INDIGENOUS TREE USES, USE-VALUES AND IMPACT OF HUMAN POPULATION ON FOREST SIZE, STRUCTURE AND SPECIES RICHNESS IN ULUGURU, MOROGORO, TANZANIA

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ABSTRACT

This study assessed tree uses and use-values as well as impacts of human population on the forest size, species richness, basal area and stand density in the Uluguru forests in Morogoro Region. Interview with locals on the tree uses were done using structured questionnaires and use-value analysis techniques were used in analysing data. Trees with a diameter at breast height ≥ 10 cm measured at 1.3 m above the ground were sampled from a total of 114 plots of 20 m x 20 m (0.04 ha) from the seven forests. A total of 42 species belonging to 20 families were listed being useful for the local livelihoods. Of the listed species, 88% serve more than one function while 64% are used for firewood and charcoaling, 45%, and 40%, are used for timber and medicinal purposes, respectively. Milicia excelsa and Sterculia quinqueloba had highest and lowest total use-value, respectively. Ocotea usambarensis is known to treat 29% of diseases while 47% and 25% of the species with medicinal values are used to treat stomach-ache and dysentery. Roots are the most utilized tree parts for making traditional medicines, followed by barks and leaves. The human population density revealed a significant negative correlation with forest size (r = –0.90), species richness (r = –0.78), and stand density (r = –0.75). The study suggests for control of human population and their associated activities, provision of awareness on sustainable utilization of forest resources, use of alternative source of energy by locals and active involvement of the locals in management and conservation programmes.

Keywords: Biodiversity, Community, Conservation, Disturbance, Eastern Arc, Medicinal

INTRODUCTION

Worldwide, tropical forests are speciose and provide a variety of products (food, medicine, energy, timber, habitats) and services (nutrient cycling, climate regulation, soil erosion control, water supply, soil formation and soil formation) to humans (Philips and Gentry 1993, Krog 2005), however, the rapid human population growth has increased the threats to these ecosystems (Myers et al. 2000, FAO 2010). In developing countries, more than 10 million ha of tropical forests are known to be cleared or converted to other land use types per annum leaving remaining forest remnants disturbed and fragmented (Tole 1998). In Tanzania, the annual loss of forest cover between 1990 – 1995 and 2000 – 2010 were 322,000 ha and 403,000 ha, respectively, which are mainly due to agricultural clearings, overgrazing, firewood and illegal timber logging (FAO 2010). The loss of forest cover seriously affects ecological structure, existing biodiversity and endangers the livelihoods of millions of people who depend on them for socio-cultural, ecological and economic services

(Newmark 1998, Blasco et al. 2000, Kacholi 2013). Although, the Eastern Arc forests (including Uluguru forests) have been targeted as a high priority area for biodiversity conservation through local, regional and global initiatives (Myers et al. 2000), the forests are facing human population pressure and encroachment, both threatening their conservation value.

In Tanzania, the human population growth rate in the naturally-rich areas, particularly the highland areas are normally higher than national average (Seymore and Girardet 1986, Jones 2000). For example, the population growth rate in Langali and Tchenzema wards located in upper and lower Mgeta in the Uluguru area was 5.9% per annum between 1978 and 1988, compared to the national average of 2.8% over the same period (Jones 2000). Also, Bhatia and Ringia (1996) reported Uluguru area to have a population growth rate of 6.5% per annum. This hasty increase in population in naturally-rich areas has resulted in more pressure to the forest ecosystems for new land resources, both for settlements and farmland (Mitinje et al. 2007), which endangers the existence of the forest ecosystems and their associated biodiversity (Madoffe et al. 2007). While the fate of tropical forests and indigenous people has recently attracted substantial popular interest, surprisingly the research into the role forests play in supporting livelihoods has less attention (Phillips and Gentry 1993, Krog et al. 2005). This study aimed at investigating local use and use-values of tree species as well as impacts of local human population density on the forest size, forest structure (tree density and basal area) and species richness. It also provides suggestions on possible management efforts to reduce if not eliminating anthropogenic pressure to the forests.

MATERIALS AND METHODS

Study area description

Uluguru Mountain is located at latitude 7° 02′ - 7° 16′ S and longitude 38° 0′ - 38° 12′ E and is found 200 km West of Dar es Salaam City (Munishi 2004). It covers an area of 1,500 km^2 and altitude ranges from *c.*150 m on the southern-eastern margin to a peak of 2630 m at its highest point above sea level (Burgess et al. 2002). The Mountain is one of the component blocks of the Eastern Arc Mountains, stretching from Taita Hills in Southern Kenya to Udzungwa Mountain in South-central Tanzania (Burgess et al. 2002, Munishi 2004). The climate is oceanic due to proximity to the Indian Ocean with bimodal rainfall regime, the long rains last from March to May, peaking in April, and the short rains last from October to December. The mean annual rainfall and temperature in the region is 740 mm and 25.1 °C, respectively (Kacholi 2013). The villagers living nearby the mountain depend on agriculture as their main socio-economic activity. Other land use practices include livestock and bee keeping, fishing, carpentry, and small scale mining.

Data collection

Data were collected from four villages, namely Milawilila, Mwarazi, Kibangile, and Zongomero. The villages were selected based on their proximity to the forest reserves listed in Table 3. Structured questionnaires were used to collect the data from villagers and forest officers. The questionnaire for villagers was in two parts; respondent's personal particulars and forest resource utilization, while that of forest officers was to collect information on how the forests are managed, conserved, and on management challenges encountered. The process of getting the village respondents was facilitated by village executive officers (VEOs) of the respective villages by bringing those who had good knowledge of trees and their uses. The villagers' questionnaires were administered to 46 respondents in the four villages (Milawilila – 13, Mwarazi – 10, Kibangile – 12, and Zongomero – 11) and the researcher guided them by providing clarification on how to fill them. The respondents were encouraged to admit if they did not know tree species used in the listed use-categories and they were not allowed to discuss among themselves about the species used in various uses-categories. On the other hand, only four forest officers were interviewed. Information on ailment cured, used tree parts, and administration route vis-à-vis the recorded medicinal species were sourced from Augustino and Gillah (2005) and Lovet et al. (2006). The human population data for the villages surrounding the forests were obtained from the Ward Executive Officers (WEOs).

In order to determine tree density (stems/ha), basal area (m^2/ha) and species richness (species/ha) of the forests, all trees with a diameter at breast height (DBH) ≥ 10 cm measured (using diameter tape) at 1.3 m above the ground were sampled from a total of 114 plots of 20 m x 20 m (0.04 ha) each. A total of 18 plots were established at Kimboza, Kisego, Kilengwe, Milawilila and Nemele forest while 12 plots of the same size were used at Ngambaula and Gunauye forest. The plots were randomly placed in the forests from the edges towards the interior. Trees were counted and identified to species level. For samples which were not identified in the field were pressed and taken to forest department Morogoro for identification where the identification was done using relevant flora identification monographs. Trees with multiple stems at 1.3 m height were treated as the single individual whereby the diameters of all stems were taken and averaged. If a tree had buttress and abnormality at 1.3 m height, the diameter was measured just above the buttress where the stem assumes near cylindrical shape.

Data analysis

The use-value analysis was performed on the listed tree species to determine the utility of the resources by the locals. In the analysis, tree species were classified as highly preferred, preferred or less preferred to various uses-categories and the use-value scores assigned to these classes were 1.5, 1.0, and 0.5, respectively. The basic assumption here was that a more preferred tree species in a certain use-category would score 1.5, and this was adjusted down by point five for preferred species. The less preferred tree species in a certain use-category was assigned 0.5 score. This assessment of relative importance of tree species to local people follows the method of quantitative ethno-botany as described by Phillips and (Gentry 1993) and modified by Kvist et al. (1995). The average use-value was calculated as a sum of scores for each species in each use category divided by the number of respondents. Total use-values were calculated for each species as the sum of average use-values across use categories. The average and total use-values are measures of the relative importance of a particular tree species for a given use and for all uses combined, respectively. Data from the respondents were analyzed using the Statistical Package for Social Sciences (SPSS version 16) software.

The tree density (stems/ha) was obtained by dividing number of counted stems to total sampled area while specie richness was represented by number of encountered species per total studied area in each forest. The basal area (m^2/ha) was calculated by multiplying the square of tree DBH with 0.00007854. The human population density was obtained by dividing total number of people living in a village by its area (in square kilometre). The assessment of impact of human population density on tree density, basal area, forest size and species richness was done by calculating the Pearson correlation coefficient using MS Excel software.

RESULTS

Tree uses and use-values

A total of 42 useful tree species belonging to 20 families were recorded in this study. Family Fabaceae and Family Moraceae had the highest number of tree species used for various purposes. *Milicia excelsa* followed by *Albizia gummifera* and *Annona senegalensis* had highest use-values, while *Sterculia quinqueloba* had the least value (Table 1). Of the total species, 88% serve more than one function. A broad range of the species is used for firewood (60% of the total species) and charcoal production (52%). Of the total respondents, 98% admitted to depend utterly on firewood/charcoal for domestic use. The most common species collected for firewood and charcoaling are *Combretum* spp., *Scorodophleous fischeri*, *Mangifera indica*, *A. senegalensis* and *Grewia similis*. The species used for timber accounted for 45% of all listed species whereas *M. excelsa, Dalbergia melanoxylon, Allanblackia uluguruensis, Antiaris toxicaria, Bombax rhodognaphalon,* and *Cedrela odorata* had highest timber use-values. Of all the species, 55% are known to be used for construction purposes whereas *M. excelsa, B. rhodognaphalon, Millettia usaramensis,* and *Burkea africana* had highest construction use-values. The species used for making domestic utensils, carvings, fodder, farm implements, and traditional medicines accounted for 55%, 40%, 29%, 41%, and 40 of all listed species, respectively. *M. indica, S. fischeri, Oxyanthus goetzei* and *Vangueria infausta* had highest use-values in making domestic utensils, *D. melanoxylon* and *A. senegalensis* had highest carving use-values and *M. excelsa, M. indica, Bridelia micrantha* and *G. similis* had highest use-values in the farm implements use category. *Xylopia longipetala, Diplorynchus condylcarpon, Xylopia aethiopica, Ficus spp. Erythrophleum suaveolens* and *Azadirachta indica* revealed the highest medicinal use-values.

Among the tree species with medicinal values, 65% are collected from the wild, while 35% are from the general land and locals farms. Majority of the species are known to treat more than one disease (Table 2). The *Ocotea usambarensis* treats the highest percentage (29%) of the diseases. In terms of frequency of tree species uses, the highest percentage of tree species (45%) are used to treat stomach-ache, followed by dysentery (25%), infertility (20%) and cough (15%). Other diseases are treated with less than 15% of the recorded tree species. The majority of the traditional medicines are administered orally (80%), followed by rubbing (17%) and rinsing (3%). The most utilized tree parts are roots (41%), followed by barks (34%), leaves (21%), and fruits (4%). Roots are mostly used to treat stomach-ache, women's infertility, and abdominal pains, while barks are mostly used in the treatment of dysentery.

Table 1: The trees species commonly used by the local community in Uluguru and their corresponding main uses arranged in order of preferences and total use-values (Fi = Firewood, Ch = Charcoal, Ti = Timber, Me = Medicinal, Co = Construction, Do = Domestic utensils, Ca = Carving, Fo = Fodder, Fe = Fencing, Fa = Farm implements, and TUV = Total use-values).

Species	**Family**	**Main tree uses**	**Total use-value**
Milicia excelsa (Welw.) C.C. Berg.	Moraceae	Ti,Co,Fa,Do,Fi,Ca,Fo,Fe,Ch	10.6
Albizia gummifera (J.F. Gmel.) C. A. Sm.	Fabaceae	Co,Fo,Ch,Fa,Fe,Ca,Do,Me,Ti,Fi	10.5
Annona senegalensis Pers.	Annonaceae	Ca,Fa,CoFa,Fe,Fi,Ch,Me,Fo	10.3
Dalbergia melanoxylon Guill. & Perr.	Fabaceae	Ca,Ti,Me,Ch,Do,Ca,Fa,Fe,Co	9.8
Erythrophleum suaveolens (Guill. & Perr.) Brenan.	Fabaceae	Me,Do,Fi,Ca,Fo,Fa,Ca,Ch,Fe,	9.5
Mangifera indica L.	Anacrdiaceae	Fe,Fa,Fi,Me,Ch,Ti,Do,	9.2
Cedrela odorata L.	Meliaceae	Co,Ti,Fi,Ch,Ca,Fo,Fe,Fa	8.5
Combretum spp.	Combretaceae	Fi,Ch,Fa,Co,Me,Do,Ca,Fa	8.4
Albizia versicolor Welw. ex. Oliv.	Fabaceae	Fe,Do,Ch,Co,Ca,Ti,Me,Fi	7.2
Vitex doniana Sweet	Verbenaceae	Fo,Do,Me,Fa, Ch,Fi, Fe	6.8
Scorodophleous fischeri (Taub.) J. Leon	Fabaceae	Do,Fi,Ch,Ti,Co,Fa	6.6
Khaya anthotheca (Welw.) C. DC.	Meliaceae	Ti,Fi,Ch,Do,CaFa	6.4
Acacia albida Delile	Fabaceae	Ch,Fi,Fo,Do,Ca	6.2
Pterocarpus angolensis DC.	Fabaceae	Ti,Co,Do,Ca,Fi,Ch	6.2
Bombax rhodognaphalon K. Schum.	Bombaceae	Ti,Me,Do,Ca,	6.1
Grewia similis K. Schum.	Tiliaceae	Fe,Fa,Fi,Fo,Me	5.9
Dombeya natalensis Sond.	Sterculiaceae	Ch,Fa,Do,Ca,Fe	5.1
Azadirachta indica A. Juss.	Meliaceae	Me,Fe,Fo,Ch	4.2
Millettia usamarensis Taub.	Fabaceae	Co,Fe,Fo,Fi	4.0
Terminalia sericea Burch. ex DC.	Combretaceae	Me,Do,Fi.Ch	4.0
Burkea africana Hook.	Fabaceae	Co,Fi,Ch,Fa	3.8
Ehretia amoena Klotzsch.	Boragnaceae	Fo,Co,Ti,Do	3.8
Afzelia quanzensis Welw.	Fabaceae	Ti,Do,Fi,Co,Ca	3.5
Oxyanthus goetzei K. Schum	Rubiaceae	Do,Fi,Fe,Fa	3.5
Terminalia sambesiaca Engl. & Diels.	Combretaceae	Fi,Fa,Co,Ch	3.5
Antiaris toxicaria (Pers.) Lesch.	Moraceae	Ti,Co,Do	3.4
Allanblackia ulugurensis Engl.	Clusiaceae	Ti,Ca,Do	3.0
Bridelia micrantha (Hochst.) Baill.	Euphorbiaceae	Fa,Me	2.8
Markhamia obtusifolia Sprague	Bignoniaceae	Co,Ca,Do	2.7
Ficus spp.	Moraceae	Me,Fi	2.5
Parinari excelsa Sabine	Chrysobalanaceae	Ti,Fi,Co	2.3
Ocotea usambarensis Engl.	Lauraceae	Me,Ti,Co	2.0
Vangueria infausta Burch.	Rubiaceae	Do,Fi,Ch	2.0
Harungana madagascariensis Lam. ex. Poir.	Hypericaceae	Do,Co	1.7
Lonchocarpus bussei Harms.	Fabaceae	Ch,Fi	1.6
Tectona grandis L. f.	Lamiaceae	Ti,Fa,Fe	1.5
Brachystegia bussei Harms.	Fabaceae	Do,Co	1.5
Diplorhynchus condylocarpon (Müll.Arg.)Pichon.	Apocynaceae	Me	1.5
Xylopia aethiopica (Dunal) A. Rich.	Anacardiaceae	Me	1.5
Xylopia longipetala De Wild & T. Durand	Anacardiaceae	Me	1.5
Voacanga africana Stapf.	Apocynaceae	Co	1.3
Sterculia quinqueloba (Garcke) K. Schum	Sterculiaceae	Ti	1.0

Table 2: Trees with medicinal properties, parts used, treated diseases, and mode of use

Species Name	Part used	Ailment cured	Mode of use
Mangifera indica	Barks	Tuberculosis, dysentery, and infertility	Drinking
	Roots	Anaemia	Drinking
Xylopia aethiopica	Fruits	Stomach-ache, coughs, dizziness, amenorrhea, bronchitis and dysentery	Drinking
Xylopia longipetala	Bark	Stomach-ache and snake bite	Drinking
Annona senegalensis	Roots	Stomach-ache and snake bite	Drinking
	Barks	Body fracture	Rubbing
Diplorhynchus condilocarpon	Leaves	Gonorrhoea, syphilis and bilharzias	Drinking
Bombax rhodognaphalon	Barks	Diarrhoea	Drinking
Combretum spp.	Leaves	Headache, epilepsy and pneumonia Oedema	Drinking
	Roots	Abdominal pains, infertility,	Rubbing
		Stomach ache, hernia and schistomiasis	Drinking
Terminalia sericea	Bark & Leaves	Meningitis and dysentery	Drinking
Terminalia sambesiaca	Roots & Leaves	Stomach-ache and infertility for women	Drinking
	Barks	Fever and colds	Drinking
Bridelia micrantha	Barks	Malaria	Drinking
		Toothache	Rinsing
Albizia gummifera	Barks	Malaria	Drinking
	Roots	Skin diseases (rashes)	Rubbing
	pod	Stomach pains	Drinking
Dalbegia melanoxylon	Roots	Stomach-ache, dysentery	Drinking
	Barks	Dysentery and convulsion	Drinking
	Leaves	Stomach-ache and infant high fever	Drinking
Pterocarpus angolensis	Roots	Women's abdominal pains after delivery	Drinking
Erythrophleum suaveolens	Roots	Stomach worms	Drinking
Ocotea usambarensis	Barks	Women's stomach-ache, infertility, anaemia, infants complications, and whooping cough	Drinking
	Roots	Body swelling, tumours, and tonsillitis	Rubbing
		Headache and malaria	Drinking
Ficus sycomorus	Roots	Stroke, swollen throats, diarrhoea, and dysentery	Drinking
Ficus exasperata	Leaves	Malaria	Drinking
Ficus natalensis	Roots	Cough	Drinking
Ficus sur	Barks	Cough	Drinking
Vitex doniana	Roots	Women's stomach-ache	Drinking

About 80% of the respondents had knowledge of species that have been prohibited from harvest by the government, which include *Afzelia quanzensis, M. excelsa, Pterocarpus angolensis, Khaya anthotheca, D. melanoxylon, E. suaveolens, Sinsepalum cerasiferum, A. uluguruensis, O. usambarensis, Dombeya natalensis* and *Brachystegia* spp. These species are depleted for timber due to their economic importance. Also, the respondents provided their opinion towards better management of the forests, which include provision of environmental education to the locals especially on the importance of forests, encouraging locals to establish tree farms and planting trees on their farmlands, improve and enhance participatory forest guard surveys especially during the night, increase the penalties for those who breach villages by laws, particularly to those dealing with illegal harvests in the forests, and they also suggested for a local community to be practically involved in the management and conservation issues of the forest reserves.

According to the interviewed forest officers, the local inhabitants are permitted to enter the forests to collect dead wood, fruits and leaves for various purposes. They also disclosed that the available arable land in Uluguru is not plenty to supply the locals' needs, which make the local inhabitants to depend on resources from the forest reserves. The most economically important and exploited tree species pointed out by the locals were also mentioned by the interviewed forest officers. Moreover, the forest officers explained that the government of Tanzania has put some initiatives in managing and conserving the threatened species, which include; (1) formation of a forest surveillance unit for the purpose of intervening in any illegal activities taking place within and around the forest sizes, (2) prohibition of the threatened species from harvest, and (3) involvement of local communities through participatory forest management (PFM) projects. Also, the forest officers mentioned some of the challenges facing the forest department in managing the forest reserves, which include; (1) illegal logging and encroachment for cultivation as populations around the reserves grows, (2) inadequate number of technical labour force, (3) lack of adequate working facilities, (4) lack of environmental and conservation awareness by the locals, and (5) insufficient funds from the government and which are untimely provided.

Human population, forest size, tree density, basal area and species richness

A total of 1335 stems/ha with DBH $\geq$ 10 cm belonging to 101 species were recorded in the seven studied forests. The forest sizes ranged from 3 to 995 ha, human population density 39–73 people/km^2, tree density 97–390 trees/ha, basal area 3–24 m^2/ha, and species richness 26 – 93 species/ha (Table 3). Table 4 displays the correlation coefficients between forest size, stand density, species richness, and the total human population surrounding the forest reserves. The human population density was significantly negatively correlated with forest size, tree density and species richness while forest size was significantly positively correlated with species richness ($p < 0.05$). Also, the human population was negatively correlated with basal area, though the relation was not statistically significant ($p > 0.05$).

Table 3: Forest size, human population density, tree density, and species richness in the Uluguru

Forest	Forest size (ha)	Human population	Tree density (Stems/ha)	Species richness (Species/ha)	Basal area (m^2/ha)
Kilengwe	995	39	276	93	8
Kimboza	405	49	390	72	24
Kisego	119	57	140	29	3
Milawilila	13	59	172	28	13
Nemele	8	63	97	26	5
Ngambaul	3	73	85	35	3
Gunauye	3	68	175	46	5

Table 4: Correlation coefficients between forest size, species richness, and human population density

	Forest size	Species richness	Tree density	Basal area	Human population density
Forest Size	1.00				
Species Richness	0.93*	1.00			
Tree Density	0.66	0.80*	1.00		
Basal area	0.28	0.44	0.85	1	
Human Population Density	–0.90*	–0.78*	–0.75*	–0.49	1.00

NB: * indicate a significant correlation ($p < 0.05$, two tailed test).

DISCUSSION

Tree uses and use-values

Among the listed species, a broad range of species (64%) are used for firewood and charcoaling. Both dead and living firewood are collected from the forest reserves in Uluguru. The collection of dead firewood is non-destructive as it involves the collection of dead branches and naturally dying trees only, yet, this practice has some ecological consequences, which include; loss of habitat for a diverse range of small fauna, effects on nutrient cycling, effects on soil and regenerating trees, as well as loss of some microbes and insects that live in decayed wood material (Brown et al. 2009). The collection of live woods for brewing and brick burning was observed in the surveyed areas. This practice is known to be destructive as it accelerates deforestation; however, it is preferred by the local people because the live woods prolong the fuel burning time (Luoga et al. 2000). Shortage of suitable habitats for other organisms, a substantial reduction of a number of mature trees, and a significant increase in the number of small trees are some ecological impacts associated with the removal of live trees and logs (Brown et al. 2009). Some of the recorded species used for firewood and charcoaling in Uluguru (Table 1) have been also recorded by other authors (Luoga et al. 2000, Wilfred et al. 2006, Kalema et al. 2010) to serve the same function. For instance, Kalema et al. (2010) reports *M. indica,* and *Acacia* spp. being the most used species for charcoal production in Uganda, while Luoga et al. (2000) recorded *Combretum* spp. and *Julbernardia globiflora* being the most common collected species for fuel wood in Maseyu and Gwata villages in Morogoro. Though *M. indica* is not a natural forest tree species, it has been reported in this study being used for firewood and charcoaling and it is mostly accessed from general lands. Species like *Bridelia cathartica* are avoided as firewood and charcoal because of pungent smell when burnt, while species like *D. Melanoxylon* and *S. quinqueloba* are avoided for cultural reasons (Luoga et al. 2000). According to Malimbwi et al. (2005) species that are harvested for charcoaling vary between users and locations due to their availability and accessibility to producers rather than quality of charcoal, while Monela et al. (1993) report charcoaling tree species to be preferred due to their high calorific values.

This study has observed that all the surveyed villages in the study area are not connected to the national electricity transmission grid, which makes them to rely on charcoal and firewood as their sources of energy. Also, affordability of alternative energy sources such as standalone-electricity systems (*e.g.* Generator), gas and renewable energy facilities for the rural inhabitants has been problematic due to their availability and high initial investment costs. The high dependency on firewood and charcoal as the main sources of energy for rural and urban inhabitants has brought about excessive vegetation cover removal (Malimbwi et al. 2004), threatening the land, water base and food production, which subsequently locks local people into soil deterioration and environmental degradation (Yanda and Munishi 2006, Ahrends 2005).

The *Sterculia* spp. are valued for traditional worship as they are associated with ancestral sacrifices in Uluguru. Perhaps the observed low use-values for *S. quinqueloba* could be related to respect to traditional importance it has to the people, but could also be associated with its low market value. The respect and preservation of tree species with traditional values have an impact in terms of conservation (Luoga et al. 2000). Regardless of the traditional values, *S. quinqueloba* are currently harvested for commercialization of their wood for timber (Table 1). The harvest of trees with traditional values and the destruction of forests which were used for traditional ceremonies can be linked with lack of morals/ethics by some people. During the survey some elders admitted that most of the traditional values have been significantly diluted, though special respects are still maintained for burial places. Moreover, people in Uluguru especially in the surveyed villages are realizing that destruction of forests is causing loss of resources for various traditional uses (*e.g.* medicines) and decrease in water quantity in their river/streams passing through the villages.

In this study, species like *M. excelsa*, *A. quanzensis*, *P. angolensis* and *D. melanoxylon* were listed to have high timber use-values in the study areas. These species have also been reported by various authors to be overexploited elsewhere in Tanzania (Ahrends 2005, Malimbwi et al. 2005, Modest et al. 2010). For instance, *A. quanzensis, P. angolensis* and *D. melanoxylon* have been reported to face high harvesting pressure and harvested below minimum harvestable diameter requirements (MHD), 50 cm for the first two species and 25 cm for the latter species (Modest et al. 2010). According to Hines et al. (1993) *P. angolensis* is also rapidly deteriorating in Tabora region due to increased anthropogenic pressure. Other common species recorded to have timber use-values include *C. odorata, A. toxicaria, B. rhodognaphalon, A.*

uluguruensis, A. versicolor, A. gummifera, M. indica, E. suaveolens, S. fischeri, and *Parinari excelsa*. Stumps of some economically important trees were observed in the studied forests. Presence of stumps in the studied forests is an indication that illegal anthropogenic activities were taking place in the forests (Kacholi 2014). The illegal harvests are driven by both local and urban markets most trading sawn wood, for furniture and a round wood export market (Ahrends 2005). Both these markets are reported to be supplied with illegally cut timber (Milledge 2004), which are mainly done and transported at night along off-road, back roads in locking tracks to avoid inspection and normally timber are hidden underneath other products (Ahrends 2005, Kacholi 2013). The presence of less highly valued timber species and harvest prohibition done by the government could also be the possible reasons for a diversification to secondary and non-merchantable tree species such as *S. quinqueloba*.

The majority of rural inhabitants still rely on local forest resources for construction of their houses (Hines et al. 1993, Luoga et al. 2000). About 98% of the houses in the villages were constructed using the wooden poles where the architectural designs use four types of poles, namely *mijengo* (wall erecting poles), *miamba* (beam poles), *pau* (roofing poles) and *fito* (withies/cross joint members). The walls and floor are plastered with mud and the roof thatched with grass. The most preferred tree species as wall erecting and beam poles are *D. natalensis, Terminalia sericea, Terminalia sambesiaca* and *A. gummifera*. *Combretum* spp. and *Markhamia obtusifolia* are commonly used as roofing poles, while *Markhamia zanzibarica* is mainly preferred as withies. The use of tree species as poles mainly depends on their resistance ability against biodegraders, their availability and cultural taboos of a place. For instance, Luoga et al. (2000) reported reduced availability of *Spirostachys africana* which was mostly used as building poles due to its resistance to termites in Lubungo and Gwata villages in Morogoro region, as a result, more uses have shifted to other species *J. globiflora* and *Combretum* spp., which were formerly not commonly used for construction purposes.

Raw materials from forest reserves are used to make a wide range of products that are categorized as domestic/household utensils and farm implements (Hines et al. 1993). Many species are used to make tools and utensils such as hair combs, pestles, mortars, stirring sticks, drums, chairs, beds, tables, spoons, bow, arrows, and tool handles for hoe, spade, spear, axe, cutlasses and bush knives, which are used to meet day to day household needs (Moshi et al. 2010). Some tree species such as *G. similis, M. Usambarensis, A. gummifera, C.odorata, V. Doniana, M. Excelsa, Acacia spp.* and *A. senegalensis* are primary sources of fodder and are instrumental in supporting the livestock population (Hines et al. 1993). Live fences are also grown around houses, with properly selected species; the trees used for fencing can also be sources of firewood, medicines, fodder, fruits and other useful household products. Moreover, live fence acts as a wind barrier, but also can be used to improve soil conditions for home gardens when species are appropriately used (Lovett et al. 2006).

This study has also revealed a diversity of medicinal tree species, which are used to treat different ailments in the villages in Uluguru. Family Fabaceae and Family Moraceae were dominant in this study and were recorded in other ethnobotanical and ethnomedicinal studies (Moshi et al. 2010, Amri and Kisangau 2012), and may possibly be due to their wide range of bioactive ingredients in them (Simbo 2010). The present study revealed roots to be the most utilized plant parts. The finding is comparable with the findings of Rukia (2007) who reported roots being the most commonly harvested plant part, followed by leaves. The harvest of roots and barks was also reported to be the most common in Namibia (Chinsembu and Hedimbi 2010). The root excavation and bark striping can be very devastating and big threat to plant survival (Amri and Kisangau 2012). The high utilization of roots is putting many plants at a risk of extinction due to damages imposed on them during uprooting (Cunningham et al. 2001, Kamatenesi et al. 2011). Also, bark striping is known to be harmful method as reported by Cunningham et al. (2002) in their study in Cameroon. To foster sustainability the local community should be encouraged to use leaves whenever possible as opposed to roots and barks utilization (Chinsembu and Hedimbi 2010).

The percentage of listed species with medicinal properties (40%) in this study was in line with other findings done elsewhere. For instance, various authors (Hamilton and Bensted-Smith 1989, Makonda et al. 1999, Luoga et al. 2000, Wilfred et al. 2006) reported 39%, 49%, 26%, and 34% of the identified species in their studies, respectively, being used as medicines, suggesting that forest plants have been a good sources of products with medicinal values. Shangali et al. (2008) recorded 83 species belonging to 50 families as being used for medicinal purposes by the Hehe tribe in Udzungwa scarp forest reserve. Moshi et al. (2010) reported that 80% of rural communities in Tanzania depend entirely on traditional healers who obtain about 90% of their remedies from plants. Villagers from the study areas disclosed that they hardly access the few modern medical services available in Kibungo China and Morogoro due to geographical distances and financial constraints. The cost sharing policy in public health services has made many rural people to refrain from visiting health facilities as majority cannot afford to pay for the services (Makonda et al. 1999), suggesting a high dependence on forest resources for medicinal purposes. In Southern Africa, more than 80% of the rural populations are poor and depend entirely on forests for their livelihoods, while 80% of the rural communities depend on medicinal plants for their health needs and income generation (Sympungami and Chirwa 2012). Moreover, weak infrastructure and poverty pose problems for the provision of health care services in most of the South African countries, which led to more than 100 million people to depend solely on herbal medicines dispensed by traditional healers (*ibid*). The over-exploitation of plants for medicines may lead to some plants to be rare and eventually extinct if sustainable uses are not advocated.

Effects of human population on the forest size, stand density, basal area and species richness

Anthropogenic activities are believed to be significant influencing factors in any natural forest ecosystems (FAO 2010). This has also been confirmed by the findings in this study where the human population revealed the negative association with forest size, species richness, basal area and tree density. The findings signify that the increase in human population will always increase demands for more land for agriculture, firewood and charcoal for fuel, and timber and poles for construction purposes, which put more pressure to the forest ecosystems (Burgess et al. 2002, Madoffe et al. 2006). The demand for more land for agriculture has also resulted to forest encroachment, which consecutively result in forest size loss and decline in species richness and tree density (Madoffe et al. 2006). Burgess et al. (2002) reported that the rates of forest loss in Uluguru are mainly due to conversion to farmlands to be 1.7% and 0.6% between 1955 – 1977 and 1977 – 2000, respectively, which are associated with increased human population around forests. Elsewhere, the forest disturbances have been reported to be strongly associated with an increase in human population density too (Wang et al. 2001). Similar findings for this study have been reported by different authors in their studies in other tropical forests. For instance, Chittababu and Parthasarathy (2000) observed that differences in human interference had a considerable influence on species richness at Kolli Hills in the Eastern Ghats, India, whereas Zhu et al. (2004) found species richness to be less in more disturbed forest fragments in Southern Yunnan, China. Moreover, Top et al. (2009) revealed a negative association between human population density and measures of forest structure (tree density, basal area, stand volume and aboveground biomass) and species richness and diversity in Kampong Thom Province, Cambodia. Thus, the present study findings, call for control of the population growth in the areas, otherwise the forests will be fragmented and ultimately the ability of the remaining patches to sustain original biodiversity will be significantly reduced.

Community involvement in forest management

In Tanzania, forests are centrally managed through Forest and Beekeeping Division (FBD) under the Ministry of Natural Resources and Tourism (MNRT) signifying that the management type is characterized by extensive state control (FBD 2002). The lack of or insignificant involvement of local communities in the forest management has caused many forests in the country to be under pressure from encroachment, illegal logging, fuel wood harvesting, charcoaling, uncontrolled grazing and fires, which result in the degradation of forests (Iddi 2002). Actually, this is due to the fact that the rural inhabitants regard forests belonging to the government only as they are not fully involved in management issues. In reality, the protection and sustainable management of the forests cannot be done by the government alone (Kacholi 2013). Community involvements together with provision of environmental education and user rights seem to be the possible solutions. Though, the national forest policy (1998) opens the way for forest-adjacent communities to become co-managers of both central and local government forest reserves through Joint Forest Management (JFM) agreements, the local communities in the surveyed area revealed to have no direct responsibility for the protection and management of the forest reserves. This kind of negative perceptions by local communities makes them look the forest reserves as a liability than an asset (Iddi 2002). Thus, it is very important for the local people to be involved in the management and protection of the forests as they very much depend on the forest resources.

CONCLUSION AND RECOMMENDATIONS

High human population growth coupled with difficult economic circumstances and lack of connectivity to national electricity grid in rural areas has led rural inhabitants in Tanzania to depend solely on forest resources for their demands. This study revealed that Uluguru forests are the central components of the local rural livelihoods as majority depend on them for basic resources. Though many trees are exceptionally useful, their levels of utilization may far exceed their regeneration, thereby spreading more environmental destructions. For instance, high dependency on firewood and charcoal as fuel by the rural households is the major cause of forests deforestation which enhances fragmentation of habitats. The study also found a negative relationship between human population density, basal area and forest size, stand density as well as species richness. Thus, it is evident that forest size, tree density and species richness, are under threats as the human population increases.

In order to ensure protection and sustainable forests management, this study suggests for the following; (1) control of anthropogenic activities/disturbances should be given priority for management and conservation of forest resources in the forests. This could be attained by promoting community forestry/plantations and the introduction of other affordable renewable energy sources. (2) the local communities surrounding forest reserves need to be practically involved in the protection and management issues and environmental education should be given to all villagers surrounding forest reserves on the importance of the forests, (3) local people should be encouraged to establish tree plantations or plant different tree species in their farms for their own benefits and future generations, which will help future conservation efforts, and (4) the government needs to ensure that there is adequate number of technical staff (*i.e.* forest officers) supplied with adequate working facilities as well as providing sufficient funds timely to the forest department and beekeeping division.

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