis and mental illnesses (Ugwoke *et al.*, 2017). In some countries, the tree is used to treat cancer due to its active chemicals. In some parts of India such as Kerala, the bark of the tree is used to make a type of bark cloth called Maravuri (Umdale *et al.*, 2020). Scientific studies revealed that the Upas tree (*A. toxicaria* Lesch) can be used to treat Tuberculosis in East Africa (Obakiro *et al.*, 2020). In Uganda, it is only known to treat headache and weakness during pregnancy (Tumuhe *et al.*, 2018).

In various countries, the tree is known for its medicine, plywood, and veneer. However, despite the importance, wide distribution, and dominance of the Upas tree in some countries, over-exploitation together with environmental challenges have been decreasing its population size, whereby only a single individual tree was recorded in some parts of the World. For example, in some parts of India, the extinction of the tree species was recorded (Umdale *et al.*, 2020).

Qualitative phytochemical studies presented the existence of some secondary metabolites including alkaloids, phenols, glycosides, anthraquinone, protein, amino acids, flavonoids, phytosterols, and saponins which were reported to cure different ailments. For example, Methanol extract showed good antibacterial activity against pathogens such as *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas* sp., while Aqueous extract showed good antifungal activity against *Cuvularia lunata* and *Aspergillus flavus* (Kemila & Krishnaveni, 2016; Umdale *et al.*, 2020). According to Porchselvi & Muthulakshmi (2018), the sap of this tree contains numerous chemicals with various properties such as antibacterial, antioxidant, anti-inflammatory, and antifungal properties. Some other chemicals found in Upas tree include countless phenolic compounds, saponins, glycosides, fatty acids, volatile oil, triterpenes, tannin, minerals, starch, protein, and glucose (Mirgal *et al.*, 2016).

However, there exist various factors affecting the seedling regeneration of various trees. Such factors include soil factors, lack of dispersal animals or pollinators, species morphology and both chemical and biological composition, light and shade as well as animal or anthropogenic disturbances (Gliniars, 2011), whereby the later are mostly attributed to the reason why Upas tree has a very low seedling regeneration capacity in Mabira CFR (Tumuhe *et al.*, 2018).

According to the study conducted in Ethiopia, some woody plant species were found to be poorly regenerated, while others were highly regenerated. The poor regeneration status was due to different reasons such as adverse environmental circumstances (i.e. stony land, poor soil quality) and human disruption (Zegeye *et al.*, 2011).

Forest tree regeneration can be affected by various factors, including climatic changes, environmental conditions, and human activities. For instance, occurrences like drought, as emphasized by Wendime Gemechu & Bekele Jiru (2021), and environmental factors such as soil properties (e.g. organic carbon, nitrogen levels, potassium content), moisture, and pH levels, as discussed by Lanker *et al.*(2010), can influence the natural regeneration process of woody species, especially native trees. While tree regeneration is influenced by multiple factors, human activities, particularly those related to trees used for charcoal and timber production due to their economic importance, are often identified as the primary threat (Ibrahim & Hassan, 2015).

In Africa, trees within protected areas serve as essential sources of goods and services for neighbouring communities. However, these communities impose considerable pressure through activities such as illegal logging, extensive grazing by livestock, agricultural land expansion, and harvesting tree stems and branches for timber and firewood. These activities negatively affect the natural regeneration of a wide range of forest tree species in various ways (Mohammed *et al.*, 2021). Human activities have been putting important medicinal plants at risk of extinction through different ways such as road construction, grazing, human settlement, ploughing land. Therefore, a combination of disturbance factors affects the vegetative reproduction of plants, especially medicinal woody plants (Chokheli *et al.*, 2020).

In sub-Saharan Africa, the use of medicinal plants is associated with socio-economic factors such as educational status, age, marital status, and wealth status among others. In the study conducted in Katikekile Sub-county (Moroto district, Uganda), the socio-economic utilisation of medicinal plants was found to be higher among older people, married people and people living far from modern health facilities. The study revealed that high socio-economic utilisation of medicinal plants hurts their health (Logiel *et al.*, 2021).

In Uganda, a socio-economic study unveiled that a significant proportion of households (87%, 48%, 25%, and 22%) located near the Mabira CFRs within the Management Plan Area acquire firewood, water, herbal medicine, and charcoal, either for personal use or for commercial purposes. Additionally, the total economic value of the CFRs within the Mabira Management Plan Area was assessed to be UGX 18,606,348,073,334, equivalent to USD 4,744,132,615 (Ministry of water and environment, 2017). Furthermore, with the rapid expansion of the construction sector and the proliferation of carpentry workshops in recent decades, the demand for sawn timber consistently increased each year. Consequently, Mabira CFR is facing increasing demand and pressure, particularly as forests on privately owned land are being depleted (Ministry of Water and Environment, 2017).

Like other Ugandan forest reserves, Mabira CFR is home to medicinal trees for the surrounding populations. Local communities mostly harvest these plants for their domestic utilisation. The survival and significance of the Mabira forest ecosystem are facing escalating threats due to unsustainable human activities. These activities include unsustainable logging practices, encroachment for agricultural purposes, population growth, land appropriation, political interference, and habitat degradation from pollution and conversion, among other factors. Unsustainable harvesting of medicinal trees was found to be a threat to their regeneration (Ministry of Water and Environment, 2017).

To address the issue of regeneration, numerous conservation methods have been developed specifically to preserve various plant species through their propagation. Such plants include rare, endangered, threatened or of economic importance, such as medicinal plants. Macro propagation is a vegetative propagation method used to multiply different plant species for various purposes, including the commercialisation of important species and restoration of native species (Fehling-Fraser & Ceccon, 2015). Vegetative propagation through shoot cuttings is advantageous because, it is cheap, fast and easy compared to other propagation techniques (Susilowati *et al.*, 2018). Vegetative propagation via shoot cuttings can assist in addressing the issue of regeneration in various tree species, whereby the new plants are genetically identical to their parent plants. The application of this technique is crucial for the production of a large number of new plants (Susilowati *et al.*, 2020). Vegetative propagation by shoot cuttings was found to be a successful and effective technique to propagate numerous medicinal tree species. Such species include *Erythrina americana* Miller(Fehling-Fraser & Ceccon, 2015), *Commiphora wightii* (Arn.) (Tripathi *et al.*, 2016), and *Dennettia tripetala* Baker f.(Onefeli & Akinyele, 2014), *Cotylelobium melanoxylon* (Hook.f.) Pierre (Susilowati *et al.*, 2020), and many others, with issues such as deforestation, over-exploitation, etc. Therefore, this study evaluated the socio-economic utilisation of the Upas tree (*Antiaris toxicaria* Lesch) and its macropropagation as an alternative strategy for its regeneration and conservation in Mabira Central Forest Reserve.

1.2. Problem Statement

The Upas tree (*Antiaris toxicaria* Lesch) in Mabira CFR has been found to have a poor capacity for regenerating seedlings, with very few or no seedlings being produced (Tumuhe *et al.*, 2018). This is due to poor seed germination under natural habitat conditions and other disturbances. Because of its high value, the Upas tree is under pressure from high utilisation by the local population living near Mabira CFR. There is limited information on the socio-economic utilisation of this tree species. Causal factors associated with this poor seedling regenerative status remain unclear. In addition to its high utilisation, the tree species has seeds with a fast loss of viability, while seeds are the main tree parts for its propagation. There is limited information on a vegetative propagation of Upas tree, an important medicinal tree found in Mabira CFR.

1.3. Objectives

1.3.1. General objective

The main objective of this research study is to assess the socio-economic utilisation of the Upas tree (*Antiaris toxicaria* Lesch) and establish macropropagation as an alternative strategy for its regeneration and conservation.

1.3.2. Specific objectives

1. To determine socio-economic factors associated with the utilisation of the Upas tree in Wakisi and Najjembe sub-counties.

2. To identify disturbance factors affecting the seedling regenerative capacity of the Upas tree in Mabira CFR of Wakisi and Najjembe sub-counties.

3. To assess the feasibility of vegetative propagation of Upas tree by shoot cuttings.

1.3.3. Research questions

1. What socio-economic factors are associated with the utilisation of the Upas tree in Wakisi and Najjembe sub-counties in Mabira CFR?

2. What are the disturbance factors affecting seedling regeneration of Upas tree in Mabira CFR of Wakisi and Najjembe sub-counties?

3. Can vegetative propagation of Upas tree by shoot cuttings be feasible?

1.4. Significance of the Study

Worldwide, Upas tree (*Antiaris toxicaria* Lesch) is an important medicinal woody plant with various uses such as medicine, plywood, and veneer according to Umdale *et al.*(2020). In Uganda, parts of the species such as leaves, were found useful in addressing various ailments such as headaches and weakness in pregnancy. Being an important plant species, Upas tree was found to have poor seedling regenerative capacity due to unclear reasons, though its poor regeneration was attributed to its high socio-economic utilisation (Tumuhe *et al.*, 2018).

Therefore, the present study contributes to a sustainable socio-economic utilisation of Upas tree (*Antiaris toxicaria* Lesch), particularly within the communities around Mabira CFR, through minimizing the plant species disturbance factors and supporting its management. Scientifically, the study establishes macropropagation as an alternative method to supplement seedling regeneration under natural conditions such as forest habitat. The outcome from the vegetative propagation feasibility of Upas tree provides information which contributes to an increase in its propagation, hence a sustainable utilisation, livelihood improvement and conservation of the tree species after a new comprehensive evaluation of the species conservation status.

1.5. Scope of the Study

The research study focused on the conservation of Upas tree: its socio-economic utilisation, disturbance factors (threats) and propagation through macropropagation by shoot cuttings. A survey on the socio-economic factors associated with the utilization of the tree species focused on people living adjacent to Mabira CFR.

1.6. Limitation of the Study

The researcher encountered some shortcomings and these are summarized in Table 1.1 as limitations to the study and mitigation measures employed.

Table 1.1. Limitations of the study

№	Limitation/challenge	How to cope with Limitation/challenge
1	Local language (Luganda)	Local data collectors were hired.
2	Difficulty in obtaining the research permit in the selected area as a non-Ugandan resident.	Submission of introductory (from Kyambogo University) and inquiry authorization letter to the research area authorities (from NFA) was made. In addition a consent was sought between the researcher and participants.
3	There could be some biases when researching the socio-economic utilisation of medicinal plants, especially when the communities and workers are involved. Some users may be timid or hesitant to express whether they utilize medicinal plants as traditional medicine (Logiel *et al.*, 2021).	Local and famous data collection assistants (who were not healthcare workers) were hired.
4	Difficulty in finding the research topic as an international student without enough knowledge about the new country.	Reading numerous research papers to find the research topic.
5	Challenge in getting results from the research experiments.	Repeating the experiment.

CHAPTER TWO

LITERATURE REVIEW

2.0. Introduction

This section presents existing theories related to the stated problem, outlines the research that has been done, and identifies any gaps in the existing theories. It provides support for and criticism of literature related to the research problem and includes information about the Upas tree (*Antiaris toxicaria* Lesch)

2.0.1. Description and taxonomy of *Antiaris toxicaria* Lesch

Kingdom: Plantae

Order: Rosales

Family: Moraceae

Species: *A. toxicaria*

Genus: Antiaris Lesch

Binomial name:

Antiaris toxicaria Lesch

Photo 2.1. Upas tree **(***Antiaris toxicaria* Lesch)

Upas tree *(Antiaris toxicaria* Lesch), as one of its common names, is a medicinal woody tree species belonging to the Moraceae family. In many countries such as Indonesia, the Democratic Republic of Congo (DRC) and Thailand the tree has local names such as Bemoe, Mkunde, and Yang yong respectively. It also has other English or common names like false mvule, false iroko, Antiaris among others. In Uganda, Upas tree is known as Kilundu (Luganda) as its local name (Tumuhe *et al.*, 2018), though it has various local names according to different Ugandan tribes or regions.

The tree species is highly and potentially dispersed around water bodies (e.g. Lake Victoria). Rainfall was found to be the most indispensable climatic factor influencing the distribution of the plant species. Moreover, the tree is suitable for various types of soils such as acrylic ferrosols and humus soils (Mbatudde, 2014).

Its seeds require no pre-treatment before being sown. However, they lose their viability fast and it is recommended that they be sown as soon as they are collected. For their germination, about 70-90% of planted seeds germinate within 18-89 days. Their germination type is hypogeal, and their sapwood is susceptible to Lyctus (Orwa *et al.*, 2009).

2.0.2. Chemical composition of Upas tree (*Antiaris toxicaria* Lesch)

The Upas tree (*Antiaris toxicaria* Lesch) has multiple uses. The tree's sap contains various chemical compounds with medicinal properties, making it useful in treating various diseases. Some of these chemicals include antiarin and antiosidin glycosides, which are poisonous and affect heart function. The leaves, bark, and seeds of the tree are used as febrifuge and to treat dysentery, indicating their medicinal importance. The tree's latex was historically used as arrow poison during ancient times (Mirgal *et al.*, 2016).

2.0.3. Importance of Upas tree

Upas tree (*Antiaris toxicaria* Lesch) is one of the important medicinal plants of Mabira CFR. The tree is used as a construction material. It is also used as a source of food (its fruits are edible), timber, and fuel wood among other things. The study conducted in Mabira CFR showed that the species' leaf is mainly used for medicinal purposes, whereby crushing in water and bathing was found to be the technique used to prepare and administer the medicine (Tumuhe *et al.,* 2018).

2.0.4. The state of Mabira CFRs Management

The Mabira Forest Management Plan Area includes six forests: Mabira, Namukupa, Nandagi, Kalagala Falls, Namawanyi, and Namananga CFRs. Namawanyi, Namananga, and Kalagala Falls are situated in Kayunga District, while Namukupa, Nandagi, and a portion of Mabira are in

Mukono District. The primary part of Mabira CFR is located in Buikwe district. This forest management plan covers an area north of Kampala along the Jinja road, from 45 km (Nandagi CFR) on the far west to 58 km on the east, approximately 28 km from Jinja. The plan encompasses the entire management area of these six forests, totalling 31,293 hectares. According to the National Forestry and Tree Planting Act of 2003, the NFA holds responsibility for managing and overseeing the Mabira CFRs. Acknowledging that these forest reserves and protected areas are meant for the benefit of Ugandan citizens, the Forest Department (FD) recognised the necessity for a more inclusive approach involving local communities. Consequently, Collaborative Forest Management (CFM) was introduced as a fresh strategy to ensure the conservation of forest reserves under its purview. Following the guidelines and plans outlined in the National Forestry and Tree Planting Act of 2003, CFM initiatives, along with constitutions for Community-Based Organizations (CBOs), were established. CFM was actively promoted as a management approach in specific sub-counties (Divisions), such as Najjembe and Wakisi. (Ministry of Water and Environment, 2017).

2.1. Theoretical and Empirical Review

2.1.1. Socio-economic factors and utilisation of medicinal plants from forests

Worldwide, medicinal plants are very important in disease prevention and treatment. This happens not only in industrialised countries and their urban areas, but also in countries that are still developing, particularly in their remote areas. Nowadays, there is an increase in worldwide interest in natural products such as medicinal plants, due to the perception of synthetic drugs' side effects (Ofori *et al.*, 2012).

In developed countries of Europe and America, more than 75% of medicinal plants collected from the wild are used to make modern drugs. However, in developing countries such as African countries, the situation is quite different because of the total dependence on medicinal plants from the wild. More than 80% of the population use medicinal plants for various purposes such as primary health care, alternatives to modern medicine which is also dependent on medicinal plants (Chen *et al.*, 2016), (Tugume *et al.*, 2016).

The investigation into medicinal tree species within the Asukese and Amama Forest Reserves in South-western Ghana revealed additional utilisations beyond their medicinal properties among Fringe communities. These supplementary uses identified in the surveyed communities include food, artisanal work, animal fodder, fuel wood, construction materials, and various others like chewing sticks, fencing, sponges, rituals, and adornment. Among these, fuel wood was found to be the most commonly employed alternative use of medicinal trees, followed by artisanal work, while fodder was the least utilized (Asigbaase *et al.*, 2024). Galabuzi *et al.* (2021), found that *Prunus africana* was utilised for medicinal purposes, timber, firewood, windbreaks, boundary demarcation, and providing shade. Research conducted in Kenya showed that the majority of households residing near Nandi forests relied on *Prunus africana* (Hook.F.) Kalkman for various purposes, including timber, charcoal production, wood, and beams/posts, attributing its popularity to its straight trunk and durability. Additionally, it served as firewood, fencing material, and fulfilled other needs such as medicinal use for both humans and livestock (Mwendwa, 2016). A research carried out in Benin regarding the traditional applications of African rosewood (*Pderocarpus erinaceus* Poir) identified the tree species as a versatile medicinal resource, deemed the most significant in traditional medicinal practices in Benin. Other recognised uses encompassed fodder, timber, craftsmanship, both human and animal nutrition, along with symbolic purposes (Ouinsavi *et al.*, 2021).

In Uganda as a member of the East African Community (EAC), some studies revealed that 90% of the population in rural areas depend on medicinal plants through traditional medicine (Tumuhe *et al.*, 2018). A survey conducted in Katikekile Sub-county showed several socio-economic elements such as old age, advanced educational status, monthly earning and marital status to be associated with a higher utilisation of traditional medicine. The findings of the study showed that the prevalence of traditional medicine use was higher amongst the older people of Katikekile Sub-county with 68 % of the utilization. In addition, the use of traditional medicine as primary treatment was found to treat most of communities' illnesses (Logiel *et al.*, 2021).

According to Abdourhamane *et al*'s study (2015), the local households living adjacent to protected forests depend on forest resources in different ways such as woody energy and medicinal utilisation. This study found that, the most plant parts utilised were leaves and roots. Woody energy was the most dominantly used category, followed by human medicinal use.

The research conducted in Tanzania on the socio-economic factors inducing people to gather and use NTFPs (including medicinal plants) for various purposes such as primary health care, household consumption, and profit-making have been found to be income status, age range, education status, size of household, habitation duration, distance range and occupational status (Mhuji *et al.*, 2018). The results from Tanzania are closely similar to those found in Uganda, where a lot of socio-economic factors including age, educational level, monthly income status, and marital status were linked to a higher utilisation of medicinal plants (Logiel *et al.*, 2021).

According to Romanus *et al.*(2018), there are some factors that impact the utilisation of medicinal plants such as social status, education, personal habits, lifestyle, and variations in the extent of development. However, this study has some similarities and differences with the studies of Logiel *et al.*(2021).

Mhuji *et al.* (2018) showed that among different types of occupation, farmers were the main gatherers and users of medicine from forest plants. Logiel *et al.* (2021) noted an association between the higher utilisation of medicinal plants and higher level of education. The older age was also associated with medicinal plant use according to the same study.

Medicinal plants are not only important in family disease self-treatment, but they also contribute to household income generation. The study conducted in Tanzania observed an increase in household income to be associated with a significant decrease in wild medicinal plant collection (Mhuji *et al.*, 2018).

The study of Andriamparany *et al.*(2014) shows that 28% of medicinal plants used in Mahafaly region of south-western Madagascar were trees whereby the utilisation of medicinal plants was not significantly associated with the age of respondents. Household size was significantly associated with the utilization of medicinal plants, hence affecting the later. In addition, household's wealth (income status) was found to affect the utilisation of forest resources, including medicinal plant products. The overall utilisation of medicinal plants was found to be 82%.

Bari *et al.* (2017) found that family size and education level were significantly related to the utilization and contribution of medicinal plants, hence influencing the respondents' socio-economic conditions. Age was found with insignificant relationship, hence no influence. The findings of Bari *et al.* (2017) support those of Andriamparany *et al.* (2014).

In the investigation conducted in Benin concerning *Pterocarpus erinaceus* Poir. Fabaceae, it was discovered that there was no significant association between the utilisation of the tree species and the age of participants. However, a significant association was observed between its usage and the level of education. Furthermore, a notable correlation was detected between its use and household size and occupation, while the correlation regarding household monthly income was deemed insignificant (Ouinsavi *et al.*, 2021). In a study carried out in Yumbe district (Uganda) regarding the socio-economic factors impacting the utilisation and traditional knowledge of the multipurpose medicinal tree species *Afzelia africana* Sm., a significant association was identified between its usage and both age and educational level (Biara *et al.*, 2020).

The study conducted by Tumuhe *et al.*(2018) shows limited data on the socio-economic utilisation of the medicinal trees; the data which is helpful to analyse different factors that threaten these plants. This illustrates gaps in research studies done on this important forest of Uganda, especially on medicinal tree species. Therefore, there is a need to conduct research on socio-economic utilisation of medicinal tree species, especially Upas tree (*Antiaris toxicaria* Lesch) of Mabira CFR. The present study contributes to providing socio-economic data on the use of Upas tree in the study area, the information which is necessary for the conservation and management of the tree species.

2.1.2. Disturbance factors and regeneration of medicinal plants

The World population depends on medicinal plants for treatment and prevention of different diseases; income generation and livelihood improvement. Studies show that an increasing dependence on medicinal plants in Africa, marked by an increase in collection, threatens many species in various ways such as preventing them from regenerating. This leads to their future extinction (Sofowora *et al.*, 2013). This is supported by the study conducted in Ghana which showed that a high reliance on wild collections of medicinal plants resulted in their increasing depletion due to factors such as uncontrolled exploitation, utilization without replacement and forest degradation which affect their seedling regeneration, hence threatening the future existence of these plants (Ofori *et al.*, 2012).

Worldwide, different medicinal plants are under threat and worrying rate due to unsustainable gathering practices and overharvesting in order to produce medical products. Also, extensive demolition of the plants' habitats caused by forest degradation, agricultural practices, urbanization among other factors, have been affecting the survival rate of important medicinal plants (Yadav *et al.*, 2012).

Medicinal plants collected from forests are classified among Non-Timber Forest Products (NTFPs) which have a significant role in livelihoods of millions of people living around forests across the World, contributing to income generation, poverty reduction, and generally improving livelihoods of communities living adjacent to the forests (Mhuji *et al.*, 2018).

Mabira CFR has both small size and big medicinal woody plants. The bigger the trees, the lower their seedling regenerative capacity. The study conducted on this forest showed that Upas tree (*Antiaris toxicaria* Lesch) had a very poor seedling regenerative capability (Tumuhe *et al.*, 2018). This research conducted in Mabira CFR is supported by that of Ofori *et al.*(2012) and Sofowora *et al.*(2013).

With overharvesting of forest products, a lot of potential medicinal plants are threatened within the tropical forests. Their diversity is affected due to natural and anthropogenic disturbances, with the later having greater negative impact through harvesting, browsing and fire, hence reducing the structure and composition of fauna and flora of the forests. The above disturbance factors are contributing to the loss of potential biodiversity of important medicinal plant species (Singh *et al.*, 2022).

Forests and their trees play a great role in human kind's livelihoods through the provision of medicine, forage, and food among others. However, their unsustainable harvesting together with other disturbance factors are challenging their sustainability. Livestock browsing and illegal cutting of trees affect their seedling regeneration (Mohammed *et al.*, 2021). Mohammed *et al.*(2021) support the findings of Ibrahim & Hassan (2015) which stated that different human activities such as logging and overgrazing by livestock are threats to forest trees species, especially to their seedling regeneration.

However, the study conducted by Tumuhe *et al.*(2018) in Mabira CFR showed the presence of lowest densities in the biggest trees class and this was attributed to disturbances by the neighbouring communities (anthropogenic disturbance factors) for medicine and timber. The research of Tumuhe is supplemented by that of Adonia, (2018), Ugwoke *et al.*(2017), and Singh *et al.*(2022). Though many trees including Upas, showed a very poor seedling regenerative capacity due the absence or relatively very small number of their young or seedlings, the study failed to identify the exact disturbance factors (threats) affecting the seedling regenerative capacity of the tree species (Tumuhe *et al.*, 2018).Therefore, this research study is a contribution to providing data on disturbance factors of Upas tree. A proper use of the provided information will help the management and conservation of the tree species.

2.1.3. Macropropagation of medicinal trees

In many countries including Uganda, plants embrace a significant contribution in national economy. With their increasing demand, they need more support for their conservation. A high attention to the management of medicinal plants can enhance the achievement of sustainable economic development (Hamilton *et al.*, 2016).

People have been using medicinal trees to solve numerous health and wealth problems. The over-utilisation of such plants brought unintended negative effects due to unsustainable harvesting and environmental degradation, which affect the survival of the plants, especially important medicinal trees which are progressively declining from their natural habitats (Tiwari *et al.*, 2016).

There are also numerous limitations within some propagation techniques which are challenges to the multiplication and conservation of some plant species, which shows a need of appropriate propagation methods/techniques in order to multiply such species for the purpose of their conservation. Macropropagation through shoot cuttings was used as a tool to maximise vegetative propagation of various tree species (Tiwari *et al.*, 2016).

In some medicinal tree species, vegetative propagation techniques through shoot cuttings showed a high survival and rooting capability, while it is not the case in other species. For example, in the macropropagation of *Cotylelobium melanoxylon* (Hook.f.) Pierre, the survival proportion was found to be from 70% to 90%, while rooting capability was from 50% to 90% (Susilowati *et al.*, 2020). However, Susilowati *et al.*(2018) found different proportions in *Dryobalanops aromatica* C.F.Gaertn., whereby its cuttings survival percentage was between 50% and 80% with a low rooting capability of 30% to 60%.

Other high cutting survival, sprouting, and rooting rates were observed in *Dennettia tripetala* Baker f. when cuttings were treated with different rooting hormone concentrations of IBA. The highest survival, sprouting, and rooting percentages were found to be 84.85%, 89.44%, and 95.5% respectively (Onefeli & Akinyele, 2014).

A high survival rate was not only observed in *Dennettia tripetala* and *Cotylelobium melanoxylon* (Hook.f.) Pierre, but also in *Erythrina americana* Miller. In the vegetative propagation of *E. americana* Miller, shoot cuttings showed a very high rooting percentage of 95% with no effect of exogenous rooting hormone (Fehling-fraser & Ceccon, 2015).

However, root formation of cuttings has different influencers such as environmental, genetic and physiological factors that affect root formation. Susilowati *et al.* (2018) suggested the use of a combination of different factors such as various rooting media and Plant growth regulators (PGRs) or rooting hormones, in order to support root formation in cuttings and produce new plants with superior root structure. While some tree species show a great rooting capability through shoot cuttings, such a capability is low or difficult in other species. Rooting hormones play an essential role in stimulating root formation in some plant species, especially through propagation via shoot cuttings. Auxins are rooting hormones which contribute to such stimulation, especially for plant species which are difficult to root or which have low rooting ability in their cuttings (Susilowati *et al.*, 2020).

A low proportion of *Strychnos henningsii* (gilg) cuttings rooting was also observed with the highest rooting mean of 66.27% in forest top soil compared to a combination of forest and sand with

27.31%. All of their cuttings were treated with Seradix 2 powder (rooting hormone, an Auxin). The effect of Seradix 2 powder treatment was significant (Kipkemoi *et al.*, 2013). In addition, the sprouting and survival rates were good in both forest and sandy soil.

The study conducted by Tumuhe *et al.*(2018) in Mabira CFR on the status of most abundant medicinal woody plants, showed a very poor to no seedling regenerative capacity of Upas tree. The same study suggested conservation efforts to protect this important plant species from disturbance factors, but the study needed to suggest the way this could be done. In addition, the study did not even suggest any alternative method or technique to increase the regenerative capacity of the species in order to supplement its poor seedling regeneration and the sustainability of the species. According to numerous literatures reviewed, there is a particular limited data on the macro propagation of Upas tree (*Antiaris toxicaria* Lesch) as an alternative technique to cope up with the regeneration issue of this tree species, especially in Mabira CFR. Therefore, the present study will provide information on how the tree species should be propagated, especially by using macropropagation technique. The information will be useful to address the regeneration issue of the tree species.

2.2. Summary of literature and Research Gaps

This section summarizes the gaps in the literature published in research on this topic. These are gaps have been pointed out to clearly bring out areas that have opportunities for this and further research.

Table 2.1. Summary of literature and research gaps

№	Gap	Reference (if any)
1	In Uganda, particularly rural areas, the utilisation of traditional medicine, including Upas tree *(Antiaris toxicaria* Lesch), is a common practice, but there are no documented data on the overall utilisation of traditional medicine (medicinal plants).	(Logiel *et al.*, 2021)
2	The lack of information about the socio-economic utilisation of medicinal plants of Mabira CFR, especially Upas tree which was found to be without seedling regenerative capacity among the overall species studied in the forest for their sustainable conservation.	(Tumuhe *et al.*,2018)
3	Disturbance factors (causes) of Upas tree *(Antiaris toxicaria* Lesch) in Mabira CFR are unclear. However, its lack of seedling regenerative capacity was attributed to disturbances by the neighbouring communities for medicine and timber. Limited information about the disturbance factors (causes) of the species.	(Tumuhe *et al.*,2018)
4	The limited information about scientific propagation techniques such macropropagation to supplement the seedling regenerative capacity of some important medicinal plants, including Upas tree (*Antiaris toxicaria* Lesch) for their conservation and management.	(Mbatudde, 2014) (Subiono *et al.*, 2017)

5	Previous research on tree medicinal tree species of Mabira CFR did not look at the propagation of Upas tree (*Antiaris toxicaria* Lesch) and the way it could be done.	(Tumuhe *et al.*,2018) (Tugume *et al.*, 2016)

2.3. Conceptual Framework

Socio-economic utilisation, disturbance factors and propagation (independent variables) influence the regeneration (dependent variable) of Upas tree (*Antiaris toxicaria* Lesch).

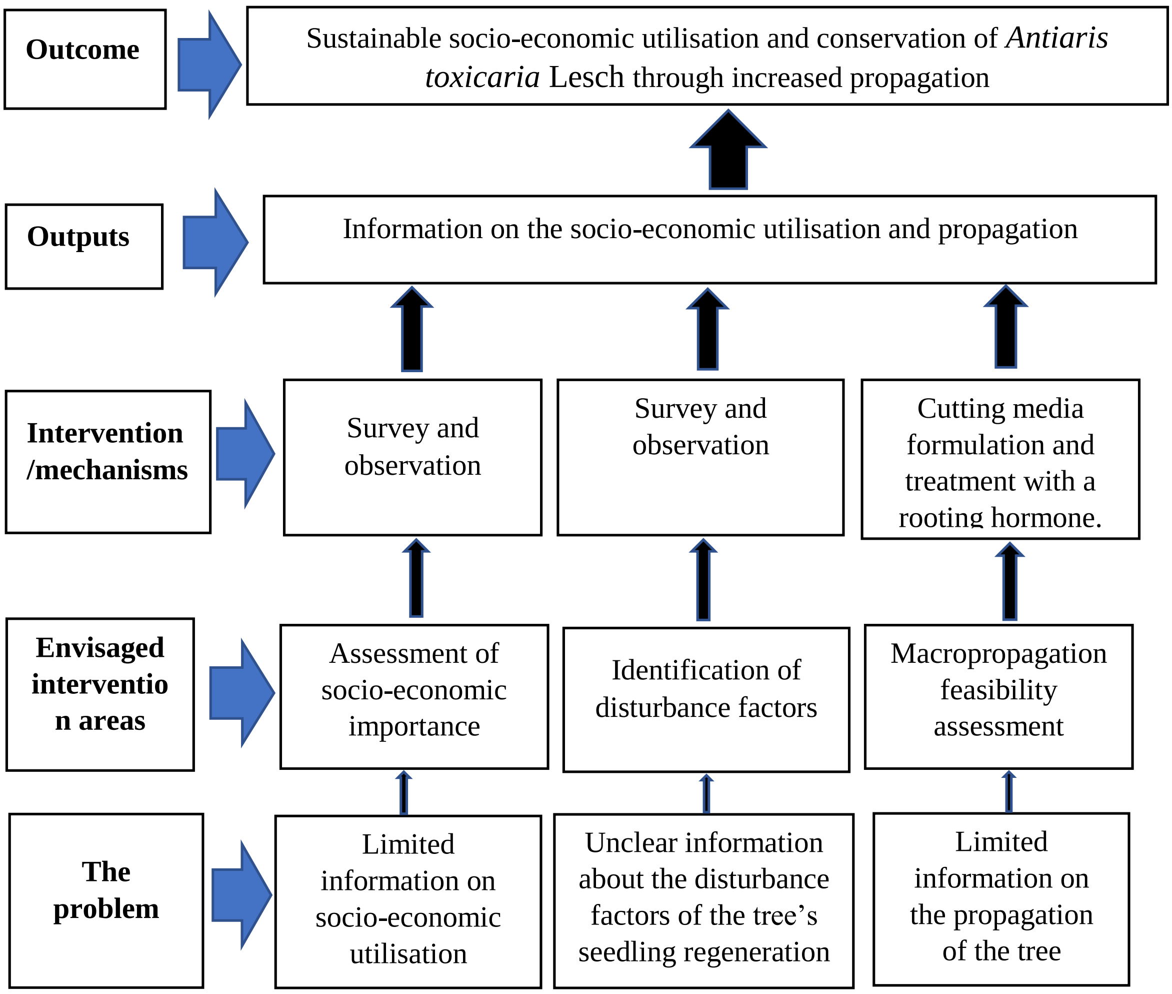

Figure: 2.3. Conceptual framework

CHAPTER THREE

MATERIALS AND METHODS

3.0. Introduction

This section comprises the study area description, research design**,** description of the target population, sampling design, data collection instruments, data collection procedure, and limitations of the study.

3.1. Study Area

3.1.1. Description

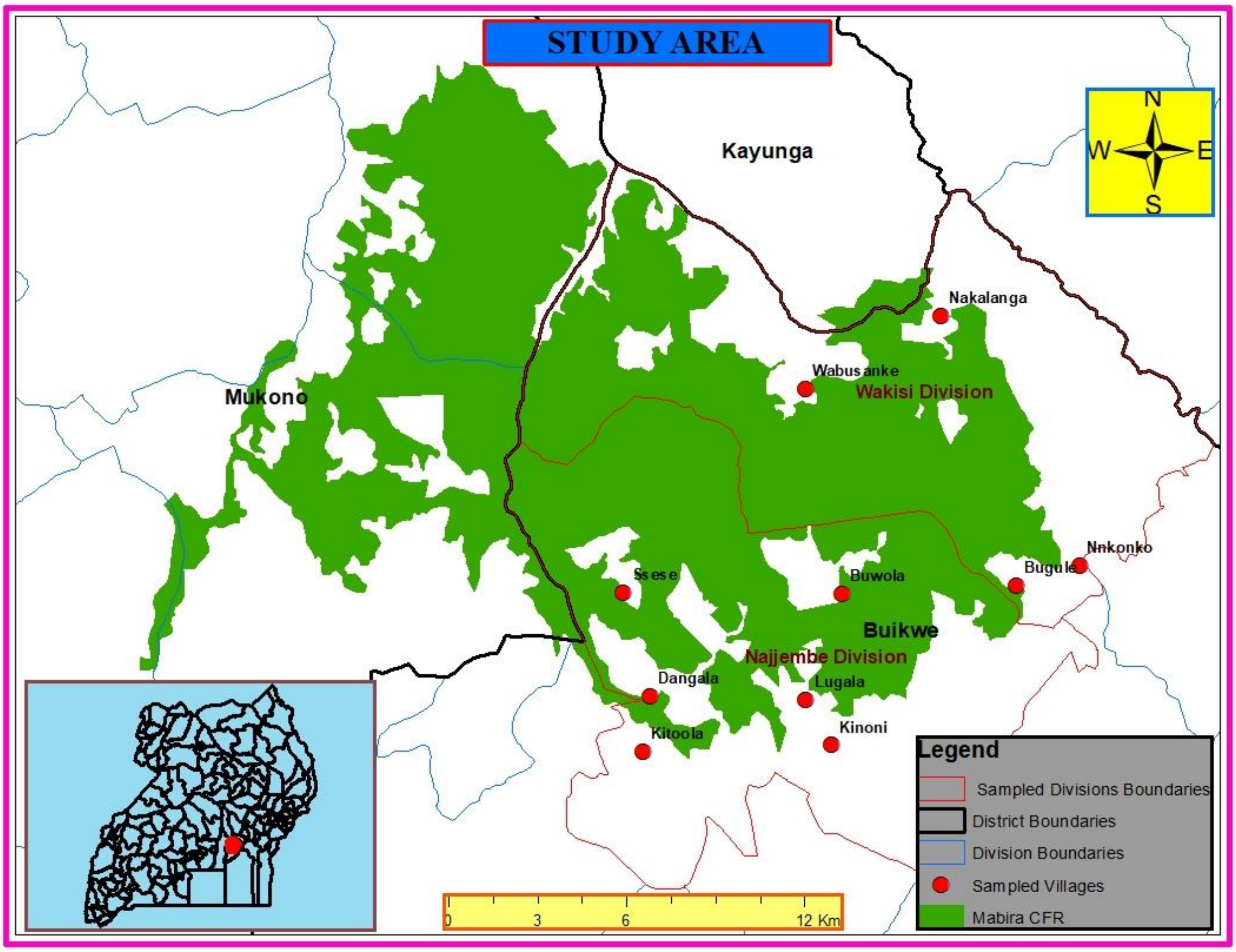

Figure: 3.1. Map of the study area showing the location of Mabira CFR, the study sub-counties/Divisions (Najjembe and Wakisi), and their sampled villages (red points).

Mabira CFR covers an area of 29,974 Hectares (Ha). 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 latitude 00^0 22'and 00^0 35' N and between 30^0

56’ and 33^0 02’East. The management and control of 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).

3.1.2. The topography and Altitude of Mabira CFR

Much of the Mabira lies between 1,000 - 1,250 m above sea level with 5% of the area lying between 1,250m and 1,340m. The topography of the forest is characterised by gently undulating plateaus from flat-topped hills to broad shallow valleys occupied by swamps. The southern part of Mabira CFR occurs at or near the watershed of rivers and streams which enter Lake Victoria to the south and Lake Kyoga to the North (Ministry of Water and Environment, 2020).

3.1.3. Soils, geology and drainage

3.1.3.1. Soils

The soils of Mabira forest belong to the ferrallitic type which is the final stage of tropical weathering. They are called Buganda catena and consist of red soil of incipient lateralisation on slopes and black clays in the valley bottoms often covered by a few centimetres of peat produced by rotting swamp vegetation. The soils of Buganda catena are not characterized by the parent rocks but by the topography which produces four catenas namely shallow lithosols, red latosols, grey sandy soils and grey clay soils (Ministry of Water and Environment, 2020).

3.1.3.2. Geology

The rock formation of southern Buganda, on some of which Mabira forest occurs, has been described as consisting of the Buganda-Toro system, which is made up of granitic gneiss and granites of that system. Metamorphosed sediments such as schists, phyllites, quartzites and amphibolites overlie them. This type of rock formation tends to be uniform and gives some resistance to erosion, except along joints and fracture planes.

3.1.3.3. Drainage

Mabira ecosystem is part of the watershed area for local and international waters of Lake Kyoga, Victoria, and rivers Nile and Ssezibwa that flow to Lake Kyoga with tributaries including Walekekata, Kasala, Luzibwe, Katogo, Nakasagazi, Namamiya, Kinyanyo, Kizibigi, Nyansa, Mayanja, Lulimba, Mulungu, Waluke, Wakisu, Namokomo, Wabuyimba, Nakalasa, Jugula, Kasininya, and Musamya flowing into river Ssezibwa. In the eastern bloc rivers Waliga, Kasate, Nakwanga, Kitigoma, Nakyeyedo, Burunginjuku, Kyetinda, Buwola, Nkuse and Mubugwe flow into river Nile.

3.1.4. Climate

There climate is an equatorial, characterised by a bimodal pattern of rainfall with two wet seasons: March-May and September-November. The mean annual rainfall is 1300mm, which is generally well distributed throughout the year. The general climate of the zone typically displays comparatively small seasonal variations of temperature, humidity and wind throughout the year (Ministry of Water and Environment, 2020).

3.1.4.1. Rainfall

There is a dry season between late December and early March and another short one in June-July but thunderstorms frequently break both. The zone, therefore, has a rainfall regime that is well distributed throughout the year, but with peaks in April-May and October-November. Much of the rainfall comes in the April-May period, the amount received being between 1375mm and 1524mm annually with the highest falls occurring in the southern part of the reserve. There is a general decrease in rainfall, in frequency and amount from the south to the north. While the south gets rain on an average of 120 days, the northern part may have 90-100 rainy days (Ministry of Water and Environment, 2020).

3.1.4.2. Temperature

The mean annual temperature is about 21-25^{0}C with ranges of a minimum of 16-17^{0}C and a maximum of 28-29^{0}C. Very high temperature seasons as such are very rare but the warmest months are January-February and the coolest are July-August. The highest monthly maximum temperature is 27^{0}C (January to March), while the lowest minimum temperature is 22^{0}C (July and August).

3.1.5. Vegetation and existing crop

The vegetation of Mabira was classified as “medium altitude moist semi-deciduous” but the forest has greatly been influenced by human activities (i.e. exploitation, cultivation and grazing) for a long time. It is regarded as a secondary forest resulting from and constantly being influenced by such activities. It is characteristic of vegetation types representing subclimax or human-altered plant communities. Accordingly, three vegetation sub-types have been recognised, namely, young or colonizing forest, mature mixed forest and *Celtis* mixed forest, the latter being dominated by the *Celtis* genus with six species making up 51% of all trees of economic group two. *Celtis* species are typically associated with other species, including *Antiaris toxicaria*, both contributing about 16% of the growing stock (Ministry of Water and Environment, 2020).

3.2. Research Design and Sampling

The present study employed a cross-sectional research design. It was carried out in Mabira CFR, communities living around Mabira CFR and at Makerere University Agricultural Research Institute located in Wakiso District (Kabanyolo). A quasi-experimental design was used to test research hypotheses such as socio-economic and disturbance factors associated with the utilisation of Upas tree (*Antiaris toxicaria* Lesch). Socio-economic survey is the appropriate way of gathering socio-economic data from respondents. It is a tool used to collect data to improve understanding on the wise, careful, and relatively important use of local resources. Therefore, socio-economic survey is suitable for gathering information about socio-economic utilisation and disturbances of Upas tree.

For socio-economic factors affecting the utilisation and disturbance factors affecting the species regeneration, two (2) sub-counties (Divisions) namely Wakisi and Najjembe of Buikwe district, were purposively selected. The purposive selection of the sub-counties was because they are adjacent and closest to the forest reserve and hold the largest part of the forest. The sampling frame of the study was households. The selection was based on the households living adjacent to Mabira CFR from which Upas tree (*Antiaris toxicaria* Lesch) is harvested. They included farmers, non-farmers (forest reserve administrators and local Government leaders), and traditional healers. The data were gathered from the heads of households because they are the ones with accurate information about the socio-economic use and disturbance factors of the tree species.

A probability (random) sampling technique of respondents (household heads) was used, whereby each household head had an equal chance of being selected. Multistage random sampling was used to sample households' populations in both Najjembe and Wakisi sub-counties, where households were randomly selected from different villages of each division. The purpose of randomisation was to avoid bias. For the macropropagation experiment, a factorial experiment was employed, while a Completely Randomised Design (CRD) with 2 factors was used.

3.2.1. Sample size determination

Buikwe district holds a total of 97,833 households. Najjembe sub-county (Division) has a total of 8,007 households, while Wakisi sub-county (Division) has 9,256 households (UBOS, 2014). From the total households number (17,263) of the two sub-counties, YAMANE's formula ($\boldsymbol{n = \frac{N}{1+N(e)2}}$) was used to estimate the sample size; where n: sample size; N: population size and **e**: margin error/level of significance = 0.05 or 5% from the confidence level of 95%. A total of 391 households (participants) was estimated. In addition, five percent (5%) of this number was added to cater for non-response due to unexpected reasons such as very old age (unable to talk well), etc. Therefore, a total of 410 participants (household heads) was randomly selected from the Divisions. This number of participants is big enough to reduce errors that might occur. In addition, the number was enough for socio-economic and disturbance factors identification.

However, during macropropagation, a total of 160 cuttings were purposively collected and used for each of the two (2) replicates. This number of cuttings was enough to assess the possibility of propagating the Upas tree through shoot cuttings.

3.2.2. Macropropagation experiment

A macropropagation experiment was conducted at Makerere University Agricultural Research Institute Kabanyolo located in Wakiso district. This research institute was chosen because it is suitable for gathering vegetative propagation data and has enough materials and equipment for the experiment. In addition, the institute is recognised for its long experience in plant propagation.

The present research employed a factorial experiment, while a CRD with 2 factors were used. The first factor was cutting media (M), comprising M_1 (only forest topsoil), M_2 (forest topsoil: sand), M_3 (forest topsoil: sand: charcoal dust), and M_4 (forest topsoil: sand: charcoal dust: saw dust). The second factor was the Plant Growth Regulator (PGR) treatment (H), comprising H_1 (with PGR addition) and H_2 (without PGR addition). Factorial CRD was employed because it is useful to study the effects within experiments with two or more factors. It is a design within which each unit has the same chance of receiving a treatment. The cutting media had the following ratios: forest top soil, the control (1:0:0:0 v/v), forest top soil and sand (1:1:0: 0 v/v), a combination of forest top soil, sand and charcoal dust (1:1:1:0 v/v), and a combination of forest top soil, sand, charcoal dust, and saw dust (1:1:1:1 v/v).

From a combination of the components of the 2 factors, the factorial CRD produced 8 different treatments as follows: M_1H_1 (Forest topsoil with PGR), M_2H_1 (Forest topsoil and sand with PGR), M_3H_1 (Forest topsoil, sand and charcoal dust with PGR), M_4H_1 (Forest topsoil, sand, charcoal dust, and saw dust with PGR), M_1H_2 (Forest topsoil without PGR), M_2H_2 (Forest topsoil and sand without PGR), M_3H_2 (Forest topsoil, sand and charcoal dust without PGR), and M_4H_2 (Forest topsoil, sand, charcoal dust, and saw dust without PGR). Each of the 2 treatments had 40 cuttings of *Antiaris toxicaria* Lesch, whereby each cutting was planted within its own black polyethylene (potting) bag containing a cutting medium, making a total of 160 cuttings for all the treatments. Within each treatment, a half of the cuttings (20) were treated (quick dip method) with a commercial Auxin growth regulator powder (IBA) called Seradix 2 to promote root formation. All the experimental treatments were arranged and placed onto a nursery bed in a green house.

Sterilised sharp machetes and knives were used to excise the explants (cuttings) from their mother tree in Mabira CFR. To facilitate their transportation, a big container was used to store the cuttings. The container was filled with water, into which each cutting was placed after its excision. According to the information provided by NFA technicians, the cuttings were taken from a mother tree of approximately 3-8 years old.

3.3. Target Population

The target population of this study was the population of the Wakisi and Najjembe divisions (sub-counties) of Buikwe district, specifically from their different villages. Data were collected from village households living around Mabira CFR and household heads were randomly selected per selected sub-county villages. Najjembe sub-county has a population size of 40,300, while Wakisi Sub-county has 49,300. The population is farming food crops, mostly for subsistence consumption. Example of crops include beans, ground nuts, maize, sweet potatoes, bananas and vegetables. Only a few households are involved in livestock rearing (Tumuhe *et al.*, 2018).

3.4. Data Collection Instruments and Procedure

This study used primary quantitative and qualitative data. A semi-structured questionnaire (open-ended and close-ended questions) was used (Mhuji et al., 2018). The questionnaire was composed of four (4) sections. All the questionnaire's sections were for objectives 1 and 2. The preliminary part of the questionnaire served as both introduction and consent. For macropropagation experiment (objective 3), green house, an autoclave, nursery bed, cuttings media together with other materials were used to collect data. A pen, notebook and a computer were used to record the data.

3.4.1. Socio-economic factors associated with the utilisation of Upas tree

First-hand information, collected through direct participation or observation, was used to gather primary data through a household survey. A semi-structured questionnaire was employed, including open and close-ended questions as used by Nahayo *et al.*(2013). A camera was used to take photographs related to the study. Geographical Information System (GIS) software (ArcGIS/Arc Map 10.8) was used to make the study area map while Geographical Positioning System (GPS) Essentials Application was used to take GPS points in order to locate study villages from which data were collected. Both software and application contributed to mapping the study area. Therefore, socio-economic data on the utilisation of Upas tree *(Antiaris toxicaria* Lesch) were obtained by using a semi-structured questionnaire with four sections, and the second, third and fourth sections contained survey (close-ended) questions.

The study used only primary data, both quantitative and qualitative data were collected. A semi-structured questionnaire with four sections was used. Section 1 consisted of the identification and characteristics of the respondents per households, while the remaining sections consisted of different questions (close-ended questions) following the research objectives.

From 410 participants (each from the selected households) for both sub-counties, 246 respondents were randomly selected from Najjembe sub-county, while 164 were selected from Wakisi sub-county. From Najjembe sub-county, six (6) villages were purposively selected, while four (4) villages were purposively selected from Wakisi Division. Fewer villages and households were chosen from the Wakisi sub-county because many households residing near the forest were not permanent residents of the area. These individuals were seasonal workers for sugar and tea companies, hailing from different districts of Uganda, and their stay in the area was temporary with a continuous influx and turnover of workers. Moreover, some of these individuals needed to gain proficiency in English, Luganda, and knowledge about forest tree uses. Consequently, these households were purposively excluded from the survey. The purposive selection of villages was based on their neighbourhood of Mabira CFR. Forty-one (41) households (respondents) were randomly selected from each village.

3.4.2. Identification of the disturbance factors of Upas tree (*Antiaris toxicaria* Lesch)

Quantitative data were collected on disturbance factors affecting the seedling regenerative capacity of Upas tree by using semi-structured questionnaire (Sections 3 and 4 of the questionnaire). Participant field observations supplemented the survey to confirm information gathered from the households. The research study by Mhuji *et al.*(2018) utilized a questionnaire with close-ended questions to gather socio-economic data. This study followed the same process as in Section 3.4.1.

3.4.3. Macropropagation of Upas tree (*Antiaris toxicaria* Lesch)

Data collection was done from a vegetative propagation (macropropagation) experiment, which was conducted in a greenhouse of Makerere University Agricultural Research Institute. The experiment was facilitated by different tools, equipment and materials such as a green house, an autoclave, a nursery bed, cuttings media together with other materials and which were used to collect data. A pen, notebook and a computer were also used to record the data. The following is the procedure of the macropropagation experiment of the Upas tree:

3.4.3.1. Preparation of Cutting media

Forest top soil, sand, charcoal dust, and saw-dust were sterilised by Autoclave before being mixed and packaged into potting bags. After sterilisation, four cutting media were prepared. A medium of only forest topsoil was prepared at a ratio of 1:0:0:0 v/v. A mixture of forest top and sand was also prepared at a ratio of 1:1:0:0 v/v to make the second medium. Forest topsoil, sand and charcoal dust were mixed at 1:1:1:0 v/v to make the third medium. The last medium was made by mixing forest topsoil, sand, charcoal, and saw dust at a ratio of 1:1:1:1 v/v. After mixing the materials, the media were packaged into black polyethylene bags according to their medium composition, making four experimental treatments. After packaging, the cutting media were transported to and arranged onto a nursery bed in a green house.

3.4.3.2. Selection and Collection of cuttings

Cuttings were excised from a young (approximately 3-8 years old) Upas tree (*Antiaris toxicaria* Lesch) of Mabira CFR by using a sharp and sterilised machete. Younger stems contain more actively dividing cells and have higher levels of Auxins that promote root formation. Older stems might have already undergone lignification (the process of becoming woody), which can impede root formation. The size of leaves was trimmed to their halves by using a sharp and sterilised knife. After the cuttings were taken, they were immediately placed in a big container with clean and sterile water/ice and transported to the nursery of Makerere University Agricultural Research Institute of Kabanyolo (MUARIK).

3.4.3.3. Preparation of cuttings

Cuttings were washed with clean water after sterilising them with fungicide for 1 hour. The fungicide was used to kill fungae on the cuttings because they were collected from a forest with high contamination with microorganisms. Fungae affect growth of a plant as they kill plant cells. The wet cuttings were put aside for a short time to allow evaporation to take off their surface water. The basal ends of the cuttings were then re-cut in 45^0 direction to avoid rooting at only one side. A sharp machete was used, while leaves were re-trimmed into a quarter size by using a sharp knife. The length of the planted cuttings was approximately 15 cm, according to Fehling-Fraser & Ceccon, (2015).

3.4.3.4. Treating the cuttings with rooting hormone and planting them into their media

In each medium, a hole was created to create a space in which cuttings were planted. For each treatment which consisted of a total of 40 polyethylene bags containing a specific medium, 20 out of 40 cuttings were treated with root growth hormone (Seradix 2, an Auxin). The basal ends of the cuttings were dipped into the Auxin powder (Quick-dip method) for approximately 5 seconds, removed and shaken to remove extra powder. Untreated and treated cuttings were planted into their respective media. The cuttings treated with rooting hormone were labelled to distinguish them from untreated cuttings. After planting, all the cuttings were watered, and the nursery bed was then covered with a thick, transparent and white polyethylene bag.

The observed parameters were the survival percentage (%), rooting percentage (%), and percentage (%) of sprouted shoots. After planting, the treatments were visited every week until the end of 6 weeks, when data were recorded.

3.5. Research Permit

For the research permit in the selected sub-counties and forest, introductory and inquiry permit letter were submitted to the research area authorities (NFA and the sub-county and village leaders). The assistance from Kyambogo University facilitated this. Informed consent was obtained from all participants. A research license was acquired from the NFA at a cost of 40,000 Uganda Shillings, as the researcher was from an EAC member country. The license was valid for one month.

3.6. Research assistance and feasibility test of the survey

For the feasibility of the study, a pre-test survey was done (Mhuji *et al.*, 2018); (Logiel *et al.*, 2021) in Najjembe village, whereby 20 households were selected before the actual survey. The survey was done by starting from Najjembe division, then Wakisi division. The type of administration of the questionnaire was both researcher-administered and respondent self-administered. The researcher's administration of the questionnaire means that respondents are helped to fill the questionnaire in the form of an interview. This is because the level of education enabling respondents to fill the questionnaire themselves was not at the same level among respondents. The questionnaire was prepared following specific objectives and in accordance with the anticipated socio-economic factors such as education level, monthly income, age, and household size among others.

Two (2) research assistants (enumerators) were selected from Najjembe division based on their level of education and proficiency in both English and Luganda, the local language of the community. The enumerators underwent training for data collection. The selected enumerators held a Uganda Advanced Certificate of Education and had knowledge in the field of conservation, as well as experience in data collection. Being locals, well-known in the study area and had a valuable knowledge of biological conservation which greatly assisted in the data collection process, their ability to communicate in Luganda was particularly beneficial since the lead researcher was not fluent in the local language.

The data were collected within 9 months (from September, 2022 to May, 2023) for both survey and macropropagation experiment, by excluding the questionnaire's pre-test which was conducted before the actual data collection period of time. The location of Upas tree *(Antiaris toxicaria* Lesch) was done with the help of botanical specialists of the National Forestry Authority (NFA).

3.7. Data Analysis and Presentation

The gathered data from the field and vegetative propagation were scrutinized (assessed several times to ensure no missing information, especially made during recording) to avoid errors. This was done immediately after data collection and missing information were removed from the sample to avoid bias. The collected data were recorded in tables and retrieved for processing and analysis.

The quantitative and qualitative data collected on socio-economic factors were analysed by employing the Statistical Package for Social Sciences (IBM SPSS, version 20) after transforming/converting the qualitative data into quantitative data. Inferential analysis was used to show the association between the utilization of Upas tree (*Antiaris toxicaria* Lesch) and socio-economic factors, whereby Chi-square ($\chi 2$) was used to determine the significance in dependency of socio-economic factors on the utilization of the Upas tree in the communities around Mabira CFR. Type I and Type II errors were controlled by using a confidence level of 95% and a margin error of 5% (or Significance level= 0.05). The results were presented in chart form. Chi-square analysis was used as exemplified by Mhuji *et al.*(2018).

Qualitative data collected on the disturbance factors affecting seedling regeneration of the Upas tree were recorded, categorized, organized, and analysed using the same software. Descriptive statistics were used to determine which factors were mostly affecting the regeneration. Data collected on the vegetative propagation of the Upas tree by shoot cuttings were summarized, and analysed. The Results were presented using bar charts.

CHAPTER FOUR

RESULTS

4.0. Introduction

This chapter presents the findings from the collected data on the local use of *A. toxicaria* Lesch, the association between the utilisation of tree species and socioeconomic factors, its disturbance factors, and its propagation. The presentation follows the order of objectives and provides a brief overview of the results, which will be discussed further in the next chapter. Additionally, the chapter includes test statistics for socio-economic factors (Chi-square, χ^2 *p-values*) and examines whether the results are consistent with the research hypothesis.

4.0.1. 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 the Upas tree (*A. toxicaria* Lesch). Most household heads (65.1%) who participated 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 and above. Of these, 75.1% were married, 21.5% were single, and 3.4% were widowed. About 64.1% of participants received formal education (ranging from primary to tertiary education, including those who dropped out of school), while the remaining 35.9% did not receive formal education. Most households (55.6%) were composed of few members (1 to 4), 30.7% were composed of 5 to 8 members, and only 13.7% were composed of 9 or more members. The majority of participants were farmers (82.4%). Employed household heads (employed or self-employed in activities other than farming) constituted 15.4%, while those without formal jobs accounted for 2.2%. In terms of monthly income, the majority of households (85.3%) earned between 1 and 200,000 Ugandan shillings, 13.2% earned between 201,000 and 500,000 Ugandan shillings, and 1.5% earned 501,000 and above.

4.1. Socio-economic Utilisation of Upas Tree (*Antiaris toxicaria* Lesch)

4.1.1. Collection and local utilisation of Upas tree

This section presents the descriptive statistics on the collection and utilisation of *Antiaris toxicaria* Lesch. With a total number of 410 participants from which the survey was conducted, only 309 participants answered to the question.

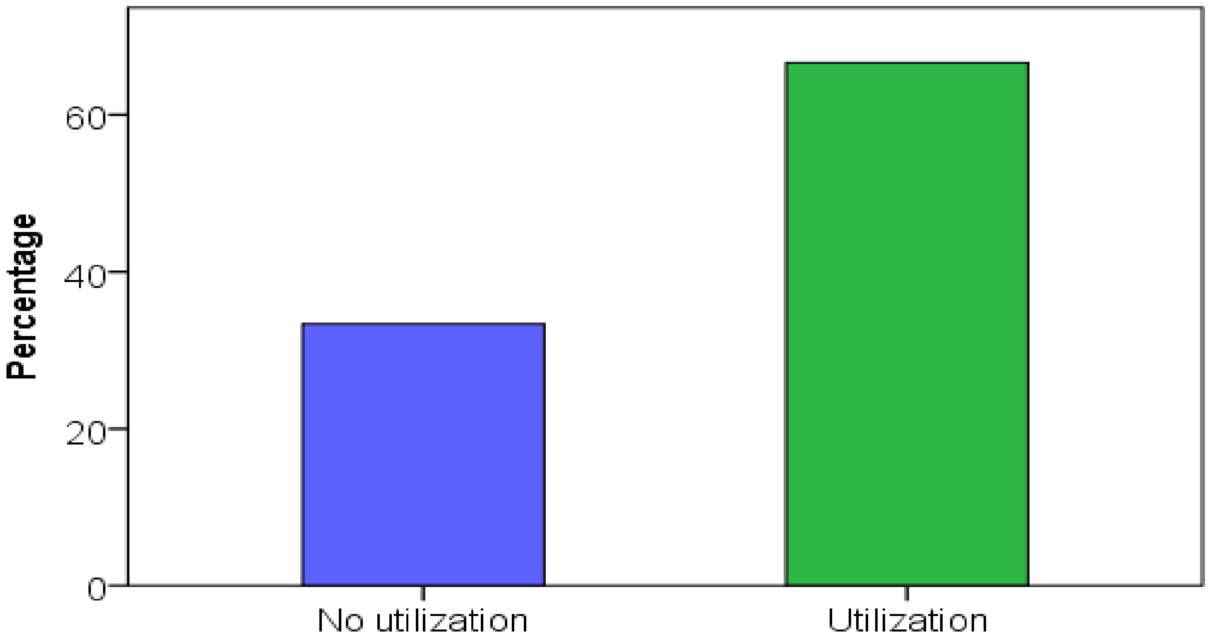

Figure: 4.1.Collection and utilisation of *A.toxicaria* Lesch

Source: Survey data, 2022

The figure above (Fig.4.1) illustrates the collection and utilisation of the Upas tree as 66.7% (utilisation), while the non-collection and non-utilisation were found to be 33.3% (no utilisation).

4.1.2. Local utilisation (importance) of Upas tree

The present section demonstrates the local use/ role of the (Upas tree) within the study area. A total of 216 participants out of the 410 answered to the survey questions.

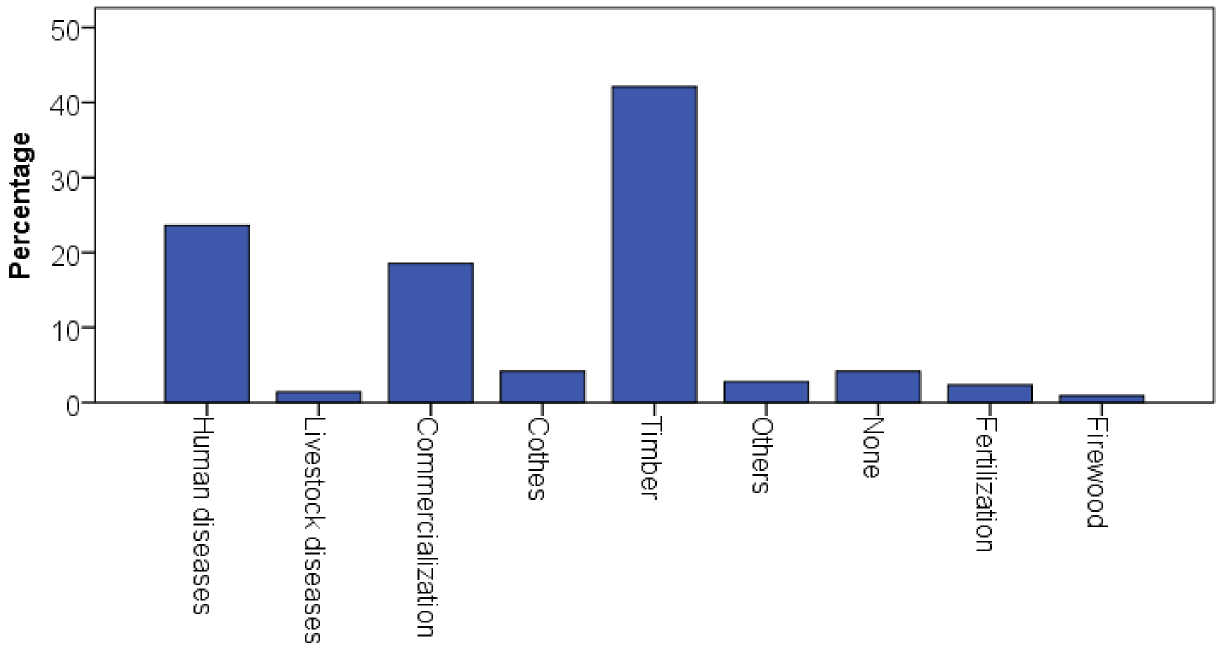

Figure 1.2: Local utilisation (importance) of *A.toxicaria* Lesch

Source: Survey data, 2022

With 66.7% of collection and local utilisation, eight (8) local uses of *Antiaris toxicaria* Lesch were identified (Fig 4.2). The tree species was mainly used as timber and medicine.

4.1.3. Association between age and local utilisation of Upas tree

This section examines the association between the age of participants and the utilisation of Upas tree. A total number of 309 participants provided answers. The results are depicted in the graph below.

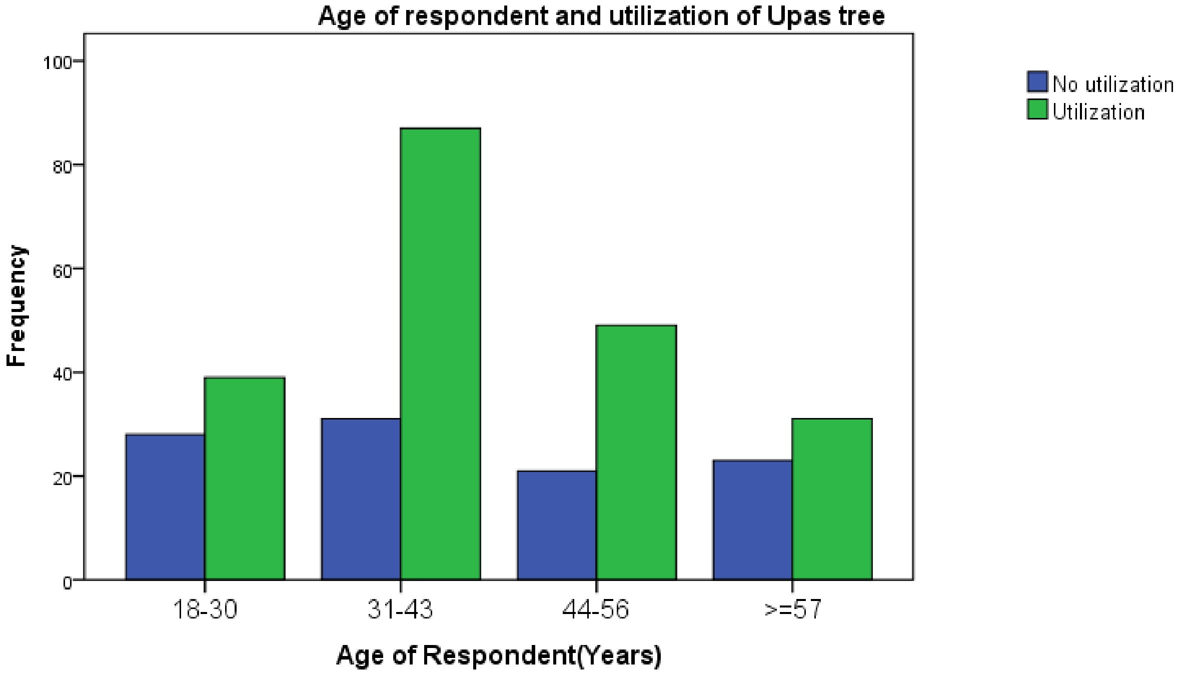

Figure: 4.3.Association between the age of participants and the utilisation of *A.toxicaria* Lesch Source: Survey data, 2022

The overall utilisation of the Upas tree for age was insignificant (Chi-square *p-value*: 0.065, greater than the significance level of 5%). The results were obtained using inferential statistics through a Chi-square ($\chi 2$) test. It is shown that the use of the Upas tree was high among middle-aged individuals (31-43 and 44-56), with the highest utilisation found within the age range of 31-43 (Fig 4.3).

4.1.4. Association between the level of education and utilisation of Upas tree

The figure below illustrates an association between participant's level of education and the utilisation of Upas tree. Only 309 out of 410 household heads responded. The results were produced to test whether there is an association between the above variables.

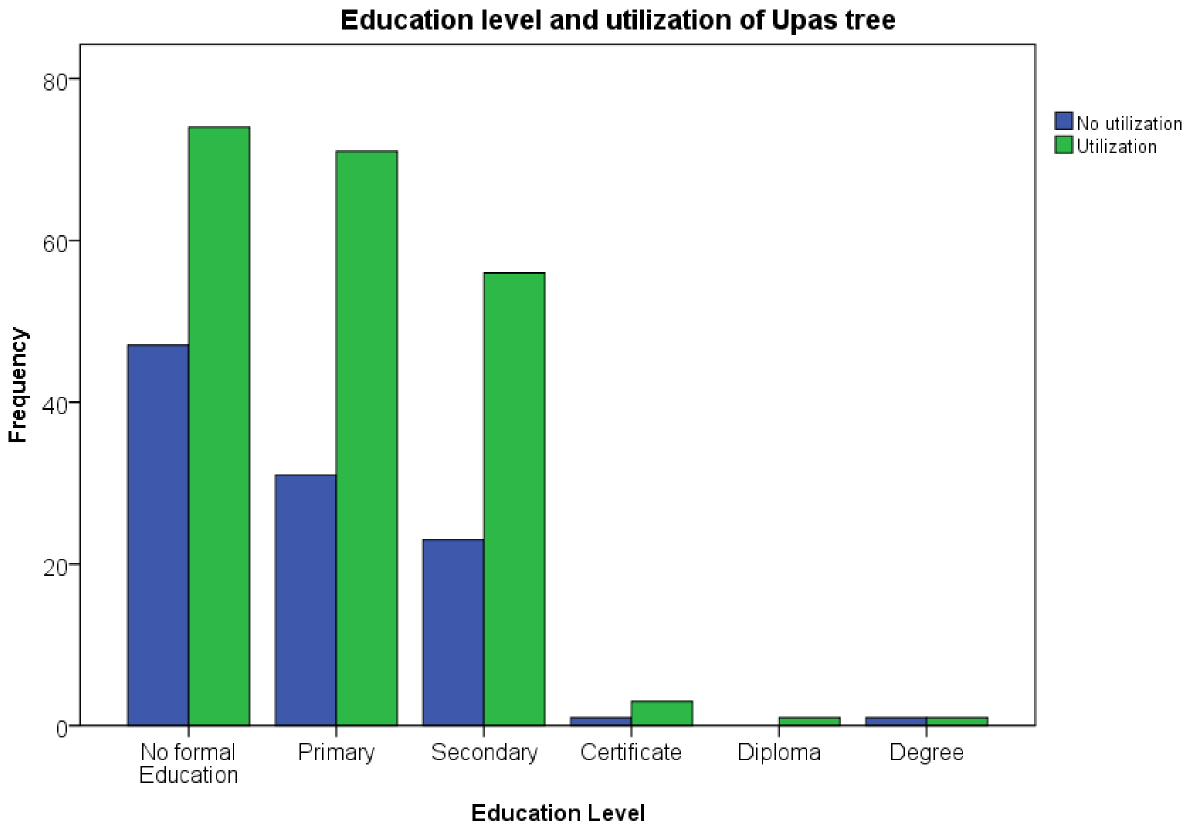

Figure: 4.4.Association between the level of education and the utilisation of *A.toxicaria* Lesch
Source: Survey data, 2022

The utilisation increased with a decrease in education level. However, according to the results, there was no significant association between the level of education and the utilisation of Upas tree ($\chi2$ *p-value*: 0.615 greater than significance level of 5%). The findings were obtained by using inferential statistics through Chi-square ($\chi2$) test statistics. They showed that the utilisation of Upas tree was higher among those with a low level of education (Fig 4.4).

4.1.5. Association between Residence duration and utilisation of Upas tree

This section presents findings regarding the association between duration of residence of participants and the utilisation of Upas tree. Only 309 responses were obtained.

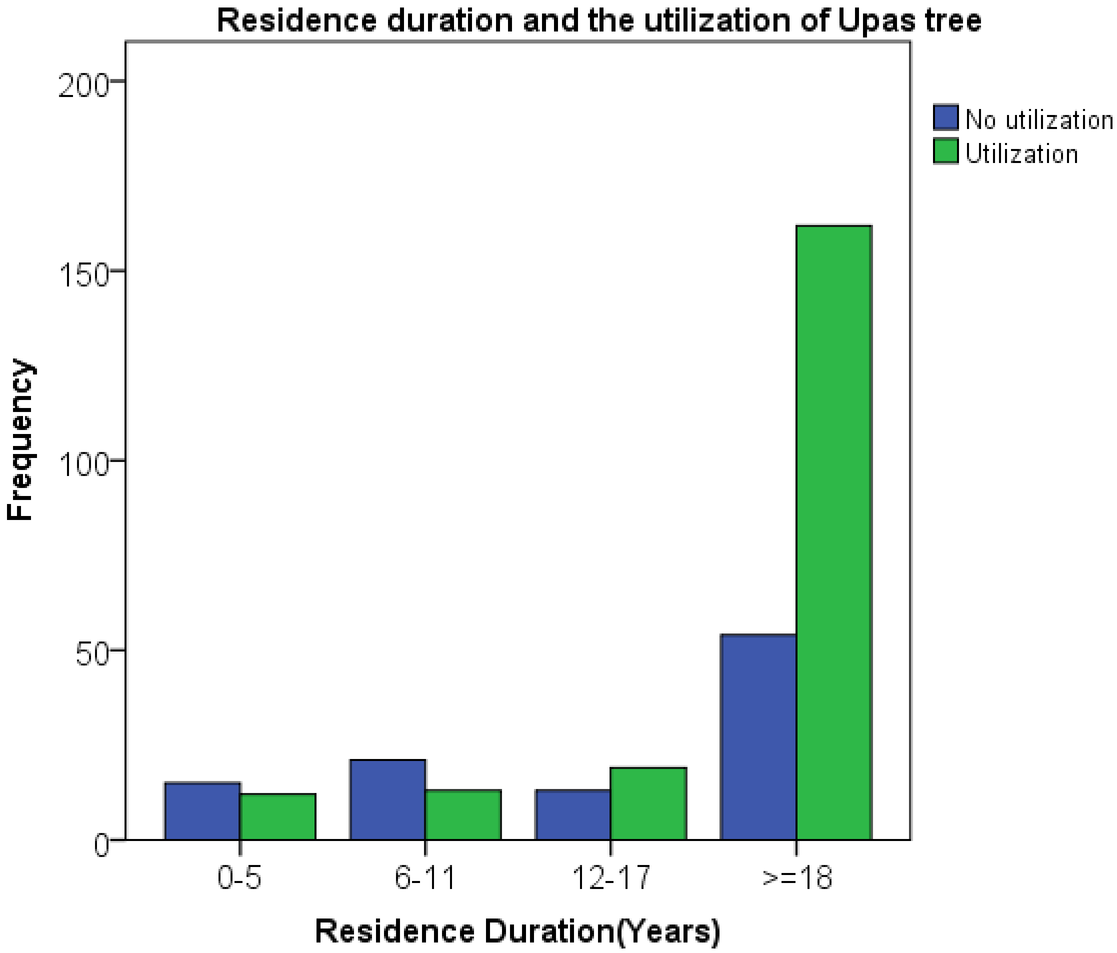

Figure: 4.5.Association between residence duration and the utilisation of *A.toxicaria* Lesch

Source: Survey data, 2022

The chi-square ($\chi 2$) *p-value* was found to be significant (sign: 0.000, much lower than the significance level of 5%). The utilisation of Upas tree was found to be the highest amongst people who resided in the study area for a long time (i.e. from 18 years and above). See (Fig 4.5).

4.1.6. Association between household size and the utilisation of Upas tree

The next graph presents the findings on the association between household size and the utilisation of Upas tree. Here, 309 responses were obtained.

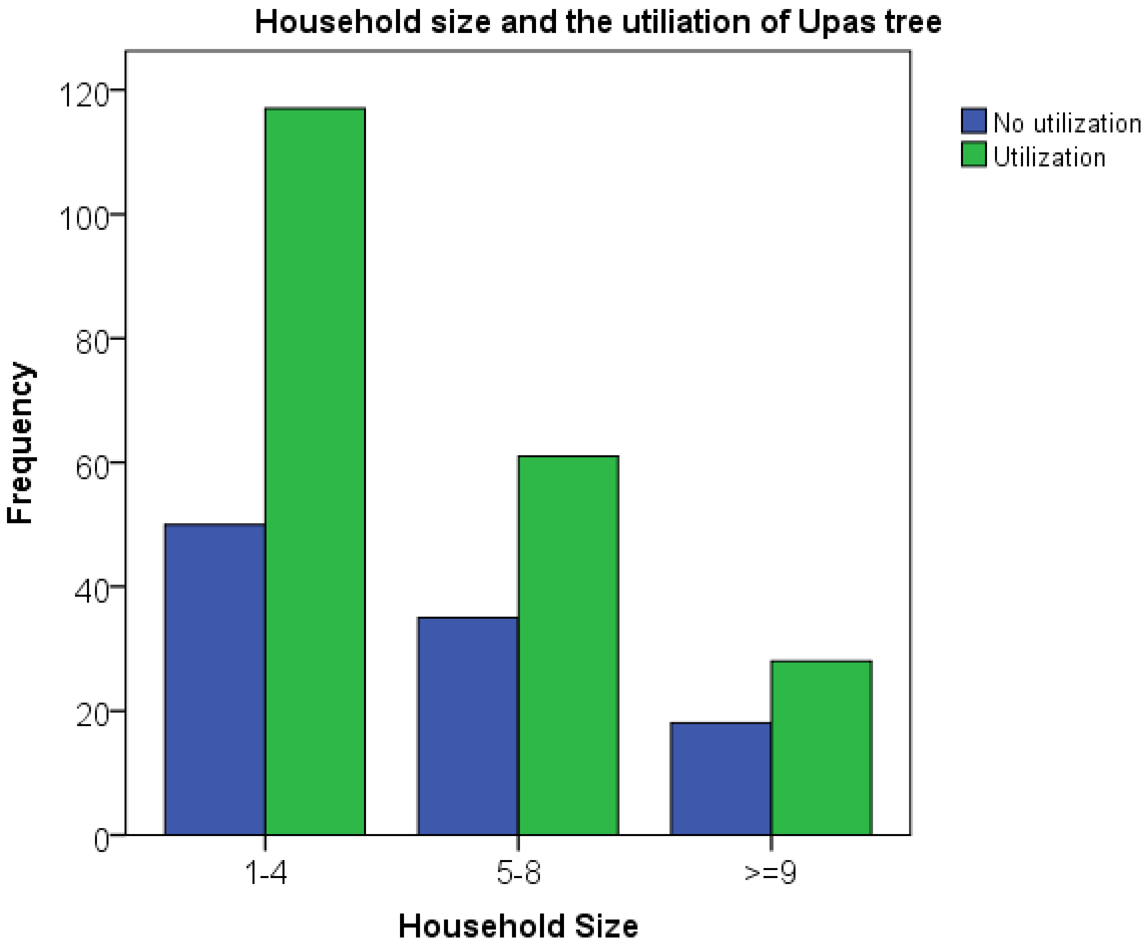

Figure: 4.6.Association between household size and the utilisation of *A. toxicaria* Lesch

Source: Survey data, 2022

The Chi-square (*χ2)* test results showed a *p-value* of 0.371, which was much greater than the significance level of 5%. Therefore, the association was not significant. The results show that the utilisation of the tree resource increases with a decrease in household size (Fig 4.6).

4.1.7. Association between the occupation of respondents and the utilisation of Upas tree

The next graph presents results on the association between the participants' occupations and the utilisation of Upas trees. Responses were collected from a total number of only 309 participants.

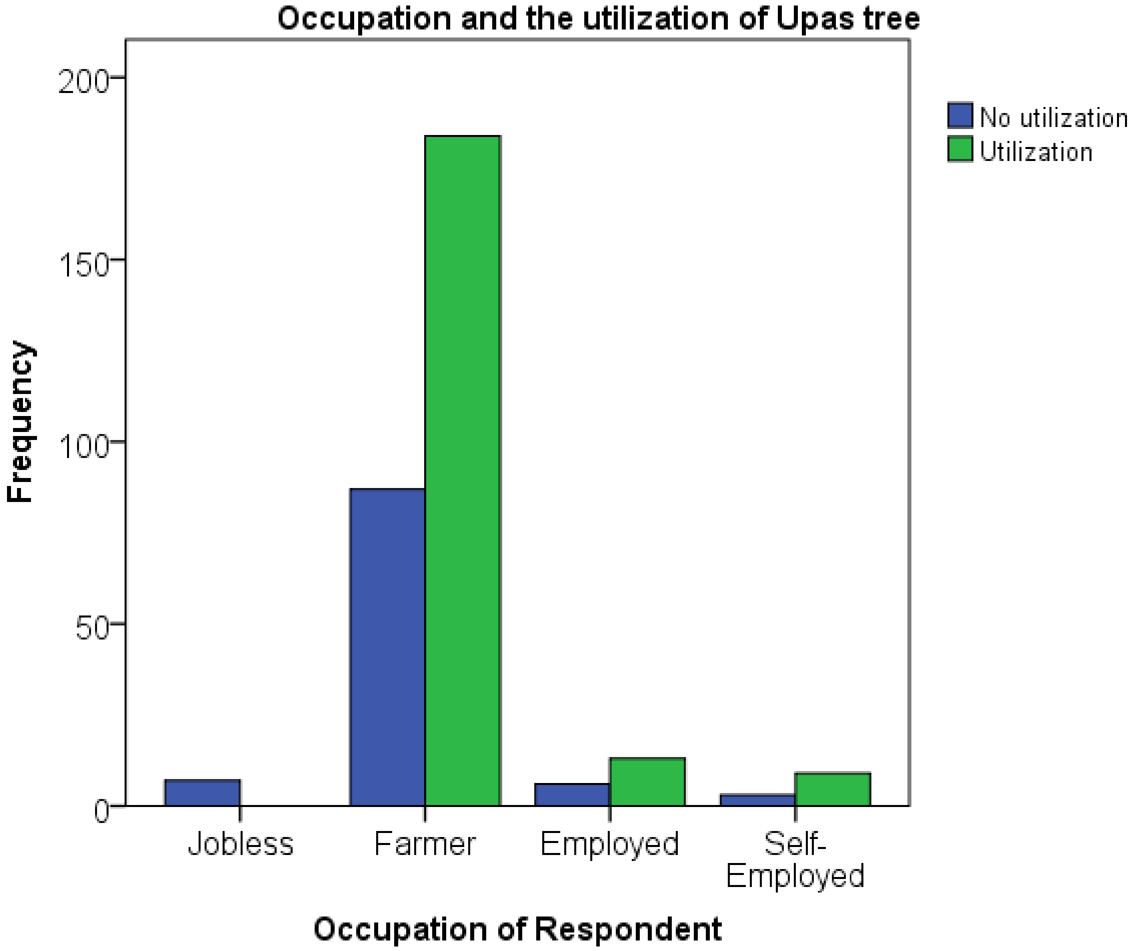

Figure: 4.7. Association between the occupation of participants and the utilisation of *A.toxicaria* Lesch Source: Survey data, 2022

The Chi-square (χ2) test results showed a *p-value* of 0.002 (sign). This value showed a significance in the results as it is far below the significance level of 5%. The utilisation of Upas tree was very high amongst the occupation class of farmers (Fig 4.7).

4.1.8. Association between participants' household monthly income and the utilisation of Upas tree

The figure below reveals whether there is an association between the family monthly income and the utilisation of Upas tree. Out of 410 expected responses, only 309 were obtained.

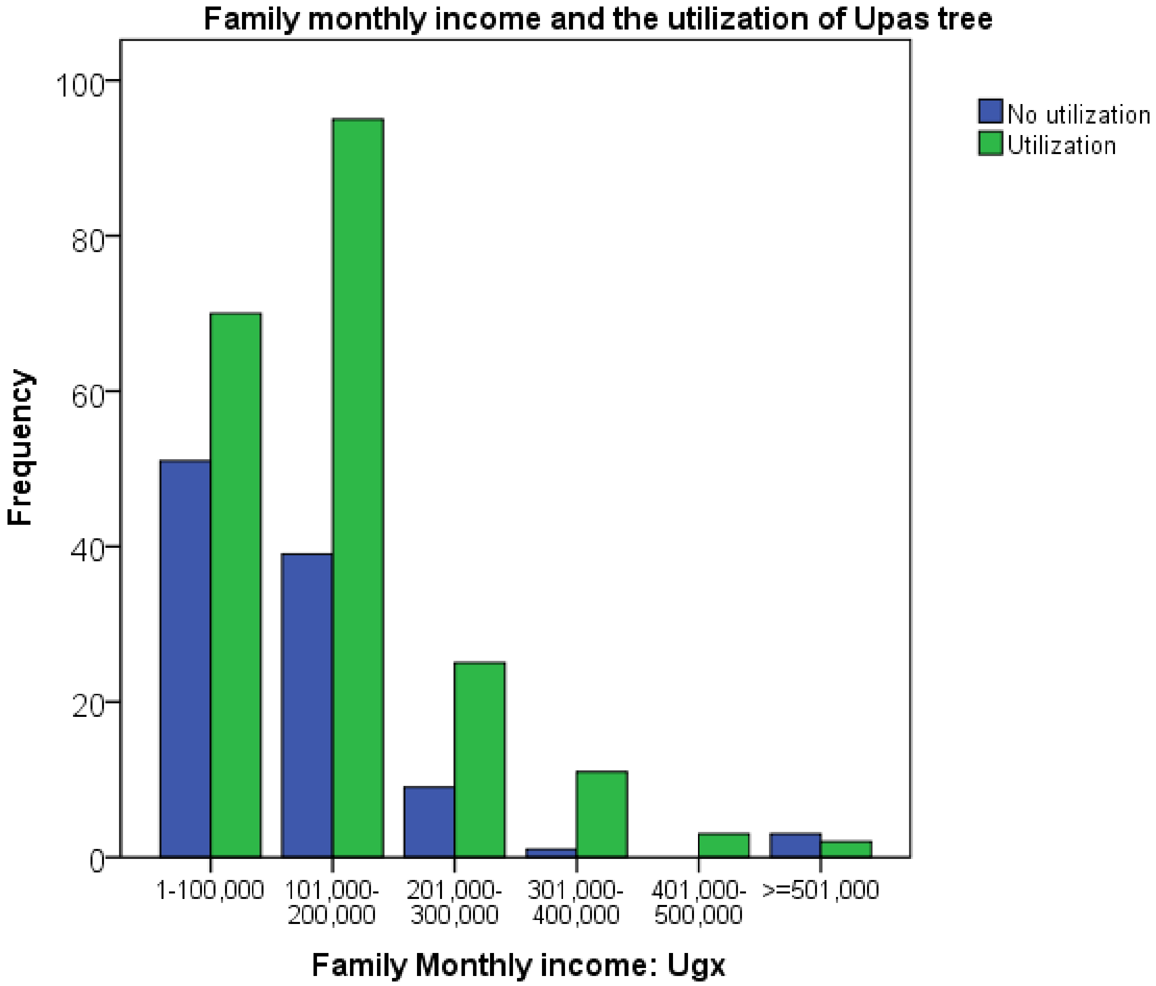

Figure: 4.8.Association between participants' household monthly income and the utilisation of A.toxicaria Lesch Source: Survey data, 2022

The *p-value* from the Chi-square ($\chi 2$) results was 0.028 (less than the significance level of 0.05), showing a significant association. The results showed a high utilisation of Upas tree among low-income families (Fig 4.8).

4.2. Disturbance Factors of Upas Tree in Mabira CFR

The following figure demonstrates major disturbance factors (causes) that make *A. toxicaria* Lesch in Mabira CFR to have no or very few seedlings. It was plotted to confirm whether disturbances exist that affect the regeneration of the tree species. A total of 264 out of 410 participants answered his question.

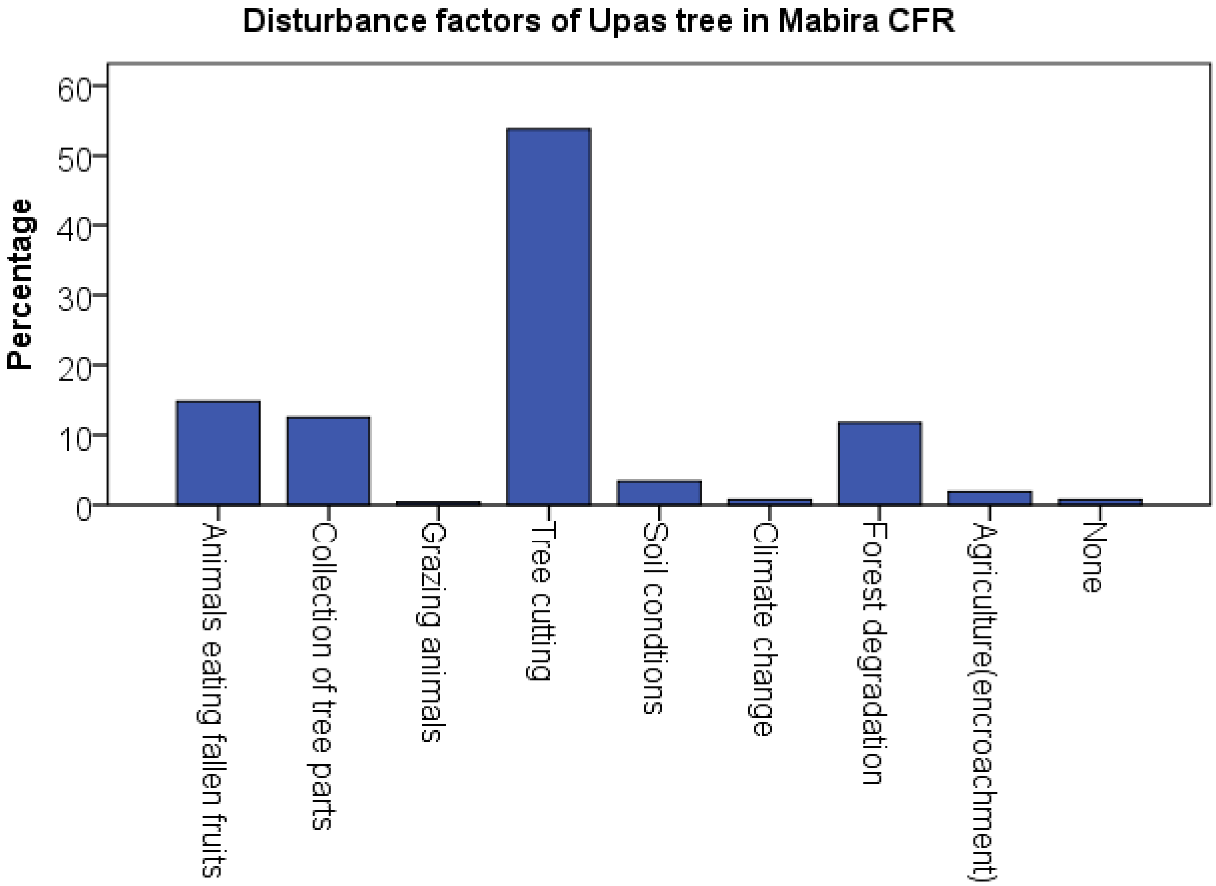

Figure: 4.9.Disturbance factors of *A. toxicaria* Lesch of Mabira CFR

Source: Survey data, 2022

The results revealed several disturbance factors of the tree species. The factors include animals eating fallen fruits (14.8%), collection of tree parts by local people (12.5%), grazing animals (0.4%), tree cutting (53.8%), poor soil conditions (3.4%), climate change (0.8%), forest degradation (11.7%), and agricultural encroachment (1.9%). Tree cutting was the principal and risky factor affecting tree regeneration in the forest reserve (Fig 4.9).

Photo 4.1. Images depicting tree cutting as one of the disturbance factors

Source: Mabira CFR, Buwola and Ssese Villages (Najjembe division, Buikwe district), 2022.

4.3. Macropropagation of Upas tree (*A. toxicaria* Lesch)

The chart below presents the findings from stem cutting experiment. The experiment used 4 different types of media, and 3 variables (survival, sprouting and rooting) were observed and recorded from each type of cutting medium. Half of 40 cuttings in each cutting medium were treated with a rooting hormone, Seradix 2.

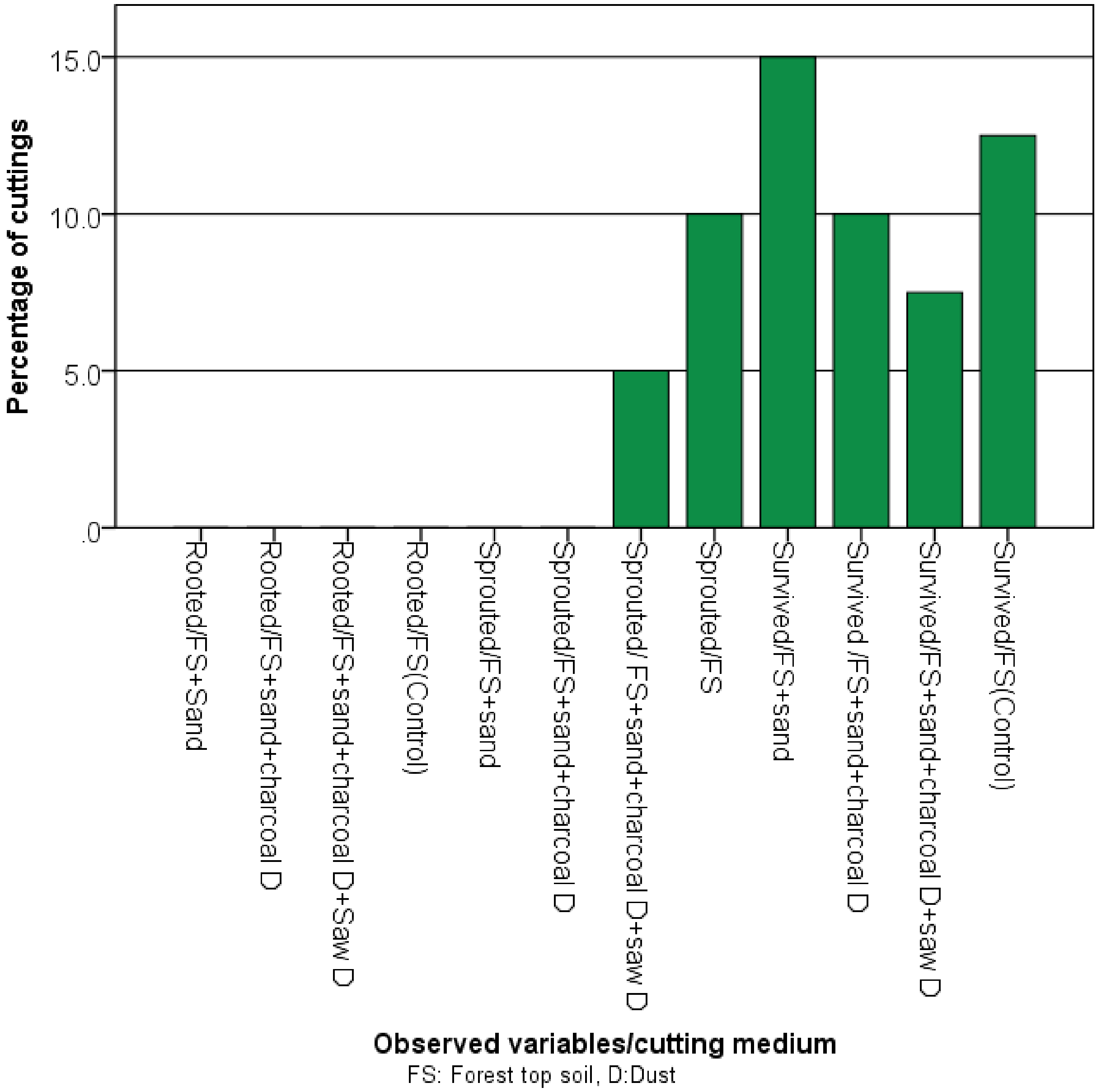

Figure: 4.10.Survival, sprouting, and rooting of Upas tree's cuttings in different cutting media Source: Macropropagation experiment, 2023

The above results show the highest survival percentage of 15% (6/40 cuttings) in the cutting medium made of soil and sand. However, neither sprouting nor rooting was observed in this medium, as represented by a percentage of 0% (0/40 cuttings) and 0% (0/40 cuttings), respectively. With the cutting medium of forest topsoil, sand, and charcoal dust, the observed survival, sprouting, and rooting percentage were 10 % (4/40 cuttings), 0% (0/40 cuttings), and 0 % (0/40 cuttings), respectively.

However, the cutting medium composed of forest topsoil, sand, charcoal dust, and saw-dust showed better results because, it illustrated at least both survival and sprouting: a survival percentage of 7.5% (3/40 cuttings), a sprouting percentage of 5 % (0/40 cuttings), and a rooting percentage of 0% (0/40 cuttings).

Among all the cutting media, the medium composed of only forest topsoil showed the best results with a survival percentage of 12.5% (5/40 cuttings), a sprouting percentage of 10% (4/40 cuttings). Nevertheless, like other cutting media, no cutting did root. This is shown by the rooting percentage of 0% (0/40 cuttings) according to Fig 4.10. Lastly, the rooting hormone (Seradix 2) did not have any effect on the rooting of the cuttings amongst all the cutting media, as shown by the absence of rooting 0% (0/40 cuttings) in all cutting media. Therefore, the overall survival, sprouting, and rooting of cuttings was 15 % (24/160 cuttings), 3.75 % (6/160 cuttings), and 0 % (0/160 cuttings), respectively.

Photo 4.2a.Sprouted cuttings during macro propagation

Source: Macro propagation experiment, green house’s nursery bed (MUARIK), 2023

Photo 4.2b.Rooting during macropropagation

Source: Macropropagation experiment, green house's nursery bed (MUARIK), 2023

CHAPTER FIVE

DISCUSSION

5.0. Introduction

This chapter provides detailed discussion of the study results, including a summary of findings, interpretations, implications, limitations, and recommendations, following the order of the objectives.

5.1. Socio-economic utilisation of Upas tree (*Antiaris toxicaria* Lesch)

5.1.1. Local Collection and utilisation of Upas tree

According to the results of the present study (Fig.4.1), the multipurpose local utilisation of the Upas tree (*Antiaris toxicaria* Lesch) was found to be at 66.7% in the study area. The findings are almost similar to those of Mwendwa (2016) on the utilisation of the multipurpose *Prunus Africana* (Hook.F.) Kalkman from Nandi forests, which was found to be 66% from Nandi forests by the surrounding communities. However, in both studies, the utilisation was relatively high. The findings are not also consistent with those of Andriamparany *et al.*(2014) in Madagascar with an overall high collection and utilisation of medicinal plants of 82%. According to present results, the researcher's participant observation, and conversation with the local people, this utilisation is high for such a single forest tree species, probably due its high value shown by a lot of uses found in the study area (Fig 4.2). This is not only shown by the above proportion (Fig.4.1), but also by trees cuts in the forest, a very small number of young trees in the forest, timbers from the forest's tree found in some households, houses constructed with timbers from the tree resource, and a high loss of the trees in the local area. This illustrates the pressure that local people have been putting on the forest for the tree resource, probably due to the high level of youth unemployment in the study area.

5.1.2. Local utilisation (Socio-economic importance)

Eight (8) local uses of *Antiaris toxicaria* Lesch were identified. The uses of the tree species were found to be medicinal, commercialization, cloth-making (bark cloth: Embugo), timber for construction, fertilizer, firewood, and others such as making bee canoes and charcoal. The tree is mainly essential in construction, disease treatment and income generation through commercialization.

The present study also identified various diseases that are treated by the tree resource. According to the participants' information, more than fifteen diseases were reported to be treated by Upas tree (*A. toxicaria* Lesch). The reported diseases were headache, mental illness, weakness in pregnancy, yellow fever, skin diseases (i.e. rush), wounds, cough, ulcers, Severe stomach pain during the female menstrual cycle (Ekigalanga), stomach complication (i.e. parasitic worms), diabetes, blood pressure**,** skin rash occurring amongst babies (Enoga), Ania, as well as treating poultry diseases. In addition, the tree species was used to treat Covid-19 symptoms (i.e. cough) during the covid-19 pandemic as reported by some households (8.6% of 233 respondents who answered to the question). Most tree parts used in disease treatment are stem, bark and leaves. Moreover, the tree species was reported to contribute to some households' livelihood improvement through income generation from sold timbers, medicine, and bark cloth (Embugo), medicine in households (homes), firewood, and construction at home.

Tumuhe *et al.*(2018) documented the treatment of weakness in pregnancy and headache, while Ugwoke *et al.*(2017) identified the treatment of wounds, parasitic worms, and mental illnesses. Bark cloth from *Antiaris toxicaria* Lesch was also identified in India (Umdale *et al.*, 2020). Andriamparany *et al.* (2014) also reported the medicinal importance of various tree species.

In the study of Abdourhamane *et al.*(2015), it was found that woody plants are used as wood energy, human disease treatment, livestock disease treatment, fodder, human food, woody services and handcraft. Therefore, being two different research studies on different trees, this study found similar and different uses of woody plants compared to the study of Abdourhamane *et al.* (2015). However, while some other medicinal trees such as *Prunus africana* Miller were found to be more valuable as medicine than their timbers (Galabuzi *et al.*, 2021), the findings of this new study demonstrate that Upas tree (*Antiaris toxicaria* Lesch) is more valuable as timber than medicinal source, probably due to a lack of knowledge on its medicinal importance found in various households. This study also clears the doubt that *A. toxicaria* Lesch is not a source of bark cloth as its bark is used to make the cloth (Embugo) which covers a dead person before being buried, probably making its bark the most used tree part. According to the responses from the study area, in Buganda region, dead people have to be buried in a bark cloth (Embugo) because the strong cloth preserves and keeps the remains intact in case of exhuming the body.

While many medicinal tree species are renowned for their medicinal properties, some serve multiple purposes, earning them the title of multipurpose trees. *A.toxicaria* Lesch (Figure 4.1) shares several uses with *Prunus africana* (Hook.F.) Kalkman. However, *A.toxicaria* Lesch is primarily utilised as timber for construction, contrasting with the high value of *Prunus africana* (Hook.F.) Kalkman as herbal medicine (Mwendwa, 2016; Galabuzi *et al.*, 2021). Additionally, *Pterocarpus erinaceus* Poir stands out as a multipurpose medicinal tree, notably significant in traditional medicine in Benin (Ouinsavi *et al.*, 2021). In South-Western Ethiopia, both *A.toxicaria* and *P.africana* hold economic importance for timber production from natural forests, sustaining the livelihoods of local communities in the vicinity (Seid *et al.*, 2020). Research conducted in South-Western Ghana forest reserves highlighted firewood as the predominant alternative use of medicinal trees, followed by food, timber for construction, craftwork, fodder, and other uses (Asigbaase *et al.*, 2024).

5.1.3. Association between the age of participants and utilisation of Upas tree

The findings of this study illustrates that the utilisation of Upas tree was high among middle-age people (31-43 and 44-56), with the highest utilisation within the age range of 31-43. There was no significant association (*p-value*: 0.065) between the age of participants and the utilisation of the Upas tree. The data provides a new insight that age distribution does not influence the utilisation of the tree resource. However, the findings are consistent with those of Bari *et al.* (2017).

Research on *Pterocarpus erinaceus* Poir uncovered its diverse uses, including timber, charcoal, and herbal medicine. However, the study found that the relationship between its use and participants' age was insignificant (Ouinsavi *et al.*, 2021). Conversely, a survey conducted in Yumbe district, Uganda, highlighted a notable association between the age of participants and the utilisation of the multipurpose medicinal tree species, *Afzelia africana* Sm. (Biara *et al.*, 2020).

5.1.4. Association between the level of education and utilisation of Upas tree

The utilisation of Upas tree is higher amongst community members with low education (Fig 4.4). This is probably due to limited income sources among low-educated households. They opt to use free forest resources to save on the costs of their essential needs. The results showed no association between the level of education and the utilisation of Upas tree. This provides new evidence that education level does not influence the utilisation of Upas tree. However, the findings of this study contrast the findings of Bari *et al.*(2017) who found that, a higher education level was significantly associated with the utilisation and contribution of medicinal plants. Ouinsavi *et al.* (2021) discovered a lack of significant association between the utilisation of *Pterocarpus erinaceus* Poir and the education level of respondents (p-value > 5%). Similarly, Biara *et al.* (2020) did not find a significant association between education level and the utilisation of *Afzelia africana* Sm.

5.1.5. Association between residence duration and utilisation of Upas tree

According to the presented data, the utilisation of Upas tree was found to be the highest amongst people who resided in the study area for a long time (Fig 4.5). However, the results showed a significant association between residence duration and the utilisation of Upas tree. This means that the utilisation of Upas tree is influenced by residence duration. This provides an insight into the importance of using indigenous knowledge in medicinal plant species utilisation around Mabira forest. People who resided in the study area for a long period of time, have acquired more knowledge of trees' use as the got enough time to explore the area. The findings of this study are consistent with the findings of Mhuji *et al.* (2018) which show an association between residence duration and the utilisation of medicinal plants whereby a long period residence time in village was related to an increase in collection and utilisation of medicinal plants.

5.1.6. Association between household size and the utilisation of Upas tree

The utilisation of Upas increases with a decrease in household size and the highest utilisation is amongst the smallest household size class (Fig 4.6). This is probably due to higher energy and more time of few household members enabling them to work especially in agriculture, compared to many household members. A big household size spends a very long time on taking care of many kids. According to the present results, there was no significant association between household size and the utilisation of Upas tree. The data provide an evidence that household size does not influence the utilisation of Upas tree. The study's findings are not consistent with the findings of Andriamparany *et al.* (2014) and Bari *et al.* (2017) from which family size was significantly associated with the utilisation and contribution of medicinal plants with effect on medicinal woody plants and influence on socio-economic conditions. Similarly, a significant association was found between the utilisation of *Pterocarpus erinaceus* Poir and household size (Ouinsavi et al., 2021).

5.1.7. Association between the occupation of respondents and the utilisation of Upas tree

From the results presented in Fig: 4.7, it was observed that the use of the Upas tree was highest among farmers. This is likely because farmers spend a significant amount of time working in the forest area. They have used the tree species for its various ways. However, the results showed a significant association between the occupation of participants and the utilisation of the tree resource. The data provide a new evidence that the occupational class significantly influences the utilisation of the tree resource. In the study of Ouinsavi *et al.* (2021), there was no significant association between the use of *Pterocarpus erinaceus* Poir and the occupation of participants, while farming was also the main occupation of participants.

5.1.8. Association between household monthly income and the utilisation of Upas tree

The results of this study presented a high utilisation of Upas tree amongst low income households (Fig 4.8). This is probably due to limited income sources in the study area, explaining the low income household's option to use the tree resource for different purposes as an alternative source of income as their income sources are limited. A significant association was found between household monthly income and the utilisation of Upas tree. The results provide a new evidence that the utilisation of Upas tree is affected by household income status. Household income was found not significant in the study conducted by Ouinsavi *et al.*(2021).

5.2. Disturbance Factors of Upas Tree in Mabira CFR

Numerous disturbances affecting the Upas tree in Mabira CFR were found (Fig 4.9). However, illegal tree cutting was the major worrying disturbance factor affecting the regeneration of the tree species was tree cutting (Fig 2 and photo 1). This is attributed to the low employment level in the study area, especially found amongst the young population. The results provide new information that there exists a number of different disturbance factors affecting the regeneration of the tree. Some disturbance factors (i.e. Tree cut signs, damaged fruits and seeds) were confirmed by the researcher's participant observations, which showed why Upas tree of the forest had a poor seedling regeneration status. Most of the tree species were old, big size, without or with very few seedlings or saplings. This was also observed by Tumuhe *et al.*(2018). The most cut trees were young trees (small size) probably because they are easier to cut compared to old and big ones with big size (photo 4.1). The results prove that tree cutting negatively affects Upas tree regeneration within the forest reserve. These findings confirm those of Mohammed *et al.*(2021) which highlighted illegal tree cutting of forest trees to affect tree regeneration and confirmed it as the main disturbance factor. This should be attributed to a high demand in timber and herbal medicine. The findings of this study are also supported by Ibrahim & Hassan (2015), Ugwoke *et al.*(2017), Tumuhe *et al.*(2018), Adonia (2018) and Singh *et al.*(2022) who stated that various human (anthropogenic) activities hurts the regeneration of forest plants, including trees of medicinal importance.

However, the results showed poor soil conditions and climate change to be among the factors affecting tree regeneration. The present study could not confirm the reliability of the two factors since they were obtained from a survey (participants' views). This means that neither climate change nor soil conditions were assessed.

5.3. Macropropagation of Upas tree (*A. toxicaria* Lesch)

The results presented the highest survival percentage of 15% in the cutting medium composed of soil and sand, without sprouting and rooting. The findings of this experiment differ from those of other medicinal trees such as *Cotylelobium melanoxylon* (Hook.f.) Pierre with a survival percentage between 70 and 90% (Susilowati *et al.*, 2020), *Dryobalanops aromatica* C.F.Gaertn. of which survival percentage was 50-80% (Susilowati *et al.*, 2018), and *Strychnos henningsii* (gilg), whose survival proportion was found to be 67.31% (Kipkemoi *et al.*, 2013), which showed a high and significant survival, sprouting and rooting percentage. Another low survival rate was observed in a medium made of a combination of forest topsoil, sand and charcoal dust with a survival percentage of 10%, without sprouting and rooting.

However, the best survival and sprouting proportion was observed in only forest top soil, followed by a combination of the soil, sand, charcoal dust, and saw dust without rooting in the two cutting media. In macropropagation, some cuttings can sprout and survive for some time without rooting, while using their stored energy. The average high survival and sprouting within the forest top soil is probably due to the ability of the soil to keep higher humidity compared to other cutting media containing sand, which possesses a high permeability, hence unable to keep enough moisture. Though these media presented the highest survival and sprouting percentage during this experiment, the percentage is too low compared to other findings from different research studies. In the macropropagation of *Strychnos henningsii* (gilg), a higher survival and rooting percentage was found in the medium of forest topsoil when cuttings were treated with various rooting hormones at different concentrations. This presented a successful macropropagation in the medicinal tree species (Kipkemoi *et al.*, 2013). The overall survival, sprouting, and rooting of cuttings is 15 % (24/160 cuttings), 3.75 % (6/160 cuttings), and 0 % (0/160 cuttings), respectively. The survival and sprouting rates, without rooting, were found to be too low for the propagation of *A. toxicaria* Lesch probably due to the indirect planting of cuttings after their collection. The rooting hormone (Seradix 2) did not affect the rooting system of the treated cuttings, as shown by the absence of roots (0%) on the cuttings in all the cutting media, probably due to a short period of the experiment and inappropriate concentration of the rooting hormone. The lack of effect of commercial rooting hormones was also observed in the macro propagation of *Erythrina americana* Miller (Fehling-Fraser & Ceccon, 2015).

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes essential elements, conclusions, recommendations, and areas for further research according to the objectives of the study.

6.1. Summary

The present research study revealed the Upas tree (*A.toxicaria* Lesch) as a multipurpose tree, which is mainly used as timber for construction and medicine to treat or prevent various diseases. The findings showed a high utilisation (66.7%) of the tree resource in the study area, while some socio-economic factors were found to be associated with the utilisation of the tree.

However, the research findings also provided information about the disturbance factors which affect the seedling regeneration of Upas tree in Mabira CFR, whereby illegal tree cutting and forest degradation are the main contributing factors.

The macropropagation feasibility assessment of *A. toxicaria* Lesch showed that forest top soil and a combination of the soil, sand, charcoal dust, and saw dust were good cutting media with at least a low survival and sprouting proportions. According to this experiment, the best cutting medium was the forest topsoil. The rooting hormone (Seradix 2) had no effect on the rooting system of the treated cuttings.

6.2. Conclusions

Residence duration, household occupation, and household monthly income were significantly associated with the utilisation of Upas tree (*Antiaris toxicaria* Lesch), and influencing such utilisation. Other socio-economic factors were not significant. The findings provide information on the use of the tree species and suggest a sustainable socio-economic utilisation of the tree species by reducing socio-economic influences.

Several disturbance factors were identified. Forest degradation and illegal tree cutting were the most worrying factors, while illegal cutting mostly affected the regeneration of the tree species. Therefore, the present study provides information on the disturbance factors of the Upas tree. The findings are important tools to minimize the disturbance factors of the plant species.

The lack of roots on all tree cuttings showed an unsuccessful experiment, although some cuttings could sprout and survive for some time. Consequently, the vegetative propagation of Upas tree by shooting is not feasible, unless the experiment is improved to stimulate root formation, and increase cutting survival and sprouting frequencies. The macropropagation experiment showed poor results, which cannot be directly used for a vegetative propagation of the tree species unless the experiment is improved. Instead, the provided information should be used as a reference for that improvement. The improved experiment will contribute to an increase in the propagation of Upas tree, hence a sustainable utilisation, livelihood improvement, and conservation of the tree species.

6.3. Recommendations

1. NFA and local government authorities, should minimize the socio-economic influences that would affect a sustainable socio-economic utilisation of not only the Upas tree (*A.toxicaria* Lesch), but also the Mabira CFR. This should be done by putting more effort into protection of Mabira CFR, promoting tree domestication, and more local job creation.

2. NFA should put more effort in managing Mabira CFR through its protection, promoting tree domestication, and forest restoration. It should focus on essential tree species such as Upas tree among others. Sensitization about the importance of the forest, more job creation, and the promotion of education in the study area should also minimize disturbances of important trees and the forest reserve. Furthermore, engaging more local communities in managing the forest reserve will have a positive impact.

3. During other macropropagation experiments, cuttings should be treated with different rooting hormones such as IBA, IAA, NAA, and Seradix at various concentrations for a higher rooting enhancement for its successful propagation. Other elements (i.e. manure/compost) should be added to cutting media to improve the experiment and cuttings should be directly planted just after their collection. The cutting media: forest top soil and a combination of forest topsoil, sand, charcoal dust, and saw-dust should be used for further research. In addition, a more significant number of cuttings per medium should also contribute to the success of the macropropagation of this tree species.

6.3.1. Areas for further research

Future research is needed to study the socio-economic and disturbance factors associated with using other important medicinal tree species of the forest to assess their local uses as the forest reserve is getting thinner

The effects of environmental factors (e.g., climate change, etc) on the regeneration and growth of tree species should be studied. Physiological studies of the Upas tree (*A. toxicaria* Lesch) are needed to understand more about the internal physical and chemical processes that might affect the growth of the tree species, especially when they are combined with external (environmental) factors.

Further research should also study the propagation of the Upas tree by using different propagation techniques such as micropropagation to promote the propagation of the tree species.

REFERENCES

Abdourhamane, H., Morou, B., Larwanou, M., Mahamane, A., Saadou, M., & Ronald, B. (2015). Uses and preferences of woody species in two protected forests of Dan Kada Dodo and Dan Gado in Niger. *Journal of Horticulture and Forestry*, *7*(6), 149–159. https://doi.org/10.5897/jhf2014.0374

Adonia, B. K. K. (2018). *Threats to conservation of Mt. Moroto Central Forest Reserve and their effects on the livelihoods of Tepeth people in Moroto District, Uganda. 2015*.

Andriamparany, J. N., Brinkmann, K., Jeannoda, V., & Buerkert, A. (2014). Effects of socio-economic household characteristics on traditional knowledge and usage of wild yams and medicinal plants in the Mahafaly region of south-western Madagascar. *Journal of Ethnobiology and Ethnomedicine*, *10*(1). https://doi.org/10.1186/1746-4269-10-82

Asigbaase, M., Adusu, D., Ayeley, A., Anaba, L., Nsor, A., Abugre, S., & Derkyi, M. (2024). Heliyon Ethnobotanical and ethnopharmacological survey of medicinal tree species used in the treatment of diseases by forest-fringe communities of Southwestern Ghana. *Heliyon*, *10*(1), e23645. https://doi.org/10.1016/j.heliyon.2023.e23645

Bai, X., Yang, L., Tian, M., Chen, J., Shi, J., Yang, Y., & Hu, X. (2011). Nitric Oxide enhances desiccation tolerance of recalcitrant antiaris toxicaria seeds via protein S-nitrosylation and carbonylation. *PLoS ONE*, *6*(6). https://doi.org/10.1371/journal.pone.0020714

Bari, M. R., Ali, M. A., Miah, M. G., Abbdullah, M. R., & Uddin, M. J. (2017). Medicinal plants and their contribution in socio economic condition of the household in Haluaghat upazila, Mymensingh. *International Journal of Business Management and Social Research*, *4*(1), 215–228. https://doi.org/10.18801/ijbmsr.040117.25

Biara, E., Egeru, A., & Mensah, S. (2020). Value and traditional knowledge in Uganda : implications for sustainable management. *Environment, Development and Sustainability*, *0123456789*. https://doi.org/10.1007/s10668-020-00673-6

Chen, S. L., Yu, H., Luo, H. M., Wu, Q., Li, C. F., & Steinmetz, A. (2016). Conservation and sustainable use of medicinal plants: Problems, progress, and prospects. *Chinese Medicine (United Kingdom)*, *11*(1), 1–10. https://doi.org/10.1186/s13020-016-0108-7

Chokheli, V. A., Dmitriev, P. A., Rajput, V. D., Bakulin, S. D., Azarov, A. S., Varduni, T. V., Stepanenko, V. V., Tarigholizadeh, S., Singh, R. K., Verma, K. K., & Minkina, T. M. (2020).

Recent development in micropropagation techniques for rare plant species. *Plants*, *9*(12), 1–21. https://doi.org/10.3390/plants9121733

Fehling-fraser, T. C., & Ceccon, E. (2015). *Macropropagation of*. *21*(Apa 6), 5–16. https://doi.org/10.5154/r.rchscfa.2014.04.016

Galabuzi, C., Agaba, H., & Eilu, G. (2021). Farmers' Perceptions, Socio-economic and Political Stakes: What Inspires the Integration of Prunus africana On-Farms in Central Uganda? *Small-Scale Forestry*, *20*(3), 371–389. https://doi.org/10.1007/s11842-021-09472-x

Gliniars, R. (2011). Tree Growth and Tree Regeneration in Two East African Rain Forests as related to the Abiotic Environment after Human Disturbance. *Dissertation, University of Hohenheim, Germany*, *210*, 1–198. opus.ub.uni-hohenheim.de

Hamilton, A. C., Karamura, D., & Kakudidi, E. (2016). History and conservation of wild and cultivated plant diversity in Uganda: Forest species and banana varieties as case studies. *Plant Diversity*, *38*(1), 23–44. https://doi.org/10.1016/j.pld.2016.04.001

Ibrahim, E. M., & Hassan, T. T. (2015). Factors affecting natural regeneration and distribution of trees species in El-Nour natural forest reserve. *Journal of Natural Resources & Environmental Studies*, *3*(3), 16–21.

Kipkemoi, N. R., Kariuki, N. P., Ngumi, P., Wambui, V., Justus, O., & Jane, K. (2013). *Macropropagation of an endangered medicinal plan, Strychnos henningsii (gilg), (loganiaceae) for sustainable conservation*. *2*(7), 247–253.

Lanker, U., Malik, A. R., Gupta, N. K., & Butola, J. S. (2010). Natural regeneration status of the endangered medicinal plant, Taxus baccata Hook. F. syn. T. wallichiana, in northwest Himalaya. *International Journal of Biodiversity Science, Ecosystem Services and Management*, *6*(1–2), 20–27. https://doi.org/10.1080/21513732.2010.527302

Logiel, A., Jørs, E., Akugizibwe, P., & Ahnfeldt-Mollerup, P. (2021). Prevalence and socio-economic factors affecting the use of traditional medicine among adults of katikekile subcounty, moroto district, Uganda. *African Health Sciences*, *21*(3), 1410–1417. https://doi.org/10.4314/ahs.v21i3.52

Mbatudde, M. (2014). (PhD Thesis). Predictive Spatial-Temporal distribution of selected tree species and their current genetic structure in East Africa. P 65-66.

Mhuji, K., Barakaeli, A. N., Dickson, M., & Paulo, O. O. (2018). Evaluation of socio-economic factors influencing exploitation of non-timber forest products in Tanzania. *International Journal of Biodiversity and Conservation*, *10*(8), 330–336. https://doi.org/10.5897/ijbc2018.1198

Ministry of water and environment. (2017). Revised forest management plan for Mabira central forest reserves. *Uganda Government Printer*, *2020*(July 2010-June 2020), 191.

Ministry of Water and Environment. (2020). Mabira central forest reserves. *Revised Forest Management Plan*, *2020*(6), 67.

Mirgal, A. B., Gunaga, R. P., & Salunkhe, C. B. (2016). Seed traits, germination pattern and seedling vigour in Antiaris toxicaria (Pers.) Lesch, a rare plant species of Western ghats. *Journal of Applied and Natural Science*, *8*(3), 1710–1713. https://doi.org/10.31018/jans.v8i3.1027

Mohammed, E. M. I., Hassan, T. T., Idris, E. A., & Abdel-Magid, T. D. (2021). Tree population structure, diversity, regeneration status, and potential disturbances in Abu Gadaf natural reserved forest, Sudan. *Environmental Challenges*,*5*(August). https://doi.org/10.1016/j.envc.2021.100366

Mwendwa, K. (2016). *Indigenous Knowledge, Uses and Conservation of Prunus africana (Hook. F.) Kalkman in Nandi Forests*. *Figure 1*, 56–62.

Nahayo, A., Ekise, I., & Niyigena, D. (2013). Assessment of the contribution of Non Timber Forest Products to the improvement of local people's livelihood in Kinigi sector, Musanze District, Rwanda. *Ethiopian Journal of Environmental Studies and Management*, *6*(6), 698–706. https://doi.org/10.4314/ejesm.v6i6.13

Obakiro, S. B., Kiprop, A., Kowino, I., Kigondu, E., Odero, M. P., Omara, T., & Bunalema, L. (2020). Ethnobotany, ethnopharmacology, and phytochemistry of traditional medicinal plants used in the management of symptoms of tuberculosis in East Africa: A systematic review. *Tropical Medicine and Health*, *48*(1), 1–21. https://doi.org/10.1186/s41182-020-00256-1

Ofori, D. A., Darko, O. B., Gyimah, A., Adam, K. A., Jimoh, S. O., & Jamnadass, R. (2012). *BR AR Socioeconomic survey AR*. 29–38.

Onefeli, A. O., & Akinyele, A. O. (2014). *Macropropagation of Dennettia tripetala Baker f* . *5*(2), 135–144.

Orwa et al.(2009). *Antiaris toxicaria Leschenault Moraceae Antiaris toxicaria Leschenault*.1–5.

Ouinsavi, C., Nawan, B., Sourou, K., Wédjangnon, A. A., Houêtchégnon, T., Akin, Y., & Dossou, J. (2021). *Traditional uses of African rosewood (Pterocarpus erinaceus Poir. Fabaceae) through the sociolinguistic groups and the pathways of conservation and sustainable management in Benin*. *13*(December), 200–213. https://doi.org/10.5897/IJBC2021.1509

Porchselvi, C., & Muthulakshmi, S. (2018). *Pharmacognostic and phytochemical evaluation of Antiaris toxicaria (Pers). Lesch*. *6*(6), 217–221.

Romanus, P. C., Mendes, F. R., & Carlini, E. de A. (2018). Factors affecting the use of medicinal plants by migrants from rural areas of Brazilian Northeast after moving to a metropolitan region in Southeast of Brazil. *Journal of Ethnobiology and Ethnomedicine*, *14*(1), 1–25. https://doi.org/10.1186/s13002-018-0270-3

Seid, M. A., Mulatu, Y., Anjulo, A., Ayalew, S., Belay, H., Nigatu, M., & Kebede, W. (2020). Population survey of *Milicia excelsa*, Pouteria adolfi-fridercii, *Antiaris toxicaria* and *Prunus africana* in south and south-western Ethiopia: implications for domesticating and establishing Seed Production Areas. *MOJ Ecology & Environmental Sciences*, *5*(4), 153–162. https://doi.org/10.15406/mojes.2020.05.00188

Singh, P. K., Prajapati, S. K., Sunita, K., & Chaturvedi, R. K. (2022). Disturbance Induced Changes in Diversity of Medicinal Plants in a Dry Tropical Forest of India. *Frontiers in Forests and Global Change*, *4*(February), 1–12. https://doi.org/10.3389/ffgc.2021.718930

Sofowora, A., Ogunbodede, E., & Onayade, A. (2013). The role and place of medicinal plants in the strategies for disease prevention. *African Journal of Traditional, Complementary, and Alternative Medicines : AJTCAM / African Networks on Ethnomedicines*, *10*(5), 210–229. https://doi.org/10.4314/ajtcam.v10i5.2

Subiono, T., Abadi, L., Himawan, T., & Utomo, E. P. (2017). *Ligan Activity of Antiaris toxicaria Lesch . and the Role of Toxicarioside in Crude Extract : In Silico , In Vitro , and In Vivo Approaches*. *3*(6), 4–10. https://doi.org/10.9790/264X-03060410

Susilowati, A., Hartini, K. S., Elfiati, D., Rachmat, H. H., Kusuma, Y. S., Zulham Efendi Sinaga, M., & Suhartati, T. (2020). Conservation of tropical tree biodiversity through macropropagation by shoot cutting of Raru (Cotylelobium melanoxylon), a highly utilized dipterocarp in North Sumatra, Indonesia. *Biodiversitas*, *21*(2), 724–730. https://doi.org/10.13057/biodiv/d210239

Susilowati, A., Kholibrina, C. U. T. R., & Rachmat, H. H. (2018). *Short Communication : Macropropagation – An important tool for conservation of North Sumatran endangered tree species, Dryobalanops aromatica*. *19*(5), 1672–1675. https://doi.org/10.13057/biodiv/d190511

Tiwari,S.K.,Krishnamurthy, G.,Pandey,A.,Goswami,M.P.,&Saini,P.(2016).Standardization of clonal macropropagation protocol of *Dillenia pentagyna* Roxb,an important and endangered medicinal tree species through stem branch cuttings.*J Biotechnol Biomater, 6:2*

Tripathi, A., Kumar Shukla, J., Gehlot, # Ashok, & Mishra, D. K. (2016). Condensed node proliferation technique (CNPT): a better low cost macro-propagation approach through mini-cuttings of Commiphora wightii (Arn.) Bhandari an endangered plant of Indian Thar Desert. *Adv. For. Sci, 4*, 65–69.

Tugume, P., Kakudidi, E. K., Buyinza, M., Namaalwa, J., Kamatenesi, M., Mucunguzi, P., & Kalema, J. (2016). Ethnobotanical survey of medicinal plant species used by communities around Mabira Central Forest Reserve, Uganda. *Journal of Ethnobiology and Ethnomedicine*, *12*(1), 1–29. https://doi.org/10.1186/s13002-015-0077-4

Tumuhe, C., Mwine, R., & Manana, S. (2018). Population Structure and Regeneration Status of Most Abundant Medicinal Woody Plants in Mabira Central Forest Reserve Management Zones. *Environment, Earth and Ecology*, *2*(1), 6–11. https://doi.org/10.24051/eee/84900

UBOS. (2014). Uganda National Population and Housing Census 2014. Revised Edition. *Uganda Bureau of Statistics*, Appendix I: Page 21. http://search.tb.ask.com/search/GGmain.jhtml?

Ugwoke, C., Anze, S., Nweze, A., & Obisike, C. (2017). Pharmacognostic Evaluation of the Leaf of Antiaris Toxicaria (Family: Moraceae). *International Journal of Pharmaceutical Sciences and Research,8,* 2696–2700. https://doi.org/10.13040/IJPSR.0975-8232.8 (6).2696-00

Umdale, S. D., Mirgal, A. B., Shinde, B. N., Sawant, R. S., Salunkhe, C. B., & Gaikwad, N. B. (2020). Evaluation of Genetic Diversity in Antiaris toxicaria Lesch. From Sacred Groves of the Western Ghats, India. *National Academy Science Letters*, *43*(4), 383–388. https://doi.org/10.1007/s40009-020-00878-3

Wendime Gemechu, H., & Bekele Jiru, D. (2021). Review on Factors Affecting Regeneration of Indigenous Tree Species in Ethiopia. *European Journal of Biophysics*, *9*(1), 24. https://doi.org/10.11648/j.ejb.20210901.14

Yadav, K., Singh, N., & Verma, S. (2012). Plant tissue culture: a biotechnological tool for solving the problem of propagation of multipurpose endangered medicinal plants in India. *Journal of Agricultural Technology*, *8*(1), 305–318.

Zegeye, H., Teketay, D., & Kelbessa, E. (2011). Diversity and regeneration status of woody species in Tara Gedam and Abebaye forests, north-western Ethiopia. *Journal of Forestry Research*, *22*(3), 315–328. https://doi.org/10.1007/s11676-011-0176-6

APPENDICES

Appendix 1. Survey questionnaire

Introduction (with a consent)

Good morning/afternoon. My name is **Emmanuel NTAWUBIZIGIRA,** a student from Kyambogo University. I am conducting an academic research to study the socio-economic utilisation of a medicinal plant species called **"KILUNDU"** (*Antiaris toxicaria* Lesch): **UPAS TREE** of Mabira Central Forest Reserve. This research will help people living around or in the forest reserve to sustainably use the plant species for livelihood improvement, for both economy and health.

If you would like to participate in this study, I will ask you some questions about utilisation of Upas tree. This survey will take about 10-15 minutes. By participating in this study, you will help to conservation of the plant resources. Your name will not appear anywhere. The information you provide will be confidential and will only be used for this study.

Thank you for your time and cooperation. I appreciate your assistance in supporting this effort to complete this research study.

Do you agree to participate in the survey? **YES** ☐ **NO** ☐

SECTION 1: DEMOGRAPHIC INFORMATION

1.1. Identification

1.1.1. District: BUIKWE

1.1.2. Sub-county: ……………………….. **1.1.3. Village:** ………………

1.1.4. Participant (household head)'s identity (Eg: HH_1, HH_2, etc.**):** ……….………..

1.1.5. Household's GPS coordinates: …………………………………………………

1.1.6. Participant's phone number: …………………………………………………….

1.2. Socio-economic factors

1. **Gender** (Sex) (Household head):	2. **Age (in years):**	3. **Marital status**	4. **Education level**
-a. Male(**M**) ☐ **-b.** Female(**F**) ☐	**-a)** 18-30 ☐ **-b)** 31- 43 ☐ **-c)** 44-56 ☐ **-d)** 57 and Above ☐	**-a)** Single ☐ **-b)** Married ☐ **-c.**)Widowed ☐ **-d)**Other (specify): ☐	**-a)** No formal education ☐ **-b)** Primary ☐ **-c)** Secondary ☐ **-d)** Certificate ☐ **-e)** Diploma ☐ **-f)** Degree ☐

5.Residence duration (years)	6.Household size (number of family or household members):	7.Occupation
-a) 0-5 ☐ - b) 6-11 ☐ -c) 12-17 ☐ - d) 18 and Above ☐	- a) 1-4 ☐ -b) 5-8 ☐ -c) 9 and Above ☐	-a. Jobless ☐ -b. Farmer ☐ -c. Employed ☐ -e. Business person(self-employed) ☐ - f. Other (specify): ☐

8.Distance from Mabira CFR	9.Family income level(monthly): Ugx
-a. Living within 500m ☐ - b. 500m- 1 Km ☐ - c. Beyond 1 Km ☐	- a) 1.00-100,000 ☐ -b) 101,000-200,000 ☐ -c) 201,000-300,000 ☐ -d) 301,000-400,000 ☐ -e) 401,000-500,000 ☐ -f) 501,000 and Above ☐

SECTION2: COLLECTION AND UTILISATION OF UPAS TREE (*A. toxicaria* Lesch) PARTS.

Q1. Do you know a tree species called Upas tree "KILUNDU"?

- 1. Yes ☐ - 2. No ☐

Q2. If YES, have you ever collected and used at least one of its parts such as leaves, fruits, flowers, bark, etc?

-1. Yes ☐ -2. No ☐

Q3. What are your reasons to collect and use this tree or its parts?

-1. ……………………………………………………………………………………………..

- 2. ……………………………………………………………………………………………..

- 3. ……………………………………………………………………………………………..

- 4. ……………………………………………………………………………………………..

- 5. ……………………………………………………………………………………………..

Q4. Which of the following parts did you collect?

-1. Fruits ☐ - 4. Roots ☐ -8.None ☐

-2. Leaves ☐ -5. The whole plant ☐

-3. Flowers ☐ -6. The Bark ☐

-7. Other part if any (specify):

Q5. What is the utilisation (use) of the collected tree part?

1) Treatment of some human diseases in your family. Specify the disease(s) treated by the following plant parts in this district, especially in your sub-county:

a. Fruits: 1……………………2……………………3……………………4………………

b. Leaves: 1……………………2……………………3……………………4……………..

c. Flowers: 1……………………2……………………3……………………4…………….

d. Roots: 1……………………2……………………3……………………4………………

e. Stem Bark: 1…………………2……………………3……………………4………………

2) Treatment of livestock diseases - (Specify): ……………………………………

3) Commercialization (collection and selling for cash income as medicines or firewood, etc)

4) Food source

5) To make clothes

6) To make bee canoes

7) Making Mvule

8) Construction of houses

9) Others if any (specify): ………………………………………

Q6. Is this tree or its parts collected as firewood? **- a.** Yes **- b.** No

Q7. Was this tree used during Covid-19 pandemic to treat some respiratory symptoms of this virus? -YES -NO

Explain………………………………………………………………………………………
………………………………………………………………………………………………
……………………………………………………………………………………..

Q7. Is there any contribution of this plant to your family's livelihood improvement? Explain…………………………………………………………………………………….

……………………………………………………………………………………………..

……………………………………………………………………………………………..

SECTION 3. DISTURBANCE FACTORS AFFECTING SEEDLING REGENERATION OF KILUNDU (*A. toxicaria* Lesch).

It is known that Kilundu brings flowers and fruits but this plant species of Mabira CFR has no or has very few seedlings (plantlets coming from germinated seed of fallen fruits) around the plant species.

Q1. Have you ever seen the seedlings of this tree species (Kilundu) within this forest?

1. Yes ☐ 2. No ☐

Q2. If yes, were the seedlings enough compared to the quantity of fruits that were on the tree? - 1. Yes ☐ -2. No ☐

Q3. If No, what do you know or think are the causes of the lack of or having few seedlings?

- 1. ………………………………………… - 2. ……………………………………….
- 3. ………………………………………… - 4. ………………………………………..

Q4. Select among the following statements, the cause of the lack or having very few seedlings by the tree species (Kilundu):

1. Animals eating the fallen fruits ☐ - (Specify the animal(s)): ………………………
2. People who collect the fallen fruits, leaves or roots from immature seedlings ☐
3. Grazing (or fodder for) animals from communities around the forest, grazing on seedlings ☐
4. Tree cutting ☐
5. Poor soil conditions ☐
6. Climate change ☐
7. Forest degradation ☐
8. Agriculture (encroachment)

7. Others (specify): a) ………………….. b) ………………… c)………………

Q5. KILUNDU (Upas Tree: *A. toxicaria* Lesch) is a very important tree species in Mabira CFR. What do you think can be done to conserve this plant?

1………………………………………………

2………………………………………………….

3……………………………………………………..

4………………………………………………………..

Q6. Mabira CFR is important for households (families) living adjacent or within the forest. **According to your observations from past years, how has been the forest? Did you see any change to the forest (in terms of forest cover area or forest resources production)?**

Any change about this tree species? Explain

a)Kilundu:………………………………………………………………………………………
……………………………………………………………………………………
b)Forest:…………………………………………………………………………………………
…………………………………………………………………………………………….

Q7. Is there any local policies, law or regulations preventing people to access Mabira CFR, especially for collecting resources from Kilundu (*A.toxicaria* Lesch)? What are they? Explain.

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………….

Q8. According to you, what should be done in order to conserve the forest as well as people keep getting forest resources from it, especially resources from Kilundu (*A. toxicaria* Lesch)?

....
....
....
....

NOTE: <u>The next section is only for the researcher</u>

SECTION 4: OBSERVATIONS DURING THE RESEARCH STUDY

Q9. Notes and observations within the study area during the research study

a) Are there people harvesting the tree resource during the survey time? **-**YES ☐ -NO ☐

b) Are there trees falling/cut? **-**YES ☐ - NO ☐

c) Were there grazing animals? -YES ☐ -NO ☐

d) Were there people farming near or within the forest reserve? **-**YES ☐ - NO ☐

e) Were there some people selling the plant tree's resources or their derivatives at local markets?

YES ☐ NO ☐

f) Others, if any ☐

Thank you so much!

- THE END!

Appendix 2. Introductory letter

KYAMBOGO UNIVERSITY

P. O. BOX 1 KYAMBOGO
Tel: 041 - 4286792 Fax: 256-41-220464
Website :www.kyu.ac.ug, Email: drgt@kyu.ac.ug

Directorate of Research and Graduate Training

Office of the Director

Date: 13/7/2023

TO WHOM IT MAY CONCERN

RE: Emmanuel NTAWUBIZIGIRA........

Dear Sir/Madam,

This is to introduce to you the above named student Reg: No 20/X/GMSM/13989/PD pursuing MSc IN CONSERVATION AND NATURAL RESOURCE, MANAGEMENT Department of ...BIOLOGICAL.....SCIENCES........., Kyambogo University.

She/he intends to carry out research on SOCIO-ECONOMIC UTILIZATION AND MACRO PROPAGATION OF UPAS TREE (Antiaris toxicaria Lesch): MABIRA CFR. in partial fulfillment of the requirements for the award of MASTER OF SCIENCE IN CONSERVATION AND NATURAL RESOURCE MANAGEMENT DEGREE OF KYAMBOGO UNIVERSITY.

The purpose of this letter therefore is to request you to grant him/her permission to carry out his/her study in your institution.

Any assistance rendered to him/her will be highly appreciated.

KYAMBOGO UNIVERSITY
13 JUL 2023
DIRECTOR
DIRECTORATE OF RESEARCH AND GRADUATE TRAINING

Yours sincerely,

Prof. Bosco Bua
AG. DIRECTOR

Appendix 3.Research licence/permit

NFA

National Forestry Authority

The National Forestry and Tree Planting Act, 2003

(Act 8, Section 41-Laws of Uganda)

PROVISIONAL LICENSE TO CARRY OUT RESEARCH IN A CENTRAL FOREST RESERVE (Not Transferable)

License No 375 **Date Prepared** 26-Aug-22 **Forest Management Zone/ Range:** LAKESHORE

Subject to the conditions of the National Forestry and Tree Planting Act, 2003 and any Regulations made under the Act and to the terms and conditions stated in this License:

M/s. NTAWEBIZIGIRA EMMANUEL of P.O.BOX 1, KYAMBOGO

Telephone: 0756340263 is authorised to carry out research in: LWANKIMA

Central Forest Reserves for the period 01-Sep-22 to 30-Sep-22

Details of lincensed activities

Sector(s)	Description of activity	No. Applicants	Period (Months)	Rate	Amount payable: (UGX)	(USD)
LWANKIMA	Scio-economic utilization and tissue culture of Barkcloth tree (Antiaris Toxicaria Lesch)	1	1	20,000	20,000	
Application fee for the research:					20,000	
TOTAL (Including application fee)					40,000	

Note:

Amount received (UGX): 40,000 (USD) Receipt No 288878

APPROVED BY THE DIRECTOR NATURAL FOREST MANAGEMENT

Signature: .... Name TOM RUKUNDO

AUTHORIZED BY THE EXECUTIVE DIRECTOR

Signature: ....6/9/2022.......... Name TOM O. OKELLO

Additional special conditions are attached.

** Applicable for all activities except harvesting and land licences*