The Role of Land Tenure Institutions in Conservation of Tree Species Diversity in Southern Malawi

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ABSTRACT

Biodiversity is declining through out southern African miombo woodlands due to poor land use practices that are detrimental to soil, vegetation and habitat. Tree species diversity and diameter distribution of *Uapaca kirkiana* forest stands under different land tenure is poorly documented despite efforts for domestication of this priority fruit tree species. This paper examines diversity and distribution of tree species under three land tenure systems namely; forest reserves, communal and leasehold lands. We assessed tree species diversity and distribution under the three land tenure systems. The results show that forest reserves have higher species diversity with an average of 16 tree families, 27 genera and 34 species as compared to only 10 tree families, six genera and six species on communal forest lands. Comparisons of diameter at breast height size class distributions showed that communal lands had significantly low numbers of small (5.0-10.0 cm) and very large (≥ 30cm) diameter classes suggesting lower levels of regeneration and high rate of anthropogenic activities. The high species diversity and richness in forest reserves and leasehold land indicate high potential for protected lands to restore tree species diversity. Our results have shown that to a greater extent levels of human activities as influenced by land tenure system underlie the pattern of variation in species diversity, composition and distribution in the different geographical sites. Our findings confirm the hypothesis that open access lands are not compatible with conservation because of high anthropogenic activities. From a policy perspective the findings call for provision of a conducive social and economic environment to enable communities around forests to use forest resources sustainably.

Key Words: Anthropogenic activities, diameter class, diversity, land tenure, *Uapaca kirkiana.*

INTRODUCTION

Rural people in savanna woodlands require ownership and guaranteed access to land as a basic asset to ensure food security as well as reduce unemployment and poverty (Shackleton, 1996). Miombo woodlands in Southern Africa continually undergoes modification through anthropogenic activities such as clearance of trees for cultivation, commercial charcoal production, fuel wood collection, rampant fires and cutting of poles for building (Luoga et al., 2000; Luoga et al., 2005). The high rate of anthropogenic activities gives a great concern with respect to maintenance of forest biodiversity. Deforestation is increasing constantly resulting in decline of species diversity and eroding genetic base especially in the communal lands (Kanschik and Becker, 2001). In Malawi management of forest resources on both customary and forest reserves was a monopoly of government through Forestry Department until 1996 when enactment of the 1996 Forestry Policy brought a fundamental shift in favour of involvement of local communities in the management, conservation and utilization of forest resources, a concept referred to as co-management. The management of forest resources is increasingly becoming the right and duty of local people within the policies and laws of the country even though it just being piloted under customary land and forest reserves. However, the combined impact of widespread poverty, dependency on subsistence agriculture and wood-based energy has resulted in forest destruction on both customary and public land at a rate of 3.6% per annum, a deforestation rate being ranked among the highest in Africa (Hyde and Seve, 1993).

The land policy in Malawi recognizes three land ownership categories namely public land, private land and customary land. Public land comprises land acquired and owned by government and dedicated to specific national use or made available for different uses at the discretion of the government. Within government land tenure is public land which is held in trust and managed by government or traditional authorities and openly used and accessible to the public at large. This includes land gazetted for use as forest reserves, national parks, recreation areas, and conservation areas, historic and cultural sites. Private land is exclusively owned, held or occupied under freehold tenure for a clearly defined individual, community, corporation, clan or family. Within private land category a leasehold estate is created out of government land upon provision of private contractual rights subject to the enforcement of development conditions imposed by the owner. The third tenure system is customary land which encompasses all land falling within the jurisdiction of a recognized traditional authority and is granted to a person or a group and used under the customary law. The customary tenure is central to cultural identity and social organization of local communities in which chiefs are trustees of the land and the chiefs' power to allocate land is delegated to village headmen. Forests on customary land are controlled by chiefs and village head persons but they are exploitable by the entire community through grazing, hunting, settlement areas, crop fields and graveyards. Land tenure is one of the principal factors affecting the way in which forest resources are managed and the manner in which benefits are shared. Land tenure insecurity results in a number of environmental problems including degradation on open access and unwillingness for people to plant trees.

In Malawi customary land covers 3.1 million ha, which is about 50.4% of the forested area comprising 17.6% of undisturbed forest and 32.8% of disturbed forest. Government public land in forest reserves cover an estimated 0.98 million ha comprising 22% of forest cover. Forest reserves are administered by the government and no human settlement is permitted but licensed harvesting of forest products is possible under strict control. Leased land comprises 12% of forest cover and they are mostly under estates involved in commercial farming of tobacco, tea and coffee (GOM, 1998). Because of the extensive area under customary ownership and public jurisdiction and the long history of customary property rights coupled with the drive towards land privatisation through the 2002 Land Development

Act land tenure seems likely to be a powerful determinant of the type of conservation that could take place at different locations across the country. Data on species diversity, plant density and distribution under different land tenure is required to guide and support the management, conservation of forest resource in Malawi. The purpose of our study was to determine the effect of different land tenure systems on tree and shrub species richness and diversity by comparing species diversity, species distribution and structure under three land tenure systems. It focuses on assessment of forest stands of *Uapaca kirkiana* a priority fruit tree species for domestication in Southern Africa.

MATERIAL AND METHODS

Study areas

A reconnaissance survey was undertaken on public (forest reserves), leasehold and customary lands from October to December in 2004 to identify areas with *U. kirkiana* tree species. In order to cover a representative sample of miombo woodlands in Southern Malawi six study sites falling within the same agroecological zone were selected. Two sites are under customary tenure; two are leased lands while two are protected forest reserves (Table 1).

Table 1: Description of sites for land tenure and species diversity in Southern Malawi

Site	Locality	Land tenure	Soil description	Min temperature ^{0}C	Max temperature ^{0}C	Elevation (m)	Rainfall (mm)
Tsamba	15^0 20’S, 34^0 37’ E	customary	ferruginous loams	15	28	850	1000
Chikumbeni	15^0 24’S 35^0 19’E	customary	lithosols	16	26	1000	970
Zomba outerslopes	15^0 23’S 35^0 19’E	leasehold	lithosols	14	26	1100	1200
Chimpeni	15^0 22’S 35^0 19’E	leasehold	lithosols	16	28	900	1200
Malosa	15^0 15’S, 35^0 19’E	reserve	ferrasols	14	27	1200	1200
Likhubula	15^0 49’S, 35^0 41’E	reserve	nitosols	12	24	1160	1000

Sampling and measurements

The local villagers surrounding the forest sites were interviewed regarding the status of the forests, use of tree species and preferences of species for different uses. Within each study site three circular plots each with 32.60m radius were established and placed at 500m intervals. The area of forest patch in each site ranged from 3.0 to 5.0 ha with a minimum distance of 3 km between sites. All stems of *U. kirkiana* in the plots were counted and diameter at breast height (dbh) of ≥ 5 cm was measured in centimetres using callipers. Basal area per hectare in square metres was determined using a relascope. Using the field areas, the stocking of U. *kirkiana* by dbh class was calculated for each site. Samples of tree and shrub species in the *U. kirkiana* stands were identified with the help of a field guide and an experienced Plant Curator from Malawi National Herbarium and Botanical Garden. Where it was not possible to determine the scientific name of a plant the local name was used and a list of their Latin equivalents was compiled based on Binns (1972) but species nomenclature followed Coates-Palgrave (1983) .Voucher specimen were collected and taken to the National Herbarium and Botanical Garden where they were deposited for future reference. Tree and shrub species diversity was calculated using Shannon-Wiener information Index (H´) and the index of dominance (D´) of the community was calculated by Simpson's index using the following formulae:

$$H' = -\sum_{j=1}^{k} p_i \log p_i$$

where p_i is the proportion of species 'i' relative to the total number of species (n_i/N)

$D' = \sum_{j=1}^{k} (\frac{n_i}{N})^2$ where D´ is the index of dominance and n_i and N being the same as in the Shannon index of general diversity. High values of H´ and low values of D' indicate high species diversity (Pukkala, 1996). Species evenness was calculated using the equitability index (J') as

$$J' = \frac{H'}{\log(S)}$$

where H' is the Shannon-Weiner Index and S the total number of species recorded in the site. As the response measures become more evenly distributed among species J' approaches 1. The taxonomic composition among land tenure systems was compared and quantified on a family basis by calculating number of individuals per site. The index of similarity (IS) between forests under different land tenure was calculated following Sorenson's similarity index (Sorensen, 1948). This is calculated as, [2C/(A+B)] x 100, where C is the number of species common to both sites being compared, A and B are the total number of species in forest sites A and B. The tree diversity indices were compared by paired *t*-test. One-way analysis of variance (ANOVA) was used to test for differences in basal area, average dbh and tree density among the sites and different forest land tenure.

RESULTS

Tree species diversity and composition

High tree species diversity as measured by species richness, genus and family richness was observed in forest reserves than on communal lands (Table 2). Tree species diversity of government forest reserves were significantly higher ($P \geq 0.05$) than diversities on both customary and leasehold forest land. In the total 6.5 ha studied 48 tree and shrub species in 24 families were found on the seven forest sites. Greater numbers of species were found in forest reserves; 26 for Likhubula and 34 for Malosa. *Uapaca kirkiana* stands on customary land had lower number of species of 12 and 10 for Tsamba and Chikumbeni respectively representing an average difference of 61.5% compared to the mean of forest reserves. *Uapaca kirkiana* stands on leasehold land had moderate species richness of 19 for each site.

Table 2. Tree and shrub species diversity, richness and evenness per hectare under different tenure

Site	Species richness/ha	Genus richness/ha	Family richness/ha	Dominance index (D')	Shannon-Weiner diversity (H')	Equitability index (J')
Zomba outerslopes	19c	15c	12b	0.25	0.93	0.73
Chimpeni	19c	16c	11b	0.20	0.96	0.75
Malosa	34a	27a	15a	0.12	1.26	0.84
Chikumbeni	10d	6d	6c	0.48	0.55	0.55
Likhubula	26b	21b	16a	0.21	1.01	0.71
Tsamba	12d	8d	7c	0.28	0.77	0.71
LSD $_{(0.05)}$	2.18	2.41	1.68			

Values in columns followed by the same letters are not significantly different from each other LSD, $P \leq 0.05$)

Plant species similarity of tree and shrubs

There was high species similarity among the forest reserves and but reserves differentiated from leasehold and communal lands with a reduction of 54.2% between forest reserves and communal forests. Only nine species (18.8%) were common to all the six sites. Results indicate highest heterogeneity and evenness on forest reserves compared to leasehold and communal forests. The highest similarity is between Malosa and Likhubula Forest Reserves sharing 70.0% of the species. The least similarity was observed between Malosa Forest Reserve and Chikumbeni Communal Forest with only 31.8% of the species common to both sites (Table 3).

Table 3: Percent similarity of tree and shrub species among forests under different land tenure

	Forest site					
Forest site	Zomba	Chimpeni	Malosa	Chikumbeni	Likhubula	Tsamba
Zomba	100					
Chimpeni	57.8	100				
Malosa	69.6	64.0	100			
Chikumbeni	48.2	34.4	31.8	100		
Likhubula	57.8	62.2	70.0	50.0	100	
Tsamba	51.6	51.6	43.4	63.6	57.8	100

Family richness and abundance across forest sites

The families with the largest number of taxa were Caesalpiniaceae (6 genera, 9 species), Euphorbiaceae (5 genera, 8 species), *Papilionaceae* (3 genera, 4 species), Mimosoceae (3 genera, 3 species). Families Anacardiaceae, Rubiaceae and Myrataceae had two genera and two species each. The largest genera are *Brachystegia* with four species (*B. spiciformis, B. floribunda, B. boehmii* and *B. utilis)* and *Uapaca* with three species. *(U. kirkiana, U. nitida* and *U. sansibarica)*. The customary land forest at Tsamba was mostly dominated by Euphorbiaceae, Caesalpiniace*ae* (mostly *Brachystegia spiciformis*) and Annonaceae families, while communal forest at higher altitude was dominated by Euphorbiaceae, *Brachystegia spiciformis* and Proteaceae. The Proteaceae family was represented in all six forest sites except on the leasehold forest land at Chimpeni (Table 4). Government forest reserves were dominated by Euphorbiaceae, Caesalpiniaceae, Papilionaceae, Annonaceae, Chrysobalanaceae and Proteaceae. However, the two government forest reserves differed in species abundance whereby Malosa had more legume species in the family Mimosoceae, Papilionaceae (genera *Dalbergia* and *Entada)* while family Mimosoceae was not represented at Likhubula Forest Reserve (Table 4). Malosa Forest Reserve had highest abundance of Myrataceae showing that there were differences in species abundance in forest reserves at different sites.

Table 4: Family richness per hectare for six most common trees and shrubs in the study sites

Family	Zomba	Chimpeni	Malosa	Chikumbeni	Likhubula	Tsamba
Anacardiacae	0	2	1	0	2	0
Caesalpiniaceae	3	2	2	1	4	1
Euphorbiaceae	3	1	4	1	4	2
Mimosoceae	0	0	2	0	0	0
Papilionaceae	2	2	4	0	2	1
Rubiaceae	1	1	2	0	1	0
Total	9	8	15	2	13	4

Uapaca kirkiana **stem density and diameter class distribution**

In total 1589, *U. kirkiana* trees of ≥5cm dbh were assessed. *Uapaca kirkiana* stand density showed great variation ranging from 122 ± 8.4 trees ha^{-1} in Chimpeni to 492 ± 22.6 trees ha^{-1} in Likhubula and the difference was statistically significant ($P \leq 0.05$). Size frequency distribution based on stem diameter of *U. kirkiana* showed poor representation on communal forests for the smallest and largest diameter classes. There were no significant differences in stem density between Chimpeni leased land and Tsamba communal lands. Forest reserves had significantly higher abundance of *U. kirkiana* stems than leased and communally-owned forest lands. The basal area varied from 3.2m^2 ha^{-1} to 9.0 m^2 ha^{-1} with an average of 8.1m^2 ha^{-1} for government forest reserves, 6.5m^2 ha^{-1} for forests on leasehold land and 4.4 m^2 ha^{-1} for communal lands (Table 5). Typically all sites had over 20% representation of stems in the diameter class 15.0- 19-9 cm. Forest reserves had more stems of *U. kirkiana* concentrated in the moderate class of 15.0- 19-9 cm, while leasehold land had more stems in the small diameter class of 10.0- 14.9 cm category. The leased land at Chimpeni had highest representation of stems (24%) in the largest diameter class.

Table 5 to be inserted here

DISCUSSION

The forests under the three land tenure systems showed great variations in species diversity, density and composition. Land tenure alone does not explain all the differences in species diversity and structure of *U. kirkiana* in different woodlands. Variations in species diversity and structure are probably a result of selective pressure through human exploitation and differences in elevation, soils and climatic factors. Variations in species diversity and structure are probably a result of selective pressure through human exploitation and differences in elevation and soil type. The species diversity of the leasehold forest land at Chimpeni is comparable to what has been reported for other studies, for instance previously miombo woodland at 1075 m asl was reported to have 20 trees and shrubs species (Bone et al., 1997) and this site is at a distance of about 5 to 8 km from our study site. Communal land tenure registered the lowest species diversity due to high anthropogenic activities by communities surrounding the forests. In many communities customary land is open access due to weakened traditional controls over land allocation (Government of Malawi, 1998). This trend agrees with Hanna et al. (1995) who reported that common property regimes have been responsible for overexploitation and destruction of natural resources. This implies that a change in land ownership through granting of leasehold title is argued to engender better land resource management. The lower number of species on communal lands shows that customary land tenure has a strong negative impact on species diversity and richness in the savanna woodlands. The results contradicts the findings of Vermeulen (1996) who found no differences in tree species richness between communal areas and protected state forests in central Zimbabwe, even though there was a much lower wood basal area and density in the communal area.

The moderate species diversity on leasehold land than customary land is a result of regulation in harvesting and responsiveness of the owners in reforestation activities. This agrees with Hyde and Seve (1993) who observed high rates of reforestation where land tenure is secure. Therefore it can be argued that conferring ownership of land and resources is often essential in creating incentives for sustainable management and conservation of biological diversity. Communal resources where responsibility remain with communities has resulted in open access situations where rules can no longer be enforced because anyone is able to use resources and because there are no bye laws in place for co-management of forest resources. However, forest conservation activities such as maintaining land under tree cover are not normally supported by local communities particularly when they result in reduced access to resources, employment and income (Wild and Mutebi, 1997).

Although the concept of co-management is advocating strong "ownership rights" for communities they have been relying upon state permission to experiment rather than a mandate for decentralisation and tenure security. Decentralisation and devolution through transfer of authority to local communities can be productive if land tenure rights are secure and if local communities are given greater autonomy to manage the resources. To this effect designation of protected reserves should be based on sound information on ecological, socioeconomic, institutional context in such a way that protected sites supports rather than constrain households deriving benefits from the resources to enhance their livelihoods. Exclusion of local communities may lead to massive conversion of forest land to cultivated land by entrepreneurs and excessive concentration of communities on communal lands.

The abundance of Euphorbiaceae and Annonaceae families on customary lands as compared to forest reserves and leasehold land can be explained by increased levels of disturbances which provide niches for establishment of fast growing pioneer taxa that grow well in open canopies after clear felling and intensive fires. Most of the abundant species on customary land are typical fire-tolerant pioneer species such as *Uapaca kirkiana, U. nitida, Bridelia micrantha* and *Annona senegalensis*. Low species diversity on customary land at Tsamba could be attributed to overexploitation through charcoal production and firewood collection. Charcoal production involves clear-felling of indigenous trees resulting in soil erosion, loss of habitat for plant and animal species, and reduced availability of wood (Makungwa, 1997). Charcoal vending is a lucrative business for poor rural households in Tsamba. Most of the charcoal is sold along the Mwanza-Blantyre road to the traveling public. Some entrepreneurs sell their charcoal to Blantyre city located about 90km where demand for charcoal is very high. Uncontrollable fires escaping from land preparation, charcoal production and from hunters have contributed to low species diversity on customary lands as compared to forest reserves and leasehold land. Government forest reserves and private forests are routinely protected from wild intensive fires through controlled early burning between the months of May to June every year. Late fires occurring after the dry season cause severe damage to woody plants while grass is not severely affected (Chidumayo et al., 1996). Chimpeni and Zomba private woodlands are commercial and institutional farms respectively and they have not lost much of tree and shrub species as compared to communal lands that are being converted into agricultural use and subjected to intensive harvesting for poles, fuel wood, charcoal, fibres and other non -timber products.

Our results also show that species diversity and richness are affected by land tenure and other factors such as change in elevation and soil type. The species diversity and richness decreased with decreased altitude below 1000m asl as observed at Tsamba whose species diversity was the lowest lower probably due to proximity to human settlements. The forest at Tsamba is at lowland and a distance of one to three kilometres from human settlements. Anthropogenic activities surrounding the forest have some important effects especially in the different class distribution of *U. kirkiana.* Small sized trees of about 5cm were very low in government forest reserves; while the most abundant class was between 15.00- 19.9 cm which produces canopy that reduce regeneration of saplings. The customary land in Tsamba was impoverished in the low to medium category of 5-9.9cm and 10.0- 14.9 cm as compared to customary land in Chikumbeni due to harvesting of the trees for firewood, charcoal and poles.

Interviews with local people around the two communal forests revealed higher preference of small size classes from ≥ 5 to15 cm dbh for firewood, poles for house construction, fencing and roofing purposes. Poor representation of smallest diameter class 5.0- 9.9 cm in the communal lands is more likely due to disturbances such as fires and browsing by animals. However, the customary land in Chikumbeni had a good representation of small to medium diameter class which can be attributed to low human population pressure of surrounding villages, Villages around Chikumbeni has a population of only about 7000 individuals (NSO, 2004). This suggests that highly frequented miombo woodlands would be depleted of saplings and small sized diameter class of valuable tree species would only be available in less accessible areas. This has also been confirmed by Grundy et al. (1993) in Zimbabwe on wood utilisation study in resettlement areas.

Trees of largest diameter class of ≥30cm were not represented on customary lands as these are young forests that are just recovering from clear felling with *U. kirkiana* as a pioneer species. *U. kirkiana* play a very important role in the regeneration of miombo woodland sites that have been cleared (Celander, 1983). Lack of largest diameter class on communal lands could be attributed to harvesting which prevents recruitment into the largest diameter class. The high proportion of stems in the smallest size class (5.0-9.9cm) and medium class (10-14.9 cm) for Malosa Forest Reserve and Zomba outer slopes respectively shows that there was on-going seedling recruitment and protection from harvesting and fire. The very few *U. kirkiana* individuals in the 5.0-9.9 cm class for the customary lands shows reduced recruitment from seedling to sapling phase. This could be attributed to frequent harvesting and higher dry season fires causing mortality of sprouting stems. Smaller diameter classes are very easy to cut and transport as head loads. This is consistent with a study by Abbot and Homewood (1999) who found that small sized trees are preferred for firewood because they are easy to carry by women as head loads; women avoid large logs because they are heavy to carry. Higher incidence of stems of 10.0-14.9cm in the leasehold tenure could be attributed to more recruitment as a result of exposure of forest floor to sunlight after opening up the canopies through thinning. This is in agreement with findings by Luoga et al., (2005) and Grundy (1995). Although forest under leasehold at Chimpeni had the lowest stem density, it had the second highest basal area comparable with the basal area for Malosa because forests on leasehold lands are routinely thinned as such trees grow very big in diameter as a result of reduced competition among woody plants.

CONCLUSION

Land tenure through increased anthropogenic activities has modified the forest structure and composition resulting in dramatic reduction of species diversity on customary lands. Land tenure drive at least part of the status of species diversity and distribution in Malawi; however more data on spatial and temporal changes in biophysical factors such as soil type, precipitation are further needed to evaluate the implication of land tenure policies on tree and shrub species diversity. Communal lands are fragile and more prone to anthropogenic disturbances therefore it is necessary to develop alternative livelihoods for communities around community forests to ensure conservation of tree and shrub species diversity. Leasehold forest land indicates high potential for private forests to restore biodiversity therefore owners of forests should be encouraged to make biodiversity management one of the main components of their tasks. On the basis of the study forest reserves should provide a good starting point for strengthening the conservation and domestication of *U. kirkiana* and other tree species in the miombo woodlands. Efforts to conserve tree species through restricted access will lead to reduced social welfare because of heavy reliance of local communities on forest resources. There is need to develop alternative livelihoods for communities around community forests to reduce pressure on forest resources. Possible strategies could include provision of income generating opportunities; food for work interventions, micro-credit schemes, enhancement of agricultural productivity in the existing crop land and market development of underexploited resources such as bamboo crafts and honey.

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Table 5: *Uapaca kirkiana* tree density, basal area and diameter class distribution of six woodland sites in Malawi

Site/ land tenure	Density no ha^{-1}	Basal area m^2 ha^{-1}	Diameter class distribution (cm)					
			5.0-9.9	10-14.9	15.0-19.9	20.0-24.9	25.0-29.9	>30
Zomba ((leasehold))	256 ± 19.8d	5.8 bc	21(8.2)	143 (55.9)	71 (27.7)	57 (22.3)	28 (10.9)	0 (0)
Chimpeni (leasehold)	122 ± 8.4e	7.3b	2 (1.6)	24 (19.7)	22 (18)	21 (17.2)	24 (19.7)	30 (24.6)
Malosa (reserve)	320 ±14.8 b	7.5 b	50 (15.6)	73 (22.8)	107 (33.4)	51(15.9)	28 (8.8)	17 (5.3)
Chikumbeni (communal)	276 ± 6.9c	3.2d	44 (15.9)	55 (19.9)	76 (27.5)	75 (27.2)	26 (9.4)	0 (0)
Likhubula (reserve)	492 ± 22.6 a	9.0 a	11 (2.2)	130 (26.4)	185 (37.6)	78 (15.9	66 (13.4)	22 (4.5)
Tsamba (communal)	123 ± 9.7e	5.6bc	6 (4.9)	13 (10.6)	59 (48.0)	38 (30.9)	8 (6.5)	0 (0)
LSD (0.05)	14.07	1.42						