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Utilisation and population structure of tree species in agroforestry parklands of Kapelebyong district, north eastern Uganda

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Abstract

The study was carried out in the subsistence agroforestry parklands of Kapelebyong district, Eastern Uganda to establish the diversity of tree species, uses, management practices, harvesting techniques and tree population structure. Data was collected using a semi-structured questionnaire administered to 60 farmers and field survey of 60 ha. of subsistence parklands. The identity of tree, uses, management practices, harvesting techniques and diameter at breast height (dbh) were captured during the survey. The voucher specimens were identified at Makerere University Herbarium. Qualitative data was collated into frequencies and presented using tables and figures. The Shannon diversity and equitability indices were used to analyze the diversity of tree species and evenness respectively. The established an inventory of 43 tree species in 18 families. The parklands have a species diversity index of H'=3.23, an evenness of 0.86 and a mean density of 5.7 trees ha^{-1}. The most prevalent species are Combretum collinum (10.8%), Vitalleria paradoxa (8.2%), Mangifera indica (7.9%) and Combretum adenogonium (7.4%). The prevalent benefits obtained from the trees include firewood, fruits, timber and shade. Nearly half of the farmers (49.0%) learnt to preserve trees on farms from their parents while 2.0% reported that they were obliged by by-laws. The prevalent tree management practices in the parklands are weeding (41.7%) and pruning (40.2%). The products are harvested mainly by pruning (28.0%), picking from tree (mainly fruits and leaves) (23.5%), felling (22.5%) and collecting from the ground (mainly fruits) (20.0%). Pseudocedrelakotyschi, Buchinia thonningii, Combretum collinum and Vitalleria paradoxa have more individuals in the lower class distributions hence positive regeneration trends. We recommend that the management of parklands in this area be enhanced through provision of forestry extension services, awareness and information dissemination as well as provision of tree planting material. This can further be enriched by research to quantify the impact of parkland trees on crop productivity, carbon sequestration and incentives for farmers to maintain trees.

Keywords: Utilization, population structure, trees, agroforestry parklands, Uganda.

Introduction

Agroforestry parklands are traditional land-use systems characterized by scattered mature trees on cultivated or recently fallowed landscapes[1]. The trees enhance landscape connectivity, reduce pressure on forests, and provide habitat for animals and pollinators[1]; enhance soil fertility, conserve water and protect the environment[1]. In addition, they provide timber and fuel wood, improve nutrition (fruits, nuts and leaves) and provide fodder for livestock[1,2]. The indigenous trees also deliver diverse environmental services[3] with greater effectiveness than do plantations of exotic species[4]. The parklands can also mitigate climate change through creation and enhancement of carbon sinks[5]. Therefore, parklands have social, economic and environmental benefits[6] which can address the twin objectives of biodiversity conservation and livelihoods[7].

Despite the benefits derived from parklands, they face threats from anthropogenic activities. In Uganda, the indigenous trees in the parklands are increasingly over-exploited for fuel wood (charcoal and firewood) and other materials[8,9]. Additionally, they are being replaced by exotic tree species in most tree planting initiatives and agricultural landscapes[10,11]. The proliferation of exotic species makes the local communities vulnerable to health, nutrition and income adversities[2]. They also reduce the heterogeneity and suitability of the habitat for other flora and fauna. In Burkina Faso, the parklands' physiognomy shows lack of regeneration due to short and suppressed fallow periods[12].

For a long time, the conservation of biodiversity in the tropics has been focused on the protection of natural forests and woodlands[13]. Conversely, less attention has been accorded to the widely dispersed woody species on farm[6]. This resonates with calls to base conservation approaches on wider conservation landscapes which include mosaics of multiple land use[1]. Thus, the prerequisite to optimizing the value of farmlands is to monitor the structure of species therein[12]. Therefore, the present

study sought to establish the diversity, uses, relative representation and regeneration trends of tree species in the parklands of Kapelebyong district, Eastern Uganda. Additionally, the study sought to ascertain the parkland management and tree harvesting techniques. The findings of this study underscore the value of parklands in fulfilling the twin objectives of conservation and livelihoods, and offer insights for evidence-based management these landscapes.

Materials and Methods

Study area: The study was conducted in the sub-humid dry lands of Kapelebyong district, North Eastern Uganda where 91.9% of the households are involved in subsistence crop growing[14] (Figure-1). The major crops grown in this area include millet, rice, sorghum, cowpeas, groundnuts, green grams, cassava and sweet potatoes. There is also livestock rearing (cattle, goats and sheep) and poultry.

The survey was specifically conducted in three sub-counties namely Obalanga, Alito and Okungur. This area is located between 33°30'E to 33°45'E and 2°24'N to 2°45'N. The vegetation is predominantly savannah dominated by *Combretum* species and *Vitalleria paradoxa* and punctuated by seasonal as well as permanent streams. The area experiences a humid and hot climate with 1000-1350mm of rainfall and 18-31.3^{0}C temperature[15].

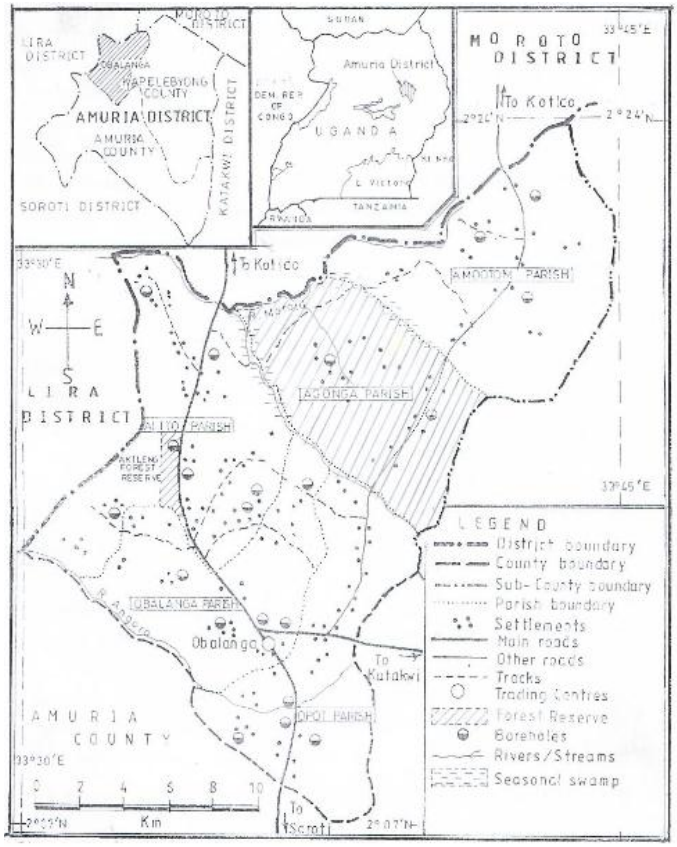

Figure-1: Location of Obalanga, Amootom/Okungur and Alito sub-counties, north eastern Uganda.

Data collection: The study targeted 60 farmers in 12 registered farmer groups in the sub-counties of Obalanga, Okungur and Alito, Kapelebyong district. The files of these groups were accessed from the respective sub-counties and a meeting was arranged with all group chairpersons to brief them on the research objectives. Thereafter, five members in each group were interviewed in their respective villages (homesteads). A village is the lowest administrative unit in Uganda under the local government structure. A semi-structured questionnaire was administered to each farmer in the field (parkland). The questionnaire elicited information on the number and identity of trees, source of knowledge on tree preservation or planting on farm, benefits derived from trees, management of trees and mode of harvesting tree products. Thereafter, the voucher specimens of the trees were collected, pressed and identified at Makerere University Herbarium. The diameter at breast height (dbh) of all the trees in 1 ha. parkland was measured using a dbh meter (800-647-5368, Jackson, MS, Germany). The tree stamps were not included in the measurement.

Data analysis: Qualitative data was collated, analysed using descriptive statistics and presented using figures and tables. The diversity of tree species in the parklands was computed using the Shannon weaner index using the formula

$$H' = -\sum_{i-1}^{s} pi \ln pi$$

where p is the proportion (n/N) of individuals of a particular species (n) divided by the total number of individuals (N), and *s* is the number of species. Shannon's equitability (E_H) was calculated following Krebs[17] procedure namely; dividing H by H_{max} (here H_{max} =lnS) using the formula E_H= H / H_{max} = H lnS.

Equitability assumes a value between 0 and 1 whereby 1 represents complete evenness. The dbh of individuals in each species were grouped into diameter classes at increments of 10 cm. This was presented using frequency histograms for both diameter and class distributions. Thereafter, the regeneration status was assessed from the shape of the histogram.

Results and discussion

Diversity of tree species: The study established an inventory of 43 tree species in 18 families (Table-1). Only 9 species (21.4%) were deliberately planted in the parklands. Similarly, local communities in the Lake Kyoga basin prefer preserving indigenous trees to planting[9]. The trend is however, in contrast to that reported in the agricultural landscapes of Kigezi sub-region in Western Uganda[17]. This low tree planting ethos is attributable to the relative abundance of the indigenous trees and limited access to tree planting material.

The Shannon diversity index of tree species in the agroforestry parklands of Kapelebyong is 3.23 with an equitability (evenness) of 0.86. This diversity index (H'=3.23) is greater than 2.0 which denotes high diversity[18]. The high equitability

index shows that the tree species are evenly distributed in the parklands. The mean tree density in these parklands is 5.7 trees ha^{-1}. This density is lower than the 15-42 mature trees/ha previously reported in some districts of Uganda[19]. The prevalent species include *Combretum denogonium, Vitalleria paradoxa, Combretum collinum* and *Mangifera indica* (Figure-2). The presence of trees in the parklands underscore their ability to enhance resilience to environmental calamities such as climate change[11]. On the basis of prevalent tree species[1], the parklands in Kapelebyong can be described as *Combretum* spp-*Vitalleria paradoxa* parklands.

Nearly all the tree species in these parklands are indigenous or naturalized. Only *Eucalyptus camaldulensis* and *Grevellia robusta* species were the exotic species encountered. This trend emanates from the limited availability of exotic tree planting materials and the poor tree planting culture. The latter stems from the perceived relative abundance of the indigenous trees and their associated products. However, elsewhere is has been reported that 69% of the species planted in Kigezi, western Uganda were exotic[17].

Uses of parkland trees: The farmers reported diverse uses of trees in the parklands (Figure-3). Provisioning services such as firewood, timber, and fruits are the most prominent uses. This highlights the dependence of the community on the parklands as a livelihood buffer[1,9]. In Burkina Faso, the carbon payment system promoted by Reducing Emission from forest Degradation and Destruction (REDD+) initiative is profitable and compensable to smallholder farmers' effort to plant and keep trees on farms[22]. However, this program is still in its infancy and is yet to benefit many smallholder farmers in Uganda. This signifies that parkland trees are exploited majorly for their consumptive value. This could be a precursor for non-renewability once demand exceeds supply.

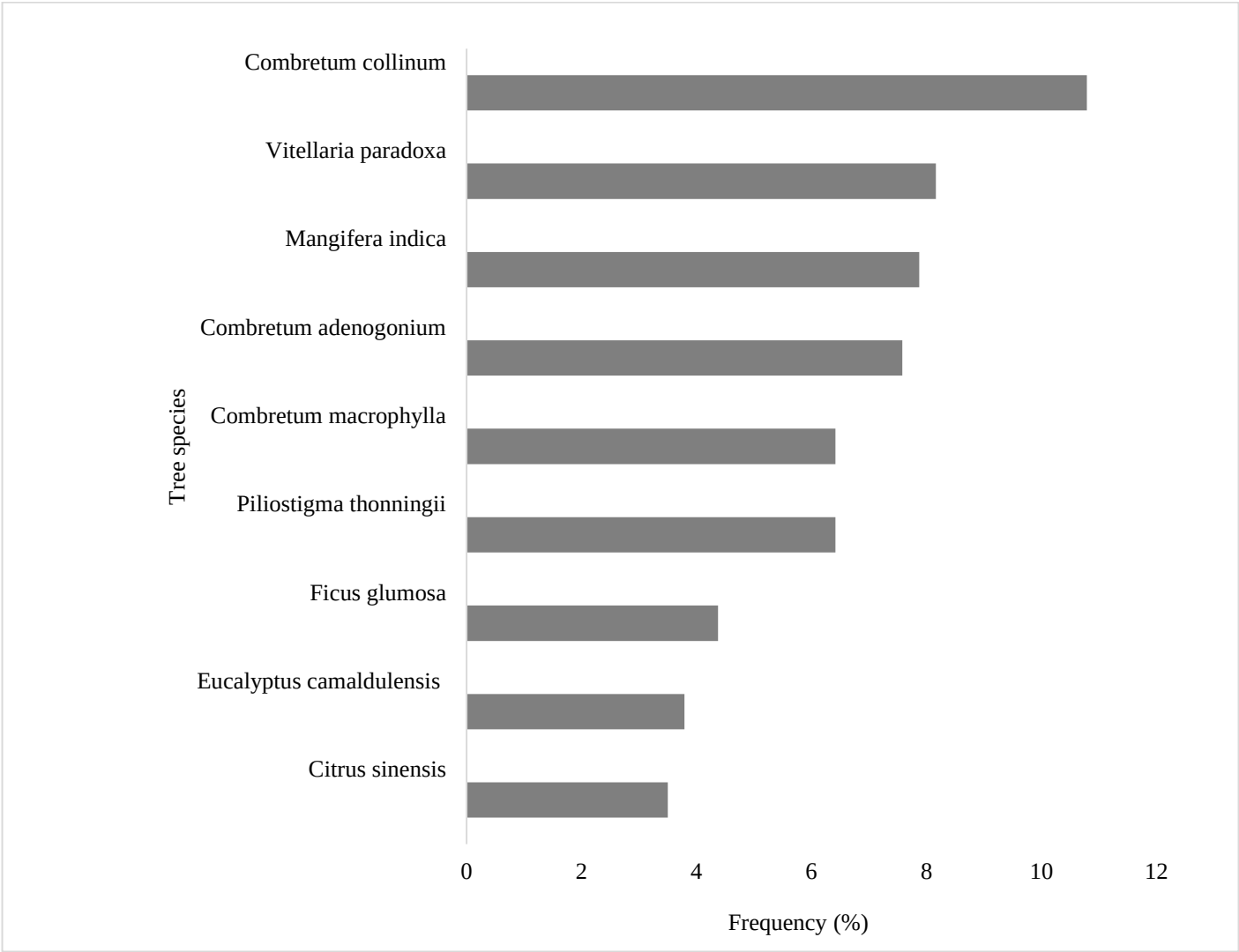

Figure-2: The frequent trees in the agroforestry parklands of Kapelebyong district, Uganda.

Table-1: Agroforestry parkland tree species and their uses in Kapelebyong district, Uganda.

Family	Scientific name	Local name (Ateso)	Utilization
Anacardiaceae	*Anacardium occidentale* L.	Ekasnat	Fr, Oi, Fi
	Mangifera indica L.	Emiebe	Fr, Ma, Sh, Wb, Fi, Cr
	Ozoroa insignis Delile	Etiling	Ti, Po, Fi, Cr
	Sclerocarya birrea (A.Rich.) Hochst.	Ejikai	Ti, Fr
Annonaceae	*Annona senegalensis* Pers.	Ebwolo	Cr, Fr, Sh
Apocynaceae	*Carissa spinarum* L.	Emuriei	Fr, Fm, Me
Caricaceae	*Carica papaya* L.	Epapalu	Fr
Combretaceae	*Combretum adenogonium* Steud. ex A. Rich.	Emeng	Po, Fi, Sh, Ca
	Combretum collinum Fresen	Ekulony	Po, Fi, Sh, Bm
	Combretum macrocalyx (Tul.) Jongkind	Ekoboi	Fi, Sh, Ch, Wb, Bh, Ti, Po
	Combretum molle R. Br. ex G. Don	Ekwooro	Fi, Ch
	Terminalia superba Engl. & Diels	Ekokobot	Po, Ch, Fi, Ma
Euphorbiaceae	*Bridelia chloroneura* Müll. Arg	Erieco	Fr, Po, Fi
Fabaceae	*Acacia hockii* De Wild	Ekisim	Fi, Fm
	Albizia coriara Oliv.	Eteka	Ti, Fi
	Albizia zygia (DC.) J.F.Macbr.	Ebata	Ti, Wb, Fi
	Erythrina abyssinica Lam.	Engosororoi	Fi, Ab, Fm, Ra
	Philenoptera laxiflora (Guill. & Perr.) Roberty	Ekaikai	Fo, Fi
	Piliostigma thonningii (Schumach.) Milne-Redh.	Epapai	Pa, Fi, Bh, Sh, Sa, Hu
	Tamarindus indica L.	Epeduru	Fr, Me, Fi, Ch, Ab, Sp
	Vachellia sieberiana (DC.) Kyal. & Boatwr.	Etirir	Fi, Fm, Ti
	Senegalia senegal (L.) Britton	Ekodokodoi	Fm, Ti, Po
Lamiaceae	*Vitex doniana* Sweet	Ekwarukei	Fr, Fi, Ma, Ti
Lauraceae	*Persea americana* Mill.	Ovacado	Fr, Sh.
Malvaceae	*Grewia mollis* Juss.	Eparis	Fr, Po, Fi, Ch
Meliaceae	*Azadirachta indica* A.Juss.	Abach	Me, Fi, Ir
	Melia azedarach L.	Elira	Ti
	Pseudocedrela kotschyi (Schweinf.) Harms	Eputon	Ti, Bm
Moraceae	*Ficus thonningii*	Emidit	Fi, Sh, Ma, Fi, Fr
	Ficus glumosa Del.	Ebiong	Ma, Ti, Sh, Fr
	Ficus platyphylla Del.	Ebule	Gu, Ma, Sh, Ti, Fr
	Ficus sycomorus L.	Eboborei	Sh, Ti, Fi
	Artocarpus heterophyllus Lam.	Efene	Fr, Sh

Myrtaceae	*Eucalyptus camaldulensis* Dehnh.	Ekalitusi	Ti, Fi
	Psidium guajava L.	Emapara	Fr, Sh
Proteaceae	*Grevillea robusta* A.Cunn. ex R.Br.	Egrivellia	Ti, Fi
	Protea madiensis Oliv.	Ebalangait	Fi, Sh, Sa
Rubiaceae	*Gardenia ternifolia* Schumach. & Thonn.	Ekoroi	Fm, Po
	Mitragyna stipulosa (DC.) Kuntze	Eutdolei	Fi, Sh
Rutaceae	*Citrus sinensis*	Emucuga	Fr
	Harrisonia abyssinica Oliv.	Ekerei	Ne, Bm, Cr, Fm
Sapotaceae	*Vitellaria paradoxa* C.F. Gaertn.	Ekungur	Oi, Ch, Fr, Fi, Ne
Zygophyllaceae	*Balanites aegpytiaca* (L.) Delile	Ecomai	Lv, Fi, Ch

KEY: Fi = Firewood, Fr = Fruits, Ch = Charcoal, Sh = Shade, Po = Poles, Ma = Manure, Sa = Soda ash, Bm = Building materials, Fm = Fencing materials, Ti = Timber, Oi = Oil, Ne = Nector, Me = Medicine, Ab = Aesthetic beauty, Sp = Spice, Pa = Paint for fish nets, Cr = Crafts, Wb = Windbreak, Fo = Fodder, Gu = Gum, Ra = Rain indicator, Ca = Clean air, Lv = Leafy vegetable, Ir = Insect repellant.

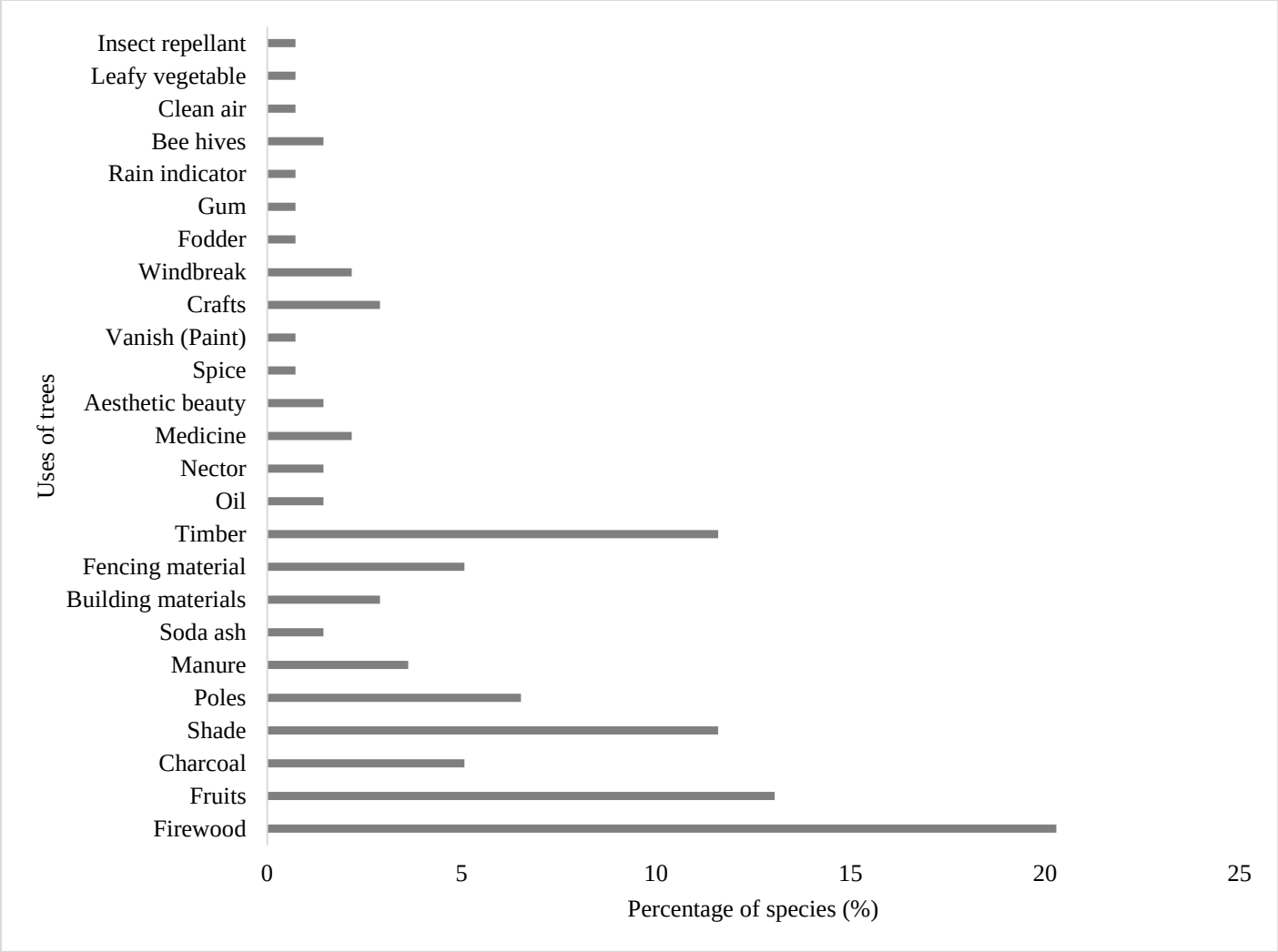

Figure-3: Uses of trees in the agroforestry parklands of Kapelebyong district, Uganda.

Knowledge to preserve trees on parklands: The knowledge to preserve and/or plant trees on farms was acquired in various ways (Figure-4). Most farmers learnt this practice from their parents because this is traditionally an agricultural community. The knowledge is passed from one generation to another orally. For this reason, parklands are referred to as a traditional land-use system[1]. Their management therefore requires integration of indigenous knowledge to provide prescriptions that are relevant to the present scenarios[1]. More farmers preserved trees on farmlands as a result of own initiative and after training than those obliged by by-laws. In this case, awareness creation is effective in promoting parkland conservation than enactment of by-laws. This ably illuminates the fact that conservation is about people as much as it is about species and ecosystems. People will protect species or ecosystems that are valuable to their livelihoods without necessarily being obliged by laws. Therefore, these results affirm the assertion that "farmers are rational decision makers who choose to conserve and regenerate trees in their fields if this brings higher benefits"[1].

Tree management techniques: Weeding and pruning are the prevalent tree management practices in the parklands of Kapelebyong district (Figure-5). Weeding is applied when crops such as finger millet, ground nuts, cowpeas are in the field to control weeds while pruning can be done with or without crops. Another management technique employed is pruning. This offers two-fold benefits; first to reduce shade thus minimize tree competition with crops and, secondly; to provide harvestable materials such as firewood construction materials among others. The other tree management measures include spraying with insecticides, watering during the dry season and application of manure. These measures are however, not widespread but only limited to fruit trees such as *Citrus sinensis* and *Psidium guajava.* In West Africa, tree pruning is an attractive option to improve crop production around tree canopies[1].

Harvesting techniques: The pruning of branches and twigs is the prominent technique of harvesting trees in the parklands (Figure-6). The low prevalence of debarking and digging roots points to the prudence of farmers and perhaps limited knowledge on the use of tree barks and roots. This demonstrates that farmers are judicious when harvesting trees on their farms. It also points to an in-built culture of ensuring sustainable use of the available resource.

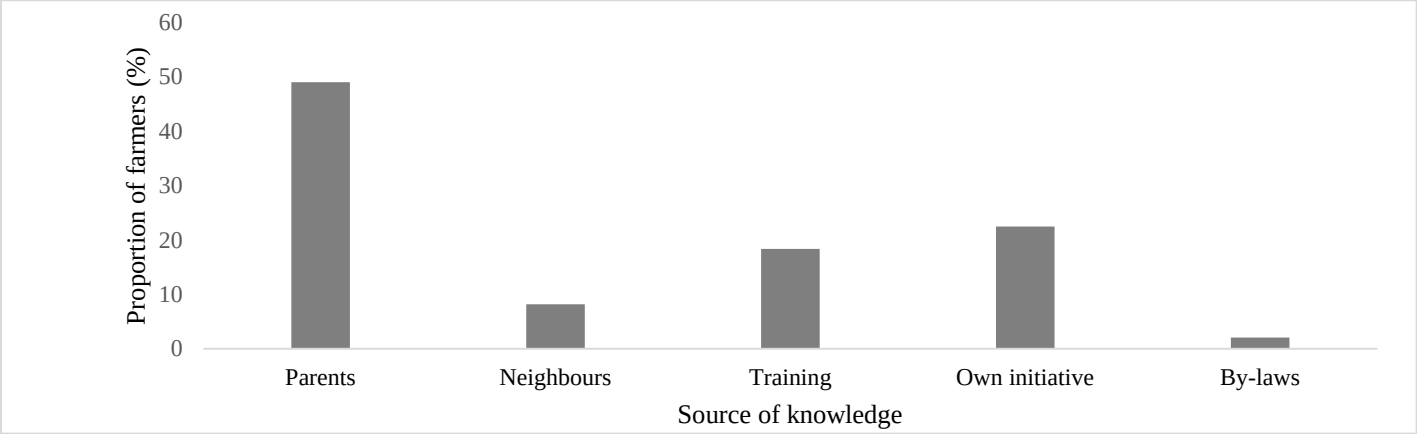

Figure-4: Source of knowledge on tree preservation in the parklands of Kapelebyong district, Uganda.

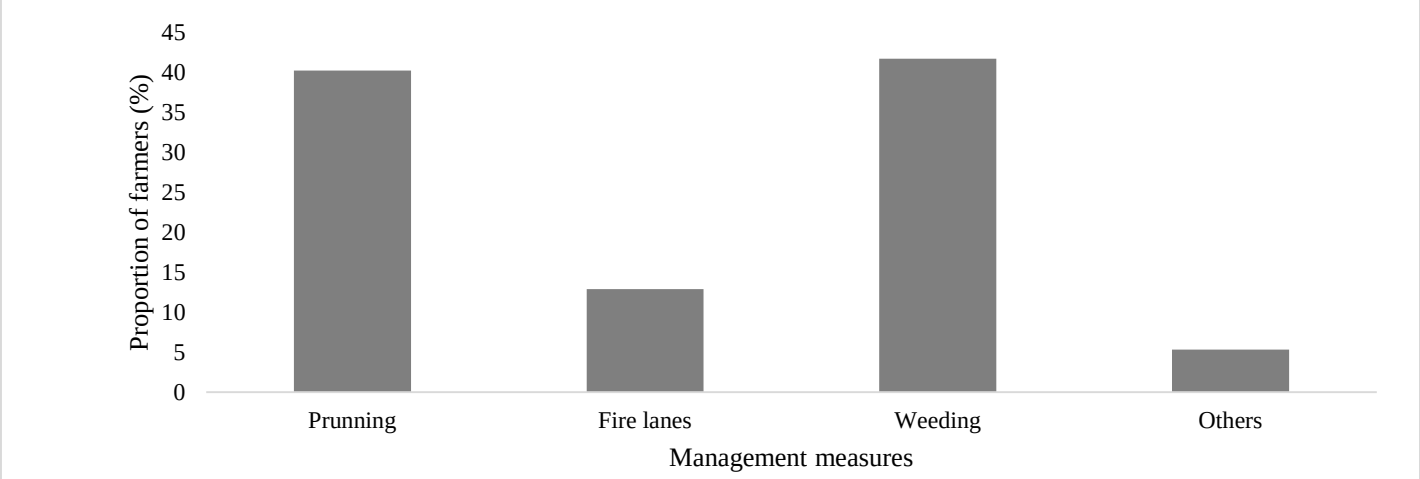

Figure-5: Management of tree species in the parklands of Kapelebyong district, Uganda.

Class size distribution: The histograms in Figure-7 to 16 present the class size distribution of ten tree species in the parklands of Kapelebyong district. These are the most frequent tree species in these parklands (Table-1).

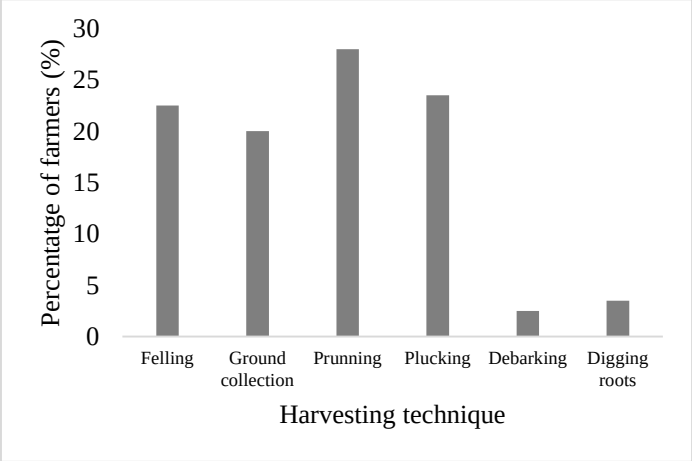

Figure-6: Techniques of harvesting tree products in the agroforestry parklands of Kapelebyong district.

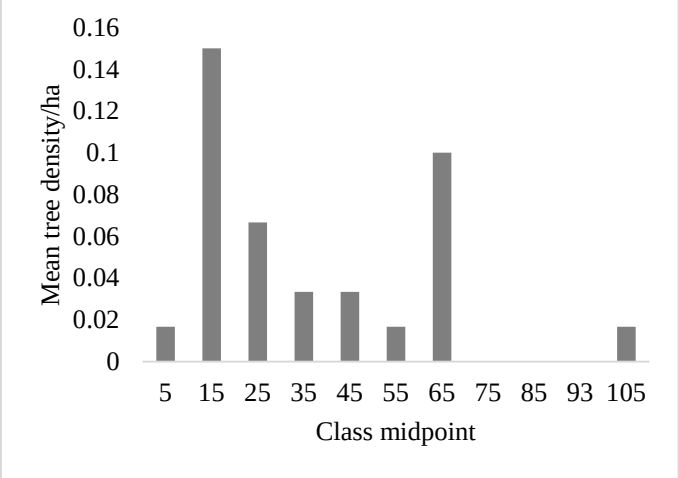

Figure-7: Population structure for *Vitellaria paradoxa*.

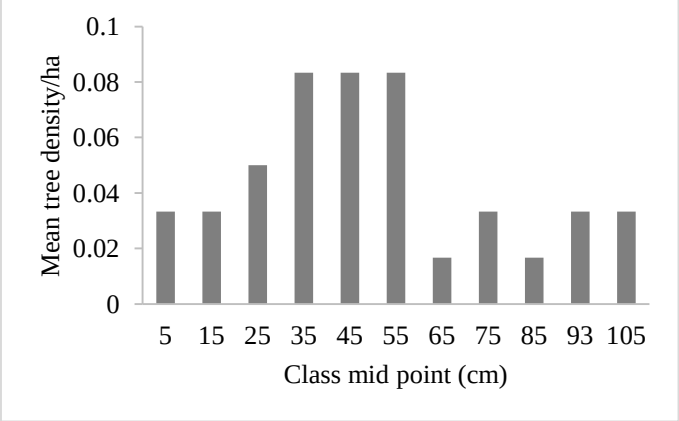

Figure-8: Population structure for *Mangifera indica*.

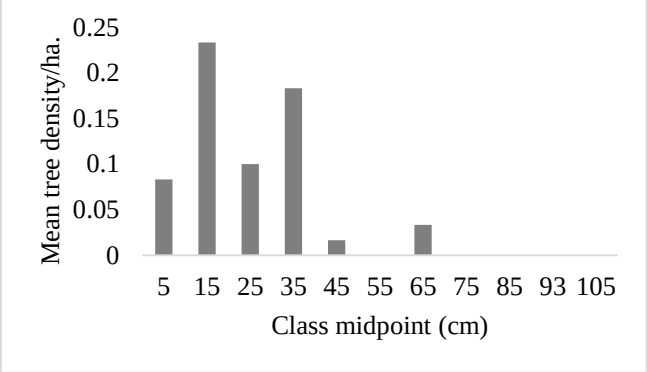

Figure-9: Population structure for *Combretum collinum*.

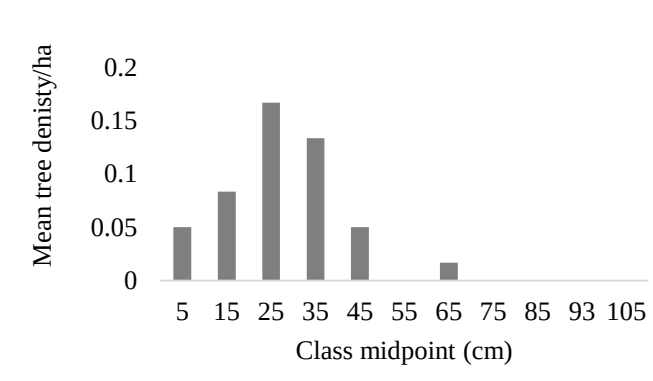

Figure-10: Population structure for *Combretum adenogonium*.

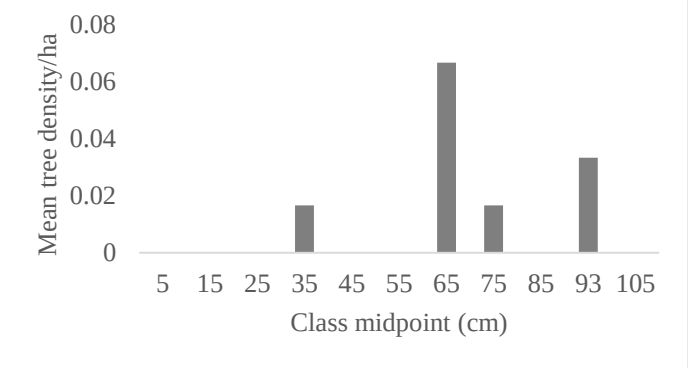

Figure-11: Population structure for *Tamarindus indica*.

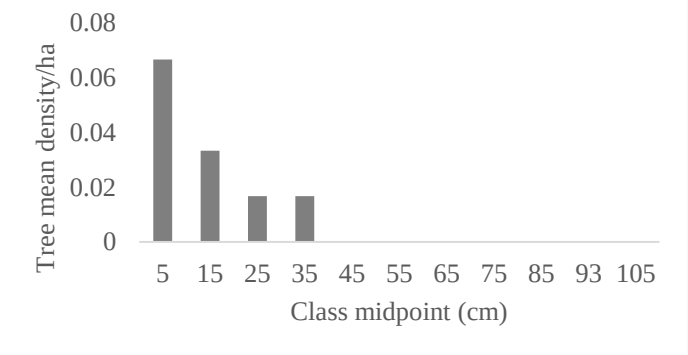

Figure-12: Population structure for *Pseudocedrela kotyschi*.

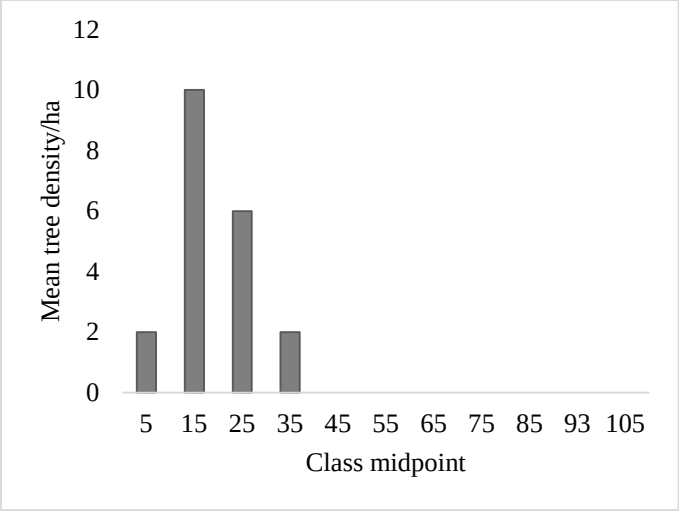

Figure-13: Population structure for *Piliostigma thonningii*.

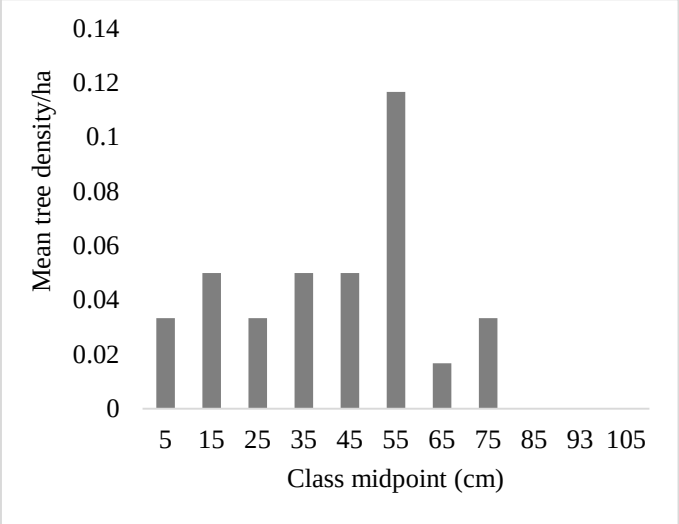

Figure-14: Population structure for *Combretum macrocalyx*.

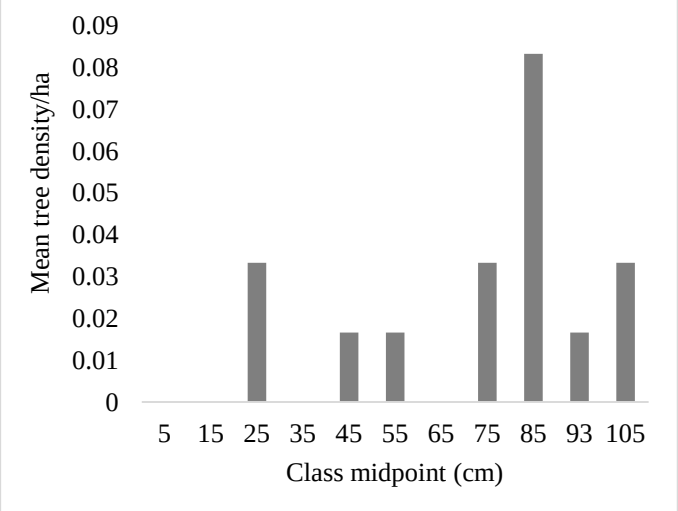

Figure-15: Population structure for *Ficus glumosa*.

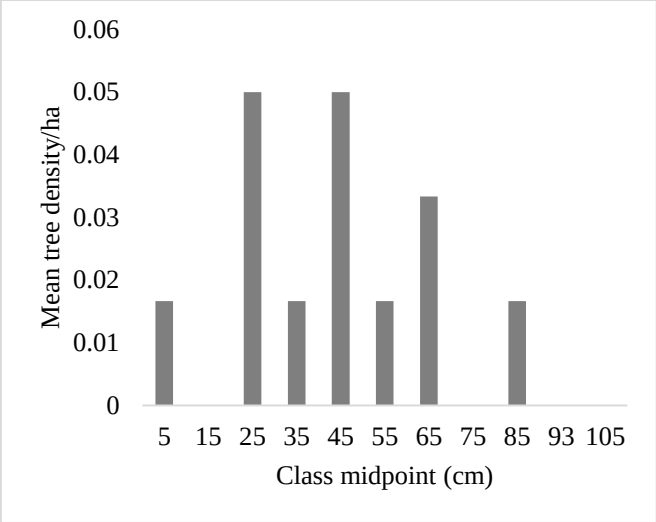

Figure-16: Population structure for *Ficus sycomorus*.

The histograms (Figure-7 to16) show that the tree species in the parklands of Kapelebyong have variable numbers of individuals in the class size distributions. This ultimately influences their population structure and regeneration trends. The high numbers of individuals of *P. kotyschi, V. paradoxa, C. collinum* and *B. thonningii* in the lower diameter classes show that these species have a positive regeneration potential. On the contrary, *F. glumosa* and *T. indica* with more individuals in the higher diameter classes have poor regeneration potential. The suppressed regeneration in these species is due to destruction of seedlings by wild fires during the fallow periods in the dry season (December to February). In Burkina Faso, the reduced regeneration in parklands is due to shorter and suppressed fallow periods[12] but this could not be ascertained in the present study.

Conclusion

The parklands of Kapelebyong district have a high diversity of tree species and equitability (evenness). The trees act as a livelihood buffer because they provide diverse products to the farmers. The majority of the trees in the parklands are indigenous species preserved during opening of the land. Some of the prevalent tree species have healthy regeneration trends while others are not. In cognizance of the status of these parklands, it is important to develop mechanisms to incentivize farmers to maintain agroforestry parklands. There is also need to improve forestry extension services and information dissemination and access to affordable and quality planting material (tree seedlings). Additionally, the effective management of these parklands can be reinforced by research that quantifies the impact of trees on crop productivity, adds value to tree products and estimates biomass carbon sequestration potential. The latter will provide information to assess the viability of the small holder parklands in the carbon payment system promoted by Reducing Emission from forest Degradation and Destruction (REDD+) initiative.

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