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Chinangwa, Linda; Pullin, Andrew; Hockley, Neal

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Impact of Forest Co-Management Programmes on Forest Conditions in Malawi

LINDA L. CHINANGWA[1&2], ANDREW S. PULLIN[3] and NEAL HOCKLEY[2]

[1]United Nations University, Institute for Advanced Study of Sustainability, Tokyo, Japan.
[2]School of Environment, Natural Resources and Geography, Bangor University, Bangor, United Kingdom.
[3]Centre for Evidence-Based Conservation, School of Environment, Natural Resources and Geography, Bangor University, Bangor, United Kingdom.

ABSTRACT

Forest co-management programmes aim to conserve forest resources. However, there is little evidence of its effectiveness. We assess the impact of co-management approaches on forest conditions in Zomba-Malosa and Ntchisi forest reserves in Malawi using a multiple-site, plot-based, control-intervention design. We used tree density and species richness as indicators of forest condition. Evidence of human activities was used as potential indicators of current and future impacts. Local peoples' perceptions of co-management impacts were also sought to validate the inventory information. Co-managed plots have higher tree density than state managed plots. Indicators of human activities including felled trees, farming and settlement plots were observed in both co-managed and state managed forest plots. A majority of respondents, 84% (Zomba-Malosa) and 73% (Ntchisi) perceive the co-management programme to have a positive impact on forest conditions against a general worsening trend. Despite having potential to improve forest conditions, the findings suggest that outcomes of a co-management may vary depending on pre-existing conditions and how communities understand and interpret the programme. Hence programmes should not be implemented as a universal package. Furthermore, even with method triangulation, lack of baseline data limited the quantification of impacts, hence integration of participatory research into the programme, is recommended.

KEYWORDS. co-management, conservation, biodiversity, sustainable use, forest reserves.

Corresponding author

Linda Chinangwa,

E-mail: chinangwa@unu.edu; lindachinangwa@yahoo.com

Address: United Nations University, Institute for the Advanced Study of Sustainability

5–53–70 Jingumae, Shibuya-ku, Tokyo 150-8925 Japan

Tel: +81 3 5467 1212

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INTRODUCTION

Traditionally, management of forests was separated from development programmes and much effort was expended in separating people from vulnerable environmental resources (Mayers, Ngalande, Bird, & Sibale, 2001; Zulu 2008; 2010). Particularly in Africa, conservation has been dominated by an authoritarian approach, where permission to use forest resources could only be acquired from government officials**.** This approach has also been labelled a *'fines and fences'* approach (Hughes & Flintan, 2001) or *'fortress conservation'* (Hulme & Murphee, 1999), because of restricted rights of access and use, accompanied by sanctions for non-compliance. Controlled access to protected areas escalated conflicts between local communities and management authorities, especially in places where local communities were heavily dependent on the forest for their subsistence (Buffum, 2012; Negendra 2007). Thus, the approach negatively affected communities' livelihoods and welfare, and in some cases consequently resulting in overexploitation of forest and natural resources (Agrawal *et al.* 2013; Buffum 2012). Therefore, convinced that state controlled natural resources management approaches were ineffective in conservation of forests and natural resources, governments and their development partners, between 1970s and the present day, have concentrated on a search for alternative and sustainable forest management measures (Arnold, 1995). One such approach is forest co-management, which explicitly recognizes the basic needs and involvement of local people in and around forests (Zulu 2008, Persha *et al.* 2011; Kamoto, 2009; Western & Wright 1994; Gibson & Mark, 1995).

One of the primary policy objectives for implementing community forest management programmes, including forest co-management is to improve forest conditions through sustainable management and utilization (Agrawal & Chhatre, 2006; Blomley et al., 2008; Malawi Government, 2008). Persha *et al.* (2011) suggest that involvement of local communities in forest management could improve forest conditions because; 1) their proximity to the resource gives them a comparative advantage in monitoring resource use; 2) they are more knowledgeable of the local environment, which is relevant in designing and implementing management strategies and; 3), they have a vested interest in the long term maintenance of the forest, as their livelihoods depend on it (Bene *et al.* 2009; Brown, 1999). Although, co-management presents communities as good custodians of resources, other theories e.g. Bradshaw (2003) and Tacconi (2007), suggest that the approaches can be detrimental to the resources especially where communities are interested in conservation. In such cases, the management and utilization rights given to them through the co-management programme may be perceived as an opening for exploitation thus, resulting in resource (Sunderlin *et al.* 2005). Therefore, co-management effectiveness in achieving sustainable forest management cannot be guaranteed (Nygren, 2004). Additionally, guaranteeing a positive co-management impact on forest conditions is difficult because, although some studies have shown that co-management approaches can conserve and improve forest conditions (e.g. Yadav, Dev, Springate-Baginski, & Soussan, 2003; Phiri, Chirwa, Watts, & Syampungani, 2012), the evidence-base still remains very weak (Bowler et al., 2012 &2010). Therefore, there is a need for more empirical studies to quantify the impact of forest co-management programmes on forest conditions.

The weak evidence-base is further exacerbated by the baseline data (before project) thus few before-after comparisons quantitative studies are available (Sherestha & Mcmanus, 2008; Bowler et al., 2012). Furthermore, Studies on outcomes of and impact of co-management programmes are done on one site, without a control (Non-CFM sites) (Bowler *et al.* 2012; Shrestha and Mcmanus, 2008). For example, the systematic review by Bowler et al. (2010), found only 12 studies with a comparison design between participatory management and state management. Hence, there is insufficient evidence to attribute the observed changes in forest condition to either the implementation of co-management programmes or other contributing factors (Sherestha & Mcmanus, 2008; Bowler et al., 2012 & 2010).

Therefore, a multi-site, plot-based comparative design was used to assess the impact of co-management approaches on forest conditions and to identify human activities that may account for observed differences *(if any)* and thus predict the potential direction or trend of impact of co-management of forest. In addition to a multi-site, plot-based comparative forest assessment, local peoples' perceptions with regards to; the status of forest before and after the co-management programme and; the programmes' impacts on the forest condition were also sought to validate the observed effects. Pandit and Bevilacqua (2011) argue that local people's perceptions are a useful tool for constructing baseline data in the absence of historical data and to validate the comparison study. Furthermore, the use of methods triangulation and multiple data types has been proposed to give a more robust impact assessment (Lund, Balooni, & Puri, 2010; Pandit & Bevilacqua, 2011). However, few studies have used multiple data types or methods in assessing the impacts of forest co-management approaches (Lund, Balooni, & Puri, 2010). Therefore, given the paucity of empirical evidence on co-management, and the rarity of baseline data, this study using the case of Malawi makes useful empirical and methodological contributions towards the evidence base of forest co-management impacts on forest conditions. Furthermore, Malawi is one of the most highly deforested countries in southern Africa with a deforestation rate of 2.8% (UNDP, 2011) and similarly, there is ongoing deforestation in many of the sub-Saharan African countries, including Mozambique (Sitoe *et al.* 2012), and Madagascar (Clack, 2012) therefore, lessons from Malawi could be a good in the promotion and implementation forest co-management in the region.

STUDY METHODOLOGY

Study Area

We assess the impact of co-management on forest condition using data from Zomba-Malose and Ntchisi forest reserves. These reserves are 2 of the 12 forest reserves within which the Malawi Government, through the Department of Forestry, are implementing an Integrated Forest Management and Sustainable Livelihood Programme (IFMSLP), with funding from European Union (Malawi Government, 2008). The forest reserves are demarcated into forest management blocks. Government jointly manages the forest blocks with communities living adjacent to the demarcated forest blocks. Though co-management approaches advocate for a bottom-up approach (Ribot, 2003), the IFMSL programme in Malawi, works with communities in a top-down manner, because government officials select the participating communities. The process includes sensitization meeting with potential communities, followed by demarcation of the forest reserve into sections called forest blocks and sub-blocks, with participation of both forest staff and community representatives. Next, block committees are established followed by the development of constitutions to govern the community group. With the facilitation of district forest extension staff, block management plans are then developed, including identification of activities, roles and responsibilities and rules for use of forest resources. Finally, co-management agreements between government (Department of Forest*)* and local communities are signed by their respective representatives. Following signing of contract agreements, participating communities participate in a number of forest management activities including boundary marking and construction, firebreak maintenance, controlled early burning, firefighting, controlled harvesting, reforestation and monitoring and patrolling. In return, for participating in sustainable forest management activities, the programme legitimizes participants' access and use of forest reserves to collect various forest products (e.g. firewood and Non-timber products) in accordance to what has been stipulated in the management plans and the contract agreement. The committee is mandated to control who and how these products are accessed, by issuing permits.

The programme is being implemented in phases; thus, within the reserve there are some blocks that are currently being co-managed by adjacent communities and government after the signing management agreements, and some blocks are still under state management as the process is still underway (Malawi government: *IFMSLP mid-term review, 2008; Personal communication, Department of forestry officers -July, 2011*). To answer the questions in this study, the study sites had to fulfil the following criteria: 1) the forest block should be under full co-management, which means that communities living in and around the reserves have signed a management agreement with the government and are thus recognized as full participants. Following meetings with forest staff at the Department of Forestry's headquarters and regional and district offices, Zomba-Malosa and Ntchisi forest reserves co-management programmes fully meet the requirement of the study.

Zomba- Malosa forest reserve has an area of 14,536 hectares demarcated into 12 management blocks, whilst Ntchisi Forest Reserve covers an area of 9,720 hectares and has 19 management blocks. Zomba district is located in the southern region of Malawi and it covers a total of 2580 square kilometres, 14.7% of which are forests and woodland (Malawi Government-Atlas, 2012). Agriculture forms a large part of the economy and livelihoods for the majority of the population in Zomba (National Statistics Office-NSO, 2012). Zomba-Malosa forest reserve in the only gazetted forest in Zomba and covers an estimated area of 15,756 hectares consisting of both miombo woodlands and pine plantations (Malawi

Government, 2007). The reserve supports the livelihoods of communities living around the forest, as Government reports that approximately, 22.2% of all the enterprises in the district are forest based and an estimated 90% of Zomba's population depend on forests for their livelihood (NSO, 2012; Malawi Government, 2009). However, the reserve is being encroached in the peripheral areas for both settlement and agriculture (Mauambeta *et al.* 2010). Additionally, the forest reserve is located near a major road, hence forest resources such as charcoal, firewood and timber are easily sold to travellers thus contributing to deforestation of the reserve (Malawi Government, 2007).

Ntchisi district is located in the central region of Malawi, and it covers a total of 1 655 square kilometres, 19.5% of which are forests and woodland (Malawi Government-Atlas, 2012). The larger percentage is under agriculture and rural settlement (78.3%) and the remaining 2.2% is urban built-up human settlement (Malawi Government-Atlas, 2012). The agricultural sector is estimated to account for almost 80% of the district economy and livelihoods (Haarstad *et al.* 2009; Malawi Government, 2005). The most common commercial crop grown in the area is tobacco, which requires a substantial amount of farmland, as well as wooden poles for processing. It is also estimated that approximately 2.6 % of the households in the district depend on forests and forest products for their livelihoods, and approximately, 22.7% of all the enterprises in the district are forest based (NSO, 2012). Key forest based activities that the local communities are involved in include harvesting timber, poles and fuel wood. Ntchisi forest reserve is the largest covering an estimated area of 9,720 hectares, whilst Kaombe and Mndilasadzu forest reserves are estimated to be 3,880 and 1,550 hectares, respectively. The reserve is also a source of non-timber forest products (NTFP) such as mushrooms, fibre and edible caterpillars. Harvesting of edible caterpillars is said to be a significant cause of tree felling in the reserve *(personal communication, District forest extension officer-July, 2012).* Additionally, Additionally, as a tobacco growing district, in Ntchisi tobacco farming is one of the major cause of deforestation, due to the high wood use for curing (e.g. Wiyo *et al*. 2014, Jumbe and Angelsen 2011).

Study Design and Approach

A before-after control-impact (BACI) study design has been suggested as most suitable for assessing the impacts of forest co-management approaches (Bowler et al., 2012). However, in this study, as is commonly the case, we were unable to access baseline data, previous inventory data, forest resource mapping and before and after satellite images of the forest area which would have facilitated in assessing forest cover changes in this study. Therefore, the study took advantage of the IFMSLP implementation plan to design a comparative control-impact (CI) study (Baker, 2000; Blomley et al., 2008). The IFMSLP is being implemented in phases; thus, some communities are co-managing blocks having already signed management contracts with government, whilst some blocks are still under state control as communities living adjacent to them have not yet signed any management agreement with government. Therefore, within a forest reserve, blocks that are currently under co-management were regarded as treatment, while those that are still under state management act as control. Data on forest conditions were collected using forest inventory procedures adapted from Hetherington (1975); Malimbwi (1994), Ahrends (2005), Mwase, Bjørnstad, Bokosi, Kwapata, and Stedje (2007), Blomley et al., (2008), Gobeze, Bekele, Lemenih, and Kassa (2009), Obiri, Hall, and Healey (2010) and Phiri, Chirwa, Watts, and Syampungani, (2012). Forest inventories were also used to collect data on human activities in the forest and verify information on forest management activities provided by communities during the focus group discussions, key informant and household interviews. Human activities such as tree felling for timber and fuelwood, grazing, encroaching for settlement and agriculture activities have been highlighted as major contributors to deforestation in both

Zomba-Malosa and Ntchisi forest reserve (e.g. Wiyo et al. 2015; Mauambeta et al., 2010) Therefore, the study hypothesised that the presence and level human activities should differ between co-managed forest plots and those under state management (i.e. few indicators of human activities were expected to be observed in co-managed forest plots). Additionally, community perceptions of the impact of co-management on forest conditions were elicited through face to face interviews with a random sample of household heads (a total of 213) from the two communities (Agrawal & Yadama 1997; International Forestry Resources and Institutions, 2008). A number of factors may vary between the forest blocks currently under co-management and those still under state management, which may confound any comparison between the sites (Bowler et al., 2010). The confounding factors considered in the design of this study include proximity to the nearest main road (i.e. access to markets for forest products), distance between forest boundary and nearest villages, conditions of the forest before the programme (i.e. degraded, suffering from deforestation). Additionally, considering that the forest blocks currently under co-management (i.e. treatment sites) are in close proximity to some management blocks that are still under state management (i.e. control sites), there is a risk of leakages or displacement effects (Vyamana, 2009), hence confounding the impact assessment results. Although distance between the forest boundary and the nearest villages was considered in the design of the study, after the initial analysis of the data, it was observed that in all sites (Zomba-Malosa and Ntchisi) the distance between the forest boundary and the nearest villages ranged from 1.5 to 2 kilometres, hence I regarded the distances as close enough not to bias the study results. Similarly, despite all effort, we were unable to access baseline data, information on selection criteria for the co-management programme targets sites and any information with regard to differences in forest composition and status prior to the programme. Hence it is difficult to control for confounding factors that are a direct effect result of pre-existing differences in the comparison sites (co-managed and state managed), prior to the programme starting and not to the difference in management differences.

Data Collection, Methods and Procedures

FOREST INVENTORY

In each of the two forest reserves, three co-managed forest blocks and three state managed forest blocks were randomly selected. Within each sampled forest block, three transect lines moving away from the forest boundary line to the centre of the reserves were randomly located along the boundary (Figure 1). This was on the assumption that forests are more degraded or more harvested along the boundary line than in the centre of the forest, due to differences in accessibility.

FIGURE 1 -HERE

Along each transect line three rectangular plots (50m*20m) were placed 50 m apart. The first plot 50m into the forest reserve, was starting from the boundary line, thus the second plot was located 100m and the third at 200m from the boundary line. However, where accessibility was hindered by thickets, rocks, permanent rivers and steep slopes, the transect line went only up to the accessible point. Therefore, only a total of 106 plots were sampled instead of a targeted 108 plots, for both forest reserves.

Tree and seedling and saplings counts were collected as indicators of forest condition (Table 1). The seedling and saplings counts included those from roots, stump and seeds. Names of trees and all woody species were first recorded in their vernacular names, and then later their scientific or English names were identified. The vernacular names were identified in the field, with the help of district forest assistants, field assistants and local representatives from adjacent communities.

Changes in tree population and seedling and saplings may take time to respond to different management approaches (Yadav, Dev, Springate-Baginski, & Soussan, 2003). Considering that the programme had only been implemented for 7 years at the time of the study, use of vegetative parameters may be inadequate to answer the questions of the study. Therefore, the study also collected additional parameters including, level and presence of human activities and disturbances, and forest management activities (Table 1), on the assumption that good forest management practices and controlled human activities in the forest facilitate improvement of forest conditions and may help explain current forest conditions in the absence of baseline data (Phiri, Chirwa, Watts, & Syampungani, 2012).

Table 1-HERE

HOUSEHOLD INTERVIEWS

Household surveys were used to collect information on communities' perceived changes in forest conditions since the co-management programmes started. The questionnaire included both closed and open ended questions to gather communities' perceived status of the forest before and after the programme, perceived impact of the programme on the forest condition and basic socio-economic information about households.

Due to differences in resource use and extraction among different gender groups, as well as influences of cultural norms and practices among rural communities (Colfer and Capistrano, 2005; Fisher *et al.* 2012; Mawaya and Kalindekafe, 2007), difference in responses between household heads and other adult members of the community, were expected. Therefore, respondents were grouped into household heads and other adult members of household. The household heads were usually male, however, in some cases widows, divorcees, or women whose husbands are working away were regarded as household heads as they do all almost all of the work customarily done by men. However, after the initial analysis of the data showed no obvious difference in opinions and perceptions between household heads and other adult members of the community, household heads and other adult members were treated as one category (i.e. community members). A total of 213 community members in participating communities were interviewed, 106 households in Zomba-Malosa and 99 in Ntchisi. In each village, a random approach was used in selecting the households to participate in the survey interviews, so as to ensure that all the different socio-economic characteristics of a heterogeneous community that may influence community perceptions on co-management impacts are included and tested in the study. In each village, a village register was requested and provided by the communities' village heads. Attention was paid to ensure that the lists do not follow a particular order or social hierarchy (e.g. wealthy status or kinship), so as to ensure that the selected sample is representative of the true population characteristics. The total household list formed the sampling frame from which every fourth household on the list was selected to form part of the study. Where all members of the household were absent, or unwilling to participate, the next household on the list was chosen. For each individual, the interviews were done in isolation to reduce the risk of influencing each other's answers.

DATA ANALYSIS

ANOVA was used to compare means of indicators for forest condition in state management and co-management blocks, and for the different locations. To assess the relationship between tree density and seedlings and saplings density in both state managed and co-managed forest block linear regression was used. Finally, for categorical data, especially in assessing the presence of human activities, chi-square test we used for analysis. The tests were done to assess if forest conditions may be affected by pre-existing forest conditions, and socio-economic variables of participating communities (Bowler et al., 2012). Therefore, the data for each forest reserve in the different districts was analysed separately, to ensure that forest or district specific effects are not masked. Descriptive statistics were used to compare and present the perception-based data. All the data were analysed using STATA 11.

RESULTS

Forest Condition in Co-managed and State managed Forest Blocks

FOREST DENSITY IN CO-MANAGED AND STATE MANAGED FOREST BLOCKS

Tree density per plot was significantly higher ($p<0.001$) in Ntchisi than Zomba-Malosa forest reserve, whilst seedlings and saplings density was significantly lower ($p = 0.04$) in Ntchisi than Zomba-Malosa forest reserve (Figure 2). In both Ntchisi and Zomba-Malosa, tree density per plot was significantly higher in co-managed than in state managed blocks ($p <0.001$, $p = 0.01$ respectively, Figure 2a.). Although the difference was not significant, the mean density per plot for seedlings and saplings was higher in co-managed plots than in state managed forest blocks in Ntchisi ($p = 0.43$, Figure 2b.). However, in Zomba-Malosa forest reserve, the mean density per plot for seedlings and saplings was significantly higher in state managed than in co-managed forest blocks ($p <0.001$, Figure 2b.). In both Zomba-Malosa and Ntchisi forest reserve, tree and seedlings and saplings density did not significantly differ with plot location along the transect moving away from the forest boundary (i.e. boundary, and middle or toward centre) in either state managed or co-managed forest blocks.

FIGURE 2-HERE

RELATIONSHIP BETWEEN TREE DENSITY AND SEEDLING AND SAPLING DENSITY IN CO-MANAGED AND STATE MANAGED FOREST BLOCKS

There is an inverse relationship between tree density and seedlings and saplings density in both state managed and co-managed forest block in Ntchisi and Zomba-Malosa forest reserve (Figure 3). However, linear regression results showed that the inverse relationship was only statistically significant in co-managed blocks in Ntchisi forest reserve ($p = 0.02$) and state managed blocks in Zomba-Malosa forest reserve ($p = 0.09$).

FIGURE 3-HERE

VARIABILITY IN TREE AND SEEDLING AND SAPLING DENSITY WITHIN MANAGEMENT TYPE

Statistically significant differences in seedling and sapling density per plot were observed among forest blocks under co-management in Ntchisi and Zomba-Malosa, as well as among forest blocks under state management in Ntchisi forest reserve (Table 2). Statistically significant differences in tree density per plot were observed among forest blocks under state management in Zomba-Malosa forest reserve (Table 2).

TABLE 2- HERE

TREE AND SEEDLING AND SAPLING SPECIES RICHNESS IN CO-MANAGED AND STATE MANAGED FOREST BLOCKS

Tree species richness per plot was significantly higher in Ntchisi forest reserve than in Zomba-Malosa forest reserve ($p < 0.001$). There was no statistically significant difference in tree species richness ($p < 0.09$) or seedling and sapling species richness ($p < 0.13$) between co-managed and state managed forest block in Ntchisi forest reserve (Figure 4). In Zomba-Malosa, co-management forest blocks have a significantly higher tree species richness than state managed forest blocks ($p < 0.001$, Figure 4a.). A total of 24 tree species were observed in co-managed forest blocks, whilst only 7 tree species were observed in state managed forest blocks in Zomba-Malosa forest reserve. However, co-managed forest blocks have significantly lower seedling and sapling species richness than state managed forest blocks ($p = 0.01$, Figure 4b.). In both Zomba-Malosa and Ntchisi forest reserves, tree and seedling and sapling species richness did not differ significantly with plot location along the transect moving away from forest boundary in both state managed or co-managed forest blocks.

FIGURE 4-HERE

PRESENCE OF HUMAN ACTIVITIES OR DISTURBANCES

Indicators of human activities or disturbances observed in the both co-managed and state managed forest block of Ntchisi and Zomba-Malosa forest reserves include: tree stumps, pole stumps, felled trees, farming plots, settlement plots, charcoal pits, debarked trees, lopped trees, hunting pits, evidence of fire and evidence of grazing (Table 3)**.**

Table 3-Here

In Ntchisi, a significantly higher number of tree stumps (p=0.00), and pole stumps (p=0.01) were recorded per plot in co-managed forest blocks than in state managed forest blocks. In Zomba-Malosa, the number of tree stumps (p=0.03), pole stumps (p=0.04), farming plots (p=0.00) and charcoal pits (p=0.04) per plot was significantly lower in co-managed forest block than in state managed forest blocks. However, the number of felled trees (p=0.04) and debarked trees (p=0.00) per plot was significantly higher in co-managed forest block than in state managed forest blocks in Zomba-Malosa forest. Chi-square test show that in Ntchisi forest there was no significant difference statistically in the presence or evidence of fire between co-managed and state management forest blocks, ($\chi2= 0.025^{a}$, p= 0.875). In Zomba-Malosa presence or evidence of fires was higher in state managed forest blocks than in co-managed forest blocks and the difference was statistically significant at 10% level of significance ($\chi2= 3.441$, p= 0. 064). The presence of human activities and disturbances per plot did not differ significantly with plot location along the transect moving away from forest boundary (i.e. boundary, and middle or toward centre) in either state or co-managed forest block, in either Ntchisi or Zomba-Malosa forest reserves.

PERCEIVED IMPACTS OF CO-MANAGEMENT ON FOREST AND FOREST CONDITIONS

In Ntchisi district, approximately 73% of respondents perceive that the co-management programme to have had positive impact on forest conditions. Respondents perceive increase in seedlings and saplings or regrowth (47%), 42% a decline in illegal cutting (42%) since the programme started. Additionally, 11% cited the introduction of reforestation and afforestation schemes as an indicator of positive impact. The majority of respondents that perceived a decline in tree population in Ntchisi district attributed the decrease to careless cutting during the edible caterpillar (Matondo) harvesting season (48%), charcoal and firewood for tobacco curing (28%) and poor leadership among committee members or programme leaders (24%).

In Zomba-Malosa district, approximately 84% of respondents perceive the co-management programme to have had a positive impact on forest conditions. Respondents cited increase in seedlings and saplings or regrowth (39%), increase in tree stems (16%), a decline in illegal harvesting (19%), introduction of reforestation and afforestation programmes (17%), and improved river flow and water availability (9%), as some of the indicators of a positive impact. Respondents who perceived a decline in tree population attributed it to charcoal production for sale (74%), timber and pole cutting (15%), poor leadership among committee members or programme leaders (8%) and encroachments for settlement and farming (3%). However, the perceived positive impact has yet not translated into increase in forest tree stocks, a majority of respondent 50% (Ntchisi) and 63% (Zomba-Malosa) indicated that the population of trees was higher before the programme started (before 2005) as compared to the current status.

MANAGEMENT ACTIVITIES UNDER CO-MANAGEMENT AND STATE MANAGEMENT

A number of forest management activities are being carried out in both the co-managed and state managed blocks in both forest reserves. These include, fire break establishment (both within the forest and around the edge of the forest), boundary marking, establishment of forest nurseries and tree planting (Table 4). In Ntchisi, management activities such as firebreak construction, boundary marking and planted trees in and around the forest block were not present in either co-managed or state managed forest blocks (Table 4). Only 2 communal forest nurseries were observed in communities that are participating in co-management programme (Table 4). A total of 11 VFA's located within communities participating in the forest co-management programme were also observed.

Table 4-Here

In Zomba-Malosa, management activities such as firebreak construction and maintenance, boundary marking and establishment of forest nurseries are mostly done in co-managed blocks and in communities that are participating in the co-management programme (Table 4). However, no planted trees were observed in or around co-managed forest blocks (Table 4). A total of 37 Village Forest Areas (VFA's) of varying sizes were observed mostly composed of mature natural trees in communities living around Zomba-Malosa forest reserve. The majority of the VFA's, were located in communities participating in the co-management programme (Table 4).

DISCUSSION

The higher tree density per plot in Ntchisi forest reserve than in Zomba-Malosa forest reserves, show that Ntchisi forest reserve is a closed canopy forest whilst Zomba-Malosa is an open forest. Co-managed forest blocks in both Ntchisi and Zomba-Malosa forest reserve have had higher tree density than state managed forest blocks. Additionally, a majority of respondents in both Zomba-Malosa and Ntchisi also perceive the co-management programme to have a positive impact on forest conditions, against a general worsening trend in forest stocks. Due to lack of information on forest conditions before the programme started, the observed difference in forest conditions between blocks under co-management and those under state management could be attributed to: 1) selection bias at the start of programme (i.e. that the tree density and forest conditions were not equal at the start of the programme, and/or; 2) differences in subsequent management, assuming that the forest conditions and tree density were equal throughout the reserve at the start of the programme (e.g. Gobeze, Bekele, Lemenih, & Kassa, 2009; Phiri, Chirwa, Watts, & Syampungani, 2012).

Considering that the programme has only been implemented for seven years at the time of the study, the higher tree density and species richness in co-managed forest blocks could suggest that co-management has resulted in conservation of the mature trees present at the start of the programme, if equal forest conditions and tree density throughout the reserves at the start of the programme is assumed. Government are limited in both human and financial resources, to effectively monitor forest resources against over exploitation hence involvement of local communities in co-management is hypothesised to facilitate forest management (i.e. in terms of human resources) and contribute to conservation. Therefore, the lack of community involvement in the management of the state managed forest blocks of Ntchisi and Zomba Malosa forest reserves may have resulted in continued exploitation of the mature trees hence the decline in tree density and species richness. Furthermore, this may imply occurrence of leakages or displacement effects in the blocks under different management types (Vyamana, 2009). As such, it is possible that the introduction of the forest co-management programme in phases and having co-managed and state managed block within a single reserve has had negative effects on state managed forest areas. Therefore, the higher tree density in co-managed forest blocks could suggest that stricter harvesting and management conditions in these blocks resulted in opening up of the state managed block for exploitation, hence translating into low forest density and species richness. In case of Zomba-Malosa forest reserve, this is further supported by the higher presence of human disturbances and activities in state managed forest block than in co-managed forest block in forest reserve. However, in the case of Ntchisi forest reserve, there is no further evidence to support that the higher tree density and species richness in co-managed forest blocks is a direct result of either the co-management programme or occurrence of leakages, since the results on human disturbance show a higher presence of human disturbances and activities in co-managed forest blocks than in state managed forest block of forest reserve. Therefore, the higher tree density and species richness in co-managed forest blocks in Ntchisi forest reserves could be a factor of existing forest conditions and tree density prior to and at the start of the programme.

Respondents in Zomba further attributed the decline in presence of human activities and disturbance (e.g. tree felling, charcoal making and encroachment) in forest reserve, to improved monitoring and enforcement of harvesting laws by the block committee and communities living in and around the reserve. Thus, suggesting that co-management can result in sustainable forest management (Blomely et al., 2008; Phiri, Chirwa, Watts, & Syampungani, 2012). Additionally, there is a lot of statistically significant variation in tree density per plot within some forest blocks under state management in Zomba-Malosa. Such that whilst other no tree counts were recorded in some plots within a block, a high number of trees was recorded in other plots in the same blocks. In plots where a high number of tree densities were recorded, the species were largely *Uapaca Kirkiana* (e.g. Anglican block). It is argued that *Uapaca Kirkiana* fruits significantly contribute rural diet during the food shortage period and sales generate cash incomes for purchasing household goods, farm inputs and meeting social obligations, hence rarely felled (Akinnifesi et al., 2004; Kadzere et al., 2006).

The higher seedling and sapling density in state managed blocks in Zomba-Malosa forest reserve indicate that state managed blocks are more heavily exploited than co-managed blocks, as higher presence of seedlings and saplings is often correlated with lower numbers of full grown trees. This is also evident in the low number of tree counts observed in state managed blocks of Zomba-Malosa forest reserve. This corroborate findings by Werren, Lowore, Abbot, Siddle, and Hardcastle (1995) showing that seedlings and saplings as well as smaller trees flourish when the tree density is minimal or in the absence of bigger trees, because there is less competition for light and nutrients. In Zomba-Malosa forest reserve, the heavy exploitation in state managed blocks than in co-managed blocks could also be as a result of differences in the block proximity to the main road and accessibility to markets for forests products. For example, in Zomba-Malosa forest reserves, two of the state managed blocks included in this study, Anglican and Minama management blocks, are located close to the main road; **M3** which connects to the country's central road-**M1** at both ends, i.e. Balaka and Blantyre respectively, whilst all the co-managed blocks are further away from the main road. Therefore, community members living adjacent to Anglican and Minama management blocks, (as well as non-community members) can easily harvest forest products (e.g. charcoal, firewood and timber) and easily sell by the roadside to travellers from other areas or transport to other markets in other area (e.g. Zomba town and Blantyre city). Therefore, the easy access to main road and increasing demand for forest products by travellers could contribute to the differences in tree density and deforestation levels between co-managed and state managed forest blocks in Zomba-Malosa forest reserve. However, the high density of seedlings and saplings in the state managed forest block indicate a potential for tree population recovery, given proper silviculture management practices and sufficient enforcement of rules and regulations (Obiri, Hall, & Healey, 2010).

In Ntchisi forest, evidence of human disturbance was significantly higher in plots under co-management than in state managed plots. However, the opposite was observed in Zomba-Malosa forest reserve. This could indicate that, in Ntchisi, co-management may have opened up the reserve for utilization and markets, as during the focus group and key informant interviews, communities in Ntchisi indicated that co-management has brought or introduced new forest based income sources including, timber sales, firewood sales and pottery (clay pots) sales. However, in Zomba-Malosa communities may have reacted to the management and utilization rights under co-management by taking charge and conserving the forest. Therefore, it is possible that co-management programmes may not always be understood or interpreted equally by different communities and hence even though the approach is similar may not always produce equal results (Poteete & Ostrom, 2004; Bowler et al., 2012 & 2010). However, it is also important to note that this could be due to the difference in harvestable forest stocks between Ntchisi and Zomba-Malosa forest reserves.

The increase in human activity in co-management forest blocks in Ntchisi forest could also be attributed to limited labour and high time cost for effective monitoring to prevent illegal harvesting in the forest blocks as participation is voluntary. Additionally, the higher presence of physical signs of human activity in co-managed forest blocks of Ntchisi forest reserve and the decline in tree density since the co-management programme began as perceived by the majority of the respondents in Ntchisi, could also be attributed to poor leadership among programme leaders, since approximately 24% of respondents in Ntchisi who perceived a decline in forest status attributed the decline to poor leadership. Poor leadership has also been highlighted as one major contributing factor to failures of participatory forest management programmes by Ostrom (1990), Poteete and Ostrom (2004), Tacconi (2007) and Zulu (2008).

A majority of respondents in Ntchisi perceive tree density to have been higher before co-management began. This could be attributed to the fact that, during state management, access and utilization was limited, hence this allowed for conservation and an increase in tree density in the reserves. Instead, the co-management programme supports forest-based enterprises among the participating communities, hence resulting in increased exploitation. Therefore, the higher evidence of human disturbance and activity observed in co-managed forest blocks in Ntchisi forest also explains why the majority of community members in Ntchisi perceived tree density to have been higher before the co-management programme began and think there has been a decrease in tree density since the co-management programme began. Furthermore, the perceived decline in tree density since co-management began could be as a result of other factors such as increase in demand of forest products due to population growth in the communities, over time.

Participating communities are allowed to collect dead trees for firewood in protected sections of co-managed forest blocks, but some individuals may debark or lop a tree heavily and let it die, just to come back and collect it as dead wood. Therefore, long term improvement in tree and woody populations could be compromised by heavy debarking and lopping. Thus, there is a need for a proper monitoring mechanism and to ensure that management and utilization rules and regulations are adhered to by all local communities. Additionally, there is a need to identify alternative trees and wood sources, so as to reduce the current pressure on the existing reserves, and also to allow for the recovery or regeneration of harvested forest areas. One such alternative tree and wood source is the establishment of VFA's, which were observed in communities living around both Zomba-Malosa and Ntchisi Forest reserve. Furthermore, VFA's could also present the communities with an investment opportunity for a sustainable flow of forest products for subsistence and commercial value.

The results show that forest boundaries were clearly marked and firebreaks constructed in co-managed forest blocks of forest reserve. However, neither marked and constructed boundaries nor were firebreaks observed in Ntchisi forest reserve. Lack of marked boundaries in Ntchisi forest reserves was attributed to the fact that natural relief forms such as rivers and streams are used to mark block boundaries. However, a number of stream and small rivers, both annual and seasonal, flow through Ntchisi forest reserve; hence unless one is well aware of the reserve, it is difficult to recognise the boundaries especially the inner boundaries. This therefore results in difficulties in identification of and exclusion from protected sections, thus making adherence to and enforcement of forest harvesting laws difficult (Ostrom, 1990).

CONCLUSION AND RECOMMENDATION

This study finds that forest co-management has the potential to improve forest conditions, however, the direction of impact may not always be positive, and vary depending on pre-existing forest conditions how participating communities understand and interpret the programme. For that although we expected that human activities and disturbance will be minimal in co-managed forest blocks, some of the activities (e.g. the number of felled trees and debarked trees per plot) was significantly higher in co-managed forest block than in state managed forest blocks in Zomba-Malosa forest. Thus this shows that co-management outcomes will vary depending on pre-existing forest conditions as well as on how participating communities understand and interpret the programme. Hence forest co-management programmes may not always be a solution to degradation, but it can also enhance degradation in other areas. Therefore, co-management programmes and activities should not be considered as a universal package, however, should be designed to take into account the socio-economic characteristics of specific participating community and pre-existing condition of the forest.

Biological indicators of conservation (e.g. tree density and species richness) take time to respond to management programmes; therefore, the inclusion of physical signs of human activities in the forests as indicators to predict potential impact of the programme on forest condition is essential in evaluation studies. This study supports the use of method triangulation and multiple data types in forest co-management impact studies as it allows for a more robust assessment, and should be widely applicable to other evaluation studies. However, the study also demonstrates that, even with method triangulation, it is difficult to determine the effectiveness of co-management on forest conditions from one-time study data. Thus, we recommended integration of participatory research as key component of the programme, to allow for evaluation and attribution of the observable changes both in time and space to the programme. We further, recommend a follow-up forest inventory study to allow for; attribution of the differences in forest condition to differences in management approaches. We further recommend identification of major drivers of the degradation, specific for each location, as this will inform future designs for effective implementation of co-management programmes.

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TABLES

Table 1: Parameters for assessing impact of co-management on forest conditions

Indicators	Parameters	Reference
Change in forest and forest resources condition	1. List of tree species[1], 2. Tree counts[2] 3. Regeneration (seedlings and saplings) counts[3]	Blomley et al. (2008), Ahrends 2005, Meshack et al. (2007)
Presence of human activities or disturbances	1. Tree stumps 2. Pole stumps 3. Number of felled trees present 4. Number of Pit-saw timber harvesting sites, 5. Counts of Charcoal production pits, 6. Number of trees debarking 7. Number of farming plots. 8. Settlement plots (*1= yes; 0= no evidence*) 9. Presence of fire (*1= yes; 0= no evidence*) 10. Hunting pits	Blomley et al. (2008), Ahrends (2005), Antinori and Rausser (2007)
Evidence of good forest management practices	1. Marked boundaries and fire breaks 2. Number of forest nurseries 3. Evidence/counts of planted village forest and afforestation	

Note

[1] List of tree species, on assumption that since its one reserve the species should be the same.

[2] Trees are defined as all trees with straight stems at least 3 m in length and exceeding 15cm DBH (Doody *et al.,* 2001).

[3] Seedlings and saplings are defined as woody plants with height ≤ 1.5 m, and > 1.5 m but less that 2m, respectively, with DBH< 10 cm (Kelbessa and Soromessa, 2004 in Gobeze, Bekele, Lemenih, & Kassa, 2009). In this study Seedlings and saplings are referred to as regeneration

Table 2: Summary of ANOVA results on tree and seedling and sapling density between blocks within management type in Ntchisi and Zomba-Malosa forest reserves

Forest Name	**Management type**	**Variable-(Density)**	**ANOVA-Significance**	
			F	***(p-value)***
Ntchisi	State management	Tree	1.300	0.291
		seedlings and saplings	9.907	0.001
	Co-management	Tree	1.300	0.291
		seedlings and saplings	5.590	0.011
Zomba-Malosa	State management	Tree	4.737	0.019
		seedlings and saplings	0.984	0.389
	Co-management	Tree	1.687	0.206
		seedlings and saplings	8.379	0.002

Table 3: Average counts of human activity indicators observed in state managed and co-managed blocks in Ntchisi and Zomba-Malosa forest reserves

Indicator	**Ntchisi forest reserve**		**Zomba-Malosa forest reserve**	
	State management (n=27)	Co-management (n=26)	State management (n=26)	Co-management (n=27)
Tree stumps	5.78	12.27**	13.73	6.81**
Felled trees	1.04	1.73	1.88	0.74**
Debarked trees	1.59	2.04	0.54	2.48**
Lopped trees	3.11	1.88	4	5.00
Farming plots	0	0	1.31	0.08**
Settlement plots	0	0	0.12	0
Charcoal pits	0	0	1.96	0.13**
Fires *(categorical scale yes=1; no=0)*	0.56	0.58	0.73	0.48*
Grazing*(categorical scale yes=1; no=0)*	0.29	0**	0	0

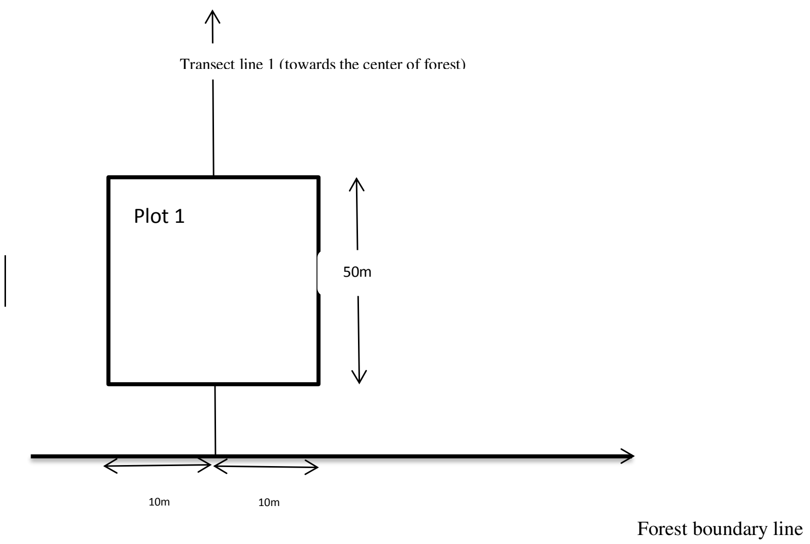
***-presence of indicator significantly different in plots under state management and co-management at 5% level of significance*

Table 4: Total number of forest management activities observed in and around state and co-management forest blocks and surrounding communities in Zomba- Malosa and Ntchisi forest reserves

Activity	**Ntchisi**		**Zomba-Malosa**	
	State management (n=26)	Co-management (n=27)	State management (n=26)	Co-management (n=27)
Firebreaks	0	0	2	10
Marked boundaries (constructed)	0	0	2	11
Number of forest nurseries	3	2	2	2
Presence of planted trees	0	0	6	0
Village Forest Areas	4	11	14	23

n = total number of plots.

LIST OF FIGURES



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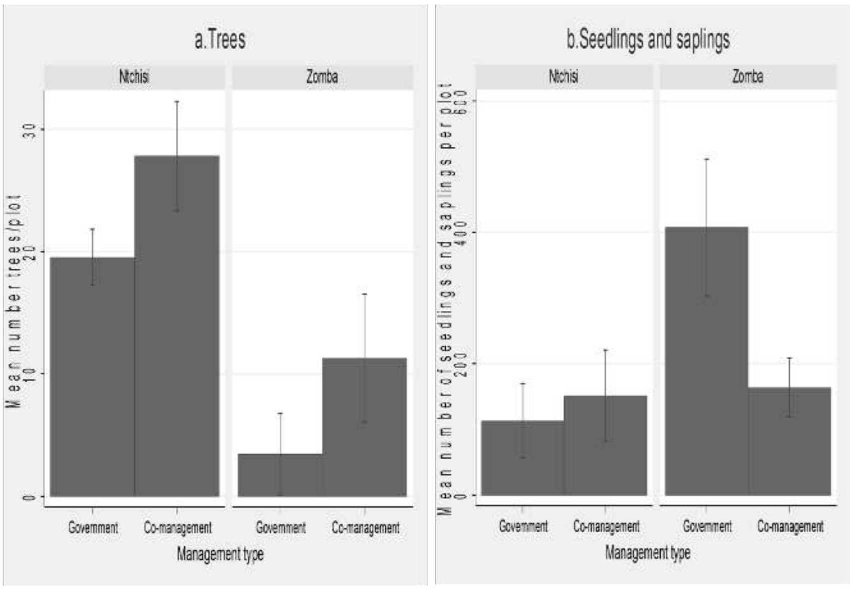
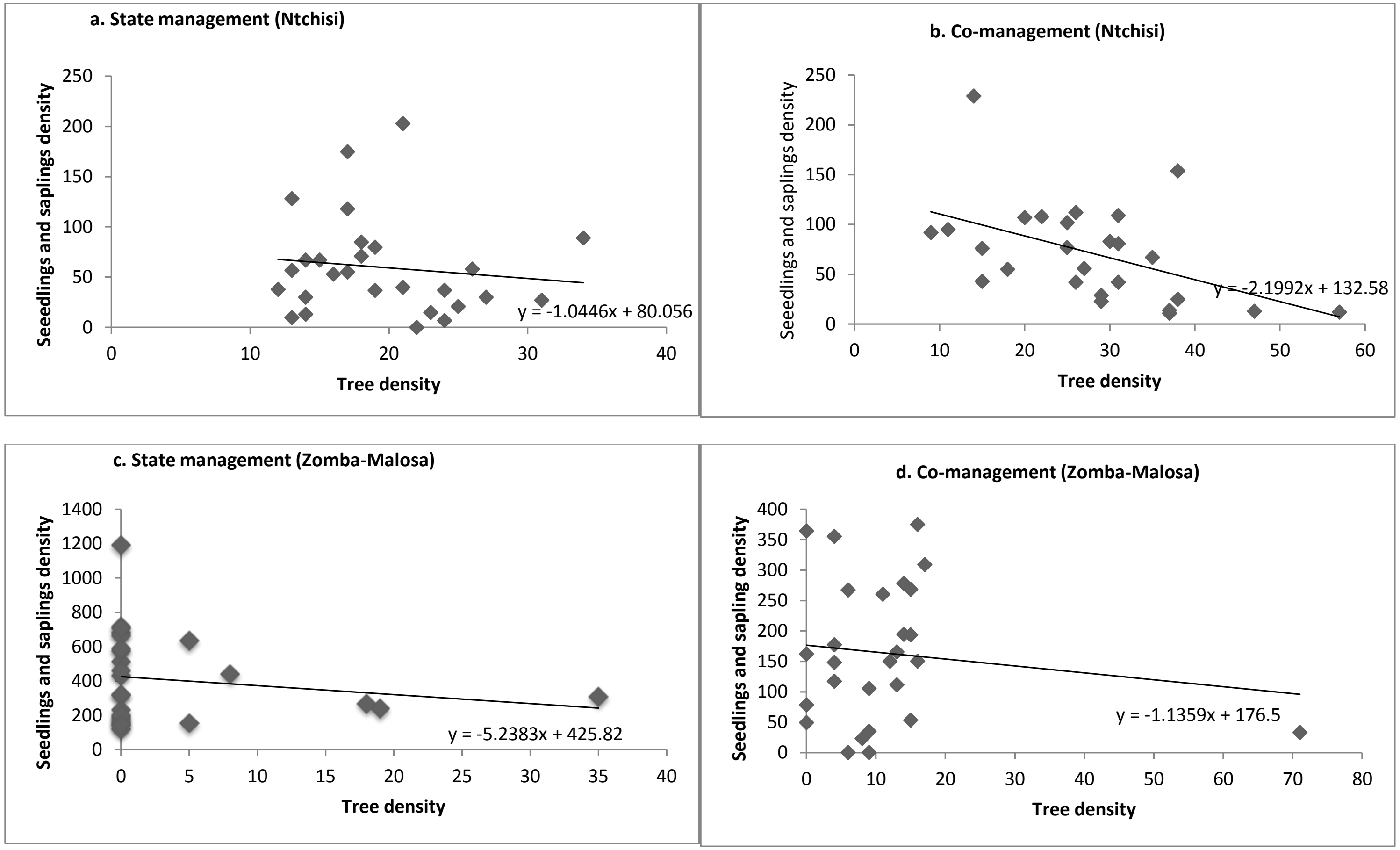
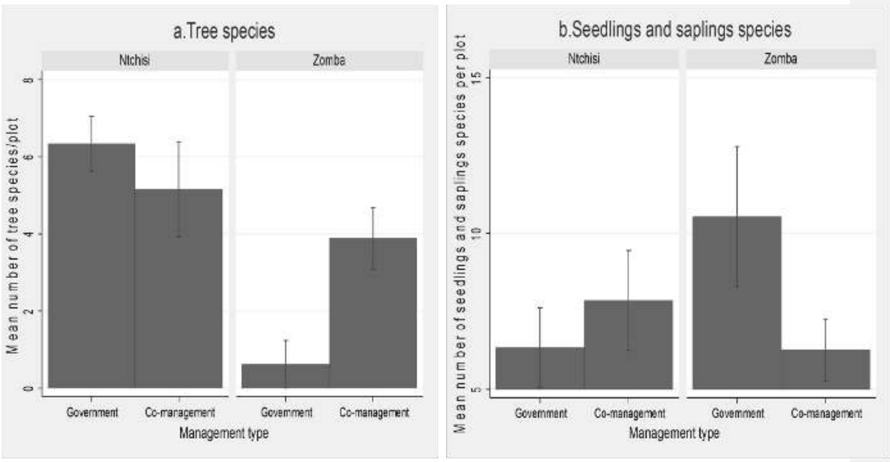

a.Trees
Ntchisi
Zomba
Mean number trees/plot
Government
Co-management
Management type
b.Seedlings and saplings
Mean number of seedlings and saplings per plot


a. State management (Ntchisi)
Seedlings and saplings density
Tree density
y = -1.0446x + 80.056
b. Co-management (Ntchisi)
Seeedlings and saplings density
Tree density
y = -2.1992x + 132.58
c. State management (Zomba-Malosa)
Seedlings and saplings density
Tree density
y = -5.2383x + 425.82
d. Co-management (Zomba-Malosa)
Seedlings and sapling density
Tree density
y = -1.1359x + 176.5


a.Tree species
Ntchisi
Zomba
Mean number of tree species/plot
0
2
4
6
8
Government
Co-management
Government
Co-management
Management type
b.Seedlings and saplings species
Ntchisi
Zomba
Mean number of seedlings and saplings species per plot
5
10
15
Government
Co-management
Government
Co-management
Management type