INFLUENCE OF FOREST LAND TENURE REGIMES ON FOREST CONDITION IN ULUGURU MOUNTAINS, TANZANIA

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ABSTRACT

The paper scrutinizes the current wave of forest land tenure reforms since the inception of the new forest policy in 1998. It explores which type of forestland tenure regime had more positive influence on forest condition in the Uluguru Mountains, Tanzania. The assessment was done with reference to vegetation types of montane and miombo woodlands. The study showed that for the montane vegetation, state regime (Uluguru Nature Reserve) had higher stocking (volume 1,233m^3/ha; basal area 78m^2/ha; density 777 stems/ha) and tree species diversity (H' 3.48) compared to communal regime (Chief Kingalu Sacred Forest) which had low stocking (volume 798m^3/ha; basal area 49m^2/ha; density 1,020 stems/ha) and tree species diversity (H' 3.21). For the miombo vegetation, corporate/private regime (Tangeni Roman Catholic Church Forest Reserve) had higher stocking (volume 122m^3/ha; basal area 27m^2/ha and density 2,573 stems/ha) and tree species diversity (H' 2.60) compared to communal regime (Misumba Village Land Forest Reserve) which had low stocking (volume 23m^3/ha; basal area 10.8m^2/ha and density 4,200 stems/ha) and tree species diversity (H' 3.53). The study concludes that state regime represented by Uluguru Nature Reserve showed improved forest condition compared to communal tenure regime (Chief Kingalu Sacred Forest) for the montane vegetation type while private regime (Tangeni Roman Catholic Church Forest Reserve) was more effective in conservation than communal regime (Misumba Village Land Forest Reserve). The study recommends that sustainable management of forests could not be addressed by tenure reforms in the forestry sector alone, but requires 'cross-sectoral', 'inter-disciplinary' and 'participatory' approach along with secure tenure. Moreover, it is essential that an in-depth forest inventory is conducted at predetermined intervals to quantify stocking of tree, shrub species and forest disturbances to understand the level of resource extraction for each tenure regime.

Key words: Tenure regimes, reforms, forest condition, Uluguru Mountains, Tanzania.

INTRODUCTION

Forests are vital resources offering different benefits to adjacent communities and society at large (Kaiza-Boshe *et al.* 1998). About 1.6 billion people of the world rely on forest resources for subsistence and economic support (FAO 2006a). Such benefits include consumptive, spiritual and aesthetic needs, employment, and ecological services such as carbon sequestration and water provision (Luoga *et al.* 2000). In spite of the importance of forests world wide, they continue undergoing modification through anthropogenic activities including clearance for cultivation, commercial charcoal production, fuel wood collection, rampant fires and cutting of poles for building and commercial timber exports (Monela 1995; Luoga *et al.* 2000, 2006; FAO 2006b; Malimbwi *et al.* 2005)

Consequently, global concern to prevent forest loss is focusing on tenure reforms in the forest sector (Kajembe *et al.* 2004). Forest tenure is a broad concept that includes ownership, tenancy, access, acquisition, partitioning, transfer and other arrangements for the use of forests by individuals, groups or the state (Bruce 1986; Kajembe *et al.* 2004; Reeb and Romano 2006). Forestland tenure reform means changing rules of tenure which includes delegation of power through decentralization, confirmation of *de facto* rights in forestland and increasing tenure security (Bruce 1999; Adams *et al.* 1999). About 85% of forests globally are publicly owned (FAO 2005; Sharma 1992). In many sub-Saharan African countries, forest land tenure reforms and the relationship of these to forest condition and rural livelihoods are currently the focus of lively policy debates (Chileshe 2005). This is being driven by the acknowledgement that state control of forests has not prevented forest loss in many agrarian societies.

Experiences in Tanzania have shown that centralized "top down" management has failed to manage forest sustainably. This has led to the review of Forest Policy (Kihiyo 1998; URT 1998) and enactment of Forest Act Cap 323 [R.E. 2002] (URT 2002). Based on the legal ownership following the policy reforms on the formal and informal control of forest resources, four types of forestland tenure systems do exist in Tanzania namely state regime (national and local authority forest reserves); communal regime (community/village forests); private regime (forests under individual or group of people) and open access forest regime (forests in general land)

The Uluguru Mountains are dominated by state, private and communal tenure regimes. A study conducted by Burgess *et al*. (2002) showed that the mountains continue to lose forests annually. In early 1900s, the Uluguru forests covered 500 ha; currently they cover about 230 ha. This is 65% loss of the total original forest cover (Burgess *et al*. 2002). Efforts to arrest the situation have not yielded the desired outcomes. It needs no emphasis to say that the Uluguru Mountains are extremely important at local, national and global levels as they support the livelihoods of millions of people and have high biodiversity and catchment values (Monela 1995; Lovett *et al.* 1995). The Mountains are also endowed with many rivers and supply water to Dar es Salaam city, Coast and Morogoro Regions for domestic, agricultural (livestock and irrigation) and industrial purposes. Sustaining these valuable resources requires effective tenure regimes for structuring and executing institutions that can ensure good forest condition for the present and future generations.

Despite the fact that many studies have been conducted to assess resource condition in the Uluguru Mountains, the influence of tenure regimes on forest stocking and tree species diversity have not been given the desired prominence (Burgess *et al*. 1998; Malimbwi *et al.* 2004; URT 2009). Forest land tenure regimes are important in determining the fate of forest resources since they define who should use what, where and when (Hatcher and Bailey 2009). Hence, three forest land tenure regimes dominating Uluguru Mountains were assessed and compared with regard to their influence on forest condition.

METHODOLOGY

Study areas

The study was conducted in Uluguru Mountains, Morogoro Tanzania (Fig. 1). The Uluguru Mountains which are located between $6^0$51'and $7^0$12'S and $37^0$36' and $37^0$45'E are part of Eastern Arc Mountains. Uluguru Mountains rise

abruptly out of the coastal plain at approximately 300m above sea level (a.s.l) to a peak of 2600 m and cover 404 km^2 (Masawe 1992; Lyamuya *et al.* 1994). Rainfall is estimated at between 2900 and 4000 mm per year on the eastern slope of the mountains and 1200 mm on the western slope (Lovett *et al.* 1995). Temperature changes with altitude ranging from below 0°C at high altitude to above 26°C at low altitude (Masawe 1992). There have been increasing rates of human population growth of 6.5% per annum with a population density of more than 150 persons per km^2 (URT 1998, 2002). Agriculture and forestry are the main economic activities and sources of livelihood in the study area.

The study was carried out in communal forest (Misumba Village Land Forest Reserve) corporate/private forest (Roman Catholic Church Forest Reserve) located in Tangeni village and state forest (part of Uluguru Nature Reserve) and another communal forest (Chief Kingalu Sacred Forest Reserve).

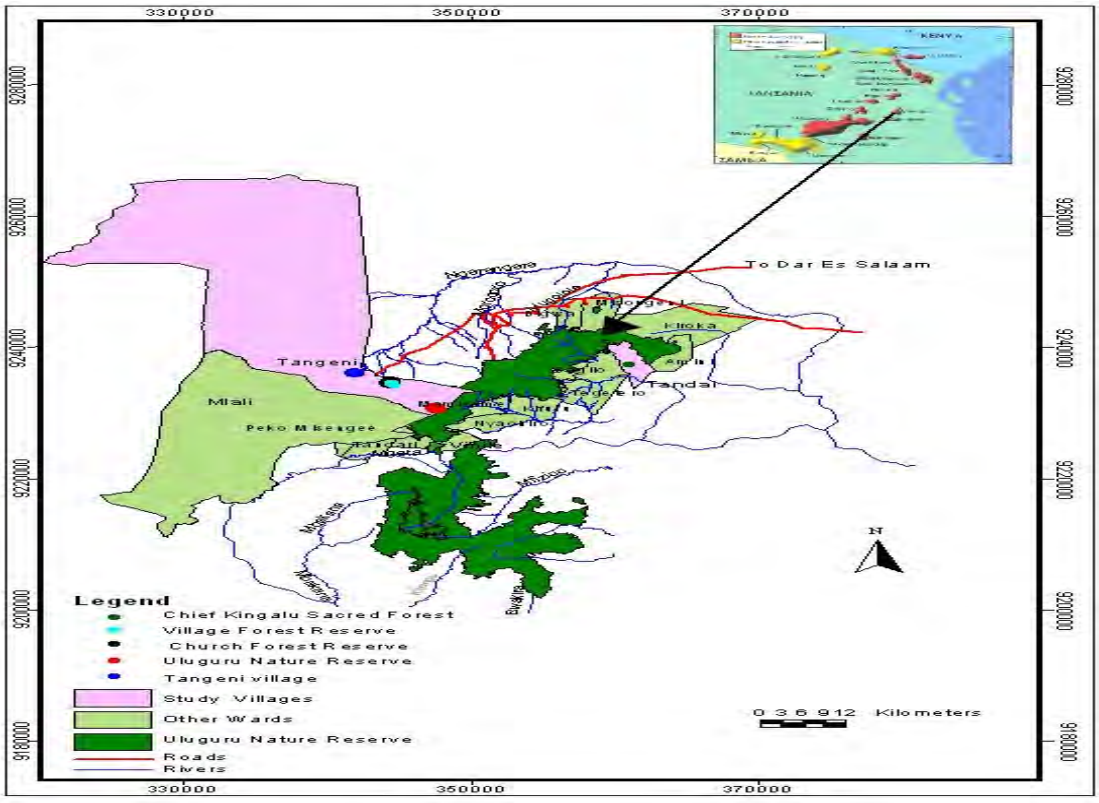

Figure 1: Map of Uluguru Mountains showing the study areas

Methods

Field data collection

For assessing forest condition, ecological data were collected through forest inventory. A systematic sampling design was adopted and concentric circular sample plots were laid down systematically on established transect lines in each forestland tenure regime namely: state regime (Uluguru Nature Reserve), communal regime (Misumba Village Land

Forest Reserve and Chief Kingalu Sacred Forest) and corporate/private regime (Tangeni Roman Catholic Church Forest Reserve). Areas of all four forests and the number of sample plots are indicated in Table 1. The design ensured even distribution of the sample plots throughout the forests and thus increased the chances of including all possible variations in the forests (Alemayehu 2007; De Vries,1986; Philip 1994; Phili, 1983).

Table 1: Sampling intensity and number of sample plots adopted in forest inventory

Tenure regime	Forest name	Forest area (ha)	Sampling intensity (%)	No. of sample
State	Uluguru Nature Reserve	10	7	10
Communal	Chief Kingalu Sacred Forest	2	14	4
Communal	Misumba Village Forest Reserve	3.7	12	6
Corporate/ private	Tangeni Roman Catholic CFR	3.8	13	7
Total		19.5		27

Concentric plots of 2, 5, 10 and 15 m were used. Data collected within each plot were: (i) within 2 m radius, all regenerants were recorded; (ii) within 5 m radius, all trees and shrubs with dbh ≤ 10 cm were measured for dbh; (iii) within 10 m radius, all trees and shrubs with dbh ≤ 20 cm were measured for dbh (iv) within 15 m radius, all trees with dbh > 20 cm were measured for dbh. About twenty trees were measured for total height in each forest (appendices 1-4). The selection of sample trees was done purposively to include most dominant tree species in all dbh classes. The number of plots and intervals between transects and sample plots varied among the sites from 50m to 100m in order to lay as many sample plots as possible depending on the size of the forest. For better layout of both transect lines and sample plots, the first plots were laid out at half interval from the boundaries (Zahabu, 2001).

Data analysis

Data from the four study forests were separately analyzed to examine tree and shrub stocking and species diversity. The Microsoft excel spread sheet was used to analyze the data for various parameters. The parameters computed for each forest were stand density (stems/ha), basal area (m^2/ha) and volume (m^3/ha) and species diversity indices (H').

Since only twenty sample trees in each forest were measured for total height due to time and financial limitations, height-diameter equations were fitted and used to estimate height of trees that were measured for dbh only. According to Malimbwi and Mugasha (2002) and Malimbwi *et al*. (2005), financial and time constraints may dictate how forest inventory should be conducted. Simple linear regression analysis using Microsoft excel spread sheet was used to fit the equations. Best equations were selected based on high coefficient of determination (R^2) and low standard error of estimate (Table 1).

Table 2: Height/ Dbh regression equations for four tenure regimes

Forest name	Tenure regime	Vegetation type	Regression equation	R^2 (%)	SE
UNR	State	Montane	Y=5.41+0.633(D)	84	4.28
CKSFR	Communal	Montane	Y=1.847 + 0.538(D)	90	5.17
TRCCFR	Corporate/private	Miombo	Y=0.095 + 0.495(D)	84	1.73
MVFR	Communal	Miombo	Y=0.849 +0.662(D)	80	1.829

Key: UNR = Uluguru Nature Reserve, CKSFR = Chief Kingalu Sacred Forest Reserve, TRCCFR = Tangeni Roman Catholic Church Forest Reserve, MVFR = Misumba Village Forest Reserve, SE = Standard Error of estimate

Single tree volume for the montane forest was calculated by using the general volume equation**.**

V = gh,*0.5……eqn (1)

Where:

V = volume of a tree (m^3)

h = total height a tree (m)

g = basal area of a tree (m^2)

0.5= tree form factor which is recommended to be used for natural forest in Tanzania (Malimbwi and Mugasha, 2002; Luoga *et al*., 2005).

Volume of standing trees in the miombo vegetation was calculated using the volume equation:

$V_i = 0.000011972 di^{3.1917}$ ……eqn (2) (Malimbwi *et al.*, 2005)

Where:

V = volume of the i^{th} tree (m^3) in a plot

di = diameter at the breast height (1.3m) of the i^{th} tree in a plot

t-test at 5% level of significance was used to test if there was significance difference in forest stocking (density, basal area, and volume). Comparison was made based on vegetation type. For the montane vegetation type, state regime (Uluguru Nature Reserve) was compared with communal regime (Chief Kingalu Sacred Forest). For the miombo vegetation communal regime (Misumba Village Forest Reserve) was compared with corporate/private regime (Tangeni Roman Catholic Church Forest Reserve).

Shannon-Wiener index

This index was used to determine tree species diversity. This is the most widely used index of diversity, which combines species richness and evenness and also is not affected by sample size. According to Krebs (1989), the Shannon-Wiener index of diversity is the measure of information contents of a sample and since information content is the measure of uncertainty, the larger the Shannon-Wiener index (the value H'), the greater the uncertainty. H was calculated as follows (Krebs 1989):

$$H = -\sum_{i=1}^{s} (Pi \log_a pi) \ldots\ldots\ldots\ldots\ldots \text{eqn (3)}$$

Where

H' = the Shannon wiener index of diversity

Pi = the proportion of individual or the abundance of species in the sample

Log_a = the logarithm to a base a (any base of logarithm may be taken)

- = the negative sign multiplied by the rest of the variables in older to make H positive

Index of dominance (ID)

The index of dominance was used to measure individual's distribution among the species in the community. This index is also called Sumpson's index of diversity and is equal to the probability of picking two organisms at random that are of different species (Krebs 1989; Misra 1989). The greater the value of dominance index the lower is the species diversity and vice versa.

This index is computed as follows.

$$ID = \sum \left(\frac{ni}{N} \right)^2 \quad \text{.....(4)}$$

Where:

ID is the index of dominance

Ni = is the number of individual of species i^{th} in the sample

N = is the number of individuals (all species) in the sample and

$\sum$ = is the summation sign

RESULTS

The performance of any forestland tenure regime governed by either formal or informal rules for securing sustainable management of forest resources is gauged on forest condition (Freedenberg 1994). In other words, forest condition is assumed to be a good indicator for assessing the performance of forestland tenure regime. Generally speaking, the results showed that tenure regimes in Uluguru Mountains are influencing stocking parameters differently (Table 3). These results concur with those reported by Balint *et al*. (2002) that various forms of forestland tenure regimes consist of different institutions have different influence in regulating forest resource condition, resource access and ownership.

Table 3: Tree stocking parameters by tenure regimes in Uluguru Mountains

Parameters	Forest tenure types		t-statistics	p-value
Montane forest	State (Uluguru Nature Reserve)	Communal (Chief Kingalu Sacred Forest)		
N	777 ± 26	1,020 ± 43	2.570	0.287 NS
G	78 ± 11	49 ± 7	2.201	0.132 NS
V	1234± 55	798 ± 25	2.200	0.236 NS
Miombo woodland	Corporate/ private (Tangeni Roman Catholic Church Forest Reserve)	Communal (Misumba Village Forest Reserve)		
N	2,573 ± 42	4,200 ± 73	2.364	0.087 NS
G	27 ± 4	10.80 ± 3	2.228	0.000**
V	122 ±10	23.08 ± 9	2.200	0.000**

NS=Not significant **= Significant ($p<0.05$)

Stand density

State regime (Uluguru Nature Reserve) versus communal regime (Chief Kingalu Sacred Forest)

It was found that there was no significant difference (p=0.287) in number of stems per ha when state regime (Uluguru Nature Reserve) (N=777 ± 26) was compared with communal regime (Chief Kingalu Sacred Forest) (N=1020 ±43). Despite the statistical insignificant difference, the communal regime had higher number of stems per ha compared to the state regime. This is probably attributed by the population being dominated by juvenile trees of 0-10 dbh (Figure 2) in the communal forest, as a result of increased gap and sunlight that enhanced high regeneration of young trees. Stems distribution in both state and communal tenure regimes followed reversed 'J' shape (Figures 2) which is a common phenomenon for natural forests. The species with the highest density in the communal forest was *Vitex doniana* (12%) while in the state forest *Ocotea usambarensis* dominated the forest (20%). The former is endemic to Uluguru Mountains while the latter is introduced from Usambara Mountains. *Ocotea usambarensis* was introduced in Uluguru Mountains in 1978 after the ban of legal extraction of forest resources. The species was preferred for rehabilitation purposes for the severely threatened places following extensive timber logging, poles and firewood collection. The introduction of different tree species for rehabilitation in the state forest of Nepal has suppressed domination of endemic species hence threatened their perpetuity (Paundel *et al.* 2007).

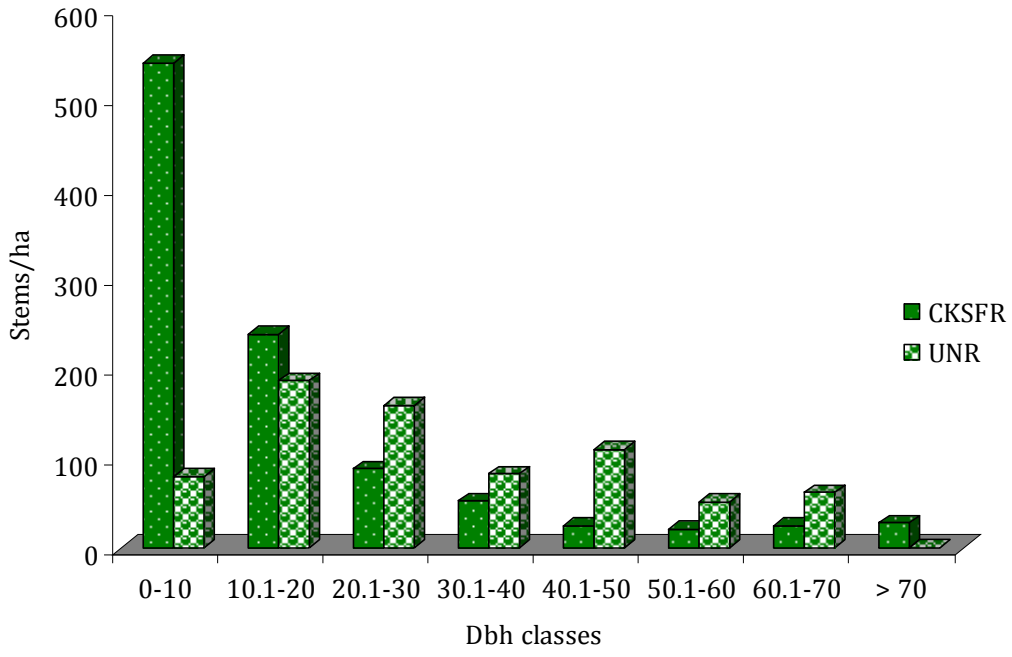

Figure: 2 Stem distributions by diameter classes in the Chief Kingalu Sacred Forest Reserve and Uluguru Nature Reserve

Corporate/private regime (Tangeni Roman Catholic Church Forest Reserve) versus communal regime (Misumba Village Land Forest Reserve)

There was higher number of stems per ha in the communal (Misumba Village Land Forest Reserve) (N=4200 ± 73) than corporate/private (Tangeni Roman Catholic Church Forest Reserve) (N=2573 ± 42). However, there was no statistically significant (p=0.087) difference in stems distribution between the regimes. Zahabu and Katani (2007) reported stem density of 3037± 641 per ha in the miombo woodland of Misumba Village Land Forest Reserve which was a bit lower than what has been observed in this study. Certainly, more trees have regenerated within the period of three years (2007-2010). The higher number of stems per ha in the communal tenure regime compared to corporate/private, is probably due to harvesting and wild fires that were witnessed to have taken place in Misumba Village Land Forest Reserve that has enhanced regeneration and recruitment of young trees. Tree species that dominated the Misumba Village Land Forest Reserve in distribution in number of stems per hectare were *Julbernadia globiflora* (33%), *Tectona grandis* (*10%), Annona senegalensis* (8%), *Ozoroa insigris* (7%), and *Diplorhnchus condilocarpon* (6%) while in Tangeni Roman Catholic Church Forest Reserve *Diplorhnchus condilocarpon* (19%), *Jurbernadia sp.* (14%), *Margarita discoidea (11%), Albizia versicolor* (11%), and *Pterocapus angolensis* (10%) were the dominant species. Presence of *Pterocapus angolensis* which is the most valuable timber species and among the rare and restricted species in Tanzania as the dominant species in the corporate/private forest indicates strong adherence of rules and regulations governing use of the forest.

Stems distribution in both communal and corporate private tenure regimes followed reversed 'J' shape (Figures 4 and 5) which is common phenomenon for natural forests with active regeneration and recruitment. Njana (2008) reported that active regeneration and recruitment in a natural forest is a good sign of sustainability which ensures sustainable supply of products and services to the surrounding communities. The distribution of number of stems per ha also shows that there are few diameter classes in Misumba Village Land Forest Reserve. This indicates that the forest is recovering following institutional rearrangement from free access to controlled use under CBFM since 2005.

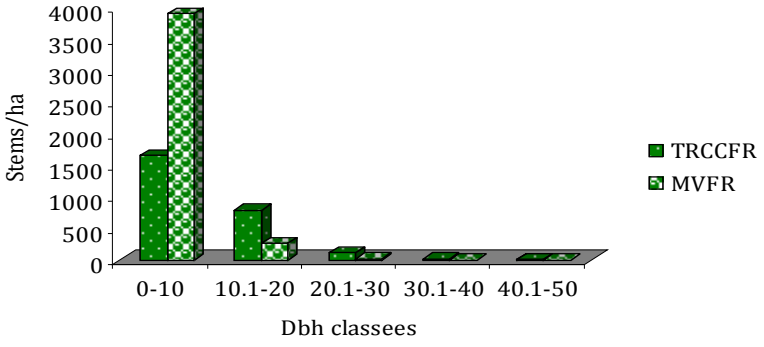

Figure 3: Stem distribution in diameter classes in Tangeni Roman Catholic Church Forest Reserve and Misumba Village Forest Reserve

Stand basal area and volume

State regime (Uluguru Nature Reserve) versus Communal regime (Chief Kingalu Sacred Forest Reserve)

Basal area distribution shows that state regime (Uluguru Nature Reserve) had higher basal area (78 ± 11 m² per hectare) than communal regime (Chief Kingalu Sacred Forest) (49 ± 7 m² per hectare) despite the non statistical significance difference (p=0.132). Lutatenekwa (2009) reported basal area of 110.53 m^2/ha in the North Pare Mountains which is higher compared to the village forest basal area of 35.64 m^2/ha. Likewise, high volume was recorded in the state regime (1234 ± 55 m^3/ha) compared to communal regime represented by the Chief Kingalu Sacred Forest (798 ± 25 m^3/ha). Similarly, these results showed no significant difference (p=0.236) between the regimes in volume distribution. High basal area and stand volume in the state regime is mainly associated with the ban of timber logging and poles collection in the state forest. Restrictions on timber and poles extraction have facilitated improvement of basal area and volume in Amani Nature Reserve (Mohammed, 2006). Tree species contributing to high basal area and volume in state regime were *Ocotea usambarensis* (11%), *Scolopia zeyheri* (7%), *Celtis zenkeri* (7%) *Dioscorea lonicuspis* (5%) and *Scrodophleus Fischer* (5%) while for the communal regime *Afzelia quanzesis (31%), Lyptonychia usambarensis (12%), Ficus stuhlmanii* (*12%), Allanblackia ulugurensins (9%), Chrysophyllum spp (7%) and Ficus exsperata (7%)* were the dominant species.

However, tree basal area and stand volume were distributed in eight diameter classes in the communal forest while there were only seven diameter classes in the state forest (Figures 4 and 5). In the Chief Kingalu Sacred Forest, some tree species including *Ficus stuhlmanii, Allanblackia ulugurensis and Afzelia quanzensis* are strictly protected by norms and taboos and used only during natural hazards for performing traditional ritual hence contributing to their presence. This implies that communal tenure regime governed by informal institutions represented by chief Kingalu sacred forest reserve was more effective in conservation of valuable tree species which have spiritual values. Shemdoe (2003) reported existence of sacred trees with larger diameter used for worshipping and offering sacrifices and other ritual purposes among the Maasai communities in Manyara Biosphere reserve.

Kijazi (2006) reported tree volume of 1338 m^3/ha in closed stratum of Amani Nature Reserve while Lutatenekwa (2009) reported a volume of 910 m^3/ha in north Pare Sacred Forest. Basal area and stand volume distribution for both regimes followed the general pattern of J-shaped trend (Figures 4 and 5).

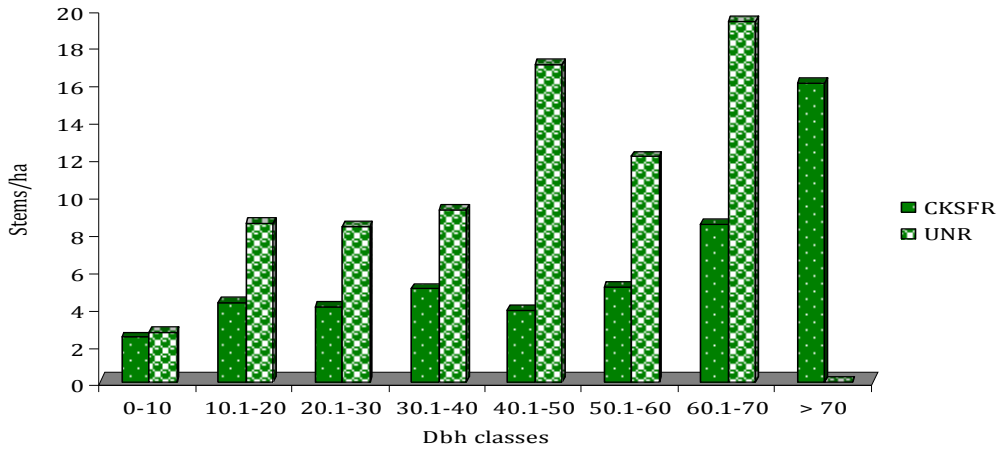

Figure 4: Basal area distributions by diameter classes in the Chief Kingalu Sacred Forest Reserve and Uluguru Nature Reserve

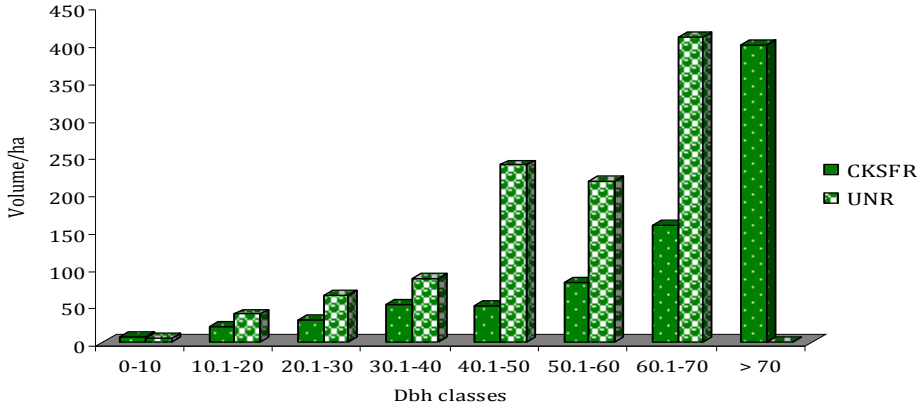

Figure 5: Stand volume distributions by diameter classes in the Chief Kingalu Sacred Forest Reserve and Uluguru Nature Reserve

Corporate/private regime (Tangeni Roman Catholic Church Forest Reserve) versus communal regime (Misumba Village Forest Reserve)

Basal area per ha for the corporate/private tenure regime represented by Tangeni Roman Catholic Church Forest Reserve (27 ± 4 m^2 ha^{-1}) was higher and significantly different (p=0.000) from communal tenure regime represented by Misumba Village Land Forest Reserve (10.83 ± 3m^2 ha^{-1}). Zahabu and Katani (2007) reported a basal area of 6.8 ±1.18 m^2 ha^{-1} in Misumba Village Land Forest Reserve. Moreover, the findings of the study showed that tree volume for the corporate/private (Tangeni Roman Catholic Church Forest Reserve) (122±10 m^3/ha) was statistically significantly (p=0.000) higher than communal (Misumba Village Land Forest Reserve) (23±9 m^3/ha). Zahabu and Katani (2007) reported a volume of 18.22 ± 5.70 m^3/ha in the Communal (Misumba Village Land Forest Reserve) which was a bit lower compared to the findings of this study. Certainly, growth has facilitated an increase in height and diameter within a

period of three years hence higher volume. The general pattern of normal 'J'- shape distribution for natural forests of mixed age species was not followed for both tenure regimes (Figures 6 and 7). This could be due to poor monitoring whereby larger diameter trees probably are illegally harvested despite the good institutional arrangements because the forests are surrounded by local communities.

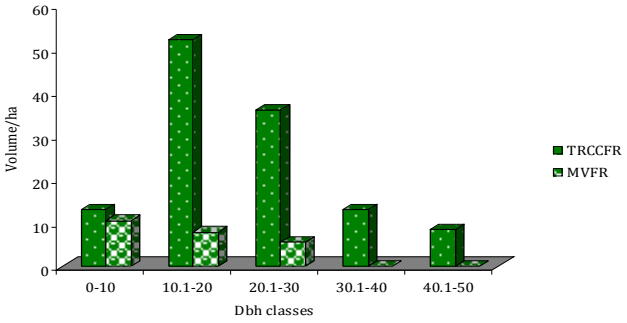

Figure 6: Basal area distribution by diameter class in Tangeni Roman Catholic Church Forest Reserve and Misumba Village Forest Reserve

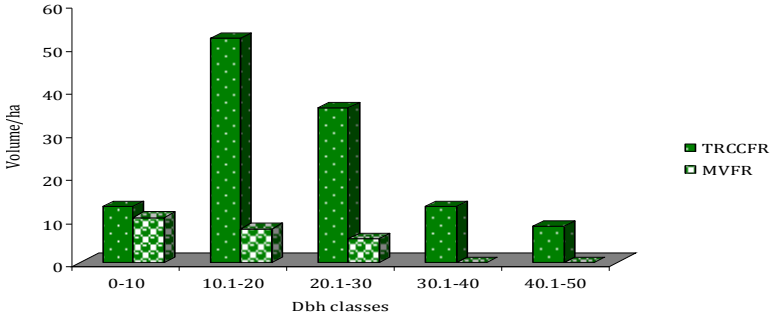

Figure 7: Distribution of tree volume by diameter classes in Tangeni Roman Catholic Church Forest Reserve and Misumba Village Forest Reserve

Influence of Forestland Tenure regimes on Tree Species Diversity

Shannon wiener Index (H')

High species diversity was found in state regime (Uluguru Nature Reserve) (3.48) from 46 enumerated species than in the Chief Kingalu Sacred Forest (3.21) from 36 different species. Species noted to have high contribution to species diversity in the state forest included *Ocotea usambarensis* (0.22), *Scolopia zeyheri* (0.20), *Celtis zenkeri* (0.19) *Scrodophleus fischeri* (0.16) and *Maesopsis eminii* (0.12). The most dominant species in the Chief Kingalu Sacred Forest were *Vitex doniana* (0.12), *Ficus sycomonus* (0.07), *Ficus stuhlmanii* (0.06), *Celtis gompghophylla* (0.06), *Isolana heinsenii* (0.06) *and Terminalia mollis* (0.05). Despite the low species diversity of the communal forest, it consists of indigenous species endemic to Uluguru Mountains as contrasted to state forest where *Maesopsis eminii* is invasive species. The Uluguru Mountains are highly threatened by invasive species despite having the highest genetic endemism compared to other mountains in East Africa (Lalika, 2006).

For the miombo vegetation, there was higher species diversity (2.60) from 34 different species in the corporate/private (Tangeni Roman Catholic Church Forest Reserve) compared to communal (Misumba Village Land Forest Reserve) (2.53) with 29 different tree species. Dominant species in the corporate/private forest were *Diplorynchus condilocarpon* (0.31), *Jurbernadia sp* (O.27), *Margaritaria discoidea* (O.24) *Albizia versicolor* (0.22) *and Pterocapus angolensis*, (0.15) while in the communal forest, *Julbernadia globiflora* (0.37), *Tectona grandis* (0.23), *Annona senegalensis* (0.21) *Ozoroa insignis* (0.18) *Diplorynchus condilocarpon* (0.17) were the dominant species.

Studies in miombo woodlands of Igombe river forest reserve, Tabora, Tanzania by Mafupa (2006) and Handeni Hill forest reserve, Tanga, Tanzania by Mohamed (2006) reported H' values of 2.90 and 3.10 respectively. Shannon-Wiener index of diversity and Simpson's index of dominance used to assess tree species diversity and evenness for the four tenure regimes in Uluguru Mountain are as shown in Table 4.

Table 4: Shannon wiener diversity indices for the Uluguru Mountains

Tenure regime	Forest name	Vegetation type	Shannon wiener Index (H')	Index of dominance (ID)
State	Uluguru Nature Reserve	Montane	3.48	0.04
Communal	Chief Kingalu sacred forest	Montane	3.21	0.04
Corporate/private	Tangeni Roman CCFR	Miombo	2.60	0.09
Communal	Misumba VLFR	Miombo	2.53	0.14

The index of dominance (ID)

The study revealed higher species for the state regime (Uluguru Nature Reserve) (0.04) compared to Communal regime (Chief Kingalu Sacred Forest) (0.05). Interviews with Village Leaders and Forest Officers revealed that there were very few fire incidences in Uluguru Nature Reserve as compared to other places in the Uluguru Mountains. This could be the main reason for the high species richness. High species richness was observed in Corporate/private regime (Tangeni Roman Catholic Church

Forest Reserve) (0.09) compared to Communal regime (Misumba Village Land Forest Reserve) (0.14). The ID values of 0.092 and 0.065 were observed in general lands and reserved forest respectively for the miombo woodland at Kitulang'alo, Morogoro (Zahabu 2001).

DISCUSSION

Forestland tenure regimes prevailing in the Uluguru Mountains influenced tree stocking and tree species diversity differently. Comparisons made of vegetation types including montane for the state regime (Uluguru Nature Reserve) and Chief Kingalu Sacred Forest (communal) found that Uluguru Nature Reserve had higher stocking and tree species diversity compared to Chief Kingalu Sacred Forest (Table 3). The higher number of stems per ha in Chief Kingalu Sacred Forest reserve compared to the state regime (Uluguru Nature Reserve) is probably attributed by the dominance of small size trees (dbh 0-10 cm) which indicates increased recent disturbance as was observed during the field visit. Nevertheless, in all merchantable Dbh classes (2-7), the state forest had higher densities compared to the communal forest (Figure 8). This is an indication that the state regime governed by formal institutions is effective in conservation compared to the communal regime.

Moreover, state regime was found to have higher basal area and volume than the communal regime. The observed difference between state and communal tenure regimes was contributed mainly by the high level of disturbance for the communal tenure regime compared to state. Disturbances were attributed to tenure change from communal to open access which was associated with institutional weakness resulting from erosion of norms and taboos governing access to Chief Kingalu Sacred Forest Reserve. Discussions held with Chief Kingalu revealed that colonialists divided the forest into two parts namely government and Chief's forest. This implies that autonomy of the indigenous people in the management of forest resources was recognized and respected by the colonial government. The Chief Kingalu Sacred Forest was demarcated and covered about four wards namely Bigwa, Kiroka, Mkuyuni and Kinole. The boundary between government and Chief's forest was laid in Kinole at Bohomela village. After the abolition of chiefdom in Tanzania in 1963, the government issued permits for timber harvesting and most part of the Chief Kingalu Sacred Forest was disturbed through agriculture and settlements establishment. This has hastened deterioration in basal area and tree volume in the communal forest. This implies that political dynamics which resulted into the abolishment of chiefdom in Tanzania in 1963 has undermined Chiefs' power in managing the forest. However, what has been observed in this study is contrary to what has been reported by Katani (2010) that traditional management by norms and taboos in Ukerewe Island have contributed to the presence of big diameter trees with high volume in micro spring forests.

The high species diversity (Table 3) observed in the state forest indicates the more effective the state is in conservation compared to the communal forest. This can be credited to the efforts of the Government of Tanzania and NGOs on conservation. The Eastern Arc Mountains are designated as one of the 20 Global Biodiversity Hot Spot Areas (NEAP, 1994; Lulandala, 1998) and Uluguru Nature Reserve (state) is part of the eastern arc Mountains. Currently, Uluguru Mountains have been promoted to nature reserve and became world heritage site (URT, 2009). According to classification of International Union of Conservation of Nature (IUCN), Nature Reserve is of higher status in terms of conservation

.Furthermore, decentralization in forest management has played crucial role in improving tree species diversity in the state forest. Although Uluguru Nature Reserve is a state forest under the central government governed by formal institutions including forest policy (URT 1998) and Forest Act Cap 323 [R.E. 2002] (URT 2002), joint forest management is adopted to curb destruction of forest resources. Local communities are vastly involved in the management of forest resources, they are given power to manage the forest in partnership with central government. Activities including tree planting, combating fire incidences and reporting to Forest Officers on illegal activities were done collectively by the natives and central government. This suggests that people are willing to contribute free labour to forest conservation initiatives hence contribute to improvement of tree species diversity. According to Paundel *et al.* (2007), joint forest management has resulted into the improvement of tree species diversity in the state forest in Nepal, despite the poor records in poverty alleviation, continued political crisis and violent conflicts of the country.

On the other hand, Chief Kingalu Sacred Forest is meant for ritual purposes. This forest management is inherited within the clan in maternal manner and devolution or joint forest management means erosion of culture. Probably this behaviour of the locals has led poor adoption of the new forest management interventions including joint forest management hence low species diversity. Discussion revealed that a portion of chief Kingalu sacred forest which was severely disturbed from encroachment and deforestation was planned for rehabilitation. The government, through the Vice President's Office secured funds from development partners (France and Norway) for the rehabilitation through joint forest management. Unfortunately, the local communities refused because the matter was misunderstood by the communities who had the feeling that Chief Kingalu and political leaders are selling their land to Europeans.

For the miombo vegetation, corporate/private (Tangeni Roman Catholic Church Forest Reserve) had higher stocking and tree species diversity compared to Communal regime (Misumba Village Forest Reserve). Although there was no significant difference in the number of stems per ha between the regimes, communal tenure regime had higher number of stems per ha compared to corporate/private, probably due to illegal harvesting and wild fires that were witnessed to have taken place in Misumba Village Land Forest Reserve. Illegal harvesting and wild fires are due to the weakness in institutional performance under communal tenure regime compared to corporate/private. Regeneration and recruitment of young trees are enhanced through increase of gaps, light, raised soil temperature and reduced nutrient competition (Augsburg 1984; Chardon and Robert 1991).

Basal area per hectare and stand volume for the corporate/private tenure regime represented by Tangeni Roman Catholic Church Forest Reserve was compared to communal tenure regime represented by Misumba Village Forest. The difference in basal area and stand volume can be attributed by the effectiveness of corporate/private forest land tenure regime on enforcing rules and regulations that have alienated the surrounding community from forest use as compared to communal tenure regime which was open access since colonial era till 2005 when it was declared as a Village Land Forest Reserve.

The observed higher species diversity in the corporate/private (Tangeni Roman Catholic Church Forest Reserve) compared to communal (Misumba Village

land Forest Reserve) provides evidence of how strong corporate/private regime institutions are in forest management. There was accelerated illegal harvesting in the Misumba Village land Forest Reserve. Discussion with village leaders revealed that there was illegal harvesting of valuable tree species including *Pterocarpus angolensis* and *Combretum mole.* This was observed during the forest inventory. It was found that there were many stumps of felled trees. Limited funds and human capital to enforce the rules was cited by the village leaders as another reason for low species diversity in the communal forest. The management initiatives introduced by the Wildlife Conservation Society Tanzania (WCST) including tree planting, provision of free seedlings to the villagers, extension services on sustainable management have stopped after the project phased out. High tendency of tree felling in the communal compared to cooperate/private regimes could be another factor causing low species diversity in communal forest. Discussions with villagers revealed that some people use money as strategic power to create cordial relationship with village leaders to have free access to forests to cut poles, firewood and timber. This does not happen corporate/private regime. According to Alemayehu (2007), strong rules governing church forests in Northern Ethiopia led to massive improvement to tree species diversity, despite of the low budget directed to them. This shows that private forest with rights of occupancy (lease) has prevented the surrounding communities from forest use hence high stocking and tree species diversity compared to Misumba Village Land Forest Reserve which was open access before the implementation of CBFM.

CONCLUSIONS AND RECOMMENDATIONS

The study concludes that forest tenure regimes were generally key factors that determine the forest condition. Forestland tenure regimes prevailing in the Uluguru Mountains influenced differently tree stocking and tree species diversity. The superiority of the state regime (Uluguru Nature Reserve) compared to communal regime (Chief Kingalu Sacred Forest) was the result of strong formal institutions which offered technical advice, enforced the law and implemented joint forest management. Currently, the informal institutions (norms and taboos) governing Chief Kingalu Sacred Forest have weak legitimacy in managing forest resource.

Corporate/private (Tangeni Roman Catholic Church Forest Reserve) tenure improved forest condition better compared to communal regime (Misumba Village Forest Reserve).

The study recommends that for the purpose of sustainable management of the forests under different tenure regimes in Uluguru Mountains, it is essential that an in-depth forest inventory is conducted so as to quantify stocking of tree, shrub species and forest disturbances so as to understand the level of resource extraction for each tenure regime. This will serve as baseline data that will be used to compare forest dynamics under different tenure regimes and act as guide in the preparation of management plans which are very important in forest management. Since forest resources use involves multiple stakeholders, the study further recommends that in order to ensure sustainable management of forest resources, 'cross sectoral', 'inter-disciplinary' and 'participatory' approach in management of the resources be adopted.

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APPENDICES

Appendix 1: Twenty trees used to fit the Height/Dbh Regression Equation for the Chief Kingalu Sacred Forest

SN	Spp code	Botanical name	Local name	Height	Dbh
1	25	*Ficus exasperata*	msasa	44	74
2	15	*Afzelia quanzesis*	Mkoya	48	95
3	14	*Lyptonychia usambarensis*	Mkole	27	53
4	2	*Antiaris usambarensis*	Mbila	59	102
5	31	*Ficus exasperata*	Mtamba	40	70
6	31	*Ficus exasperata*	Mtamba	46	83
7	15	*Afzelia quanzesis*	Mkoya	57	95
8	15	*Afzelia quanzesis*	Mkoya	39	67
9	2	*Antiaris usambarensis*	Mbila	6	8
10	12	*Khaya anthotheca*	Mkangazi	8	12
11	15	*Afzelia quanzesis*	Mkoya	18	35
12	18	*Xylopia aethiopica*	Mlawilila	32	40
13	1	*Trema oreintalis*	Mbefu	39	63
14	5	*Artocarpus heterophyllus*	Mfenesi	9	15
15	10	*Synsepalum cerasiferum*	Mikumbulu	21	27
16	8	*Macaranga kilomandscharica*	Mgida	56	82
17	32	*Ficus sycomonus*	Mvulanze	38	68
18	31	*Ficus stuhimanii*	Mtamba	31	72
19	14	*Lyptonychia usambarensis*	Mkole	25	53
20	29	*Dracaena usambarensis*	Msigisi	30	69

Appendix-2: Twenty trees used to fit the Regression Equation for the Uluguru Nature Reserve

SN	Specie code	Scientific name	Local name	Height	Dbh
1	20	*Ficus lutea*	Mkuyu	43	62.3
2	15	*Ocotea usambarensis*	Mseli	12	16
3	14	*Bombeya rotundifolia*	Mtati	21	28.4
4	23	*Celtis zenkeri*	Msese	32	46.3
5	22	*Newtonia buchananii*	Mkuvi	37	52.4
6	34	*Trilepsium madagascariense*	Chititu	30	46.7
7	16	*Unkown*	Chiambaza	24	41.1
8	25	*Macaranga kilimandschrica*	Mkongolo	18	21.9
9	17	*Mangifera indica*	Mwembe	40	55
10	27	*Scrodophleus fischeri*	Mkande	39	52.1
11	32	Schefflera lukwangulensis	Mlumangadu	42	58.3
12	18	*Podocarpus latifolius*	Mnyanzili	50	65
13	28	*Tragia brevipes*	Chiange	48	65.2
14	26	*Ficus kirkii*	Msumba	21	32.3
15	31	*Rhus vulgaris*	Msulu	28	37.8
16	19	*Scolopia zeyheri*	Mzona	45	51.1
17	21	*Synsepalum cirasiferum*	Mkumbulu	30	28
18	17	*Mangifera indica*	Mwembe	24	16.3
19	24	*Parinari excelsa*	Mngama	37	46.8
20	15	*Ocotea usambarensis*	Mseli	**35**	**43**

Appendix 3: Twenty trees used to fit the Regression Equation for the Misumba Village Forest Reserve

SN	Spp code	Botanical name	Local name	HEIGHT	DBH
1	7	*Brachistegia bussei*	Mmanga	13	20
2	23	*Acacia hockii*	Mgunga	8	7
3	16	*Tectona grandis*	Mtiki	18	21
4	16	*Tectona grandis*	Mtiki	16	21
5	16	*Tectona grandis*	Mtiki	6	16
6	4	*Diplorynchus condilocarpon*	Mtogo	11	8
7	3	*Julbernadia globiflora*	Mhangala	5	6.3
8	3	*Julbernadia globiflora*	Mhangala	7	10.6
9	3	*Julbernadia globiflora*	Mhangala	6	10
10	9	*Albizia versicolor*	Mnyanza	7	11.2
11	7	*Brachystegia boehmii*	Myombwe	9	11
12	7	*Brachystegia boehmii*	Myombwe	7	8
13	9	*Albizia versicolor*	Mnyanza	4	6
14	9	*Albizia versicolor*	Mnyanza	8	20
15	3	*Julbernadia globiflora*	Mhangala	5	8
16	7	*Brachystegia boehmii*	Myombwe	4	6
17	4	*Diplorynchus condilocarpon*	Mtogo	6	8
18	4	*Diplorynchus condilocarpon*	Mtogo	8	14
19	3	*Julbernadia globiflora*	Mhangala	5	8
20	5	*Margaritaria discoidea*	Mkwalekwale	11	17

Appendix 4: Twenty trees used to fit the Regression Equation for Tangeni Roman Catholic church Forest Reserve

SN	Spp code	Scientific name	Local name	Dbh	Height (m)
1	31	*Senna siamea*	Mkenge	20.2	8
2	27	*Cedrella odorata*	Msedelela	22.5	9
3	11	*Ozoroa insignis*	Mpondelo	11	6
4	19	*Entandrophragma excelsum*	Mbokoboko	23.9	8
5	23	*Leptonychia usambarensis*	Mkole	8.2	4
6	29	*Piper umbellatum*	Mnembonembo	17.5	7
7	18	*Combretum molle*	Mlama	32	10
8	17	*Albizia harveyi*	Mvulamvula	12.3	6
9	14	*Sterculia appendiculata*	Mgude	17.3	9
10	21	*Dracaena sp*	Msenene	28.9	11
11	21	*Dracaena sp*	Msenene	23.2	10
12	13	*Albizia versicolor*	Mnyanza	12.3	6.5
13	2	*Cussonia zimmermania*	Mdindilingoma	17.9	8.5
14	19	*Entandrophragma excelsum*	Mbokoboko	22	10
15	34	*Brachystegia boehmii*	Myombwe	7.2	4
16	11	*Ozoroa insignis*	Mpondelo	8.2	5
17	26	*Tabernaemontana pachysiphon*	Mlongelonge	23.1	12
18	27	*Cedrella odorata*	Msedelela	33.1	13
19	27	*Cedrella odorata*	Msedelela	28	12
20	23	*Leptonychia usambarensis*	Mkole	21	8