Extent of Illegal Harvesting on Availability of Timber Species in Nyanganje Forest Reserve, Tanzania

Author(s): J.S. Makero and R.E. Malimbwi
Source: International Forestry Review, 14(2):177-183.
Published By: Commonwealth Forestry Association
URL: http://www.bioone.org/doi/full/10.1505/146554812800923372

Extent of illegal harvesting on availability of timber species in Nyanganje Forest Reserve, Tanzania

J.S. MAKERO and R.E. MALIMBWI

Forestry Training Institute, Olmotonyi, P.O.Box 943, Arusha, Tanzania and Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture, P. O. Box 3013, Morogoro, Tanzania

Email: makerojons@yahoo.com and remalimbwi@yahoo.com

SUMMARY

The study was conducted to determine the extent of illegal harvesting of timber species in Nyanganje Forest Reserve (NFR). Data on the extent of timber stocks harvested illegally in NFR were collected using both socio-economic and ecological surveys. Linear regression analysis showed that extraction of timber species in NFR mostly occurs at the roadside. The mean annual quantity of wood harvested illegally was estimated to be 6.2 m^3 per ha. Although the NFR has high potential of timber species (standing stock of 119 m^3 per ha), this is threatened by the high demand for timber species. Illegal harvesting of timber species is likely in NFR because the Government is providing few resources to safeguarding this reserve. Therefore, some arrangement from the Government is immediately needed to rescue this reserve and ensure its sustainability.

Keywords: timber, Nyaganje, illegal, harvest, extent

Etendue de la récolte illégale sur la disponibilité des espèces d'arbres dans la réserve forestière du Nyanganje en Tanzanie

J.S. MAKERO et R.E. MALIMBWI

Cette étude a été poursuivie pour déterminer l' étendue de la récolte illégale d'espèces d'arbres dans la réserve forestière du Nyanganje (NFR). Les données de l'étendue des réserves de bois récoltées illégalement dans la NFR ont été recueillies en utilisant des enquêtes socio-économiques et écologiques. L'analyse de régression linéaire montrait que l'extraction des espèces d'arbres dans la NFR se produit principalement en bord de route. La quantité annuelle moyenne révélait que la quantité de bois récolté illégalement était estimée à 6.2 m^3 par ha. Bien que la NFR possède un fort potentiel d'espèces (avec une population de 119 m^3 par ha), cet aspect est menacé par la forte demande d'espèces spécifiques. La récolte illégale est probable dans la NFR du fait que le gouvernement n'offre que de maigres ressources pour protéger cette dernière. Il est par conséquent immédiatement nécessaire que le gouvernement fournisse un arrangement pour sauvegarder cette réserve et assurer sa durabilité.

Magnitud del aprovechamiento ilegal y la disponibilidad de especies maderables en la Reserva Forestal de Nyanganje, Tanzania

J.S. MAKERO y R.E MALIMBWI

Este estudio fue llevado a cabo para determinar la magnitud del aprovechamiento ilegal de especies maderables en la Reserva Forestal de Nyanganje (RFN). Se recolectaron datos de las existencias de madera aprovechadas ilegalmente en la RFN, obtenidos a partir de muestreos socio-económicos y ecológicos. Un análisis de regresión lineal mostró que la extracción de especies maderables en la RFN sucede principalmente al borde de las vías de acceso. Se estimó que la media anual de madera aprovechada ilegalmente fue de 6,2 m^3 por ha. Aunque el potencial de crecimiento de especies maderables en la RFN es considerable (existencias en pie de 119 m^3 por ha), las existencias se encuentran amenazadas por la elevada demanda de especies maderables. Es probable que esté sucediendo un aprovechamiento ilegal de especies en la RFN, debido a los pocos recursos que el Gobierno dedica a la protección de esta reserva. Por tanto, es necesario que el Gobierno intervenga de algún modo para proteger esta reserva y asegurar su sostenibilidad.

INTRODUCTION

Tanzania has an area of about 38.8 million ha covered by forests and woodlands. Out of 38.8 million ha of forested land, almost two thirds is woodlands and general (public) land (Silayo 2004). The other one third include; Afro alpine heath and moorland, forests, grasslands, bushlands and thickets, swamps, mangroves and man-made forests (Mugasha *et al.* 2004).

The forests of Tanzania where Nyanganje Forest Reserve (NFR) is found are rich in diversity of species both fauna and flora such as birds, animals and plants (Lovett, 1998). Most of the plants are trees and shrubs, which are used as source of medicine and timber. Despite this huge natural resource base, the forests are undergoing an accelerated rate of destruction because majority of people cannot afford or have no access to furniture or building materials other than wood (Lovett 1998). Among the natural resources in the forests that face particular risk of degradation are timber trees. The underlying causes include; population growth and uncontrolled harvesting of trees (Iddi 2002, Augustino 2006).

Sustainable management of these forests is a major concern due to the fact that timber extraction, particularly for hardwood species is a major pressure. Inventories have shown that timber harvesting is taking place even in protected forests like NFR despite being prohibited by laws (Tanzania Forest Act 14 of 2002) (Malimbwi *et al.* 2005, URT, 2004). There is, therefore, an urgent need to document the status of destruction if changes are to be made to reverse or slow the degradation process. The results of this study will contribute to the knowledge on the extent and trend of timber species exploitation in NFR.

MATERIALS AND METHODS

Study Areas

NFR is located between latitude 7°56′ to 8°4′ South and longitude 36°39′ to 36°50′ East and occupies 18 980 ha. It is 70 km from Morogoro-Iringa trunk road and is among the forests of Eastern-Arc Mountains found in Udzungwa block. The forest is characterized by undulating landscape from 270 to 962 metres above sea level. The climate of the area is influenced by oceanic rainfall and temperature. Estimated rainfall is 2 000 mm per year with mist effect at high altitude. The dry season is from June to October and temperatures range from 19°C to a maximum of 27°C (MNRT 2004). The forest has two main vegetation types; miombo woodland and riverine forests (Pocs, 1993, Malimbwi *et al.* 2002). There are five villages that border the reserve. Namely; Signali, Sagamaganga, Lungongole, Kilama and Kibaoni, all falling within Kilombero district. The reserve falls under Joint Forest Management (JFM; Partnership in forest management involving government and local communities). Under JFM, extraction of any resources other than Non Timber Forest Products (NTFPs; dead wood, honey collection) is strictly prohibited and any activity involving cutting trees, mining or hunting is illegal. The villages surrounding the reserve are subject to a growing population and peri-urban communities, and increasing social and ethnic heterogeneity through increased migration and exposure to forces of globalization and decentralization of natural resource management.

Data Collection Methods

Ecological survey

A forest inventory was conducted to understand the extent of illegal harvesting of tree species in the reserve. This procedure involved obtaining information on the quantity and quality of the woodland resources and information on other characteristics of the land (Malimbwi 1997). The actual inventory was preceded by a reconnaissance survey which involved laying out plots on a map of the forest reserve and establishing transects.

To cover the variation between vegetation cover a systematic sampling design was adopted in this study. This ensured that all vegetation types in the woodland were sampled (Philip 1983). Rectangular shaped plots (10 m × 50 m) were adopted and laid out because they are easy to use; they reduce edge effects in the samples and counting errors during inventory.

In order to find the volume of timber species which had been cut and removed from the reserve, the Basal Diameter (BD) of stumps recorded were measured in each plot and identified to genus level. The age of the individual stump was determined by looking freshness of exposed wood, colour of the wood and coppices. Stumps with fresh exposed wood and colour and without coppices were one year, stumps with older exposed wood and beginning to sprout were two years and those with coppices and starting to decompose were more than two years. This work was done with the aid of an expert in ethnobotany and aspects of wood utilization.

The criteria used to determine the reason of harvesting timber species include: (i) Type of species of the remaining stump; in tropical forests there are variety of timber species and different species are preferred for different uses, such as making furniture, charcoal or building houses. (ii) Basal diameter of the remaining stump. In most cases trees with a big diameter are felled for use as lumber or make charcoal, while trees with a small diameter are felled for building materials or firewood. (iii) Proximity of charcoal kiln and sawing platform; experience from other studies shows that timber sawyers and charcoal makers do not make their kiln or pitsaw/platform more than 100 meters from where they get their resources (i.e. trees) because they do not have the means to transporting big trees over long distance. Therefore, a combination of all these criteria can determine the reason of felling and removing trees for different purposes from the reserve.

In this study, individuals of 1 to ≤ 15 cm are defined as small trees for poles while >15 as trees for charcoal and timber depending on species and proximity of sawing platform or charcoal kiln.

A total of 74 standing trees were identified (i.e. one tree in each plot); Basal Diameter (BD cm), Diameter at Breast

Height (DBH cm) and Height were measured to establish DBH/BD relationship. The criteria used to select tree for measurement in each plot was based on a tree nearest to the plot centre. Other information collected in each plot were distance from forest edge, distance from road, vegetation type and slope (steep/gentle).

Socio-economic survey

Questionnaire survey, in-depth interviews and focus group discussions were used to complement information on human activities influencing illegal harvesting of timber species in NFR. Three villages were selected based on their closeness to the forest reserve. Within these villages, key informants, knowledgeable about timber species and the reserve, were selected (i.e. carpenters, charcoal makers, timber sawyers, village environmental committee and village leaders). During the questionnaire survey, participant group meetings and Participatory Rural Appraisal (PRA) were conducted in each village and research objectives explained. Each meeting comprised of 20 community members. Stratified random sampling procedures was adopted to select community members aiming to include groups of people with different economic status, power in decision-making, gender, educational background, attitudes, perceptions, experiences and location (near to and far from NFR).

Data Analysis

Ecological data

Both descriptive and inferential statistical methods were used to analyze the quantitative data. Descriptive statistics such as frequency counts and percentages were used to explain and illustrate number of trees and timber species felled and removed in the forest reserve. Inferential data analysis was done using linear regression to analyze dependent variables. The dependent variables were DBH, Height (H) and Volume (V). The independent variable was BD of the stump. The Microsoft Excel software package and Statistical Package for Social Sciences (SPSS) were used for the quantitative data analysis.

The total volume of timber stock harvested illegally was calculated using the regression equation developed for miombo woodlands at Kitulanghalo Forest Reserve, Tanzania by Malimbwi *et al.* (1994) cited by Luoga *et al.* (2002). This equation was chosen because the vegetation type in the study area is also miombo woodland.

$$V = 0.0001\ DBH^{2.032}\ H^{0.659} \quad (1)$$

where V is the total volume of timber stock harvested illegally in NFR, DBH is the diameter of tree at breast height before the tree was felled and removed from the reserve, H is the height of tree before the tree was felled and removed from the forest.

Since volume is the factor of DBH and H, DBH/BD and DBH/H relationships were developed using the sampled trees whose height were measured. These equations were used to estimate the DBH and H of trees that stumps only left;

$$DBH = 0.7255 + 0.848\ BD \quad (2)$$

where BD (cm) is basal diameter of the remained stump.

$$H = 1.1761 \times DBH^{0.6928} \quad (3)$$

The extent of illegal harvesting of timber species per year was calculated by dividing the total volume of trees harvested illegally from the reserve by the period lapsed since the tree was cut;

$$V_a = \frac{V_t}{n} \quad (4)$$

where by V_a is annual quantity of trees removed (m^3/ha/year), V_t is total volume of trees harvested (m^3/ha), n is number of years lapsed since the tree was cut.

Socio-economic data

The components of verbal discussion collected through PRA were analysed. The recorded conversations with respondents were broken down into smallest meaningful units of information to ascertain values and attitudes of the respondents. Kajembe (1994) stated that structural functional analysis seeks to explain social facts related to each other within the social system and by the manner in which they are related to physical surrounding.

RESULTS

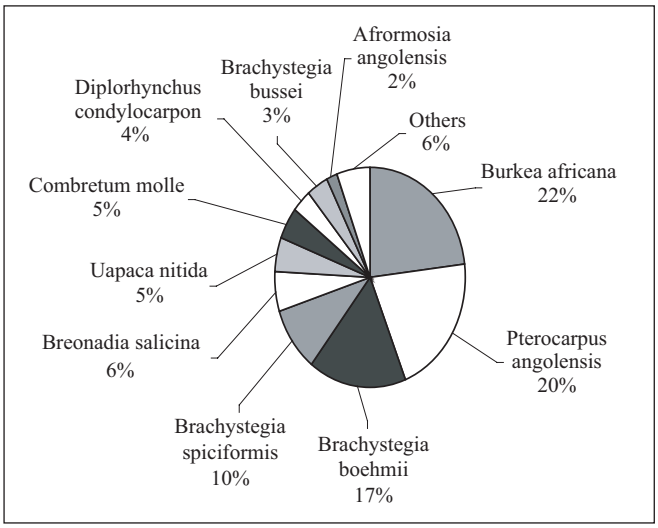
Quantity of timber species harvested illegal

The ecological survey revealed that about 18.7 m^3 per ha of timber species is harvested illegal in Nyanganje Forest Reserve (Table 1). The volume of newly cut (one year) was 9.7 m^3 per ha compared to old cuts (two and more than two

TABLE 1 *Quantity of timber species harvested illegal in NFR*

Age (Year)	Parameter	Quantity	Time lapse (Year)	Annual harvest (m^3)
One	Stem ha^{-1}	29	3	3.8
	Basal area ha^{-1}	1.4		
	Volume ha^{-1}	9.7		
Two	Stem ha^{-1}	8		
	Basal area ha^{-1}	0.5		
	Volume ha^{-1}	1.6		
More than two	Stem ha^{-1}	10	10	6.2
	Basal area ha^{-1}	0.6		
	Volume ha^{-1}	7.4		
Total	Stem ha^{-1}	47		
	Basal area ha^{-1}	2.5		
	Volume ha^{-1}	18.7		

FIGURE 1 *Percentage volume of timber species harvested illegally in NFR*



years) of 9 m^3 per ha. Considering the number of stem numbers per ha, new cut is almost two times higher than old cut, perhaps signifying an increase in the magnitude of removals through illegal harvesting in the reserve.

The most targeted timber species felled illegally were; *Burkea africana* (22%), followed by *Pterocarpus angolensis* (20%) and *Brachystegia boehmii* (Figure 1).

Table 1 shows that, the annual harvesting intensity are 3.8 m^3 per ha for the stumps inventoried within three years and 6.2 m^3 per ha assuming that all stumps inventoried were cut within ten years in NFR.

Analysis of diameter distribution shows that there was a large number of individuals of diameter classes one to four removed from the forest compared to large diameter classes five to eight (Figure 2). This could be because large trees in NFR within 5 km of the road were lost to previous exploitation of timber.

Number of stumps sampled in relation to distance from the roadside

The number of stems cut in relation to distance from the road along the Ifakara-Mikumi road is shown in Figure 3. The trend suggests that harvesting is most intensive up to 3 km from the roadside probably due to increased accessibility compared areas far from roads. At 1 km distance from the roadside the number of stumps sampled was 60 compared to just 1 stump found at 5 km distance from roadside. Our reported rate of removal (6.2 m^3 per ha per year) may, therefore, be an overestimate because the length of transects was only 5 km. The average rate across the whole reserve might be lower.

Harvesting intensity tended to decline with increasing distance from roadside ($y = -16.6x+85$, $R^2 = 0.84$; Figure 4) (where –16.6 and + 85 are coefficients of independent variables (distance) showing marginal effect (positive or negative) of the unit change in the distance on the dependent variable (stems cut), this implies that distance has a negative relationship with cutting intensity. The number of timber species cut decreases with increasing distance from the roads (forest edge) to far areas in the forest reserve.

Drivers of illegal harvest of timber species

The majority of respondents interviewed in three villages (81%) acknowledged that there is illegal harvesting of timber species in NFR. Relatively few (19%) did not know of any illegal timber harvesting taking place in the forest reserve. Illegal harvested timber species were used for building materials (53%), firewood collection for commercial and family use (21.1%), illegal lumbering (14%), charcoal production (10%) and other (0.01%; including making wooden tools and medicine; Table 2). This was also spotted during inventory work (Plate 1). Population increase and poverty could be the reasons that led local communities to engage in these activities.

FIGURE 2 *Number of stems cut per ha in different diameter classes in Nyanganje Forest Reserve*

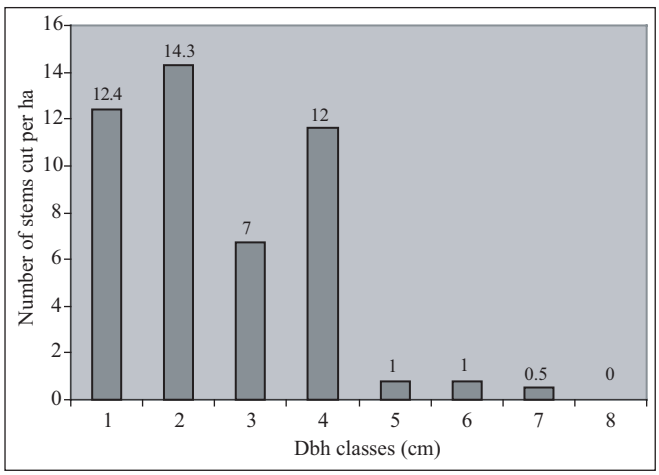


FIGURE 3 *Number of stumps sampled in relation to distance from the roadside in NFR*

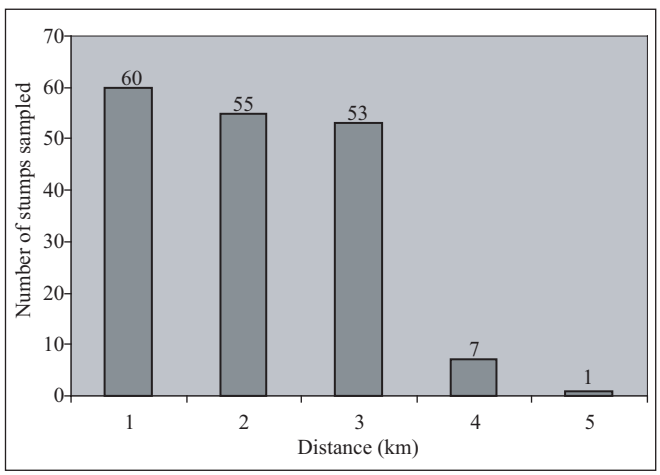


FIGURE 4 *Relationship between distance and cutting intensity*

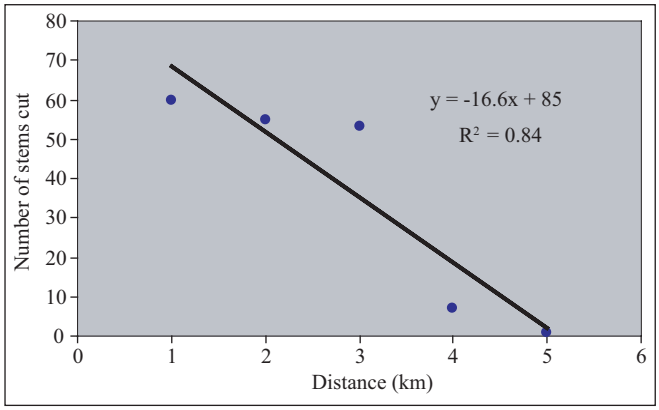


Table 3 shows that the leading driver of timber species harvesting was for poles for building (36.2%), followed by charcoal making (22.5%) and timber for furniture (14.3%) and building posts (4.6%).

DISCUSSION

Quantity of timber species harvested illegal

According to Malimbwi *et al.* (2005), the standing volume in Nyanganje Forest Reserve was around 119 m^3 per ha. The results presented here suggest that illegal harvest of this standing stock is around 19/119. Since the inventoried stumps were not more than ten years old, the annual harvesting intensity reported here is greater than the most common mean annual increment (MAI) reported in miombo woodlands which range from about 1 to 3 m^3 per ha per year (Zahabu 2001).

Drivers of tree cutting

Based on the set criteria, the findings revealed that timber species harvested illegally were used for different purposes including furniture, building materials and energy for cooking. The mean diameter of timber species for furniture was 45.5 cm, and the species felled for furniture included *Brachystegia boehmii, Brachystegia bussei, Brachystegia*

TABLE 2 *Illegal harvests of timber species identified by respondents around NFR*

Category	Count (%)	Measurements	Total count		Villages		
			Count (n=90)	%	Signali %	Sagamaganga %	Lungongole %
Yes	73 (81.1)	Lumbering	13	14.4	2.4	7.1	4.9
		Charcoal making	9	10.0	1.1	5	3.9
No	17 (18.8)	Building materials	48	53.3	10	11.3	32
		Firewood collection	19	21.1	7.1	8	6
		Others	1	1.1	0.10	0.9	0.1

PLATE 1 *Charcoal kiln and sawing platform spotted in NFR*

TABLE 3 *Drivers causing illegal harvest of timber species spotted in NFR*

Driver	Stumps sampled		Quantity		
	Number	%	Stems ha^{-1}	Basal area ha^{-1}	Volume ha^{-1}
Lumbering	28	14.3	7.6	0.9	8.1
Charcoal making	44	22.5	11.9	1.0	8.5
Building posts	9	4.6	2.4	0.1	0.8
Building poles	71	36.2	19.2	0.2	0.9
Others	44	22.4	11.9.	0.6	2.9
Total	**196**	**100.0**	**53.0**	**2.8**	**21.0**

spiciformis, Breonadia salicina, Burkea africana, Pterocarpus angolensis and *Uapaca nitida*. One quality timber species, *Milicia excelsa,* was reported to have been abundant in the past, but is now almost extinct. Other dwindling timber species include *Khaya anthotheca* and *Swatzia madagascariensis*. During ecological survey it was noted that whenever there was more than one big stump cut in a plot there was either a sawing platform or a charcoal kiln nearby too.

The preferred tree species for charcoal in this area include *Brachystegia boehmii, Brachystegia spiciformis*, *Burkea africana, Combretum molle, Pterocarpus angolensis* and *Flueggea virosa*. Selection of timber species for charcoal making is based on the species properties such as those with a high recovery rate, high calorific value and which do not break easily during transport. Where charcoal production is in progress, prime timber species such as *Pterocarpus angolensis* are not exempted from the kiln.

The timber species harvested for building materials consist of *Brachystegia boehmii, Brachystegia bussei, Brachystegia spiciformis, Breonadia salicina, Burkea africana, Combretum molle, Diplorhynchus condylocarpon* and *Flueggea virosa*. These species were mostly preferred due to their availability, durability, straightness, length and resistance to rot and attack by insects. Nduwamungu (2001) reported similar pole species from miombo woodlands in Kilosa district. Though pole cutting constitutes the highest percentage of all cut trees, the number was underestimated because stumps with DBH > 15 cm were considered not suitable for poles. However, reports by Malimbwi *et al.* (2002) suggest that big trees can be split into smaller dimensions suitable for poles.

Other uses for timber species include being used to make home items such as cooking utensils, tool handles and ropes. Handles may be for hoes, local weapons called *nyengos,* spears or axes. In this study the species used for such purposes include *Brachystegia bussei, Brachystegia spiciformis, Burkea africana, Diplorhynchus condylocarpon, Markhamia obtusifolia, Pterocarpus angolensis* and *Syzygium guineense.* Frontier-Tanzania (2005) reported similar tree species used to make handles for hoes, *nyengos* and mortars in Mtwara.

Tree species preference for various uses

The trend of tree species preferences for the various uses in the villages around NFR confirms the importance of the forest to the livelihood of the people living adjacent to the forest. *Burkea africana, Pterocarpus angolensis* and *Brachystegia spiciformis* appeared to be the most important tree species to the community in the surveyed villages. The respondents ranked *Burkea africana*, to be the most popular for furniture and building followed by *Pterocarpus angolensis*, and *Brachystegia spiciformis*. *Brachystegia spiciformis* was ranked first for firewood followed by *Burkea africana* and *Pterocarpus angolensis*. Preference varies from place to place especially in relation to the abundance of preferred species for specific uses. For example in the case of timber, scarcity of preferred species compels people to use other species, providing they have high strength properties, are workable and are naturally durability.

CONCLUSION AND RECOMMENDATIONS

Illegal harvesting of timber species is pronounced in NFR because the Government is committing few resources to safeguarding this reserve. Although Joint Forest Management is practiced in the reserve, it seems weak. This may be caused by a general reluctance of the people assigned to protect the reserve. Therefore, some arrangement from the Government is immediately needed to rescue this reserve and ensure its sustainability.

ACKNOWLEDGEMENT

This study was funded by Leverhulme Trust Fund, UK through University of Cambridge at the Sokoine University of Agriculture. The authors are grateful for this support and also are thankful to Neil Burgess and Jonathan Green for commenting on previous versions of this manuscript.

REFERENCES

AUGUSTINO, S. 2006. Medicinal plant resources with special reference to *Pterocarpus tinctorius* and *Strychnos spinosa* at Urumwa, Tabora Region, Tanzania. Thesis for Award of PhD Degree at University of Wales, Bangor. 270 p.

FRONTIER-TANZANIA 2005. *Mtwara Reconnaissance Project 2005*. The Society for Environmental Exploration, Dar es Salaam, Tanzania. 303 p.

KAJEMBE, G.C. 1994. Indigenous management systems as a basis for community forest in Tanzania: A case study of Dodoma Urban and Lushoto Districts. Tropical Resource Management Paper No 6. Wageningen Agricultural University, Netherlands. 15 p.

LOVETT, J.C. 1998. Eastern Tropical African Centre of Endemism: A candidate for world heritage status. *Journal of the East African Natural History Society* **87**: 1–7.

LUOGA, E.J., WITKOWSKI, E.T.F. and BALKWILL, K. 2002. Harvested and standing wood stocks in protected and communal miombo woodlands of eastern Tanzania. *Journal of Forest Ecology and Management* **164**: 15–30.

MADOFFE, S.S. and MUNISHI, P.K.T. 2005. *Forest condition Assessment in the Eastern Arc Mountain Forests of Tanzania.* FOCONSULT, Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture, Morogoro, Tanzania. 129 pp.

MALIMBWI, R.E. 1997. *Fundamentals of Forest Mensuration*: A compendium. Department of Forest Mensuration and Management, Sokoine University of Agriculture, Morogoro, Tanzania. 85 p.

MALIMBWI, R.E., LUOGA, E.J. and HASSAN, S. 2002. *Inventory Report for Nyanganje Forest Reserve in Kilombero District, Morogoro, Tanzania*. FOCONSULT, Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture, Morogoro, Tanzania. 43 p.

MALIMBWI, R.E., SHEMWETTA, D.T.K., ZAHABU, E., KINGAZI, S.P., KATANI, J.Z. and SILAYO, D.A. 2005. *Forestry Inventory Report for 11 Districts*; *Tanzania.* FOCONSULT, Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture, Morogoro, Tanzania. 39 p.

MNRT 2004. *Management Plan for Nyanganje Forest Reserve*. Forestry and Beekeeeping Division (FBD), Morogoro, Tanzania. 42 p.

MUGASHA, A.G., CHAMSHAMA, S.A.O. and GERALD, V.V.K. 2004. *Indicators and Tools for Restoration and Sustainable Management of Forests on East Africa*. State of Forests and Forestry Research in Tanzania paper 3, 66 p.

NDUWAMUNGU, J. 2001. Dynamics of deforestation in miombo woodlands: A Case Study of Kilosa District, Tanzania. Thesis for Award of PhD Degrees at Sokoine University of Agriculture, Morogoro, Tanzania. 274 p.

PHILIP, M.S. 1983. *Measuring Trees and Forests*. Division of Forestry, University of Dar es Salaam, Tanzania. Aberdeen University Press, Great Britain. 337 p.

SILAYO, D.S.A. 2004. Productivity analysis for an optimum timber harvesting system in Shume Magamba. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 109 p.

URT 2004. *Subsidiary Legislation* includes: Notice of the Commencement and Regulations of the forest (Act, No. 14 of 2002). Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism. 119 p.

ZAHABU, E. 2001. Impact of Charcoal extraction on the miombo woodland: The case of Kitulanghalo Area, Tanzania. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 156 p.