Forest cover changes, stocking and removals under different decentralised forest management regimes in Tanzania

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FOREST COVER CHANGES, STOCKING AND REMOVALS UNDER DIFFERENT DECENTRALISED FOREST MANAGEMENT REGIMES IN TANZANIA

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MONGO C, EID T, KASHAIGILI JJ, MALIMBWI RE, KAJEMBE GC & KATANI J. 2014. Forest cover changes, stocking and removals under different decentralised forest management regimes in Tanzania. By the end of the last century many countries including Tanzania moved from centralised towards decentralised forest management but little empirical evidence exists on how such changes have influenced forest conditions. The objective of this study was to provide insights on how decentralised approaches might influence forest resource conditions. Forest cover analyses from satellite images (1993, 2000 and 2009) and systematic sample plot inventories (2009) in two state forest reserves under joint forest management (JFM) and two village forest reserves under community-based forest management (CBFM) in Babati District, Tanzania were carried out. Based on the results, it was not possible to claim that the decentralised management had been successful in improving forest conditions. Proportions of closed woodland decreased significantly over time (from over 80 to 50–60% under JFM and from around 70 to almost 0% under CBFM. In all forests, numbers of regenerants were high, but proportions of larger trees were low and levels of removals (legal and illegal) were relatively high. In general the situation under JFM was better than under CBFM. Results of this study can be used by policymakers to assess the influence of decentralised forest management in Tanzania.

Keywords: Joint forest management, community-based forest management, miombo woodland

INTRODUCTION

Deforestation and forest degradation are crucial challenges at global and local levels. In the last century many governments reduced community involvement and instead imposed centralised state tenure and management (Enters et al. 2000, Zahabu et al. 2009) but deforestation and forest degradation worsened compared with when local communities managed their own resources (Enters et al. 2000, White & Martin 2002, Gautam et al. 2004). Therefore, by the end of the last century, many countries, including Tanzania, moved away from centralised state forest management towards more decentralised and multi-stakeholder management (White & Martin 2002, Gautam et al. 2004, Hayes 2006).

Devolution of forest resources to local communities leads to better forest management (Meshack et al. 2006, Zoysa & Inoue 2008, Kobbail 2010). However, the quality of the empirical data describing successes or failures regarding the condition of forest resources in such studies is often questionable. Poor study designs and descriptions of study methodology or context have been reported as main challenges (Blaikie 2006, Hayes 2006, Ferraro 2009, Bowler et al. 2012). Three main issues that can be improved in such studies are (1) descriptions of the actual policy, (2) descriptions and use of indicators to study impacts of the policy and (3) considerations on how to isolate the impact of the actual policy from other factors influencing the conditions (Lund et al. 2009).

Tanzania has for many years faced deforestation and forest degradation. The country is now reported to be among those with the largest forest loss per year in Africa (FAO 2010). Tanzania, like many other countries in the mid-1990s, started to experiment with management regimes focusing on involvement of local communities, which by the end of 1990s resulted in their inclusion in the forest policy and legislation (URT 2006). Both the current National Forest Policy of 1998 and its subsequent Forest Act of 2002 recognise the role of community participation in forest management (URT 1998, 2002). The general term for this forest management is participatory forest management (PFM), emphasising community empowerment. PFM is legally supported by the Forest Act No. 14 of 2002 (URT 2002). PFM is applied in two ways: joint forest management (JFM) and community-based forest management (CBFM). JFM takes place in national forest reserves (also in some local authority reserves) where communities adjacent to the forests are partners in the management of responsibilities and returns but the owner remains to be the government. CBFM mostly takes place in forests under village lands. Legal requirements for setting up CBFM include registration of the village land, election of a village natural resource committee and development of management plans and by-laws. Under this institutional arrangement, villagers are the owners and managers of the forests (URT 2002). Presently in Tanzania, of a total of 33.4 mil ha of forested land, about 1.8 and 2.3 mil ha fall under JFM and CBFM respectively.

The forests in Babati District in Manyara Region, like elsewhere in Tanzania, have been subjected to a wide range of disturbances of variable duration, intensities and frequencies, hence deforestation and forest degradation (Chamshama & Nduwayezu 2002, Malimbwi 2003). Tenure and management have been changed in order to reduce these negative impacts and JFM and CBFM have now been applied in a number of forests over some years. Several studies have been conducted in various forests in Babati but most of them have focused on general challenges related to PFM such as the transfer of ownership to communities and empowering communities to manage natural resources. However, very little empirical evidence exists on how the management changes influence forest resources (Persha & Blomly 2009, Robinson & Lokina 2011, Mbwambo et al. 2012).

The main objective of the study was, therefore to provide some insights into how different decentralised management regimes influenced forest resource conditions. More specifically, we assessed state land tenure under JFM and village land tenure under CBFM regarding forest cover changes, forest stocking, regeneration and removals in the Babati District, Tanzania.

MATERIALS AND METHODS

Study area

The Babati District in Manyara Region is located between 4° 13' – 4° 22' S and 35° 45' – 35° 75' E (Figure 1). The district is characterised by bi-modal and irregular rainfall events ranging from 300 to 1200 mm per year with short rains from October till January and long rains from February till May. Mean annual temperature is about 23 °C with a minimum of 18 °C and a maximum of 28 °C. The district has favourable conditions for agriculture and, thus, has attracted people from other parts of the country to settle here (Backlund 2006).

The selected forest reserves were Bereku and Haraa, which presently are under JFM, and Riroda and Bubu, under CBFM (Table 1). Bereku and Haraa were under centralised state management regime before the institutional changes in 2000, while Riroda and Bubu were on general land (under open access with no appropriate management) before the changes in 1994.

Bereku Forest Reserve is dominated by miombo woodlands of *Brachystegia microphylla*. The elevation ranges from 1600 to 1830 m above sea level (asl). The reserve is an important water catchment reservoir with areas of seasonally waterlogged grassland and occasional small clumps of dry montane forest in the higher elevation. The lower slopes of Haraa Forest Reserve are dominated by miombo species but are also partly covered by dry montane forests and a small proportion of wooded grassland on the eastern side dominated by *Dodonea viscosa*. The elevation is between 1280 and 1810 m asl. Riroda Forest Reserve, ranging in elevation from 950 to 1800 m asl, is also dominated by *B. microphylla*, confirming it to be a typical miombo woodland. Bubu Forest Reserve (950–1800 m asl) consists of four mountain ridges, namely, Singe, Endarbo A, Endarbo B and Endadu. The vegetation here is dominated by *B. microphylla* and *B. spiciformis*.

Data collection

Landsat imageries of the years 1993 (Landsat 5 TM, path/row 168/63, acquisition date 17 February), 2000 (Landsat 7 ETM+, paths/rows 168/63 and 169/63, acquisition date 23 September) and 2009 (Landsat 5 TM, path/

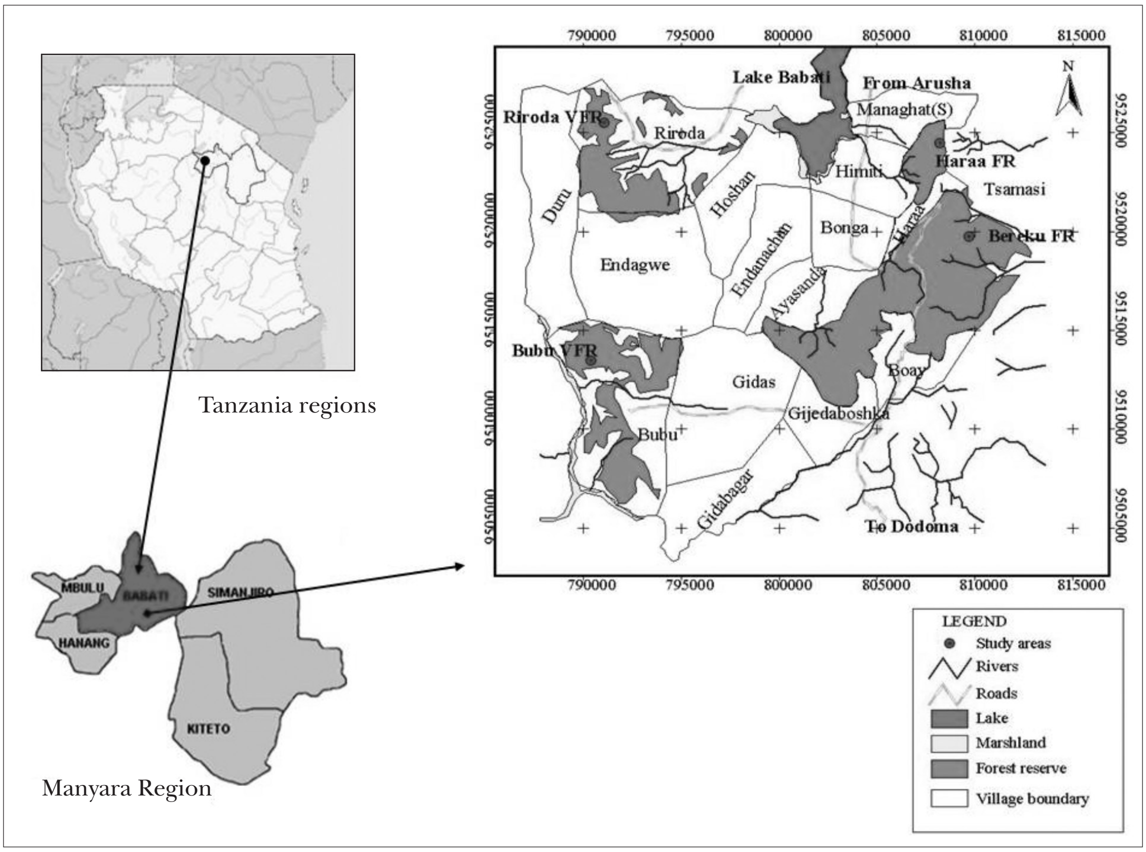

Figure 1 Location of the study area in Babati District, Manyara Region, Tanzania

Table 1 Description of study site

Forest reserve	Area (ha)	Forest type	Previous tenure	Previous management	Year of change	Present tenure	Present management
Bereku	6111	Miombo and dry montane	State	Centralised state	2000	State	JFM
Haraa	605	Miombo and dry montane	State	Centralised state	2000	State	JFM
Riroda	1800	Miombo	General land	None	1994	Village	CBFM
Bubu	2300	Miombo	General land	None	1994	Village	CBFM

JFM = joint forest management, CBFM = community-based forest management

row 168/63, acquisition date 4 November) were applied to determine the forest cover changes for the periods 1993–2000 and 2000–2009. The 2009 imagery was used as base map. By using a hand-held global positioning system (GPS) receiver, ground truthing was conducted in the field based on sample plot inventories to verify and modify the land covers on imageries.

Systematic sample plot inventories were carried out for all forest reserves in 2009, mainly for determination of stocking and removal parameters but also for ground truthing of satellite imageries. Sample plot grids were distributed on the 2009 base maps derived from satellite imageries and geo-referenced in field with GPS. In all forest reserves the first plot was located randomly at 150 m from the boundary of the forest. Subsequent plots were located systematically at 300 m intervals along transects while the distances between transects varied from 500 to 1000 m.

Concentric circular sample plots with radii 2, 5, 10 and 15 m were laid out. Tree diameters at breast height (dbh) were measured as follows: in the 5 m radius subplot for trees with dbh of 5.0–9.9 cm, in the 10 m subplot for trees with dbh of 10.0–19.9 cm and in the 15 m subplot for trees with dbh ≥ 20 cm. All trees were identified to species level. Two sample trees were randomly selected (the two nearest to the plot centre) for each plot and the species, stump diameter at 30 cm above ground, dbh and height were recorded. In the inner 2 m radius subplot, all regenerants (i.e. trees with dbh < 5 cm) were counted. Diameter of all stumps with dbh > 1 cm was measured for the whole 15 m radius plot.

Data analyses

Forest cover analysis followed two steps, namely, satellite imagery interpretation, classification and accuracy assessment, and change detection analysis. The first step involved image pre-processing and classification, i.e. mainly image rectification/geo-referencing, image enhancement, preliminary classification, ground truthing and classification accuracy assessment. To ensure accurate identification of temporal changes and geometric compatibility with other sources of information, images were coded to the coordinate and mapping system of national topographic maps (UTM coordinate, Zone 36 South, Datum Arc 1960). In order to reinforce visual interpretability of images, a colour composite (Landsat TM bands 4, 5 and 3) was prepared and its contrast was stretched using Gaussian distribution function. The 3 × 3 weighted kernel neighborhood high pass filters were applied to the colour composite to further enhance visual interpretation of linear features, e.g. rivers and vegetation features. Supervised image classification using maximum likelihood classifier was performed using ERDAS IMAGINE software. Training fields were identified by inspecting enhanced colour composite imagery. Base maps were prepared from preliminary imagery classification and were used during ground truthing to verify the classes and collect ground cover sample points for classification of accuracy assessment. The final classification of vegetation types used the following key based on the National Forestry Resources Monitoring and Assessment of Tanzania scheme of landuse/cover classification (MNRT 2010), namely, closed woodland, open woodland, bushed woodland, shrubs, grassland and settlements.

The second step of the forest cover analysis involved change detection. Many change detection methods have been developed and used for various applications. However, they can broadly be divided into post-classification and spectral change detection approaches (Kashaigili & Majaliwa 2010). We applied-post classification change detection method followed by spatial overlay analysis (Reusing 2000) in ArcGIS environment and produced attribute tables. The tables were exported to MS-Excel to compile area change detection matrixes for 1993–2000 and 2000–2009. Estimations for the rates of change for the different covers were computed based on formulae developed by Kashaigili and Majaliwa (2010).

From the systematic sample plot inventories, number of stems (N) and basal area ha^{-1} (BA) were computed using standard formulae. To estimate height for the trees that were not measured for height, site and vegetation specific height–diameter equations were developed from the 356 sample trees.

Volumes (v) of individual trees in the miombo forests were calculated using equation 1 (Malimbwi et al. 1994):

$$v \text{ (in } m^3) = 0.0001 dbh^{2.032} \times h^{0.66} \quad (1)$$

where dbh = diameter at breast height (m) and h = tree height (m). In the dry montane forests the volume was calculated using equation 2:

$$v = f \times g \times h \quad (2)$$

where f = form factor and g = tree basal area at breast height (m^2). A form factor of 0.5 which was recommended for Tanzania without distinction of vegetation types (Haule & Munyuku 1994, Mbwambo et al. 2012) was applied.

Based on the inner 2 m radius subplot, all regenerants were counted and transformed into ha^{-1} values (N_{reg}). The same procedure was applied for all stumps within the 15 m radius plot (N_{stump}). From the sample trees, a relationship between basal diameter (db) and dbh was established, and based on this, basal area of removed trees were calculated and thereafter summarised to plot level ha^{-1} values (G_{stump}). Volume of each removed tree for plots on miombo woodland was estimated using the equation 3 developed by Chamshama et al. (2004):

$$v = 0.000047 db^{2.56} \quad (3)$$

whereas in the dry montane forest, equation 2 was used, and then transformed into ha^{-1} values (V_{stump}).

We calculated confidence intervals, which is the range of deviation from the true mean for a given level of probability (95%), for all stocking and removal parameters based on equation 4 (Philip 1994):

$$CI = \bar{x} \pm tS_{\bar{x}} \quad (4)$$

where CI = confidence interval, $\bar{x}$ = mean of stocking and removal parameters, t = student t-test value and $S_{\bar{x}}$ = standard error. Bonferroni t-tests (Miller 1981) were carried out to compare different parameter values between sites. The level of significance in such tests was determined as $\alpha/(k\ (k - 1)/2)$ where α = 0.05 and k = number of pairwise comparisons, i.e. six with four sites.

RESULTS

In 1993 the proportions of closed woodland (Table 2) were somewhat higher in Beruku and Haraa, which comprised a mixture of miombo woodland and dry montane forest, compared with Riroda and Bubu, which comprised miombo woodland only. Seen over the whole period from 1993 till 2009, the proportions of closed woodland in general for all sites decreased substantially. This trend was particularly strong for the two village land forests reserves where the closed woodland decreased from 75 and 68% to almost zero for Riroda and Bubu respectively. The closed woodland proportions for two state forest reserves were still relatively high in 2009.

For Bereku and Haraa Forest Reserves, where the management changed from centralised state management to JFM in 2000, the annual decrease of closed woodland was higher after

Table 2 Forest cover and forest cover changes from 1993 till 2009 based on satellite analyses

Forest reserve	Forest cover class	Forest cover 1993		Forest cover 2000		Forest cover 2009		Annual forest cover change 1993–2000		Annual forest cover change 2000–2009	
		(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Bereku	Closed woodland	5076.7	83.1	4616.5	75.5	2967.9	48.6	-65.7	-1.1	-183.2	-3.0
	Open woodland	602.5	9.9	620.9	10.2	1889.6	30.9	2.6	0	141.0	2.3
	Bushed woodland	290.9	4.8	681.9	11.2	788.6	12.9	55.8	0.9	11.9	0.2
	Scrub	61.2	1.0	52.3	0.9	278.9	4.6	-1.3	0	25.2	0.4
	Grassland	79.7	1.3	139.4	2.3	186.1	3.0	8.5	0.1	5.2	0.1
	Total	6111.0	100.0	6111.0	100.0	6111.0	100.0	-	-	-	-
Haraa	Closed woodland	508.4	84.0	505.9	83.6	404.5	66.9	-0.3	-0.1	-11.3	-1.9
	Open woodland	82.9	13.7	94.0	15.5	175.0	28.9	1.6	0.3	9.0	1.5
	Bushed woodland	11.1	1.8	4.3	0.7	18.6	3.1	-1.0	-0.2	1.6	0.3
	Scrub	1.5	0.3	0.6	0.1	2.7	0.4	-0.1	0	0.2	0
	Grassland	1.1	0.2	0.1	0.0	4.2	0.7	-0.1	0	0.5	0.1
	Total	605.0	100.0	605.0	100.0	605.0	100.0	-	-	-	-
Riroda	Closed woodland	1343.4	74.6	169.1	9.4	27.7	1.5	-167.8	-9.3	-15.7	-0.9
	Open woodland	283.6	15.8	984.4	54.7	307.5	17.1	100.1	5.6	-75.2	-4.2
	Bushed woodland	125.7	7.0	328.2	18.2	784.7	43.6	28.9	1.6	50.7	2.8
	Scrub	31.5	1.7	210.6	11.7	441.9	24.6	25.6	1.4	25.7	1.4
	Grassland	15.8	0.9	107.8	6.0	238.2	13.2	13.1	0.7	14.5	0.8
	Total	1800.0	100.0	1800.0	100.0	1800.0	100.0	-	-	-	-
Bubu	Closed woodland	1564.8	68.0	580.2	25.2	17.9	0.8	-140.7	-6.1	-62.5	-2.7
	Open woodland	58.1	2.5	410.4	17.8	302.1	13.1	50.3	2.2	-12.0	-0.5
	Bushed woodland	382.3	16.6	675.6	29.4	760.3	33.1	41.9	1.8	9.4	0.4
	Scrub	196.7	8.6	206.4	9.0	691.1	30.0	1.4	0.1	53.9	2.3
	Grassland	98.1	4.3	267.7	11.6	528.6	23.0	24.2	1.1	29.0	1.3
	Settlements	0.0	0.0	159.7	6.9	0.0	0.0	22.8	1.0	-17.7	-0.8
	Total	2300.0	100.0	2300.0	100.0	2300.0	100.0	-	-	-	-

the institutional change than before, i.e. 1.1 and 0.1% before and 3.0 and 1.9% after the change in Bereku and Haraa respectively. For Riroda and and Bubu Forest Reserves, where the tenure and management changed in 1994, there was a steady decrease of closed woodland over the whole period, although the rates were slowing down in the last period, i.e. from 9.3 to 0.9% for Riroda and from 6.1 to 2.7% for Bubu. A part of the Bubu was classified as settlement in 2000, but it was changed to woodlands, scrub or grassland in 1993 and 2009.

The stem numbers (dbh > 5 cm) in the state forest reserves Bereku and Haraa were slightly higher than in the village forest reserves Riroda and Bubu (Table 3). The differences, however, are not significant. Basal area and volume were generally higher in the state forests compared with the village forests. For basal area, the differences are significant between Bereku and Riroda as well as Bubu, while for volume the differences are significant only between Bereku and Bubu. The distribution of stems ha^{-1} in both state and village forest reserves show a reversed J- shaped trend (Figure 2). In general, the proportions of basal area also decreased with increasing diameter classes for all forests, although there were relatively high basal areas in the largest diameter classes for Haraa and Riroda. The numbers of regenerants were generally higher in the state forest compared with the village forests (Table 3). In Haraa the number of regenerants ha^{-1} was 22823, which is significantly higher than the two village forests.

In general, removals were higher in the village forest reserve Riroda compared with the three other forests (Table 4). The differences between the reserves are only significant for the number of stems ha^{-1}. However, in Riroda, 86% of the stems were removed from the basal diameter class of 1–10 cm (Table 5). The corresponding removals were 76% in the village forest Bubu and 35 and 63% in the state forests Bereku and Haraa respectively. Removals of stems ha^{-1} in per cent of total number of standing stems ha^{-1} were 2.6, 2.0, 10.0 and 2.7% for Bereku, Haraa, Riroda and Bubu respectively and the corresponding figures for basal area were 1.9, 1.7, 4.6 and 2.4%.

DISCUSSION

In Tanzania there are three main policy objectives related to decentralised forest management i.e. to improve forest resource conditions, to improve livelihoods of people living adjacent to the forests and to improve governance in terms of effectiveness and transparency (URT 2008). In the present study we focused on

Table 3 Stocking and regeneration parameters based on sample plot inventories in 2009

Forest Reserve	No. of plots	Parameter	Mean ± SE
Bereku	55	N (ha^{-1})	1027 ± 146 a
Haraa	33		1134 ± 256 a
Riroda	36		1015 ± 216 a
Bubu	30		848 ± 129 a
Bereku	55	G ($m^2 h^{-1}$)	15.0 ± 1.8 a
Haraa	33		13.0 ± 2.2 ab
Riroda	36		11.3 ± 2.1 b
Bubu	30		10.5 ± 1.7 b
Bereku	55	V ($m^3 ha^{-1}$)	118.3 ± 16.3 a
Haraa	33		93.5 ± 18.3 ab
Riroda	36		89.9 ± 23.4 ab
Bubu	30		78.0 ± 15.1 b
Bereku	55	N_{reg} (ha^{-1})	19600 ± 7007 ab
Haraa	33		22823 ± 7676 a
Riroda	36		10062 ± 3275 b
Bubu	30		9368 ± 3597 b

N = number of stems, G = basal area, V = volume, N_{reg} = number of regenerants; SE = standard error; means with the same letter are not significantly different using Bonferoni t-test (α = 0.05)

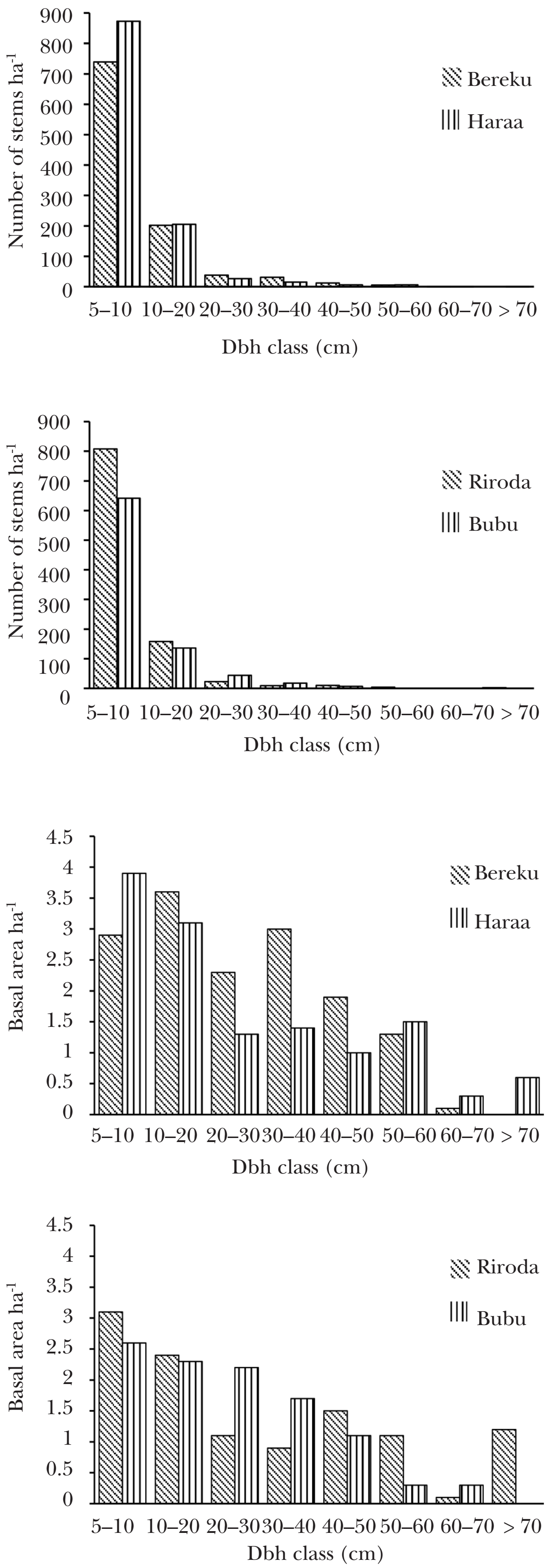

Figure 2 Distribution of number of stems and basal area over classes of diameter at breast height (dbh)

the forest resource conditions (present state as well as changes over time). However, these conditions can be attributed to many different factors, including to a possible impact of the actual changes towards decentralised forest management.

The review by Lund et al. (2009) emphasised lack of empirical data in descriptions of the policy related to the management, inappropriate descriptions of the indicators used to study the impact of the management and inadequate separation of the impact of the actual policy from other factors influencing the situation as major weaknesses of previous studies on community involvement. Similar weaknesses are also found in previous Tanzanian studies on how the management changes towards PFM have influenced forest resources (Blomley et al. 2008, Persha & Blomly 2009, Robinson & Lokina 2011, Mbwambo et al. 2012).

In the present study we used changes in forest cover over time, and present stocking level and removals as indicators to study the impacts of management. In the beginning of the study period (1993), all selected forests had high proportions of closed woodland (Table 2). At least for the two village forest reserves (Riroda and Bubu), dominance of closed woodland forests was a prerequisite for gazetting them into forest reserves (Kajembe et al. 2003). The fact that the proportions of closed woodland were even higher for the two state forest reserves (Beruku and Haraa) could be due to the existence of scattered dense montane forest areas in these forests in addition to miombo woodland, as opposed to the two village reserves with miombo woodland only. The forest cover analyses clearly show a negative trend over the study period for all forest reserves, i.e. from high proportions of closed woodland in the beginning of the period, they have all moved towards larger proportions of less dense woodlands, scrub and grasslands (Table 2). This trend was particularly obvious for the two village reserves.

It was also difficult to see any positive changes in the trends when considering the timing of the management changes that have taken place over this period. For Bereku and Haraa, where management was changed from centralised state to JFM in 2000, annual decrease of closed woodland was higher after the change than before (Table 2). For Riroda and Bubu, after the change in 1994, the rates of decrease for

Table 4 Removal parameters based on sample plot inventories in 2009

Forest reserve	No. of plots	Parameter	Mean ± SE
Bereku	55	N_{stump} (ha^{-1})	27 ± 9 a
Haraa	33		23 ± 14 b
Riroda	36		101 ± 28 a
Bubu	30		23 ± 13 b
Bereku	55	G_{stump} ($m^2 h^{-1}$)	0.29 ± 0.18 a
Haraa	33		0.22 ± 0.19 a
Riroda	36		0.52 ± 0.24 a
Bubu	30		0.25 ± 0.32 a
Bereku	55	V_{stump} ($m^3 ha^{-1}$)	1.60 ± 1.60 a
Haraa	33		1.15 ± 1.13 a
Riroda	36		2.21 ± 1.87 a
Bubu	30		1.35 ± 2.09 a

N_{stump} = number of removed stems, G_{stump} = removed basal area, V_{stump} = removed volume; SE = standard error; means with the same letter are not significantly different Bonferoni t-test (α = 0.05)

Table 5 Trees removed over diameter classes and removal relative to standing trees based on sample plot inventories in 2009

Forest reserve	Trees removed (%) distributed over basal diameter classes (cm)						Removal relative to standing trees (%)		
	1–10	11–20	21–30	31–40	41–50	> 50	No. of trees	Basal area	Volume
Bereku	35	49	4	3	2	7	2.6	1.9	1.4
Haraa	63	20	4	0	2	11	2.0	1.7	1.2
Riroda	86	12	1	1	0	0	10.0	4.6	2.5
Bubu	76	10	5	9	0	0	2.7	2.4	1.7

closed woodland were slowing down in the last period, i.e. from 9.3 to 0.9% and from 6.1 to 2.7% respectively. This is in contrast to the results of Robinson and Lokina (2011) who found that improvements in forest conditions tended to be high in the first years after the management change, after which the quality of the forest conditions declines.

For Bubu, part of the area was classified as settlement in 2000 (Table 2). This area was distributed to woodlands, scrub or grassland in 1993 and 2009. The most likely explanation for this is the controversy that took place just before the management was changed to CBFM in 1994. Due to low awareness, people in adjacent villages feared that their customary tenure was threatened. They therefore started to use the resources as much as possible before the forest was lost. By 1994 the forest was encroached by new farms (Wily 2001), something that was not observed in the satellite images from 1993. After the forests were handed over to respective villages under CBFM, those who resided in the forests were not allowed to cultivate or expand their homesteads and, accordingly, for the coming years most of them moved to other places. The areas classified as settlements in 2000 were therefore residuals of these farms and croplands, which by 2009 had changed to mainly grassland and scrubs. Generally, the history of landuse is likely to influence results (Lund et al. 2009). Nevertheless, the controversy in Bubu did not seem to be very important since patterns in changes in forest conditions were the same in both village forest reserves.

Results from the systematic sample plots inventories in 2009 show that state forests under JFM had higher densities, although not statistically significant for all parameters (number of trees, basal area and volume) compared with village forest under CBFM (Table 3). Site-specific ecological conditions should be considered when trying to isolate impacts of different managements (Lund et al. 2009). State forests comprised some areas of montane forest with generally high density (Mpanda et al. 2011). This may indicate that the higher densities in the state forest are due to more than just different management regimes.

The distributions of stems ha^{-1} over dbh classes show the reversed J-shaped trend (Figure 2), typically seen in natural forests. The numbers of trees in the smallest diameter classes were relatively high for all forest reserves, indicating that regeneration is appropriate. High numbers of regenerants, i.e. trees with dbh < 5 cm, especially in the two state forest reserves Beruku and Haraa (Table 3), however, could also be due to recent disturbances (harvesting, forest fires). The lower number of regenerants in the village forests could be due to the fact that livestock grazing here was allowed during the peak of the dry season. Although numbers of regenerants and trees in the smallest dbh classes were high, the numbers of larger trees were lower than they should be in well balanced and healthy natural forests, which, in addition to a large number of smaller trees, comprised an appropriate number of larger trees distributed over different size classes (Vanclay 1994).

Removals varied between 1.15 and 2.21 $m^3 ha^{-1}$ (Table 4). Since fresh as well as older stumps were included in this assessment, it was not possible to state how many years the removals accounted for. Thus, it was not possible to judge whether these levels were high or low when considering long-term sustainable use of the resources. The removal levels found in the present study are, however, lower than those assessed in a similar way by Mbwambo et al. (2012).

The largest numbers of trees were removed in small diameter classes (Table 5). However, in the state forest reserves under JFM many large trees have been removed too. The state forest reserves issue permits for collection of dry wood for firewood as part of JFM agreements but illegal logging of large diameter trees was frequently observed during inventory. In the village forest reserves, most removals involved small diameters trees only. Particularly high removals were seen in Riroda village forest reserve under CBFM management (Tables 4 and 5). This reserve are divided into production (1440 ha) and protective (360 ha) forests. Substantial activities were seen during inventory in the production forest, namely, cutting for fuelwood and poles.

The application of multiple indicators in the present study, such as forest cover changes over time and present forest stocking and removals, to assess the impact of management changes is in line with some of the recommendations by Lund et al. (2009). A combination of large scale and temporal aspects (forest cover) was considered through satellite image analysis and details regarding forest stocking and removals were based on field inventories. Our study did not provide any in-depth analysis of policy issues as recommended by Lund et al. (2009), but a general description of JFM and CBFM is given. We did not have any control sites that could be used as benchmarks to assess what could have happened if the PFM regimes were not implemented (Ferraro 2009). We have, however, identified factors related to the history of landuse (e.g. changes towards PFM regimes took place under varying environments regarding consensus/support among the people living in adjacent communities and differences in forest conditions before the changes took place that may have influenced the results.

Based on our results, it is not clear if changes to decentralised management have been a success towards improving forest resource conditions. On the contrary, from the forest cover analyses we see that the forests have been changed, partly quite dramatically, from closed woodland towards areas with open and bushed woodland and scrub. In addition, the structure of the forests can hardly be considered as well balanced and healthy, typical for a natural forest. There are still relatively high levels of removals, illegal as well as legal, taking place in the forests studied. Our results contradict findings by Blomley et al. (2008), Persha and Blomley (2009) and Mbwambo et al. (2012) who concluded that the decentralised management regimes performed relatively well.

Theory on the use of common natural resources and decentralisation suggests that partners must have net benefit from decentralisation, i.e. monetary income and other benefits should exceed direct costs and other disadvantages such as limited access to forest (Ostrom 1999). Therefore, forests that are both managed and owned by communities, such as those under CBFM with relatively high potential for generating local economic returns, are expected to provide more incentives than those managed under JFM, where incentives and returns are potentially lower (Blomley et al. 2008). Such scenario is not confirmed by the present study where state forest reserves under JFM are generally better, i.e. larger proportion of closed woodland and less removals than the village forest under CBFM. Similar findings are also concluded by Blomley et al. (2008) when comparing JFM and CBFM,

The current forest policy and legislation in Tanzania emphasise decentralised forest management. The results of this study on forest conditions, and also of previous studies, will be valuable for policymakers when they decide future policy means. It is also important to get more documentation and knowledge on the two other main objectives of decentralised management in the country, i.e. improved livelihood and improved governance structures. Only then can we understand the functions of different governance structures and how they facilitate an appropriate livelihood for the people.

CONCLUSIONS

Based on this study it was not possible to claim that the changes towards decentralised management were successful in improving forest resource conditions. The proportions of closed woodland had decreased significantly over time, although the numbers of regenerants were high. Proportions of larger trees were also low and levels of removals (legal and illegal) were relatively high. The situation in the state forest reserves under JFM in general was better with larger proportion of closed woodland and less removals compared with the village forests under CBFM.

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