Does Participatory Forest Management Promote Sustainable Forest Utilisation in Tanzania?

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Source: International Forestry Review, 16(1):23-38.
Published By: Commonwealth Forestry Association
URL: http://www.bioone.org/doi/full/10.1505/146554814811031279

Does participatory forest management promote sustainable forest utilisation in Tanzania?

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SUMMARY

Over the past 20 years, Participatory Forest Management (PFM) has become a dominant forest management strategy in Tanzania, covering more than 4.1 million hectares. Sustainable forest use and supply of wood products to local people are major aims of PFM. This paper assesses the sustainability of forest utilisation under PFM, using estimates of forest condition and extraction rates based on forest inventories and 480 household surveys from 12 forests; seven under Community Based Forest Management (CBFM), three under Joint Forest Management (JFM) and two under government management (non-PFM). Extraction of products is intense in forests close to Dar es Salaam, regardless of management regime. Further from Dar es Salaam, harvesting levels in forests under PFM are, with one prominent exception, broadly sustainable. Using GIS data from 116 wards, it is shown that half of the PFM forests in Tanzania are likely to be too small to satisfy current local wood demand.

Keywords: Community Based Forest Management, Joint Forest Management, wood extraction, sustainable harvest, tropical forest

La gestion participative des ressources forestières promeut-elle une utilisation durable en Tanzanie?

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Au cours des 20 dernières années, la gestion participative des forêts (GPF) est devenue la stratégie prédominante de gestion forestière en Tanzanie, couvrant à elle-seule plus de 4.1 millions d'hectares. Un des principaux objectifs de la GPF est d'assurer une utilisation durable des produits ligneux par les ménages ruraux locaux. Cet article a pour but d'évaluer la durabilité de l'utilisation des ressources forestières gérées de façon participative, en utilisant des données sur l'état des forêts et les taux d'extraction basés sur des inventaires forestiers de 12 forêts (sept sous gestion forestière communautaire, trois sous gestion conjointe des forêts (GCF) et deux sous gestion gouvernementale (non-GPF)) et enquêtes effectués auprès de 480 ménages. Le taux d'extraction de produits est élevé dans les forêts situées en proximité de Dar es Salaam, peu importe le système de gestion. Pour les forêts plus éloignées de Dar es Salaam, les taux d'extraction dans les forêts sous GPF sont, à une exception près, largement durable. En utilisant des données SIG provenant de 116 circonscriptions, l'article démontre que la moitié des forêts sous GPF en Tanzanie sont susceptibles d'être trop petites pour satisfaire la demande locale actuelle en bois.

Fomenta el manejo forestal participativo el uso sostenible de los bosques en Tanzania?

T. TREUE, Y.M. NGAGA, H. MEILBY, J.F. LUND, G. KAJEMBE, S. IDDI, T. BLOMLEY, I. THEILADE, S.A.O. CHAMSHAMA, K. SKEIE, M.A. NJANA, S.E. NGOWI, J.A.K. ISANGO y N.D. BURGESS

Durante los últimos 20 años, el Manejo Forestal Participativo (MFP) se ha convertido en una estrategia de gestión forestal preponderante en Tanzania, que abarca más de 4,1 millones de hectáreas. Los principales objetivos del MFP son el aprovechamiento sostenible de los bosques y el suministro de productos maderables para la población local. Este artículo evalúa la sostenibilidad del aprovechamiento de bosques bajo MFP, por medio de estimaciones del estado en que se encuentran los bosques y las tasas de extracción, a partir de inventarios forestales y 480 encuestas de hogares de 12 bosques: siete bajo Gestión Forestal de Base Comunitaria (GFBC), tres bajo Manejo Forestal Conjunto (MFC) y dos gestionados por el gobierno (sin MFP). El aprovechamiento de productos del bosque es intenso en aquellos cercanos a Dar es Salaam, independientemente del régimen de manejo. A medida que nos alejamos de Dar es Salaam, los niveles de aprovechamiento de los bosques bajo MFP son sostenibles en general, salvo una notable excepción. Mediante el uso de datos de SIG de 116 *wards* (municipios) se muestra que la mitad de los bosques de Tanzania bajo MFP son probablemente demasiado pequeños como para satisfacer la demanda local de madera en este momento.

INTRODUCTION

In 2005, according to the official forestry statistics, Tanzanian mainland had 35.3 million (ha) of forests, equalling 39.9% of the total land area (FAO 2007). The main forest types include deciduous miombo woodlands in the western, central and southern parts of the country, *Acacia-Commiphora* woodlands in the northern regions, coastal forests or woodland mosaics in the east, mangrove forests along the Indian Ocean coast, and closed canopy forests, which grow on the ancient mountains of the Eastern Arc, along the Albertine Rift close to Lake Tanganyika in the west, and on the younger volcanic mountains in the north and central parts of the country (Burgess *et al.* 2004). According to government statistics, 14.3 million ha of this forestland was found within gazetted Forest Reserves whilst around 2 million ha was found in Game Reserves or National Parks (MNRT 2008). The remaining 16.5 million ha of forest, more than half the total area, was located on village and general land (Blomley and Iddi 2009, MJUMITA and TFCG 2011).

Over the past 20 years, the involvement of local communities in the management of the natural resources on which they depend has become central to many of the forest management strategies that have been promoted, especially in the developing world (White and Martin 2002, Sunderlin *et al*. 2008). This increased emphasis on community participation in forest management is generally regarded as a paradigm shift by scientists and practitioners alike (Hobley 1996, Agrawal and Chhatre 2006, Andersson and Gibson 2006, Blomley *et al.* 2008, 2009; Chhatre and Agrawal 2008, Roe *et al.* 2009, Persha *et al.* 2011).

The principles of Participatory Forest Management (PFM), the central tenet of which is the transfer of forest management authority from central government agencies to democratically elected village governments, was first introduced to Tanzania in the 1990s. Pilot projects were carried out in Babati district (Wily 2001, Wily and Mbaya 2001, Kajembe *et al.* 2002), and later in Iringa, Tanga and Morogoro regions (Blomley *et al.* 2008, Persha and Blomley 2009, Pfliegner 2011). These pilot projects were then extended nationally (Blomley 2006, Blomley and Ramadhani 2006), a process that continues today.

The PFM pilot projects inspired the development of a new national Forest Policy, intended to transform the way Tanzanian forests are managed (URT 1998). The goals of the 1998 Forest Policy were later embedded in law through the Forest Act No. 14 of 2002 (URT 2002), and in regulations and guidelines for Community Based Forest Management (CBFM) and Joint Forest Management (JFM) (MNRT 2003, 2008). The government of Tanzania has invested millions of US dollars of its own funds and those of development partners over the past two decades, producing PFM policies and legislation, and on implementation.

One of the main goals of PFM in Tanzania is to promote the sustainable use of forest resources and to govern the forests at the lowest level of management possible (the village) for the benefit of local communities. Although assessments have been made of the impacts of PFM on forest conservation (Blomley *et al.* 2008, Lund and Treue 2008, Persha and Blomley 2009, Nielsen 2011), opportunity costs (Meshack *et al.* 2006), livelihoods (Lund and Nielsen 2006, Lund and Treue 2008, Lund 2007, Vyamana *et al.* 2008, Vyamana 2009, Nielsen and Treue 2012, Pfliegner 2011), and issues of governance (Goldman 2003, Mustalahti 2006, Brockington 2007, 2008, Nielsen and Lund 2012, Pfliegner 2011), large-scale empirical evidence remains scarce, which presents a barrier to the further development of PFM approaches.

This paper aims to examine whether PFM management is delivering sustainable forest management, which is one of its main policy goals. To this end two main data sets are used.

The first is composed of field data collected from 12 study sites in eastern and southern Tanzania, including 10 under the PFM management regime, over a 3.5-year period (July 2007–December 2010). Field data comprise forest stand and stump biophysical inventories (348 plots) as well as answers to structured questionnaires by 480 individual households (40 per site) that detail the communities' use of environmental products and the products' sources (PFM forests, non-PFM forests and non-forest environments). These data are used to assess stocking and harvesting levels in the forests over time and in relation to the different management regimes. Sustainability is then assessed by comparing the estimated off-take of woody biomass with the estimated re-growth (further details below).

The second dataset is derived from the Tanzanian national PFM database on the names, areas, year of establishment, which was developed in 2006 and updated in 2008 (MNRT 2008). The PFM database is linked to GIS information on population densities at ward level across the country (2002 national population census). Field data and literature results on growth and harvesting rates are then used to assess the potential for existing PFM forests to sustainably supply local people with forest products, if these were the only available sources of woody biomass.

DEVELOPMENT OF PARTICIPATORY FOREST MANAGEMENT (PFM) IN TANZANIA

In Tanzania, PFM has grown from a few pilot projects in the late 1990s to a generalised management system, which operates across hundreds of reserves, hundreds of villages and covers approximately 4.1 million ha of forest across the entire country (Fig. 1) (MNRT 2001, 2003, 2008).

The 1998 Tanzanian Forest Policy promoted, for the first time in the country, community participation in forest conservation and management through; a) the creation of mechanisms for village governments to protect unreserved forest through the establishment of Village Land Forest Reserves (VLFR), which are owned and managed by village governments under a system known as Community Based Forest Management (CBFM), and through; b) Joint Forest Management (JFM), where local village governments and central or district government forest offices co-manage National or Local Government Forest Reserves (Blomley and Iddi 2009).

A key feature of CBFM and JFM is that the central government, through specified legal procedures, can re-centralize management of the forests, if village governments fail to conserve them. Together, CBFM and JFM form the Participatory Forest Management (PFM) approach analysed here.

PFM management operates through by-laws, i.e. local-level forest rules vested with the Village Councils, under the legal provisions of the Local Government Act No. 7 of 1982 (URT 1982). There are around 10 500 Village Councils across Tanzania and these bodies delegate forest management to Village Environmental Committees (VECs) or Village Natural Resources Committees (VNRCs) that are established through direct democratic elections where all villagers above 18 years of age are entitled to vote. The importance of village government institutions in managing natural resources is also recognised in the Land Act No. 4 of 1999 and the Village Land Act No. 5 of 1999 (URT 1999a,b). Within a set of overall criteria and procedures defined by the central government, CBFM forest rules are, thus, defined and enforced by villagers through a representative democratic process. JFM forest rules are generally defined by the concerned government forest office, c.f. above, but enforced by VECs/VNRCs subject to voluntary partnership agreements between the concerned village governments and district or central government forestry institution. Accordingly, Tanzania is currently considered to have one of the strongest formal local institutional frameworks for PFM in sub-Saharan Africa (Roe *et al.* 2009).

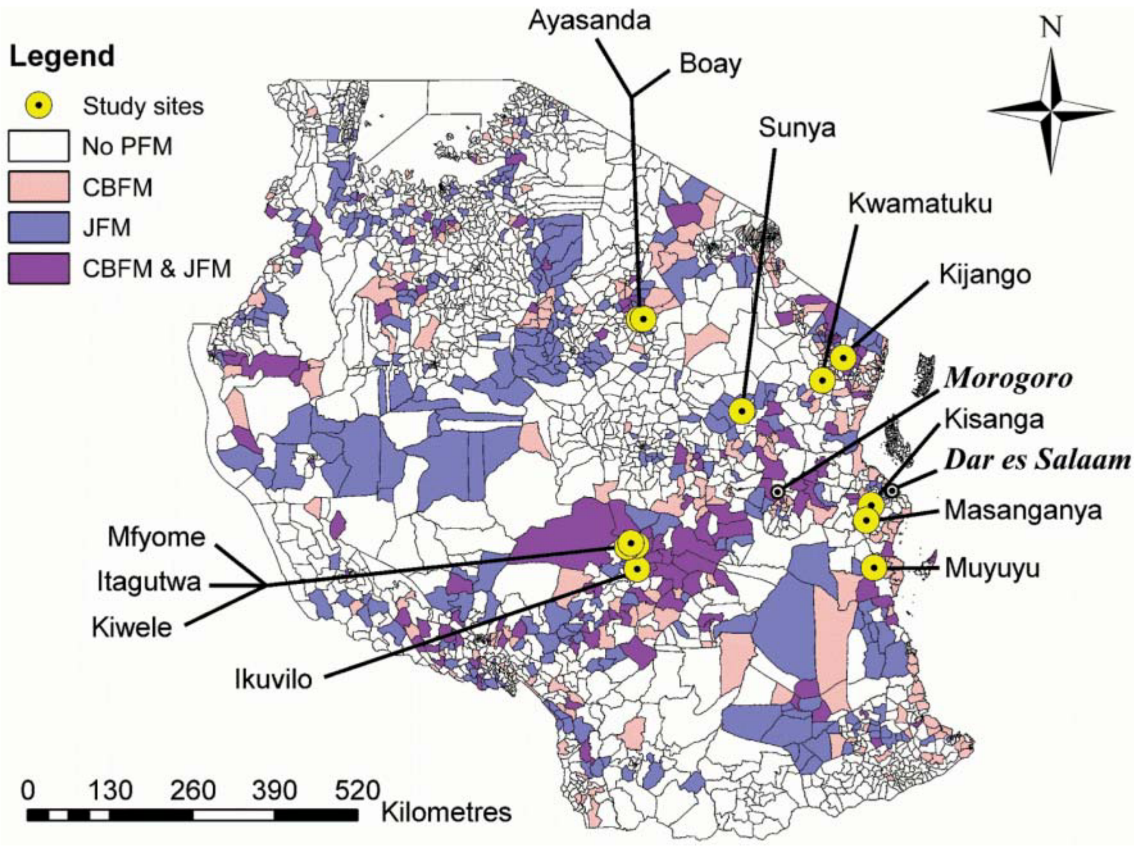
The Tanzanian PFM programme is strongly supported by the Tanzanian government, in particular the Forestry and Beekeeping Division (FBD) of the Ministry of Natural Resources and Tourism (MNRT), which has transferred many of its responsibilities to the Tanzania Forest Service (TFS), and the Prime Minister's Office, Regional Administration and Local Government (PMO-RALG). These ministries have been supported in their work on PFM by a number of international donors and international and national NGOs. Estimated investments in PFM by the Danish, Finnish, German and UK governments – together with the World Bank and UNDP-GEF (and other smaller actors) amount to over US$ 20–30 million.

METHODS

Field data

Subject to financial and logistical constraints, 12 sites within reasonable distance from Morogoro (base of the fieldwork team) were selected (Fig. 1). The focus was on miombo and *Acacia* woodlands as these represent the largest area coverage in Tanzania and thus presumably also represent forest types that most people depend on. As CBFM sites represent the highest degree of local autonomy (c.f. above) most (seven) of these were included while also including nearby JFM sites (three) to cover the variety of PFM. Two non-PFM sites were

FIGURE 1 *Spatial distribution of PFM in Tanzania and location of the study sites*



Source: MNRT (2008)

also included to serve as a kind of controls –mainly for the effect of proximity to towns and cities (not as "non-treatment" controls which would require a large-N set-up).

Fieldwork in the 12 villages was conducted over 30 months in the dry seasons of 2007–2010 (Table 1). The dry seasons were selected to facilitate the participation of farmers who are less occupied at that time of year where forest inventory work is also most convenient to undertake. The same field team spent approximately two weeks in each location (Table 1), where forest inventory work was conducted during the first week and household surveys, the second.

Forest surveys

Data on forest condition were collected using a standardised sample plot-based inventory (LIFE and SUA 2007). In addition to forest condition in terms of stem numbers, basal area, volume of growing stock, tree size, and canopy cover (Table 2), harvesting levels were also recorded through measurement and age assessment of stumps (Table 3).

Forest condition was assessed using 15–69 circular sample plots in each forest, with a radius of 15 meters (0.071 ha) for live trees and 20 meters (0.126 ha) for stumps (Tables 1, 3). This yielded sampling intensities of 0.08–0.1% for live trees and 0.14–0.17% for stumps. To ensure randomization, a systematic grid was created and projected randomly onto a map of each study area. Natural starting points, such as roads and footpaths, which were bisected by the grid lines, were located on the map and the distance from the starting point to the first plot in each transect was chosen randomly. The remaining plots were located at a fixed distance from each other along the resulting transects. In each plot, the following three measurements were recorded: (1) diameter 1.3 m above ground, referred to as diameter at breast height (dbh), for all trees with dbh $\geq$ 5 cm; (2) diameter 20 cm above ground for all stumps with a diameter $\geq$ 5 cm and; (3) the total height and diameter 20 cm above ground for two trees per plot: (a) the tree located nearest to the plot centre, and (b) the thickest tree within the plot. Whenever possible, species were identified using local names.

The age of stumps was assessed by local informants who, based on the colour and degree of decay of the cut surface, combined with their knowledge on where harvesting activities had historically taken place, assigned them to categories of 1–2, 3–5, 6–10, and more than 10 years old. Later, dendrochronological analyses in Kiwele and Mfyome showed that informants did not distinguish reliably between the 3–5 and 6–10 year categories and these were therefore merged (Mwakalukwa *et al.* in prep). The sizes and ages of stumps were used to derive an average estimate of forest extraction level for the past 10 years. This was done by applying local, forest-specific regression models relating stump diameter to dbh and total tree height in combination with Malimbwi *et al.*'s (1994) volume function for miombo woodland.

Household surveys

Data were collected through 40 detailed household surveys per village (n = 480). All household representatives' names and ages as well as their relation to the head of household were recorded, but anonymity naturally protected by the research team. The majority of the respondents were household heads and most were men. In each household, the head, and often his wife as well as other household members were interviewed. The interviews followed a structured questionnaire, which, based on recollection of the past year's economic activities, was designed to elicit information about households' annual income sources including the use and origin of environmental products. Environmental products are here defined as non-cultivated wood and non-wood biological products (firewood, charcoal, poles, timber, withies, wild fruits, mushrooms, bushmeat, medicinal plants, etc.) derived from PFM forests, non-PFM forests, farmland including fallows and non-forest non-farmland areas such as open savannah.

In each of the 12 villages, all households (HH) were categorized into three different wealth categories. This was done through group meetings with key informants (village and sub-village chair persons) whose consensus-based perceptions of what constituted wealth and poverty in their respective communities was used to categorize each and every HH in the village register. Once rankings had been established, the village register for the main settlement and sub-villages was used to randomly select a sample of households within each wealth category. Care was taken to include households from all parts of the villages and the surrounding village lands as some sub-villages were situated more than 10 km from the main settlement. Proportional sampling was then used to select 40 households from each village such that simple averages within wealth categories and across the entire sample would be central estimates for wealth classes and the village as a whole. As a selected HH might be unavailable or decline to participate in the survey three 'extra' HHs within each wealth category were randomly selected and used as 'back-up HHs' in the order they were drawn. In each site, two 'back-up HHs' or less form part of the sample.

Of particular interest for this study, was to estimate the annual outtake by village members of woody biomass from the inventoried PFM and non-PFM forests as this would complement the above described stump-based outtake estimates. Accordingly, all local units of woody biomass such as head-loads, bags of charcoal, poles and planks, were measured in metric values (kg and m^3) and converted to round wood equivalents (rwe) through literature-based conversion factors that express how many m^3 round wood goes into producing e.g. 100 kg of firewood, a metric ton of charcoal, one m^3 of planks and so on (further details below).

Analysis of field data

All field data were transcribed into Microsoft Access. Data checking was completed between Denmark and Tanzania, and the final analyses were carried out using a combination of Access, Excel, and SAS version 9.2 statistical software.

TABLE 1 *Study sites and basic forest attributes within the areas researched in this project*

Village name	Forest Description						Geographical location			Data collection	
	Forest name	**Vegetation type**	**Mgt. system**	**PFM established**	**Sampled area (ha)**	**# of plots**	**District name**	**Lat. (S)**	**Long. (E)**	**Survey dates**	**Team Days (6 people)**
Ayasanda	Duru-Haitemba VLFR	Miombo	CBFM	1994	550	20	Babati	4.38°	35.71°	Oct, 2008	8
Kijango	Mfundia VLFR	Miombo	CBFM	2001	119	15	Korogwe	4.93°	38.59°	Mar, 2008	5
Kisanga	Kisanga	Coastal Forest	CBFM	1998	101	15	Kisarawe	7.01°	38.99°	Dec, 2010	7
Kiwele	Kidundakiyave VLFR	Miombo	CBFM	2002	4 904	69	Iringa Rural	7.59°	35.54°	July, 2007	13
Kwamatuku	Ntumbili	Miombo	CBFM	2008	125	15	Handeni	5.24°	38.30°	Nov, 2010	9
Mfyome	Gangalamtumba VLFR	Miombo	CBFM	2002	6 065	69	Iringa Rural	7.55°	35.59°	July, 2007	20
Sunya	Suledo	Miombo	CBFM	1994	10 000†	30	Kiteto	5.68°	37.16°	April, 2009	10
Boay	Bereko FR	Miombo	JFM	2000	1 491‡	25	Babati	4.37°	35.76°	Oct, 2008	15
Itagutwa	Kitapilimwa FR	Miombo	JFM	2002	3 699	25	Iringa Rural	7.57°	35.67°	July, 2008	8
Muyuyu	Ngumburuni FR	Coastal Forest	JFM	2004	2 999	25	Rufiji	7.89°	39.03°	May, 2009	8
Ikuvilo	Lugala MT	Miombo	Non-PFM	n/a	199	15	Iringa Rural	7.91°	35.68°	June, 2008	7
Masanganya	Masanganya FR	Coastal Forest	Non-PFM	n/a	2 989	25	Kisarawe	7.22°	38.92°	May, 2009	11

† Total area of Suledo Forest Village Land Reserve is 167 000 ha; Sunya's part is 10 000 ha (the sampled area).
‡ Total area of Bereko Forest Reserve is 5 373 ha; Boay's part is 1 491 ha (the sampled area).

Standing and harvested volumes according to forest survey

Field data on live trees were used to estimate the forest-level growing stock. Diameter and height measurements of live trees were used to derive site-specific allometric relationships, such that the diameter and number of tree stumps could be used to estimate the diameter, height and aggregate volume (m^3) of wood per ha per year harvested from each of the forest areas (Table 3). Being the only established volume functions for miombo species in Tanzania, the models developed by Malimbwi *et al*. (1994) were used for volume estimation based on individual-tree diameter and height estimated using a site-specific regression of height on diameter.

Harvested volumes according to household data

The local units of forest products (head-loads, bags, cart loads, pieces, etc.) were converted to metric values of wood through measurements of 176 bags of charcoal and 154 planks from markets in the four regions (Iringa, Manyara, Pwani and Tanga) along with 288 head-loads of firewood and 346 poles from the twelve study villages. Conversion factors were developed from these measurements, and from available literature.

For charcoal, the conversion factor assumes that 137.8–159 kg (mean of 148.4 kg) of marketable charcoal is obtained from every m^3 of harvested wood (Chaposa 2002), based on a kiln efficiency of around 19% and the burning of primarily freshly cut, wet hardwood. Mwampamba (2007) suggests that 7% of the cut tree is not used for charcoal, which implies a conversion rate of 0.0072 m^3 of live wood to every kg of charcoal. Weighing large numbers of charcoal bags (Ishengoma and Ngaga 2000, Schaafsma *et al.* 2012, field data), from several different towns, show that an average bag of charcoal weighs around 56 kg. This brings us to a final conversion factor of 0.43 m^3 live wood per charcoal bag (or 0.5m^3 per bag for simplicity).

For firewood, the conversion factor was based on the measurement and weighing of 289 head-loads of wood in the 12 study villages. These were converted to volumes of living tree mass using an average wood density of 650 kg/m^3 and a 25% water content, which resulted in a volume of 0.00123 m^3 per kg of firewood.

For planks, the conversion factor is based on the teams' estimated output of 0.34 m^3 of planks for every cubic metre of round wood harvested. With an assumed further 4% reduction due to the loss of branches, the volume of trees felled per cubic meter of planks is 3.04 m^3.

On this basis, data from the household surveys were used to estimate the total annual volume (m^3) of wood the entire village extracted from adjacent forests, from PFM forests, and other sources, c.f. above, as well as of the total amount of wood used by individual villages (Tables 3,5). Further, household survey data (Table 4) were compared with biophysical data to identify conspicuous differences between the two. Since household surveys do not measure harvesting by external/non-community members, discrepancies between stump and household surveys are likely to indicate that outsiders are operating in the forests. Qualitative information and direct observations on control of access to the forests obtained during field work was used to triangulate the matching of bio-physical and HH survey data.

Estimating harvesting sustainability and the potential for PFM to meet local demands for wood

Sustainability is here defined as harvesting where the estimated off-take of woody biomass does not exceed the estimated re-growth over a given period. This conforms to the classic sustained yield definition of sustainability in production forest, but does not consider possible changes in diameter classes or species composition and associated ecological consequences. Under these limitations the question of sustainability within the context of PFM is approached in two ways.

Field data approach

To assess rates of growth in miombo woodlands, 16 permanent sample plots (0.04–0.09 ha each) measured in 2002–2003 in Mfyome and Kiwele forests were re-measured in 2008. Estimated volume increments varied from 0.8 to 3.3 $m^3ha^{-1}yr^{-1}$ with a mean of 1.6 (standard error, SE=0.2) $m^3ha^{-1}yr^{-1}$. This was compared with published data on annual increments in coppiced dry miombo woodland (Chidumayo 1988, cited in Frost 1996), which suggest growth rates of 2 $m^3ha^{-1}yr^{-1}$ in coppice plots. Based on the aggregate evidence base, 1.5 $m^3ha^{-1}yr^{-1}$ was selected to represent the typical growth rate of miombo woodland. Increment data for coastal forests eastern African is lacking from field studies and published literature alike. For Kitulang'halo forest near Morogoro Malimbwi *et al.* (2005) reported a growth rate of 2.35 $m^3ha^{-1}yr^{-1}$. The rate of 1.5 $m^3ha^{-1}yr^{-1}$ used herein is therefore taken to be a safe minimum value for coastal forests.

Harvesting data from the forest assessments and the household surveys were compared to the reference growth rate. In forests where the estimated harvesting rates exceeded the assumed growth rate, extraction levels were deemed unsustainable.

Whether PFM is the cause and forest harvest vs. re-growth is the effect is extremely difficult to establish – even with randomized large N and/or time series studies of areas with and without PFM. The reason being that confounding factors like changes over time and/or differences between sites in market access and prices of forest and agricultural products, livelihood strategies, access to credit and so on (the list is virtually endless), cannot be fully controlled for. Further, rigorous matching of PFM and non-PFM sites is challenging and the complexity of the matter implies that a perfect match resembling randomized treatment conditions is unlikely. Accordingly, the counterfactual situation (what would have happened in the absence of PFM) will, always remain partly unknown. Moreover, PFM itself changes the dynamics of the system because the introduction of PFM in a given village will change the likely impact of PFM in neighbouring villages. These challenges in evaluating conservation impacts of PFM are well described in recent reviews of the literature (Lund *et al*. 2009, Bowler *et al*. 2012). In this paper, these challenges are sought alleviated by interpreting bio-physical data (current growing stock and harvesting intensity as well as harvesting history) in the light of available qualitative information on the effect (or lack of effect) that PFM has had on harvesting practices.

National GIS approach

To assess the sustainability of harvesting in Tanzania's PFM forests at national scale, the national survey of PFM status in Tanzania (MNRT 2008) was imported into GIS. This enabled a linking of PFM forests to GIS polygons for administrative wards (a few villages), and to the human population estimates for these wards according to the 2002 national population census.

By extrapolating the wood consumption needs of the human population within these wards based on field survey data, and the estimated forest growth rates, it was assessed whether the individual PFM forests might be large enough to meet the demand for wood in that area, should all other sources of wood be exhausted. The results provide a rough estimate of whether PFM forests are capable of supplying the wood required by their associated communities without compromising their long-term survival.

RESULTS

Standing biomass and harvesting regimes

Estimates of tree biomass from biophysical surveys

The growing stock varies considerably, from a minimum of 12 m^3ha^{-1} (SE=3) to a maximum of 185 m^3ha^{-1} (SE=31) around the overall mean across all sites of 65 m^3ha^{-1}, with around 50–60 m^3ha^{-1} in miombo woodland and higher stock in the coastal forests, 95 m^3ha^{-1} in Masanganya and 185 m^3ha^{-1} in Muyuyu (Table 2).

All studied forests are disturbed to some extent, as illustrated by the tree canopy cover, which varies from 13% to 61% (mean 43%). In a pristine forest, the tree canopy cover would be about 70–100% (Table 2).

Estimates of harvesting from biophysical surveys

Tree stump survey data show that harvesting is taking place in all study forests irrespective of management system. The past 1–2 years harvesting varies from 0.004 $m^3ha^{-1}yr^{-1}$ (SE=0.003) in the remote Kiwele forest, to 6.7 $m^3ha^{-1}yr^{-1}$ (SE=2.010) in Masanganya coastal forest, which is close to Dar es Salaam (Dar) (Table 3). In four forests (Ayasanda, Kisanga, Muyuyu and Masanganya), the estimated mean harvesting exceeds the estimated sustainability limit of 1.5 $m^3ha^{-1}yr^{-1}$ (Table 3) the past 10 years' harvesting histories also vary considerably (see below).

TABLE 2 *Basic forest statistics for ten PFM and two non-PFM forests in Tanzania. Standard errors (SE) in parentheses*

Village	Type	Stem number [no./ha] (SE)	Basal area [m²/ha] (SE)	Volume [m³/ha] (SE)	D_g† [cm]	H_g‡ [m]	Cover of trees [%]	Cover of herbs [%]	Number of Plots
Ayasanda	CBFM	468 (81)	10.9 (1.4)	86 (12)	18.8	10.1	56	21	20
Kijango	CBFM	3 504 (331)	13.0 (1.3)	65 (7)	7.1	4.5	53	26	15
Kisanga	CBFM	352 (91)	2.4 (0.6)	12 (3)	9.6	5.9	16	28	15
Kiwele	CBFM	779 (38)	9.1 (0.6)	47 (4)	12.2	6.1	43	37	69
Kwamatuku	CBFM	320 (53)	5.5 (0.7)	35 (5)	15.6	7.7	13	23	15
Mfyome	CBFM	988 (51)	11.6 (0.7)	63 (4)	12.3	6.7	50	37	69
Sunya	CBFM	375 (38)	6.8 (0.8)	48 (6)	15.7	8.7	40	37	30
Mean	*CBFM*	*970*	*8.5*	*51*	*13.0*	*7.1*	*39*	*30*	-
Boay	JFM	613 (44)	9.8 (0.9)	77 (8)	14.5	9.8	61	27	25
Itagutwa	JFM	751 (69)	6.6 (0.5)	32 (3)	10.7	5.8	44	32	25
Muyuyu	JFM	448 (55)	16.7 (2.4)	185 (31)	22.4	13.7	41	54	25
Mean	*JFM*	*604*	*11.1*	*98*	*15.9*	*9.7*	*49*	*37*	-
Ikuvilo	Non-PFM	777 (91)	7.8 (1.2)	34 (6)	11.1	4.9	47	39	15
Masanganya	Non-PFM	460 (62)	9.7 (1.2)	95 (16)	17.3	10.2	46	56	25
Mean	*Non-PFM*	*619*	*8.8*	*65*	*14.2*	*7.5*	*46*	*47*	-
Overall mean	*All*	*820*	*9.2*	*65*	*13.0*	*7.2*	*43*	*35*	-

† Diameter of the imaginary tree with the mean basal area.

‡ Height of the D_g tree, estimated through a site specific diameter-height regression.

TABLE 3 *Stump-based estimates of total volumes harvested*

Village	Management System	PFM established	# of plots [n]	Felled 1–2 years ago			Felled 3–10 years ago	
				Mean [$m^3ha^{-1}yr^{-1}$]	SE [$m^3ha^{-1}yr^{-1}$]	95% CI [$m^3ha^{-1}yr^{-1}$]	Mean [$m^3ha^{-1}yr^{-1}$]	SE [$m^3ha^{-1}yr^{-1}$]
Ayasanda	CBFM	1994	20	2.770	0.560	±1.18	0.26	0.08
Kijango	CBFM	2001	15	0.870	0.320	±0.69	2.06	0.36
Kisanga	CBFM	1998	15	2.960	0.800	±1.72	0.84	0.21
Kiwele	CBFM	2002	69	0.004	0.003	±0.01	0.18	0.07
Kwamatuku	CBFM	2008	15	1.240	0.650	±1.40	0.62	0.29
Mfyome	CBFM	2002	69	0.160	0.090	±0.18	0.08	0.04
Sunya	CBFM	1994	30	0.240	0.190	±0.40	0.13	0.05
Boay	JFM	2000	25	1.060	0.360	±0.75	0.40	0.25
Itagutwa	JFM	2002	25	0.029	0.019	±0.04	0.38	0.10
Muyuyu	JFM	2004	25	2.160	1.260	±2.60	1.02	0.36
Ikuvilo	Non-PFM	n/a	15	0.410	0.110	±0.24	0.48	0.11
Masanganya	Non-PFM	n/a	25	6.740	2.010	±4.15	1.06	0.43

Estimates of harvesting from household surveys

Harvesting rates vary but are not statistically correlated with the PFM management regime (Table 4). This is primarily because fuel wood is the most important forest product for local communities and demands for fuel wood per capita are quite similar across the study areas. The total amount of wood consumed in the villages varied from 1 030 (SE=150) m^3yr^{-1} in Ikuvilo (non-PFM) to 3 530 (SE=490) m^3yr^{-1} in Kwamatuku (CBFM). Per capita woody biomass consumption varied from 0.41 (SE=0.06) $m^3cap^{-1}yr^{-1}$ in Boay (JFM) to 1.12 (SE=0.16) $m^3cap^{-1}yr^{-1}$ in Masanganya (non-PFM) around an overall average of 0.65 (SE≈0.07) $m^3cap^{-1}yr^{-1}$ (Table 4).

The villages also varied in terms of the relative amounts of woody products reported to come from PFM forests, non-PFM forest, non-forest areas and unspecified sources (Table 4). Three villages, Kwamatuku (CBFM), Muyuyu (JFM) and Masanganya (non-PFM), reported high harvesting rates from non-forest areas; 1 610 (SE=440), 1 520 (SE=450) and 2 280 (SE=410) m^3yr^{-1}, respectively (Table 4). Of these, the latter two are situated close to Dar (Fig. 1), where local people's access to local forest resources appeared constrained by outsiders and many of the interviewed households indicated they no longer considered the officially designated areas as forests since these were being overharvested anyway. Thus, some of the stated non-forest extraction may, in fact, origin from the JFM and government forests (see below). In Kwamatuku, the main village is located far from the CBFM forest and people appear to source their woody biomass consumption equally from closer-by non-PFM forest and non-forest areas including own farms and fallows (Table 4). In all PFM sites, where both stump and household data indicate sustainable harvesting levels, a substantial part, ranging from 16% in Boay (JFM) to 46% in Mfyome (CBFM), of the respondents' total wood consumption is reported to be sourced from non-PFM forests (Table 4).

Comparison of biophysical survey and household data

In Kisanga (CBFM), Kwamatuku (CBFM), Boay (JFM), and Muyuyu (JFM) the stump survey shows higher levels of harvesting than the household surveys (Fig. 2). Two of these sites are close to Dar es Salaam (see below).

In Kijango's small (119 ha) CBFM forest (Table 1), the stump survey shows significantly lower harvesting levels than the household survey, while their per capita extraction of 0.51 m^3yr^{-1} is in the lower range of the 12 villages (Fig. 2, Table 4). Kijango was the first site to be surveyed and the data suggest that misunderstandings between enumerators and respondents have resulted in failure to clearly distinguish between sources of woody products. Household survey data do not apply in non-PFM sites where extraction from non-PFM forest includes but is not limited to the surveyed forest (Table 4). However, stump-based harvesting patterns in the two non-PFM sites, Masanganya and Ikuvilo differ substantially with the former being off scale and the latter well below the sustainability threshold (Fig. 2). In Ikuvilo, people report non-PFM forest as their main source of wood while people in Masanganya report this to be non-forest land (Table 4).

Harvesting histories and distance from Dar es Salaam

The harvesting histories of the 12 sites were reconstructed by placing the stump data into time periods and diameter classes (Table 3 and Fig. 3). All sites located close to Dar (Kisanga, Masanganya and Muyuyu) have experienced high and significantly increasing harvesting pressures over the past 10 years (Figs. 1, 2, 3 and Table 3). Whether managed as PFM or non-PFM forests makes no difference to the levels of harvesting in these Dar-adjacent forests, which are highly unsustainable (Fig. 2). The demand from Dar is presumably so great that it overrides any form of attempted official forest management regime, be that state or community enforced (see below).

TABLE 4 *Household survey-based harvesting and consumption estimates*

Management System Village	# HHs	Persons per HH	Sources of extraction [m³/year] (SE, standard error)					Consumed [m³/year](SE)	
			Total*	PFM forest	Non-PFM forest	Non-forest land	Unspecified sources	Within village*	Per capita
CBFM									
Ayasanda	465	7.0	2 040 (280)	1 620 (250)	0 (0)	310 (100)	100 (70)	1 860 (290)	0.57 (0.09)
Kijango	439	6.0	1 690 (400)	750 (230)	610 (210)	320 (100)	0 (0)	1 330 (170)	0.51 (0.07)
Kisanga	463	5.4	1 310 (240)	90 (60)	240 (80)	970 (240)	0 (0)	1 160 (230)	0.47 (0.09)
Kiwele	412	4.6	2 070 (850)	1 410 (850)	610 (70)	60 (40)	0 (0)	1 380 (540)	0.74 (0.29)
Kwamatuku	908	8.1	3 300 (530)	0 (0)	1 680 (350)	1 610 (440)	0 (0)	3 530 (490)	0.48 (0.07)
Mfyome	716	4.7	3 810 (650)	1 820 (550)	1 810 (330)	180 (90)	0 (0)	3 370 (510)	1.00 (0.15)
Sunya	604	6.3	1 850 (340)	760 (250)	450 (270)	640 (170)	0 (0)	1 740 (320)	0.46 (0.09)
JFM									
Boay	407	6.6	1 270 (180)	590 (110)	210 (60)	380 (130)	100 (90)	1 100 (150)	0.41 (0.06)
Itagutwa	385	3.9	1 170 (200)	550 (170)	390 (70)	220 (40)	20 (10)	1 150 (180)	0.77 (0.12)
Muyuyu	300	6.3	1 910 (500)	280 (280)	90 (50)	1 520 (450)	30 (30)	1 500 (320)	0.80 (0.17)
Non-PFM									
Ikuvilo	392	5.2	1 030 (150)	n/a	940 (150)	60 (40)	30 (30)	1 030 (150)	0.51 (0.07)
Masanganya	433	4.6	2 610 (400)	n/a	110 (60)	2 280 (410)	220 (170)	2 250 (330)	1.12 (0.16)

* Differences between total extraction and within village consumption signify a net 'export' or 'import' from/to the village.

The harvesting situation is much more variable in the forests remote from Dar. In Ayasanda CBFM forest, which was very degraded in 1994 when it became a VLFR, harvesting intensity has increased, from zero to 0.26 $m^3ha^{-1}yr^{-1}$ over the period 3–10 years ago to 2.77 $m^3ha^{-1}yr^{-1}$ over the past 1–2 years, but the standing volume above 20 cm dbh remains high. In all other CBFM sites, harvesting has either been significantly reduced (Kijango) or remained at a relatively stable low level over the past decade (Table 3, Fig. 3). The live to harvested tree volume ratio is also generally above 3.0 for all diameter classes and much higher for the largest trees (Fig. 3). A similar pattern of stable or decreasing harvesting intensity and high living to harvested tree volume ratios is also apparent in Boay and Itagutwa, the two JFM forests farthest from Dar es Salaam, and in Ikuvilo, the non-PFM forest farthest from Dar.

Are the current harvesting levels sustainable?

Data from the field

Assuming that household survey data for Kijango (CBFM) are mistaken (c.f. above) only the villagers of Ayasanda (CBFM), seem to overharvest their *own* forest as both stump and household survey data estimate the harvest at approximately 3 $m^3ha^{-1}yr^{-1}$ or twice the estimated regenerative capacity (Fig. 2, Table 3). In the three forests near Dar; Kisanga (CBFM), Muyuyu (JFM) and Masanganya (non-PFM), stump data central estimates indicate substantial overharvesting, c.f. above. Stump data for two forests, Kwamatuku (CBFM) and Boay (JFM), indicate they might be overharvested as the 95% confidence intervals but not the central estimates go above the limit of 1.5 $m^3ha^{-1}yr^{-1}$ (Fig. 2). In the remaining five forests; Kiwele (CBFM), Mfyome (CBFM), Sunya (CBFM), Itagutwa (JFM) and Ikuvilo (non-PFM) stump as well as household survey data including their 95% confidence intervals suggest these are harvested well below their regenerative capacity (Fig. 2).

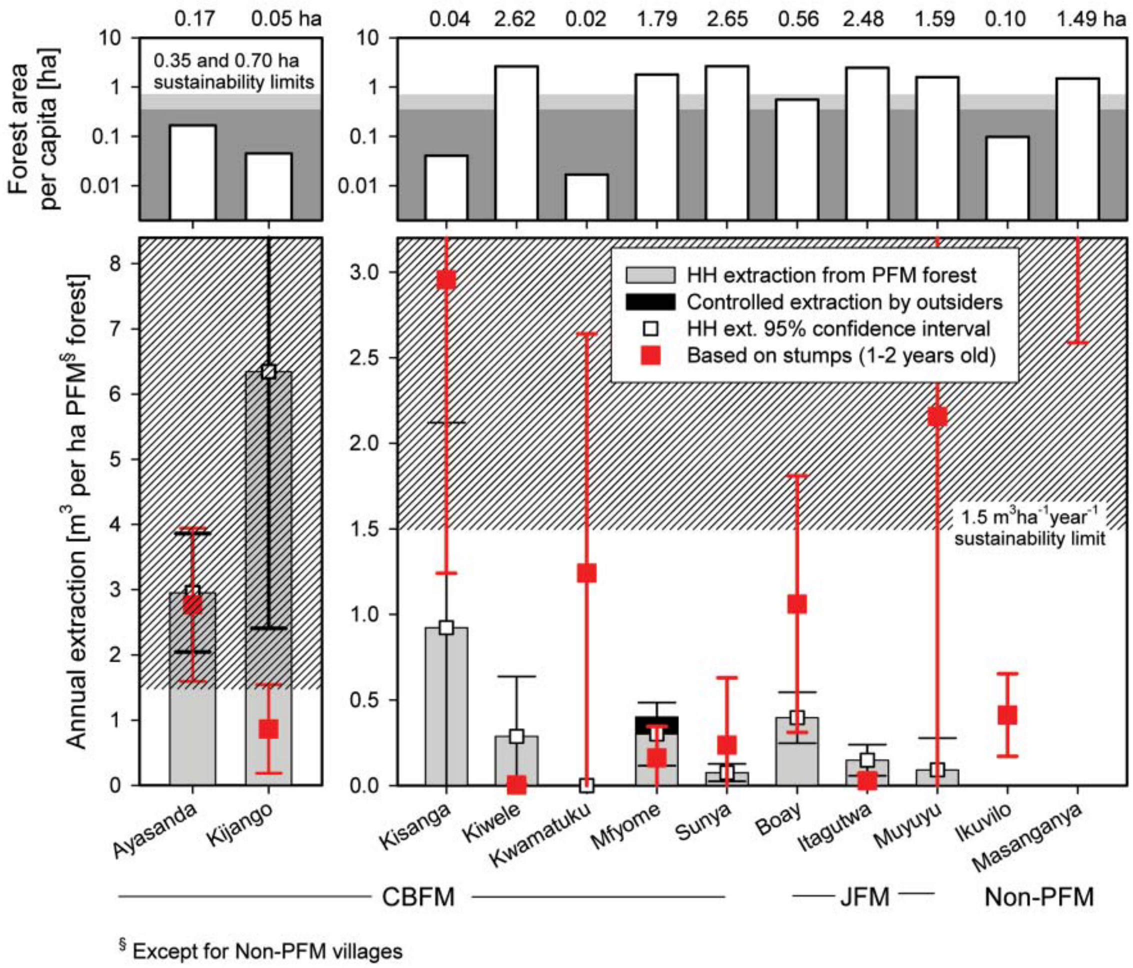
GIS results

When a rounded average annual per capita wood consumption of 0.7 m^3 (0.65 m^3 in Table 4) is used on the sample of 116 wards in the hypothetical scenario, where PFM forests constitute the only remaining sources of wood, only 34 (29%) of these would have access to at least 0.70 ha/capita, which is needed if the increment is 1.0 $m^3ha^{-1}yr^{-1}$. Should the growth be 2.0 $m^3ha^{-1}yr^{-1}$, 55 (47%) wards would have access to the needed 0.35 ha/capita, or more (Fig. 4). In comparison, five of the 10 studied PFM forests would be too small (less than 0.7 ha/capita) to supply local needs (Fig. 2).

DISCUSSION

This paper is based on biophysical field data, household surveys and qualitative information from CBFM, JFM and non-PFM forest areas, which is used to assess present and the

FIGURE 2 *Forest area per capita, estimated wood extraction and sustainability limits*



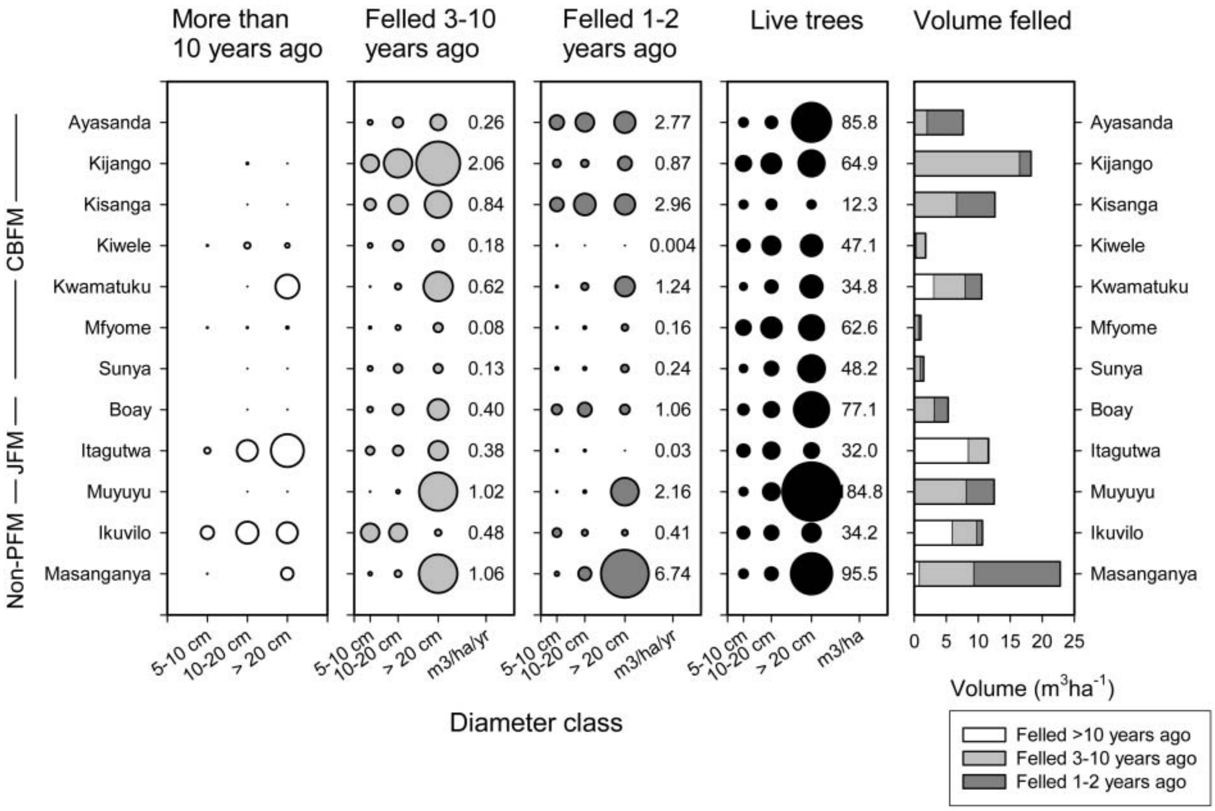
Notes: The upper and lower limits of the light grey sustainability band indicate 0.70 and 0.35 ha/capita, which corresponds to an estimated growth of 1 and 2 $m^3ha^{-1}year^{-1}$, respectively.

recent past's forest utilisation sustainability and to relate that to the PFM management regime. The most consistent finding is that the impacts of PFM in terms of harvesting sustainability are overlaid with other site-dependent factors among which distance to urban centres appears of particular and, when this distance is small, overriding importance.

Forests where current extraction exceeds regrowth

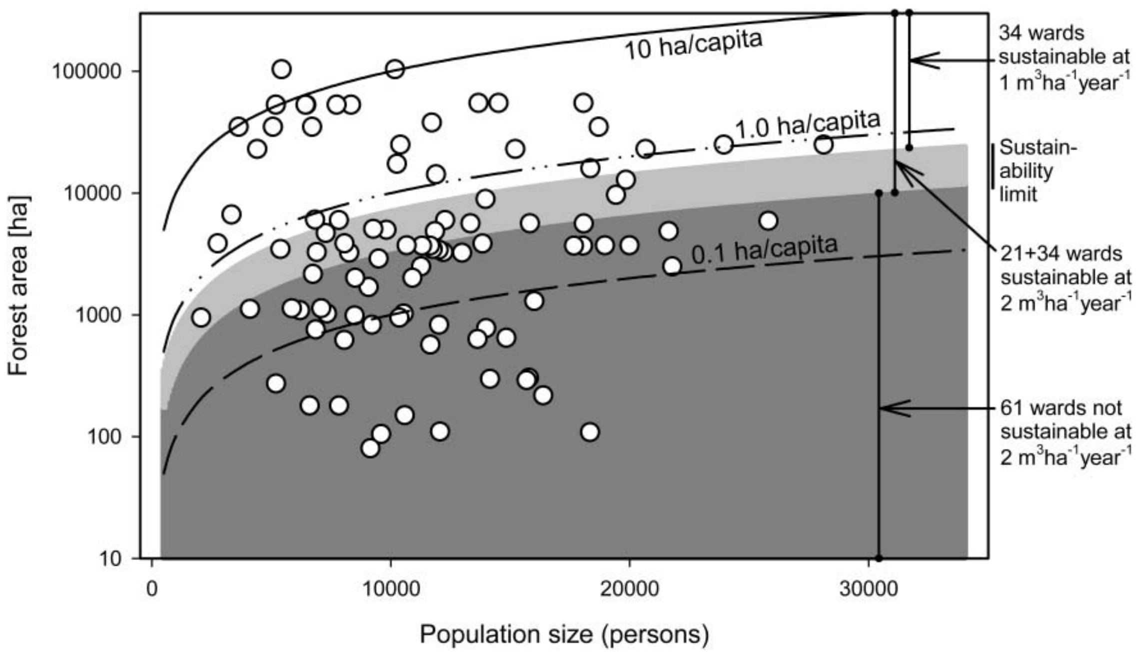
Site proximity to major urban centres, where charcoal is the most frequently used cooking fuel, especially Dar es Salaam city, appears to have a major effect on harvesting rates irrespective of formal management regimes, be they local (CBFM), joint (JFM), or governmental (non-PFM). In the two PFM forests close to Dar (Kisanga, CBFM and Muyuyu, JFM), household survey data suggest that local people's extraction rates are below the sustainability threshold, whilst the stump data show significant and accelerating overharvesting (Figs, 2, 3). In Masanganya (non-PFM) the stump data reveal the most dramatic overharvesting – both in terms of the level and acceleration (Figs, 2, 3). The survey team encountered numerous charcoaling groups in these three forests, often migrants from Mbeya region, who were operating without official permission and who made it clear that attempts to arrest them would be resisted. Even the local population's demand for forest products needed to be satisfied from alternative sources, including their own farmlands (Table 4) as the forests had *de facto* been taken over by external people who are (over)utilising them for profit. The almost perfect overlap between stump-based and interview-based data for Ayasanda's CBFM forest shows that the annual extraction rate is about twice the long-term sustainable level although the per capita consumption of 0.57 m^3yr^{-1} among the villagers is quite modest (Table 4, Figs. 2, 3). This forest was one of the first VLFR's to be gazetted in Tanzania (Table 1) and as indicated by the estimated age of stumps (Fig. 3), unsustainable harvesting has only started to occur in the past two years. During fieldwork, the team encountered several groups of pit sawyers and charcoal producers in the forest. All were village members, and made no effort to conceal their activities or intimidate the inventory team. Interestingly, household data for Ayasanda also differs significantly from all other PFM sites as the PFM forest is reported to supply 79% of the villagers' wood consumption while non-PFM forests supply

FIGURE 3 *Volume harvested by period and diameter classes*



Notes: 1. Circle areas are proportional to the volume removed (calculated from stump diameters) or the growing stock (calculated from live trees' dbh) with the scale for live trees being three times larger than for stumps.
2. The histogram summarizes the harvesting history.

FIGURE 4 *PFM forest area per capita across 116 wards on which PFM forest area and human population density were available*



Note: The upper and lower limits of the light grey sustainability band indicate 0.70 and 0.35 ha/capita, which corresponds to an estimated growth of 1 and 2 $m^3ha^{-1}year^{-1}$, respectively.

nothing (Table 4). However, the VLFR management plan does not allow harvesting of living trees, a fact, that was repeatedly emphasised by a village leader and former VNRC chairman. Furthermore, informal discussion with the district forest officer revealed that he was unaware of the *de facto* harvesting activities. Accordingly, it seems that, although the forest had regenerated to allow for harvesting, the VNRC has failed to officially modify rules from a protection to a sustainable utilization regime. Furthermore, poor accountability relations between villagers and their VNRC as well as the absence of effective monitoring by district forest authorities seems to have invited overharvesting by insiders who appear to have recently exchanged other sources of wood with Ayasanda VLFR. The high growing stock and live to felled trees ratio (Table 2, Fig. 3) leaves time for possible management adjustments to turn around the current trend, but the size of the forest (550 ha) in comparison to the village population (3 255) implies that even current subsistence uses are unlikely to be met, i.e. implying that supplementary sources must be developed to ensure long-term sustainability unless substitutes for wood become locally available and affordable (see also below).

Previous studies have documented devastating forest impacts due to the demands of Dar es Salaam and other cities (Malimbwi *et al.* 2005, Ahrends *et al.* 2010, Pfliegner 2011). This study appears to confirm and explain this by the apparent inability of any formal governance regime to control external people's access to forests close to Dar. In addition, the case of Ayasanda points to other possible threats. Here, a low forest area per capita (0.17 ha cap^{-1}, Fig. 2) possibly together with poor accountability relations between the VNRC and the villagers and definitely between the VNRC and the district forest authorities seemed decisive since harvesting levels in the nearby Boay JFM forest (Fig. 1) appeared sustainable (see below).

PFM forests where harvesting appears to be sustainable

According to the stumps as well as the household surveys, the more remote CBFM forests of Kiwele, Kwamatuku, Mfyome and Sunya all appear to be harvested at or below their estimated regenerative potential, and, with the exception of Kwamatuku, data from the two survey approaches agree. In Kwamatuku, the mensuration team was told that the largest trees were being targeted by 'outsiders' who operate beyond the control of the village environmental committee. This has apparently been the case since before the area was declared a VLFR in 2008 (Figs 2, 3). Furthermore, the forest's location almost 30 km from the main village settlement probably explains why villagers are basically not using it (Table 4). Hence, PFM does not seem to have influenced the harvesting pattern in Kwamatuku.

Kiwele and Mfyome resemble each other in terms of the distribution and age of tree stumps, and the pattern suggests that, in recent years, harvesting rates have remained fairly constant, perhaps with a slight increase in Mfyome, which may be explained by the recorded harvesting for charcoal production by invited external agents (the black upper part of the Mfyome-bar in Fig. 2). Although felling in Kiwele and Mfyome takes place on a regular basis and in fairly large absolute quantities, the high ratio of living to felled trees (Fig. 3) indicates that the local forest regimes are effectively managing harvesting intensity and maintaining forest regeneration. Interestingly, this happens in the presence of an obvious demand pressure from Iringa town (see e.g. Lund 2007 and Lund and Treue 2008). In Sunya, commercial utilisation of the forest for timber has only begun recently (see Fig. 3), and the general abundance of forest resources, which surround this site, most likely explains the relatively low off-take by villagers from the CBFM forest (Table 4), since, in many instances, forest resources are found closer to households.

In Boay and Itagutwa, where JFM was established in 2000 and 2002, respectively, the harvesting also appears sustainable, although their harvesting histories are distinctly different. In the fairly well stocked Boay forest (Table 2), the introduction of JFM appears to have been a catalyst for controlled harvesting (Figs. 2, 3) by village members, supplemented by less controlled harvesting by external agents (Fig. 2). Itagutwa's forest, by contrast, was according to local informants, heavily degraded before the introduction of JFM, after which it seems to have been transformed into a well-protected resource. This sequence of events is supported by the harvesting history (Fig. 3) and although still poorly stocked this forest, which borders the CBFM forests of Mfyome and Kiwele, now seems to be regenerating (Table 2, Figs. 2, 3). The stocking, vegetation type and harvesting history of the seemingly sustainably harvested non-PFM forest, Ikuvilo, is similar to that of Itagutwa (Table 2, Figs. 2, 3).

A common denominator for all PFM forests where harvest appears sustainable is that a substantial part of the local wood consumption is sourced from non-PFM forest (Table 4). Furthermore, forest to people ratios are significantly above 0.70 ha cap^{-1} for the four PFM forests (Kiwele, Mfyome, Sunya and Itagutwa) where both household and stump data most clearly indicate sustainable harvest levels (Fig. 2).

Overall sustainability of the PFM management regime

By linking the national PFM database to data from the study villages some rough estimates can be made on the degree to which PFM forests are likely to meet local communities' demands for wood products nationally (Fig. 4). If an average village inhabitant in rural Tanzania requires around 0.7 m^3 wood per annum to meet his/her needs (c.f. above and Table 4), and forest in Tanzania regrows between 1.0 and 2.0 $m^3ha^{-1}yr^{-1}$, then every villager requires the equivalent of 0.35–0.70 ha of forest for sustainable long-term utilisation (Fig. 4). This figure provides a simple rule of thumb for estimating the size of the forest areas, which will be required to meet peoples' demands for forest products into the future. Although a part of people's wood extraction from non-forest areas (c.f. Table 4) is likely to be sustainable, many of the existing PFM forests seem too small to supply villagers with the woody materials that they need. Hence, the establishment of more as well as larger PFM and/or plantation forests of fast growing species as well as trees on farmland appear necessary approaches to counter overall deforestation in Tanzania.

Conclusions

A number of conclusions can be drawn from the study.

Firstly, the results strongly indicate that, irrespective of the formal management regime, forests close to big urban centres are at risk of being heavily exploited to supply the urban demand for cooking fuel. When managers of the CBFM and JFM forests of Kisanga and Muyuyu, are unable to successfully enforce their *de jure* exclusive rights, over-harvesting results, as predicted by common pool resource management theory (e.g. Ostrom 2008, Lindsay 1998, Schlager and Ostrom 1992).

Secondly, extraction estimates based on household surveys do not always correspond with evidence from biophysical (stumps) surveys. Possible explanations for such divergences include deliberate and democratic decisions by villages to earn revenue by authorising forest utilization by outsiders, corrupt behaviour by a few village forest management officials, unwillingness by villagers to provide accurate assessments of their own activities, or harvesting by powerful external actors. In all PFM cases in this study where stump data indicate substantially higher levels of harvesting than the household surveys (Kisanga, Kwamatuku, Boay and Muyuyu; Fig. 2) qualitative information and field observations suggest that external actors' *unauthorised* activities is the cause. Yet, further investigations into whose activities' leave fresh stumps as evidence would be needed to confirm this. Methodologically, these findings emphasize the importance and relevance of a mixed methods approach, i.e. including stumps in forest inventories and conducting household surveys when aiming to assess the sustainability of *de facto* management regimes.

Thirdly, some of the results resemble those of other, similar studies. For example, a recent study of forest condition in the Eastern Arc Mountain Forests, Coastal Forests and Miombo Woodlands (Blomley *et al.* 2008) showed that forests subject to either CBFM or JFM were likely to exhibit better forest condition responses than forests managed as Forest Reserves with no community involvement, or as semi-open access areas. A similar study of two forests in the Eastern Arc Mountains (Persha and Blomley 2009) found significantly lower levels of illegal harvesting in a communal forest compared with a national Forest Reserve, although subsistence pole cutting was common across both management regimes. Persha and Blomley (2009) concluded that the greater tenure security and institutional autonomy associated with the PFM approach contributed to more effective management, less illegal harvesting, and maintenance of forest condition. Mbwambo *et al*. (2012), in their study of six forests in Northern Tanzania arrive at largely similar results as they conclude that CBFM and JFM exhibit better forest conservation results than 'ordinary state management', although uncontrolled exploitation of the PFM forests had not ceased.

Fourthly, communities tend to differ in terms of how they utilize their PFM forests. However, in all PFM forests villagers' own harvesting rates appear reduced to (Kijango) or maintained below their forests' estimated regenerative capacity (all other except Ayasanda). In Aysanda (CBFM), forest regeneration was then followed by villagers' own over-harvesting (while outsiders moved in and caused over-harvesting in Kisanga and Muyuyu, c.f. above). This is in general accordance with large as well as small-N empirical studies that find positive conservation effects of local people's involvement in forest rule-making and rule enforcement (Persha *et al.* 2011; Chhatre and Agrawal 2008; Ostrom and Nagendra 2006, Blomley *et al.* 2008; Lund and Treue 2008; Persha and Blomley 2009). It also agrees with theory, which suggests that *if* downwardly accountable local forest institutions get legally secure, long-term, exclusive and enforceable rights to forest where sustainable management is economically feasible, *then*, provided a reasonable system of checks and balances vis á vis higher levels of forest government is operational, harvesting rates are likely to be guided by the limits of sustainability, i.e. heavily degraded forests are allowed to regenerate while better stocked forests are more intensively harvested (Dietz *et al.* 2003; Lindsay 1998; Ostrom 1998; Ostrom 2008; Schlager and Ostrom 1992; Ribot 2004). Accordingly, the study documents how the impact of PFM as a general policy is likely to be influenced by pre-PFM conditions in terms of forest condition, size and accessibility of non-PFM forest resources as well as post-PFM differences in market pressure and local forest managers' ability to enforce exclusive rights. To expect uniform nation-wide impacts of a nation-wide PFM policy is thus illusory. With this in mind, and although methodological limitations prevent claims of proven causality (c.f. above), PFM seems the likely cause of observed sustainable outtake levels. The contrary proposition, that PFM promotes overharvesting, lacks an economic rationale because village governments would then lose their forest rights and is in any case much less supported by bio-physical and qualitative data. Yet, the relatively high importance of non-PFM forests as sources of wood in most sites raises concerns about long-term sustainability. To expect villages with PFM forests to stop extracting wood from accessible non-reserved forest would, however, be naïve – especially if PFM forests are too small to satisfy even local subsistence needs and if local agricultural activity involves (rotational) clearing of woody vegetation. That PFM does not result in improved conservation of non-PFM forests should, in other words, not come as a surprise. For lack of documented better alternatives and in light of centralized forest governance's historical inability to conserve Tanzania's reserved as well as unreserved forest resources, establishing more PFM forests therefore appears, if not the perfect, then the preferable approach to forest conservation.

Fifthly, linking field data to the national PFM database enabled construction of the first estimates of potential sustainability of biomass from PFM forests to villages across the country. This shows that if all wards' woody biomass needs had to be derived exclusively from PFM forests, most (at least 53%) of these would be too small. An area of around 2–4 ha of forest per household (0.35–0.70 ha per capita) is required to meet *local* demands on a sustained yield basis for the forest types and villages studied. If towns and cities were also to be supplied on a sustained yield basis, this would require substantially larger PFM forests and/or enhanced establishment of fast growing plantation forests as well as trees on farmland. The economics of doing so would, however, depend on how effectively unauthorized harvest of such plantations, private trees as well as existing natural forests (under PFM or not) can be controlled, c.f. below.

Lastly, it is concluded that if the Government of Tanzania wants to further promote and expand PFM, this might be most cost effective and efficient in relatively remote areas where (i) local forest management institutions through CBFM or JFM arrangements are able to control access to forests, (ii) the forests under PFM are large and close enough to the village settlements to make the economics of sustainable utilization attractive and (iii) that stable and fair conditions for local people to market products from PFM forests are maintained. Furthermore, promotion of VNRCs' accountability towards their fellow villagers as well as higher levels of government by monitoring PFM forests' condition (crown coverage, basal area and growing stock) seem obvious areas for enhanced engagement by national and district level forest authorities. Unless the Government of Tanzania makes it a political priority to actively assist rule-of-law governance in forest areas close to large urban centres, such forest resources may be virtually impossible to govern, irrespective of formal management arrangements be they community-based, central government-based, or a combination. While lawlessness might be the general rule for forest use near urban centres in developing countries, conditions for agricultural production in the very same landscapes are worth considering. Who would grow vegetables and grain for themselves and nearby markets, if ownership to the mature crop was entirely uncertain? Why should PFM managers think differently about forest products? This study's sites near Iringa town might be exceptions, but they show that PFM forests near urban centres *can* be sustainably managed and in the case of Mfyome (CBFM) even with the inclusion of commercial charcoal production.

ACKNOWLEDGEMENTS

We thank Danida for financing this study through the Forest and Landscape Department at Copenhagen University in Demark (research grant LIFE 725) and the Tanzania Forestry Research Institute (TAFORI) and Sokoine University of Agriculture in Tanzania. Neil Burgess thanks the Danish Research Council through the Centre of Macroecology, Evolution and Climate (CMEC) and the Conservation Science Program of WWF-USA for time and institutional support to work on this paper. The team also wishes to thank the District and Village officials who allowed the field teams to work in the area and gather the data used here. In addition, we wish to thank the four anonymous reviewers whose comments helped to improve the paper. Lastly, the team wishes to honour the memory of Stephen Ngowi, a cherished friend and colleague, who participated in the field work and preliminary data analyses but sadly and unexpectedly passed away on the 13th of January, 2013.

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