



IMPACT OF DECENTRALISED FOREST MANAGEMENT ON FOREST COVER CHANGES IN THE NORTH EASTERN TANZANIA

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ABSTRACT

This study aimed to assess the impact of decentralised forest management on forest cover changes in the north eastern Tanzania. Six contrasting forests namely: Shagayu (JFM), Shume-Magamba (exclusive state management) and Sagara (CBFM) in the montane, and Handeni Hill (JFM), Kiva Hill (exclusive state management) and Kwakirunga (CBFM) in semi-arid forests were studied. Forest cover changes were assessed for periods before and after decentralised forest management. Cover maps were derived from Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM) images. Forest inventory techniques were used to estimate tree harvests as major drivers of forest cover changes. The area under closed forest cover decreased substantially ranging from $0.4\%.y^{-1}$ to $1.3\%.y^{-1}$ in the montane forests with higher forest loss recorded under exclusive state management. In the semi-arid, the forest under JFM experienced substantial increase in forest cover ($+3.5\%.y^{-1}$) as compared to exclusive state management and CBFM. More tree basal area were harvested under exclusive state management in the montane study forests as compared to JFM and CBFM and the differences were significant ($p < 0.05$). In the semi-arid study forests, higher tree harvests were recorded under CBFM followed by JFM and exclusively state and the differences were significant ($p < 0.05$). It was

observed in this study that, regardless of management regime, participating villagers were unable to exclude people with no formal rights to the forests under PFM. It is therefore concluded that, decentralised management can impact forest resources both positively and negatively depending on institutional arrangements. However, some empirical evidence indicates that JFM and CBFM performed better than those under exclusive state management, although uncontrolled exploitation of the forest has continued also under these regimes. Although the two regimes are promising forest decentralisation models for Tanzania, more research is needed to understand the functions of different governance structures for decentralized forest management to achieve the goal of improving forest condition.

Keywords: decentralised forest management, forest cover, montane, semi-arid, north eastern Tanzania

INTRODUCTION

Tanzania is one of the countries in southern Africa with the major proportion of its landscape under forests and woodlands (URT 1998). Over the years, Tanzanian forests have undergone considerable reduction (FAO 2006; 2007; 2010). According to FAO (2006), Tanzania had 41.4 million hectares (ha) of forests in 1990 which decreased to 37.3



million ha in 2000 and currently forests and woodlands in Tanzania mainland cover 35.3 million ha (FAO 2007) representing about 38% of the total country land area. Annual deforestation and forest degradation was about 412,000 ha, an average of 1.1% loss of forested area (FAO 2007). FAO (2010) global forest resource assessment report indicated a decrease in annual deforestation and degradation in Tanzania at 403,000 ha, almost the same percentage. Deforestation refers to the depletion of forest crown cover to less than 10% while degradation refers to the long-term reduction of the overall supply of forest benefits, provided forest cover remains above 10% (FAO 2000). Forest clearing has contributed to biodiversity loss, including extinction of species and loss of genetic diversity within species (Chasek *et al.* 2006). Scholars (Misana *et al.* 1996; Ostrom 2000; Vatn 2005; Chasek *et al.* 2006) have argued that deforestation in sub-Saharan Africa is a result of local community exclusion from management of forests. Forest loss in Sub-Saharan Africa led to the recognition of the important role that local communities can play in the management and conservation of biological diversity in the past two decades (Kajembe 1994; URT 1998; Petersen and Sandhövel 2001; Ylhäisi 2003; Malimbwi and Munyanziza 2004; FAO 2007). In that regard, Tanzania and most developing countries have in recent years launched forest management decentralisation initiatives (Wily 1999; Ribot 2002; Larson *et al.* 2007), marking a major paradigm shift towards sustainable forest management (FAO 2007).

Tanzania introduced decentralisation of forest management through Participatory Forest Management (PFM) program in early 1990s in order to improve forest condition, livelihoods and governance (Blomley *et al.*, 2008). It is estimated that over 4.1 million ha of forests (12.8% of total forest area) are under decentralised management in the form of Joint Forest

Management (JFM) or Community Based Forest Management (CBFM) in more than 2,000 villages until 2008 (URT 2008). PFM follows two approaches: JFM and CBFM. Non-PFM forests are under Centralised Management (exclusively State) or open access regimes. The two approaches differ on ownership and roles played by actors (Zahabu 2008). Under JFM arrangement, the state owns the forestland and enters into Joint Management Agreements (JMAs) with adjacent communities. This form of PFM takes place on National Forest Reserves, Local Authority Forest Reserves and private forests. CBFM takes place in forests on surveyed village land as per Village Land Act No. 5 of 1999 (URT 1999) and managed by the Village Council. The ownership and management responsibility is fully vested on villagers (Blomley *et al.* 2007; URT 2007). The villagers are also exempted from regulations controlling harvesting of reserved tree species and are not obliged to share royalties with central or local government (URT 2002; Blomley *et al.* 2007). Under exclusive state management, the state is the sole owner and manager of the forestland.

This study aimed at assessing the impact of decentralized forest management on forest cover and harvested stocks in selected high rainfall mountainous and semi-arid forests in Tanzania using Remote Sensing and Geographic Information System (GIS) and forest inventory techniques.

MATERIALS AND METHODS

Study sites

This study was carried out in Lushoto (4°25'-5°07'S and 38°10'- 38°35'E) and Handeni (4°55' - 6°04' S and 37°47' - 38°46' E) districts in north eastern Tanzania covering 3500 km² and 7080 km² respectively Figure 1 shows the



location of the study forests. The selected forest reserves were Shagayu Forest Reserve (38° 18' E, 4° 30' S) under JFM, Shume-Magamba Forest Reserve (38°15' E, 4°40' S) under ordinary state management and Sagara Forest Reserve (38°30' E, 4°50' S) under CBFM, in Lushoto district with montane forest vegetation. Handeni Hill Forest Reserve (38°30' E, 5°27' S) was under JFM partly with miombo woodland and lowland forest, Kiva Hill Forest Reserve (38°06' E, 5°28' S) was under ordinary state management with lowland forest and Kwakirunga Forest Reserve (38°23' E, 5°14' S) was under CBFM with lowland forest. The changes in management regimes for the Shagayu, Sagara, Handeni

and Kwakirunga forest reserves took place in 2002, 1999, 1999 and 2005, respectively, while the reserves under ordinary state management namely Shume-Magamba and Kiva have remained unchanged regarding tenure and management regimes. The montane forest reserves are located between 1475-1800 m above sea level and receive around 1000 mm annual rainfall, while the miombo and lowland forests are located between 350-1000 m above sea level and receive around 800 mm annual rainfall. Number of adjacent villages, number of inhabitants in these villages and number of inhabitants per ha of forest among the reserves are varying considerably (Table 1).

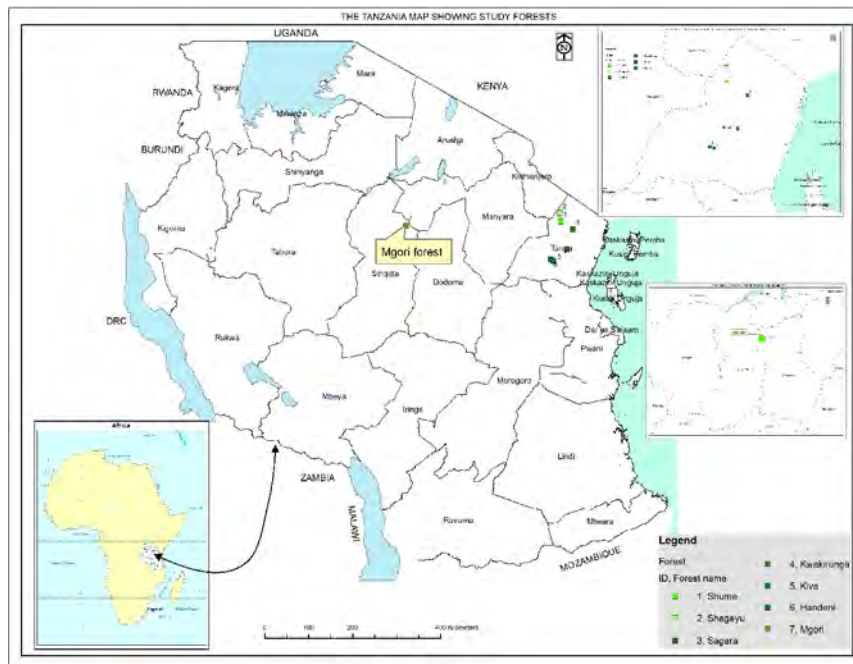


Figure 1: Location of study forests



Table 1: Description of the forest reserves

Forest reserve	Forest type	Management	Management change	Area (ha)	No. of villages	Inhabitants	Inhabitants per ha forest
Shagayu	Montane	JFM	Ordinary state to JFM	7830	13	27400	3.5
Shume-Magamba	Montane	Ordinary state	No change	9284	17	59000	7.4
Sagara	Montane	CBFM	Private to CBFM	256	1	1850	7.2
Handeni Hill	Miombo/Lowland	JFM	Ordinary state to JFM	544	3	8800	16.2
Kiva Hill	Lowland	Ordinary state	No change	655	3	7970	12.2
Kwakirunga	Lowland	CBFM	Open access to CBFM	227	2	4067	17.9

Political and historical events that shaped management and the current resource conditions of selected study forests were similar. According to Conte (1999), although little is documented on the management during pre-colonial period, it is on anecdotal record that their use was limited to hunting and gathering, and that communities identified forests based on their role as sanctuary rather than on their economic value. Large sawmills were introduced in Shagayu and Shume-Magamba to supply colonial as well as empire timber requirements. Pit sawing was also widespread. Exploited timber tree species in the montane forest sites included; *Ocotea usambarensis* Engl., *Podocarpus spp*, *Entandrophragma excelsum* Sprague and *Juniperus procera* Hochst. ex Endl (Conte 1999). Other species were exploited for non-timber forest products including; *Catha edulis* Forsk, *Warbugia spp*, and *Prunus africana* (Hook. f.) Kalkman (Msuya 1998). The forests in the semi-arid sites share the historical background with forests in the montane site. These forests were subjected to heavy utilization to satisfy sawmills during colonial era and thereafter. Weak forest governance and monitoring of timber harvesting licenses led to over-utilization which triggered the need for institutional changes in the 1990s.

Currently, most sawmills have either been closed or operate below their rated capacities due to lack/shortage of raw materials. Major exploited tree species for timber in semi-arid study forests included *Pterocarpus angolensis* DC, *Pterocarpus tinctorius* Welw., *Azelia quanzensis* Welw., *Brachystegia spiciformis* Benth and *Brachylaena huillensis* O. Hoffm. (Malimbwi *et al.* 2005).

Data collection

Forest cover data

Forest cover data was collected using remote sensing and GIS techniques. Landsat Thematic Mapper (TM) satellite images of 1995/1996 (taken on 7 January) and 2000 (22 February) were used to assess forest cover before the introduction of management decentralisation policy. The images of 2008 (acquired on 3 January) and 2010 (acquired on 2 March) were used to discern forest cover changes over 10 years after the introduction of management decentralisation. Hand held Etrex Garmin Global Positioning System (GPS) was used to record waypoints during forest inventory which were later used to visually interpret obtained spectral classes into actual forest cover classes (Kashaigili and Majaliwa 2010).



Forest resource harvests data

Forest resource harvests data was collected to supplement remotely sensed data using conventional inventory. Systematic sample inventories were carried for each forest reserve. The number of sample plots in Shagayu, Shume-Magamba, Sagara, Handeni Hill, Kiva Hill and Kwakirunga were 35, 36, 30, 44, 30 and 31 respectively. The sample plots were concentric circular plots of 15 m maximum radius (700 m²) (URT 2010). Plots were marked using a GPS and were located systematically at 200 m interval along transects and the distance between transects was 500 m to 1 000 m. In each plot, data was collected on stump basal diameter (BD) of all cut trees and the age of tree stumps was estimated based on field experience of local people and the researchers. The stump was categorised new if the age was ≤ 1 year and old if the age was ≥ 1 year. Three sample standing trees were randomly selected and measured for diameter at breast height (DBH), height and basal diameter. These were used to develop models for estimating DBH of cut trees. Information was collected on forest cover types in randomly selected plots.

Data analysis

Forest cover

Earth Resource Data Analysis System (ERDAS) imagine version 9.2 (ERDAS, 1999) and ArcView GIS Software Version 3.2 were the main software used during image pre-processing and analysis. Image sub-setting was done to obtain the areas of interest, i.e. the forest area. Unsupervised classification was carried out to classify the image sub-scenes into 16 spectral classes. This was done in order to have preliminary information about the forest cover classes. Thereafter, supervised classification using Maximum Likelihood Classifier (MLC) was performed to

visually interpret spectral classes into forest covers of the study forest maps (ERDAS, 1999). Classification accuracy is receiving increased attention from remote sensing specialists (Lillesand and Kiefer 2000). In order to improve classification accuracy, for each forest cover class identified on the image colour composite, training sites were generated by on-screen digitisation of selected areas (ERDAS, 1999). ERDAS (1999) define training sites as sites of pixels that represent specific land classes to be mapped. These are pixels that represent what is recognised as a discernable pattern, or potential land cover class (Kashaigili and Majaliwa 2010). Visual interpretation involved the use of image characteristics such as texture, pattern and colour to translate image into forest covers. In this operation, the enhanced image colour composite was used. Visual image classification has an advantage that knowledge of local experts can be intergrated during interpretation (Kashaigili and Majaliwa 2010).

The training was an iterative process, whereby the selected training pixels were evaluated by performing an estimated classification (ALARM command). The image alarm performs a quick “pre-classification” of the image data and indicates where potential confusion among classes may occur. Image alarm is a visual tool that gives an overview of where the classes will be assigned in the image and whether there are needs for additional classes (ERDAS, 1999). Training samples were refined until a satisfactory result was obtained based on the inspection of alarm results. The objective was to produce thematic classes that resembled or could be related to actual forest cover types on the earth’s surface (Kashaigili and Majaliwa 2010).

Finally, after detailed visual interpretation, clearly discriminated forest cover classes were closed forest, open forest, bareland, bushland, grasslands and shrubs. These are



common forest land cover types reported in the Tanzanian land cover and use maps (Newmark 1998; URT 2010). Change detection analysis employed the post-classification approach where the 1995/1996 and 2000 cover maps (before management decentralisation) were compared with 2008 and 2010 maps (after management decentralisation). In order to compute total cover change, percentage total area change and percentage annual rate of change from extracted areas, a linear relationship was assumed (Kashaigili and Majaliwa 2010).

Total cover area change (ha), percentage total area change (%) and percentage annual rate of change (%.y⁻¹) were computed using the following equations (Kashaigili 2006; Kashaigili and Majaliwa 2010).

$$\text{Total cover area change} = \text{Area}_{\text{year } x} - \text{Area}_{\text{year } x+1} \dots\dots\dots (1)$$

$$\text{Percentage change}_{\text{year } t} = \frac{\text{Area}_{\text{year } x} - \text{Area}_{\text{year } x+1}}{\text{Area}_{\text{year } x}} \times 100 \dots\dots\dots (2)$$

$$\text{Percentage Annual rate of change}_{\text{year } t} = \frac{\text{Area}_{\text{year } x} - \text{Area}_{\text{year } x+1}}{\text{Area}_{\text{year } x} \times t_{\text{years}}} \times 100 \dots\dots\dots (3)$$

Where: Area_{years x} = area of cover i at the first date,

Area_{years x+1} = area of cover i at the second date, and

t_{years} = period in years between the first and second scene acquisition dates

Forest resource harvest data

Forest resource harvest data analysis involved computation of forest variables in terms of stumps (N) and basal area (G) per ha using Microsoft Excel and Minitab 15 software. Descriptive data analysis was used to construct confidence intervals for the reported variables. Analysis of variance was used to compare harvests between forests.

Number of stumps per ha

Number of stumps per hectare was computed as:

$$N = \sum(n_i/a_i)/n \dots\dots\dots (4)$$

Where; N is number of stumps per hectare; n_i is stump counts in the ith plot;

a_i is area of the ith plot in hectares; n is total number of sampled plots.

Basal area per ha (G)

The cross-sectional area of a tree estimated at breast height (1.3 m or above buttress) is the tree basal area (g) expressed in m². For cut trees, this required computation of DBH using equations developed from sample tree (in general form DBH=a + b*BD, R² from 96.9 to 99.4%) presented in Table 2.



Table 2: Equations applied for estimating harvests in studied forests

Site	Vegetation	Equation	R ²	Source
Shagayu	Montane	DBH = 0.24+0.86BD	- 97.8	Own data
Shume	Montane	DBH = 0.79+0.97BD	- 99.4	Own data
Sagara	Montane	DBH = 0.21+0.86BD	- 97.3	Own data
Handeni Hill	Lowland	DBH = 0.42+0.89BD	- 98.9	Own data
Handeni Hill	Miombo	DBH = 0.09+0.92BD	- 96.9	Own data
Kiva Hill	Lowland	DBH = 0.42+0.89BD	- 98.9	Own data
Kwakirunga	Lowland	DBH = 0.67+0.93BD	- 98.4	Own data

After computing DBH from developed equations, basal area per tree (g) was computed as follows:

$$g = 0.0000785DBH^2 \text{ (m}^2\text{)} \dots\dots\dots (5)$$

Mean basal area per ha was therefore calculated at plot level using the following formula:

$$G = \sum(g_i/a_i)/n \text{ (m}^2\text{/ha)} \dots\dots\dots (6)$$

Where; G is basal area per ha; g_i is tree basal area in the i th plot; a_i is area of the i th plot in ha; n is total number of sampled plots.

RESULTS

Forest cover changes

Forest cover maps for before and after decentralization of forest management for Shagayu (JFM), Shume-Magamba (exclusively state management) and Sagara

(CBFM) are presented in Figures 2-7. Total forest cover changes, percentage cover changes and percentage annual rate of forest cover changes in these forest reserves presented in Table 4. All studied montane forests experienced a decrease in closed forest cover area with Shume-Magamba under exclusively state management experiencing higher loss (1.3%.y⁻¹) than Shagayu (0.4%.y⁻¹) and Sagara (0.4%.y⁻¹) under JFM and CBFM respectively. Bareland and open forest covers in Shume-Magamba increased by 10.9%.y⁻¹ and 7.9%.y⁻¹ respectively. Shagayu forest had higher annual rate of increase in bareland than Shume-Magamba and Sagara forests. Shume-Magamba had one hundred times higher annual rate of open forest cover increase as compared to Shagayu. The trend in Sagara was different where there was decrease in open forest cover for the past 13 years.

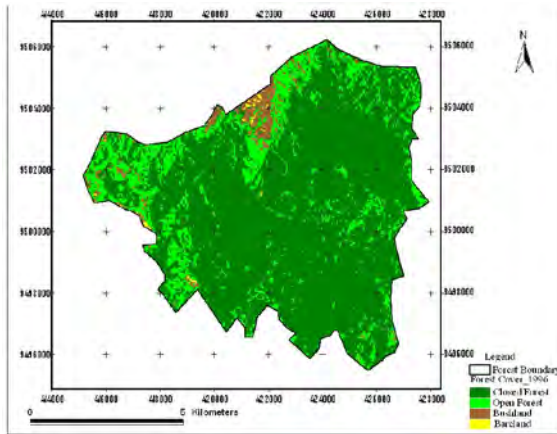


Figure 2: Forest cover map Shagayu 1996

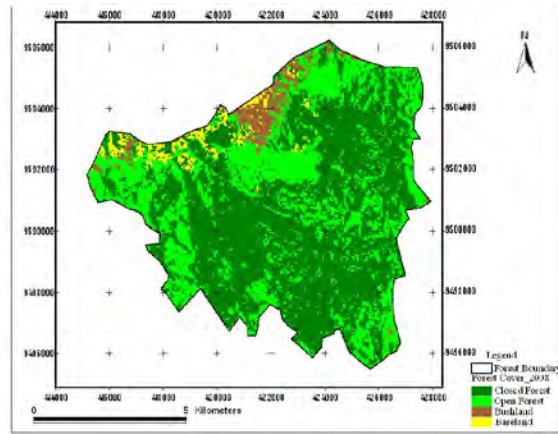


Figure 3: Forest cover map Shagayu 2008

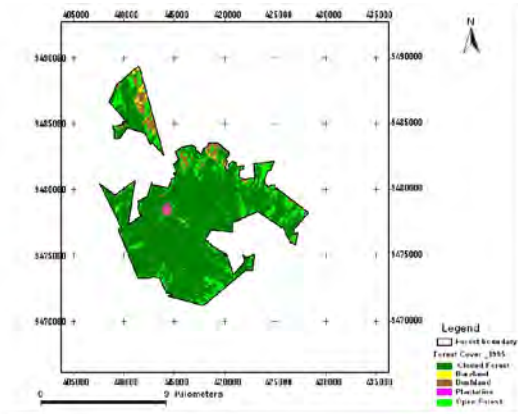


Figure 4: Forest cover map Shume-Magamba 1995

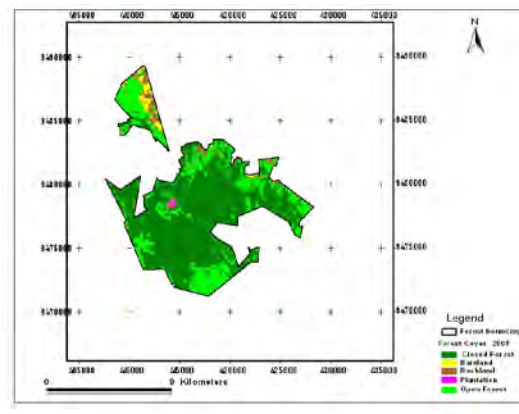


Figure 5: Forest cover map Shume-Magamba 2008

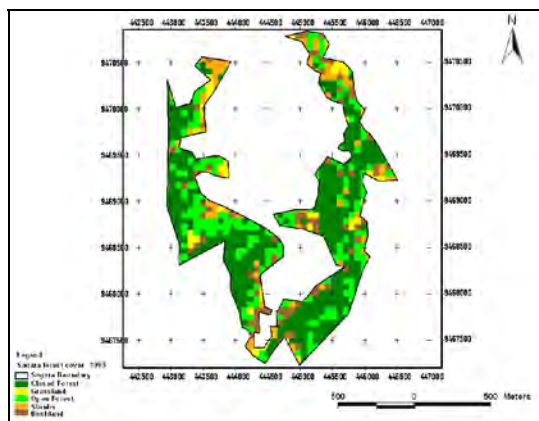


Figure 6: Forest cover map Sagara 1995

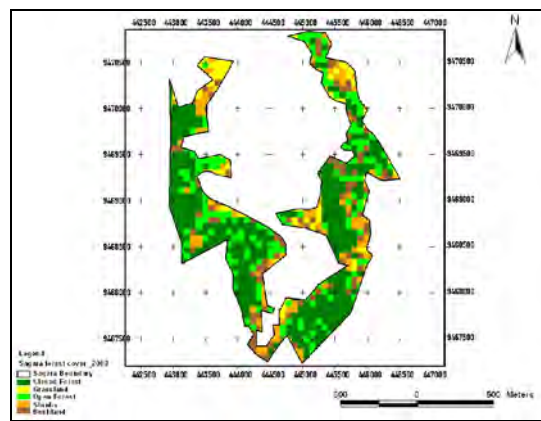


Figure 7: Forest cover map Sagara 2008



Table 4: Total forest cover changes, percentage change and percentage annual rate of forest cover changes in the study forests before and after decentralised management

Forest	Cover	Before	After	Change (ha)	% change	% annual rate of change
		(1995/96)	(2008)			
		Area (ha)	Area (ha)			
Shagayu	CF	4691.5	4482.5	-209	-4.5	-0.4
	BL	48.6	248.6	200	411.5	34.3
	OF	1999.8	2018.3	18.5	0.9	0.1
	BS	300.4	290.9	-9.5	-3.2	-0.3
Shume	CF	7355.6	6100	-1255.6	-17.1	-1.3
	BL	95	229.4	134.4	141.5	10.9
	OF	1241.6	2512.4	1270.8	102.4	7.9
	BS	587.7	438.1	-149.6	-25.5	-2.0
Sagara	CF	127.9	121.4	-6.5	-5.1	-0.4
	BL	13.8	17.9	4.1	29.7	2.3
	OF	64.8	54.4	-10.4	-16.0	-1.2
	BS	26.6	31.9	5.7	21.4	1.6
	SR	22.4	29.8	7.4	33.0	2.5

Note: CF = Closed forest; GL = Grassland; OF = Open forest; SR = Shrubs; BL = Bareland; BS = Bushland

Field observations recorded selective illegal logging going on in Shagayu and Shume-Magamba. Shume-Magamba was gutted by a severe fire in late 1990s and since then fire disturbances have continued to disturb this forest. The high forest disturbance in Shume-Magamba, coupled with limited funding, forced the government to propose change of its status to a Nature Reserve since 2010. Area under bushland cover showed a decreasing trend in Shagayu and Shume-Magamba forests. This cover occurs in the lower elevations of these forests, with larger part bordering the villages, thus experiencing high pressure for firewood collection. Area under bushland cover in Sagara depicted an increasing trend. Furthermore, shrub was recorded as an additional cover class in Sagara and it showed a positive annual rate of change indicating forest re-growth from abandoned fields after encroachment

and previous logging. Sagara forest has its large part bordering tea farms and some farmers have been invading the forest borders to expand their cultivated land and therefore creating bareland along the border.

Forest cover maps for Handeni Hill (JFM), Kiva Hill (exclusively state management) and Kwakirunga (CBFM) for before and after decentralised forest management are presented in Figures 8-11. Table 5 presents total forest cover area changes, percentage change and percentage annual rate of forest cover changes in these semi-arid study forests. Handeni Hill forest under JFM experienced substantial positive percentage annual closed forest cover change rate of 3.5%.y⁻¹, increasing from 282.8 ha in 1995 to 429.9 ha in 2010. This was further supported by the decrease in area under grassland (4.9%.y⁻¹), open forest (4.0%.y⁻¹), and bushland (2.7%.y⁻¹).

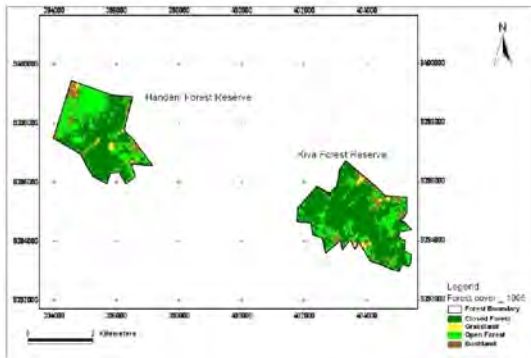


Figure 8: Forest cover map for Handeni and Kiva 1995

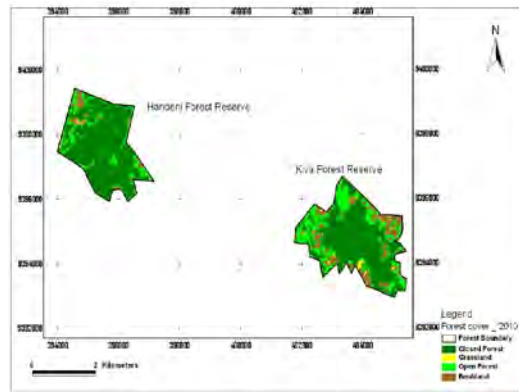


Figure 9: Forest cover map for Handeni and Kiva 2010

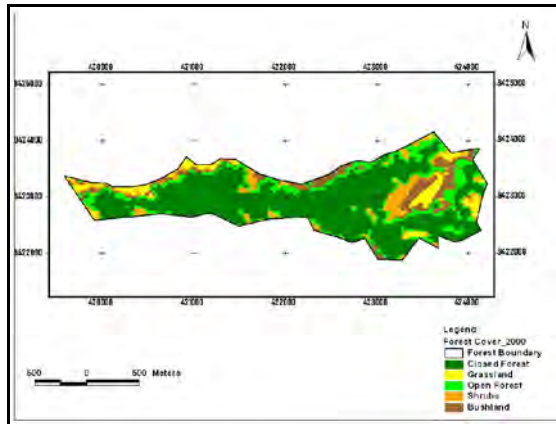


Figure 10: Forest cover map for Kwakirunga 2000

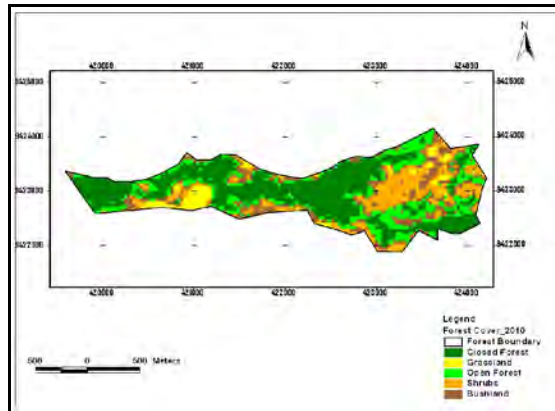


Figure 11: Forest cover map for Kwakirunga 2010

There was reduction in area with closed forest cover from 451 ha to 370 ha between 1995 and 2008 in Kiva Hill forest. This is equivalent to $-1.2\%.y^{-1}$ annual forest cover rate of change. Grassland decreased by $2.2\%.y^{-1}$ while open forest and bushland area covers showed percentage annual rate of change of $+1.6\%.y^{-1}$ and $+6.7\%.y^{-1}$ respectively, indicating forest degradation. Kwakirunga forest under CBFM had undergone drastic decrease in closed forest cover at the

annual percentage rate of $2.9\%.y^{-1}$. Grassland cover area decreased at an annual percentage rate of $2.0\%.y^{-1}$. On the other hand open forest, shrubs and bushland cover areas increased at percentage annual rates of $2.6\%.y^{-1}$, $7.7\%.y^{-1}$ and $6.9\%.y^{-1}$ respectively. Activities recorded in this forest during forest inventory included firewood extraction, charcoal making and grazing.



Table 5: Total forest cover changes, percentage change and percentage annual rate of forest cover changes in the Handeni Hill, Kiva Hill and Kwakirunga forests before and after decentralised management

Forest	Cover	Before		Change (ha)	% change	% Annual Rate of Change
		(1995/2000)	After (2010)			
		Area (ha)	Area (ha)			
H/Hill	CF	282.8	429.9	147.1	52.0	3.5
	GL	14.8	4	-10.8	-73.0	-4.9
	OF	195.1	79.2	-115.9	-59.4	-4.0
	BS	51.1	30.7	-20.4	-39.9	-2.7
K/Hill	CF	451.2	370.4	-80.8	-17.9	-1.2
	GL	15.2	10.1	-5.1	-33.6	-2.2
	OF	135.5	167.4	31.9	23.5	1.6
	BS	53.7	107.7	54	100.6	6.7
K/runga	CF	133.5	95.2	-38.3	-28.7	-2.9
	GL	14.6	11.7	-2.9	-19.9	-2.0
	OF	34.9	43.8	8.9	25.5	2.6
	SR	21.2	37.6	16.4	77.4	7.7
	BS	22.8	38.6	15.8	69.3	6.9

Note: CF = Closed forest; GL = Grassland; OF = Open forest; SR = Shrubs; BS = Bushland

Forest resource harvests

Table 6 shows the mean number of stems, basal area and volume per ha harvested in relation to decentralisation of forest management in the study forests. In this

study, higher new cuts are associated with increasing harvests and higher old cuts indicate reduction in harvests.

Table 6: Wood harvests with respect to decentralisation of forest management

Variable	Age	Montane forests			Semi-arid forests		
		Shagayu	Shume	Sagara	Handeni	Kiva	K/runga
N	New	243±99	199±125	51±18	180±42	75±30	95±39
	Old	38±10	34±18	57±26	102±36	56±25	67±47
	All	121±76	98±64	49±15	129±46	62±19	74±29
G	New	2.0±1.6	7.1±4.2	0.4±0.4	2.9±1.8	1.0±0.8	2.3±1.6
	Old	0.7±1.0	3.8±2.2	1.2±1.0	1.3±0.6	1.1±0.4	4.2±3.1
	All	1.1±0.91	4.4±2.3	0.69±0.49	2.0±1.0	0.95±0.53	3.06±1.67

Numbers after +/- are 95% confidence limits (products of Standard Errors of the Mean and t-value at 95% confidence level)

In Shume Forest Reserve which is under exclusive state management,, there was more harvested basal area per ha compared to Shagayu (JFM) and Sagara (CBFM). Analysis of variance showed significant differences in harvested basal area per ha ($F_{2, 100}=9.05, p<0.05$) between the montane

study forests under JFM, CBFM and exclusive state management. Tukey's post hoc test showed that the most significant differences in harvested basal area per ha were between Shume and Shagayu, and Shume and Sagara forests. In the semi-arid study forests, more stems were harvested from Handeni Hill (JFM) compared to Kiva



Hill (exclusively state managed) and Kwakirunga (CBFM) forests. In terms of basal area, there were more harvests in Kwakirunga. There were significant differences ($F_{2, 104}=7.76$, $p<0.05$) in removed mean basal area per ha between these semi-arid forests. Tukey's post hoc test showed that the most significant differences were between Kwakirunga and Handeni Hill, and Kwakirunga and Kiva Hill forests. In all study forests, both in montane and semi-arid sites, new harvests were higher or equal to old harvests, indicating increasing tree harvesting trend regardless of management and tenure regimes.

DISCUSSION

Forest cover changes and tree harvest trends in the studied forests portray legacies of management regimes, before and after decentralisation of forest management in Tanzania. Ecosystems around the world are in a state of permanent change at spatial and temporal scales attributed to natural and anthropogenic factors (Coppin *et al.* 2004). Prins and Kikula (1996) showed that MSS data could be used to assess deforestation and re-growth in miombo woodlands of south western Tanzania. According to Sheridan (2004), the material, social and cultural legacies of policy reforms in Tanzania include environmental change and declining natural resource management capacity. The recorded cover changes in the study montane forests are attributed to logging which continued until the government ban it in 1989 (Persha and Blomley 2009). Pit-sawing, pole cutting, firewood extraction, grazing and forest fires are major contributors of degradation in these Forest Reserves (Maliondo *et al.*, 2000). Deforestation in West Usambara Mountains has been reported to be widespread (Newmark 1998; Hall *et al.* 2009). About 84% of historic forest cover in the Usambara was reported to be converted to other land uses (Newmark 1998). Annual

forest loss for West Usambara Mountain forests is estimated at $0.3\%.y^{-1}$ as compared to $0.1\%.y^{-1}$ for the East Usambara forests (Tabor *et al.* 2010). The montane forests of West Usambara have been impacted by large scale logging to satisfy big sawmills and illegal harvest of timber and fuelwood since the mid 1960s (Maliondo *et al.*, 2000). The last two decades have witnessed increased fire incidences in Shume-Magamba caused by prolonged droughts and the first largest fire gutted the forest in 1997 (Maliondo *et al.* 2000). Forest fires are now a common phenomenon in Shagayu and Shume-Magamba forest reserves. Tabor *et al.* (2010) reported lower rates of forest loss in protected forests compared to unprotected forests in the Coastal Tanzania and Kenya for the period 1990 to 2000. In this study forests under JFM and CBFM, depending on the stage of implementation were better than forests under sole state management which were practically under open access.

Tabor *et al.* (2010) found that forest loss outside protected areas in the Zanzibar-Inhambane coastal forests mosaic was 8 times faster than the rate inside protected areas. In this study, except for the Handeni Hill forest under JFM, all forests experienced forest loss to open forest, bushland, shrubs and bareland. According to Coppin *et al.* (2004) the rate of cover change can either be dramatic or gradual. The resulting forest cover classes in this study are a result of short and long term policy changes. Ecosystem scientists and managers are particularly interested in changes resulting from human activities such as resource exploitation and land use conversion.

Luoga *et al.* (2005), working in Kitulang'alo miombo woodlands in eastern Tanzania, found woodlands on general lands declining by 50% between 1964 and 1996, with 599% increase in bushlands and croplands and 277% increase in settlements and home gardens.



A study by Mbeyale (2009) in the lowland eastern part of Same-Mkomazi revealed a decrease in forest cover of 0.43% to 0.22% and woodland cover of 0.43% to 0.22% between 1954 and 2000. Mbeyale (2009) found that in a time span of 40+ years, cultivated land increased drastically from 18% to 59% between 1954 and 2000 in the lowland eastern part of Same-Mkomazi area. Luoga *et al.* (2005) found main drivers of land cover and use changes to be tree harvesting for charcoal production and shifting cultivation around Kitulang'alo area, eastern Tanzania. Observed drivers of forest cover changes in the semi-arid study forests were tree harvesting for firewood, charcoal making, encroachment for agriculture, pole cutting and timber extraction.

All studied forests under JFM and CBFM were found to be equally suffering from encroachment, although this was more so in semi-arid than montane forests. Plausible explanation for this might be the low land productivity caused by low and erratic rainfall forcing people to obtain their livelihoods from the forests. Unclear boundaries and tenure are other problems causing uncontrolled forest exploitation in semi-arid Tanzania, thus shifting cultivation is a common phenomenon. Literature on common property resource management advocates clear boundaries and clear user groups (Ostrom 2000) however, studies elsewhere have shown that this is in reality often impossible to achieve (Campbell *et al.* 2003). Unclear boundaries and multiple claims have severely led to degradation of Kwakirunga forest which is under early stages of CBFM establishment. According to Ostrom (2000), despite the fact that many communities have been successful to manage forest resources over long periods of time, others have failed to control forest overuse and degradation. It was observed in this study that exclusion of people from distant villages has been impossible because these forests are public goods and all citizens have the right to use them.

Allocating user rights to forest adjacent communities only may marginalize other citizens and this might lead to conflicts. In all study forests, the bylaws and management plans have not been signed by relevant authorities and this gave the committees less powers to control the forests. According to Acheson (2006), in cases where central government officials are reluctant to cede powers to local communities, local level forest management efforts are likely to fail. This follows the argument by Ostrom (2000) that, when forest users are not communicating and have no way of gaining trust through their own efforts or with the help of the macro-institutional system within which they are embedded, the prediction by Hardin (1968) of the conventional theory is likely to be empirically supported. Hardin (1968) predicted that users of common resources will not be able to extricate themselves from the tragedy of the commons. Under such conditions often referred to as "open access" where boundaries cannot be effectively defended, outsiders gain the benefits of the resource management effort and this is a disincentive for local people to invest their time and energy in conservation (Acheson 2006). JFM, CBFM and exclusivestate management regimes have equally showed weak control over resource exploitation with varying degrees. The two forests, Shume (Oexclusive state management in the montane and Kiva Hill (exclusive state management) in the semi-arid forests are practically under open access, making them more prone to over-utilisation. Under such situation, according to Ostrom (2000), anyone enters the forest and appropriates forest products. Users obtain property rights particularly to products harvested and sold in open competitive markets. The individual who owns the resource gets the profit from uses that the market supports (Vatn 2005). The availability of timber markets and high demand on wood products around the study forests and in closer major towns might be an incentive for the continued exploitation



of the forests. Both institutional arrangements (JFM and CBFM) are however still new in Tanzania and may take some time to be robust.

At this stage of decentralised forest management in Tanzania, the observed situation is contrary to the claim that decentralisation will have positive environmental impacts on forest resources (Wily 1999; Larson and Ribot 2004), that is, reduced degradation. It has been argued elsewhere that decentralisation can also lead to deforestation in some cases if deforestation benefited the people (Tacconi 2007). Despite the introduction of decentralised forest management in the study forests, uncontrolled exploitation of the forest products has continued. This follows the argument by Campbell *et al.* (2003) that the evidence that moving the forest management locus closer to the people make forest resource management cost-effective is lacking. Based on experience from Malawi, Tanzania and Zimbabwe Campbell *et al.* (2003) noted that there is a fair degree of misplaced optimism about common property resource systems. Case studies in southern Africa have shown that, institutional arrangements for managing woodlands are weak. The narrated contributing factors include lack of enabling policy environment, exploitation of woodlands as the only alternative for the poor households, increasing household differentiation within communities that place pressure on common property resource institutions and lack of legitimate local institutions (Campbell *et al.* 2003). In the studied forests eligible users and managers were not easily distinguished and under such situations where the community fails to devise property rights institutional failure occurs (Acheson 2006). This is because both forest adjacent and distant villagers depend on these forests for their livelihoods and the former lack the exclusionary powers.

CONCLUSION

This study concludes that regardless of management regime, decentralised forest management has not been able to deliver its goal of improving forest condition. The differences in the results between the studied forest reserves however, could be attributed to several factors; ecological site specific conditions like productivity, forest conditions before the management and tenure changes that took place, site specific socio-economic conditions over the past years and, finally, a possible impact of the actual management regime changes. In general, it is hard to distinguish between these factors. Furthermore, unclear boundaries, lack of alternative sources of wood and multiple claims were key factors negatively affecting forest condition in both study sites. JFM and CBFM are promising forest decentralisation models for Tanzania in improving forest condition. However, more research is needed to understand the functions of different governance structures and how they may facilitate sustainability in forest use.

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