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The impact of participatory forest management on Miombo woodland tree species diversity and local livelihoods

A case study of Bereku Miombo woodland, Babati District, Tanzania

Zacharia John Lupala

Supervisor

Dr. Ebba Lisberg Jensen

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Dedication

To my Wife Angel, Son Gregory and Daughters Adventina & Grace, thanks for your Love & Persevering.

Abstract

Enabling local community participation in management is a key to stop alarming degradation in the Miombo woodlands. This study examined the socio-economic and ecological impact of participatory management practised in Bereku woodland, Babati district, Tanzania. Semi-structured questionnaire, focus group interview and field observation used for socio-economic study. Random sampling was done to select 10 percent of the households for questionnaire interview. While ecological data was collected by systematic sampling using transects of circular plots with different radius. Within 5m radius all trees with dbh ≥ 4cm; within10 m radius all trees with dbh ≥ 10 cm and within 15 m radius all trees with dbh ≥ 20cm were identified and measured. The socio-economic results revealed significant satisfaction with management ($P<0.05$) Chi-square of (14.49). Remarkable synergies at household's level were fuel wood, construction materials and environmental goods and services. At village level, strengthened institutions and revenue were outstanding. Ecological survey revealed 87 tree species in 37 families of 63 genera, Shannon index was higher, (3.8), Species diversity index (96). Importance Value Index showed *Brachystegia microphylla* (11.38), *Brachystegia. speciformis* (9.03) and *Julbernardia globiflora* (6.42) were the most important woodland tree species. Stocking was high (981 stems/ha), mean basal area (13.24m^2/ha) but low mean volume (64.76 m^3/ha). There is need to increase tangible benefits at household's level and more strengthening village institutions.

Keywords: Babati, Bereku woodland, local livelihoods, Miombo, participatory management, tree species diversity, Tanzania

Contents

Introduction

Forests and woodlands support about 65 percent of the world's terrestrial taxa (World Commission on Forests and Sustainable Development, 1999) and have the highest species diversity (WCMC, 2000). Its conservation and management is therefore a critical task (Aanderaa et al., 1996; Putz et al., 2000) and has become a key component of many national and international agreements including the Convention on Biological Diversity (CBD, 1992) and Forest Stewardship Certification (FSC, 2004).

Large part of forests and woodlands in sub-Saharan Africa is miombo woodlands approximating to 2.7 million km^2 (Campbell et al., 1996). Miombo is a colloquial term (Campbell et al., 1996), denoting *Brachystegia* in local language (Backeus, et al., 2006). It extends from Tanzania and southern Democratic Republic of Congo (DRC) in the north to the northern provinces of South Africa in the south, and across the continent from Angola in the west through Zambia to Malawi and Mozambique in the east (Chidumayo, 1987).

The woodland is distinguished from other African savanna woodlands and forest formations, by the domination of tree species in the legume family Fabaceae, subfamily Caesalpinioideae, particularly the genera *Brachystegia*, *Julbernardia* and *Isoberlinia* (Campbell et al., 1996; Burgess et al., 2004; Backeus et al 2006). It composed of tree species differing in characteristics, some are widespread fire-adapted, others do well on nutrient poor soils (Kielland-Lund, 1990 cited by Luoga et al., 2000).

Miombo woodlands provide settlements for about 100 millions of Africans, who enjoy goods and services from it (Campbell et al., 2007; Desanker et al., 1997). Historically, the woodland has been used by humans since the upper Pleistocene (Musonda, 1986, cited by Backeus et al., 2006) and on larger scale at least some 10,000 years (Chidumayo, 1997).
Miserably, degradation is alarming and posing threats to biodiversity and local livelihoods (UNEP, 2007; FAO, 2009). Various attempts have been made to find ways to manage forests and woodlands for biodiversity conservation and improving local livelihoods (FAO, 2003; Matose, 2006). Participatory management approach has become internationally acclaimed as a means to deal with vanishing biodiversity and also improve local livelihoods (Wily and Dewee, 2001; Arnold, 2002; UNEP, 2007).

The Tanzanian forest policy emphasize on management and conservation of forest and woodlands through participation of local community (MNRT, 1998). The policy has duel objectives of improving forest and woodlands conditions on one hand and local livelihoods on other. Participatory management strategy in Tanzania encompasses two management regimes, Community-Based Forest Management (CBFM) and Joint Forest Management (JFM) (MNRT, 1998). Joint forest management is the one adopted and implemented in management of Bereku miombo woodland.

Before participatory forest management regime, all forest reserves were managed by the Forest and Beekeeping Division (FBD), a government designated body in the Ministry of Natural Resources and Tourism (MNRT). The management was through policing and generating revenues to the National treasuries without the consideration of the surrounding communities. As a result, reserved forests and woodlands degraded by illegal activities and local livelihoods deteriorated disproportionately (MNRT, 1998).

Participatory management approaches were taken as remedial measures (Wily and Dewees, 2001; URT, 2001; MNRT, 1998). To date Tanzania has remarkable achievements in participatory forest management regime (Blomley and Ramadhani, 2006). For example, by year 2000 about 500 villages had declared new forest reserves and 318,000 ha of forests and woodlands under community-based forestry management and 70,000 ha under joint management (Masanyika and Mgoo, 2001; MNRT, 2008). The strategy spread rapidly, with community and joint managed areas now covering more than 3 million hectare (ha), established over 1800 villages (Blomley and Ramadhani, 2006; MNRT, 2008), including Bereku woodland.

Problem statement

Despite conservation efforts, Tanzania is losing 420,000 hectares of forests annually through deforestation (FAO, 2009). Overall forest cover is estimated to be 34 million hectares and decreased by 15 percent between 1990 and 2005 due to deforestation (FAO, 2009). Miombo woodlands estimated to cover about 93 percent of total forested area (Mnangwone 1999) and support the livelihoods of the largest population (Nshubemuki and Mbwambo, 2007). Degradation is more severe in miombo woodlands (Luoga et al., 2000). The causes include continuing threat posed by human activities such as encroachments for agriculture and overgrazing, wildfires and illegal logging (MNRT, 2007). Moreover the woodlands are threatened by poor management practices and unsustainable resources utilization while the surrounding local livelihoods continue to be worsening (URT, 2001).

Number of studies which have examined the impact of participatory management in sustainable forest management used mainly people's perceptions rather than integrating ecological and socio-economic data (Agrawal and Yadama, 1997). Moreover, little research efforts have been focused on the structure, dynamics and tree species diversity of miombo woodlands (Valkonen, 2007). This study examined the impact of participatory management practised on miombo woodland tree species diversity, ecosystem resilience and in boosting local livelihoods, using the case study of Bereku miombo woodland in Babati district, Tanzania.

The study objectives

The general objective

To assess the socio-economic and ecological impacts of participatory management regime on enhancing local livelihoods, woodland tree species diversity, stocking and resilience in Bereku miombo woodland, Babati district, Tanzania (Fig. 1).

Specific objectives

Examine the practised participatory management regime for enhancing local livelihoods.

Investigate accrued socio-economic potentials and implications on sustainable management of miombo woodlands.

Determine woodland tree species diversity, abundance, regeneration potentials and disturbances.

Working hypothesis

Participatory management practised on Bereku miombo woodland have potentials to enhance local livelihoods in Babati district.

Based on practised participatory management regime, the resilience of the woodland and tree species is enhanced.

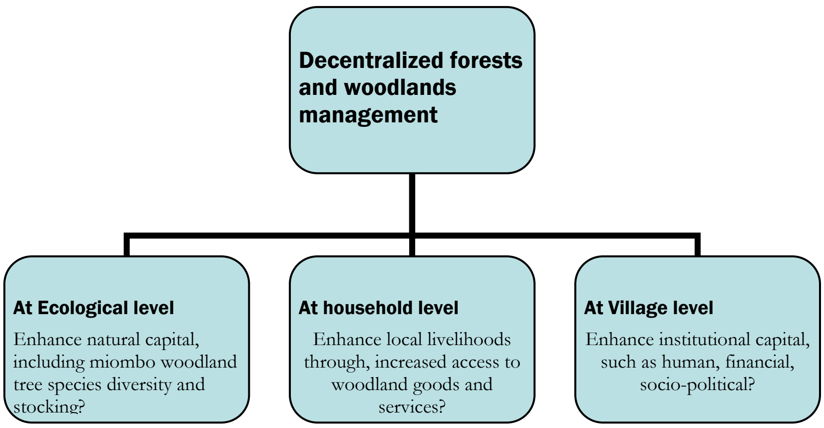


Fig.1. Conceptual framework used to guide the research work, which involved decentralized forest and woodland management from three different perspectives; ecological, village to household levels

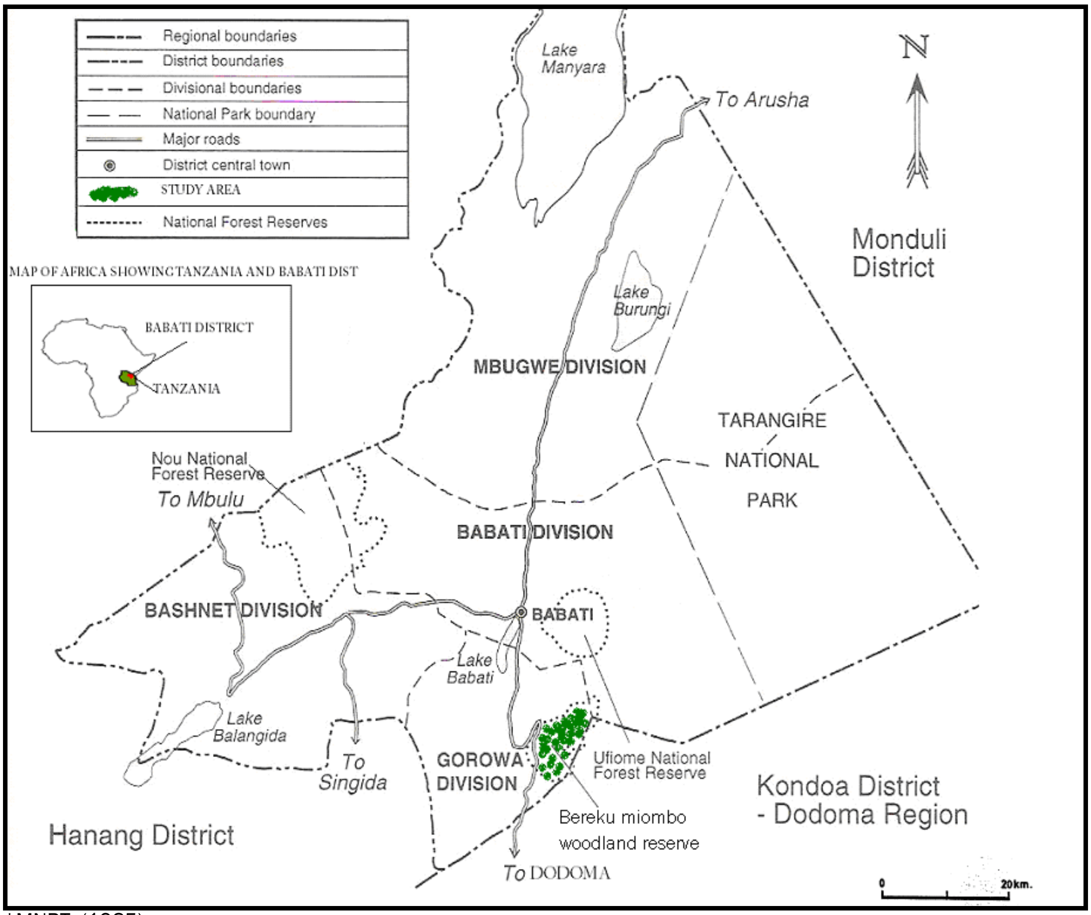
Methodological approach

Description of the study area

Location

Bereku miombo woodland is one of the few remaining tracts of dry miombo woodlands located in the well-settled and agriculturally important Babati District of Tanzania. The district is located in Northern Highlands of Tanzania along the rift valley escapement and Maasai steppe. It covers an area of about 6069 km^2 and divided into four administrative divisions (Mbugwe, Babati, Bashnet and Gorowa), (Fig.2), 21 wards and 81 villages.

Fig .2: Babati district and its four divisions showing the location of Bereku miombo woodland reserve, Tarangire national park, National forest reserves and main roads.



*MNRT, (1985)

The Bereku forest reserve was established in 1941 with the declaration or government note 294 of 5/9/41 having the gazettement area of 24,600 acres (9,956 ha). The reserve is situated 30 km south of Babati town and covers the Bereku ridge and Gedabosh mountain of Babati, having an elevation range of 1,280 to 1,810 m.

Main socio-economic activities

The main socio-economic activities in Babati district includes crop farming, livestock keeping and forestry related activities. Agriculture is predominant activity employing more than 90 percent of the population (URT, 2002). About 20 percent of the land in Babati district is suitable for cultivation (Fig.3). Because of semi-aridity climate, the dependence of rain fed agriculture is very common. The most prevalent production system is agro-pastoralism (crop farming and livestock keeping) (Lupala, 2006).

Distribution of land use in Babati district comprise of grazing (42 percent), followed by reserved land as national parks and game reserves (24 percent) and agricultural land (20 percent) (Fig.3). Different ethnic group perform distinguished land use activities, for example, Gorowa, Iraqw and Mbugwe are agro-pastoralists; Barabaig and Maasai are pastoralists while Chagga, Meru, Somali and Asian to European are practising market oriented farming. Agricultural crops in the area include maize, sorghum, beans, pigeon peas, wheat and millet and cash crops ranging from groundnuts, sunflower, sugarcane, banana and coffee.

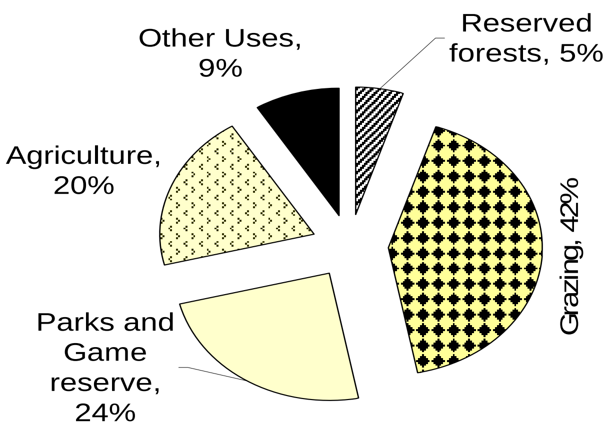


Fig. 3: Estimated land use suitability of Babati district based on expert interview.

Also there is livestock keeping, predominantly cattle, sheep and goats; however number of livestock has decreased due to the shortage of grazing area, drought and tsetse fly infection (Pastoral Bulletin, 2007). Forests, game and national parks related activities including tourism are becoming important socio-economic components in the area.

Population

Babati district has high birth rate (3.6) compared to the national average of 2.9 (URT, 2002). According to the national census report, the district has population of 303,013 of which 156,169 males and 146,844 female (URT, 2002). It has unexpected population structure, with more male individuals to female individuals (Fig.4). There could be number of reasons to explain this trend, nomadic life style, for example Barabaig tribe is polygamist which can cause a husband to be counted in more than one family. Number of males visiting Babati district searching for employment also may add to the number of males counted. People usually migrate searching for more land, petty business and or employment on the large scale commercial plantations established in some part of Babati district. Besides the above mentioned possible causes for exceptional population structure, the general tendency indicate more males to female from the childhood (Fig.4), this is unusual.

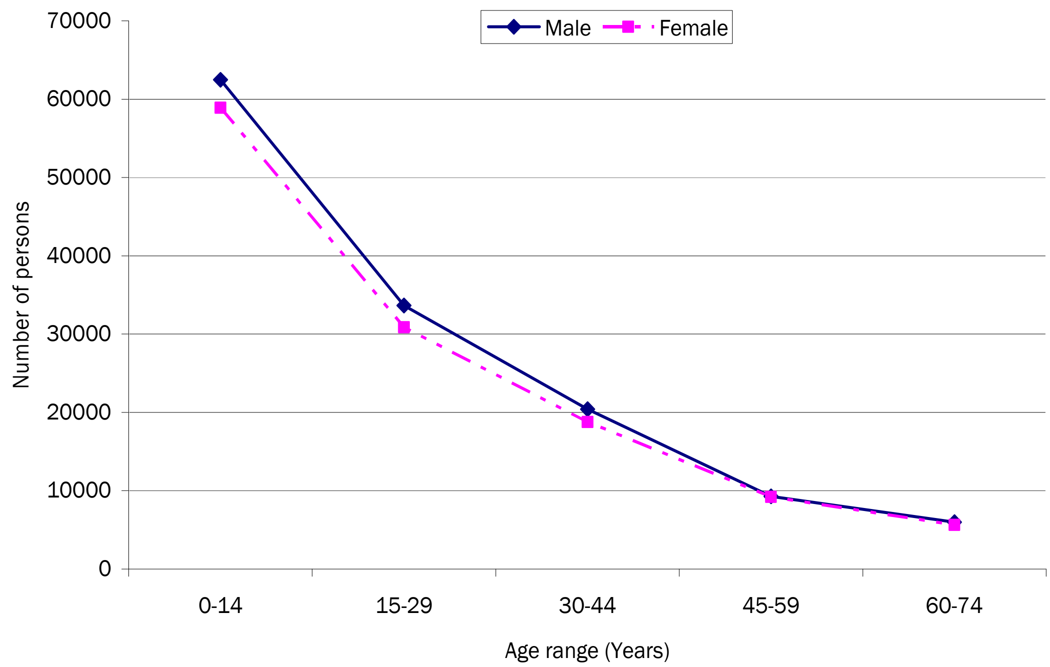


Fig. 4: The population structure by gender in rural areas of Babati district, as synthesized from Tanzania population and housing census
Source: (URT, 2002).

There is exceptional ethnic mixture, resulting into sociological and linguistic complexity than in almost any other part of Tanzania. All four major African language groups are represented in the district; Cushitic speakers (the Iraqw, Gorowa, Alagwa and Burunge), Nilotic speakers (the Barabaig and Maasai), Bantu speakers (among others are the Mbugwe, Rangi, Chagga and Nyaturu) and two small groups of Khoisan speakers (the Sandawe and the Hadzabe). It is also possible to find Asians, Somalians and a few Europeans.

Ecological features

Babati district have semi-arid climate with monomodial annual precipitation of about 750 to 1000mm per year and a mist effect on the higher ridges (Pastoralists Bulletin, 2007). Generally from January to May the district receive significant amount of rainfall and there is dry season from June to October (Fig. 5). During dry season temperature goes to about 25°C maximum and 16.5°C minimum in lower altitudes. The mean maximum temperature is 25°C and means minimum temperature is 12°C, with altitude ranging from 950m to 2,450m.

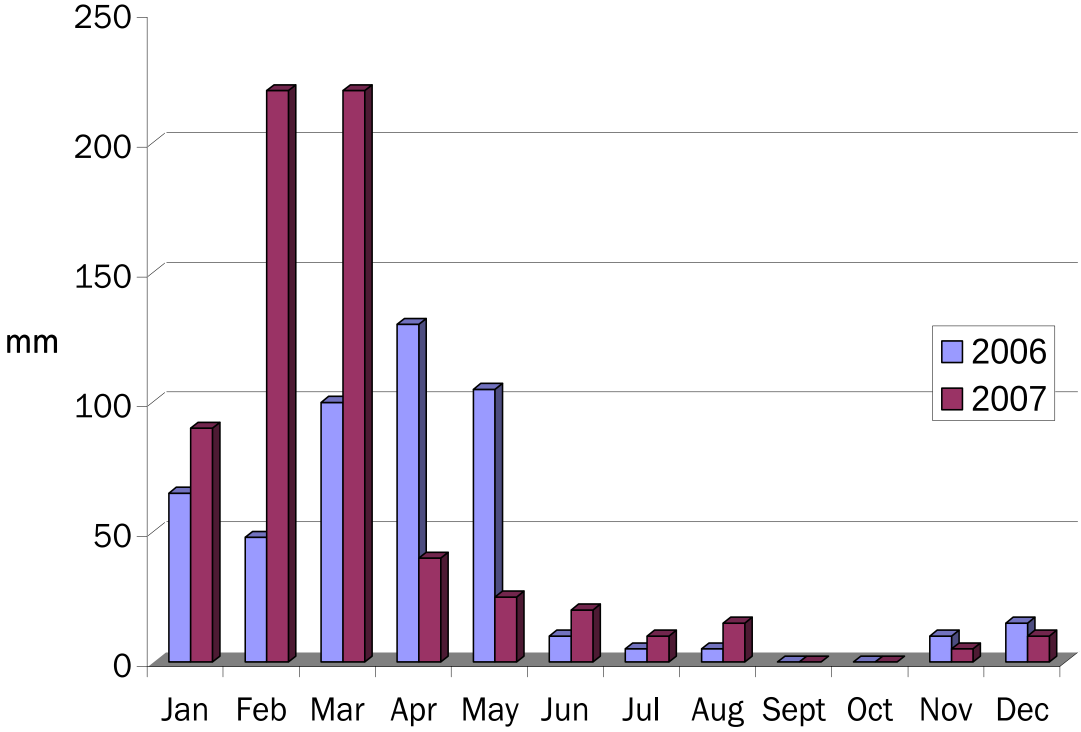


Fig. 5: Monthly rainfall distribution in Babati district as compared between 2006 and 2007 years according to Pastoral Bulletin (2007)

The climatic condition of Babati district is perhaps influenced by Tarangire-Lake Manyara ecosystem which covers about 20 percent of the district, as well as forests and game reserves which occupy 12 percent. The district is covered by vegetation which can be grouped into four main types, open grass lands without woody species in the salt plains around lakes, the *Acacia* woodland in drier areas, but Miombo woodland found mainly in Bereku. The District also has montane forests in the higher altitude with interlinked ridges of vegetation structure characterized by open canopy, trees interspaced with grasslands (MNRT, 1985).

Data collection techniques

Socio-economic data collection

The socio-economic survey was aimed at collecting information in socio-economic synergies accrued from woodland management practices. Data was collected from both household based perspectives and village based aspects. Semi-structured questionnaire (Appendix 1), focused group discussions and expert opinions aided by checklist (Appendix 2) as well as participant observation were employed. In semi-structured interview, a mixture of both open and close-ended questions was used. Pre-testing of questionnaire was done in order to see if the questions sets are understood and address the problem under investigation. The households used as sampling unit, and were defined as all people living under the same roof and sharing meals. This aimed at avoiding the complication from possible polygamist and extended families. Selection of households to be interviewed was made in three villages namely Ayasanda, Boay and Haraa which were among of five villages bordering the reserve (Appendix 8).

A simple random sampling technique was used to select household's respondents as per existing village registers. The representation of social groups in terms of gender, age classes and wealth were taken into considerations and therefore little bias was accepted. The respondents were the head of households because they are responsible for making decision on the household related activities and resource use. According to Tanzanian life style, males are the head of household but women were opted in order to have gender representation. The sampling intensity of ten percent (Table 1) was used to guide the number of household's selection.

Table 1: Total number of households and sample size of respondents in three study villages

Village name	Ayasanda	Boay	Haraa	Total
Total number of households	466	318	248	1032
Number of sample size	40	40	40	120
Sampling intensity (%)	8.6	12.6	16.13	11.6

In total, the households from the three villages were 1,032 and only 120 were selected for the questionnaire interview (Table 1). The questionnaires covered broad social and economic perspectives of the households in regard to the use and management of miombo woodland and the livelihood issues, as well as the past and present status of the woodland. There was no previous livelihood data at household level before the introduction of participatory management regime. Therefore, this study relied on household perception on the goods and services accrued compared to the previous management history.

In addition, focus group discussion with village natural resources committee (VNC) members, and expert opinions were carried out. This involved regional forest officer, district forest officer, beekeeping officer and environmental officer. Agricultural and other experts from FARM Africa, a Non Governmental Organization (NGO), dealing with conservation and development issues in Babati district were also consulted for more details.

Participant observation techniques were used on arrival to the study village in order to overcome with the problem of orientation and familiarize in the community. The technique allowed the researcher to participate in activities while maintaining the goal of the study (Frankfort-Nachimias, 1997). In so doing gains confidence from each other and presence do not interfere with the natural course of the events. As a result, the respondents provide the researcher with honest answers to questions and not hide important facts (Kajembe and Luoga, 1996).

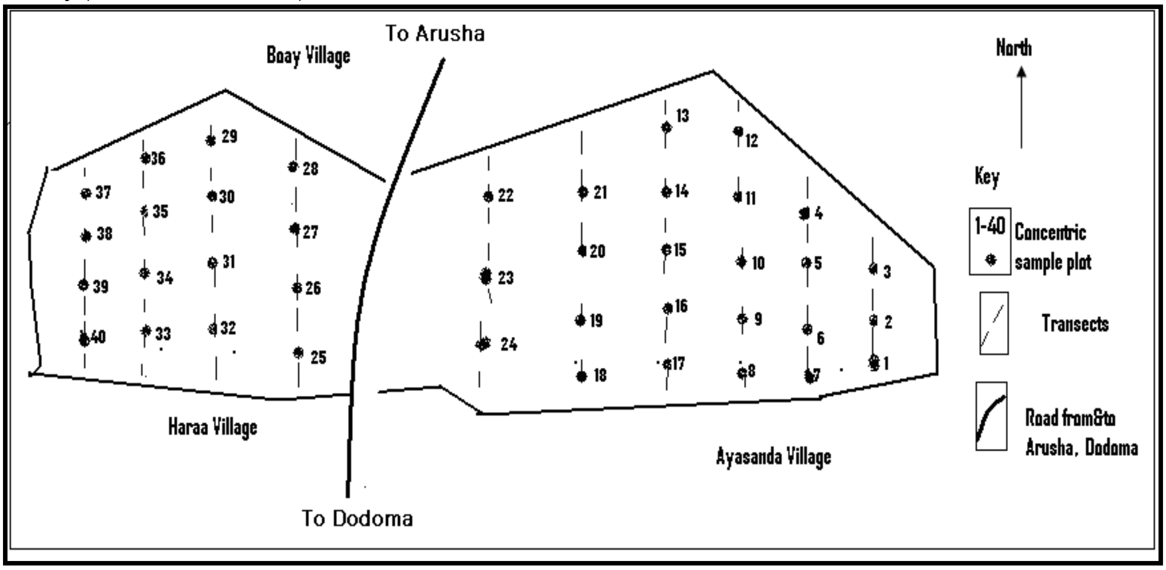
Data collection for woodland tree species diversity

For the tree species assessment in natural forests, including miombo woodlands, due to high variation in stand age, size and species, diameter frequencies by species and diversity indices are preferable (Malimbwi et al., 1998). Number of diversity indices such as Shannon-Wiener, Simpson and Brillouin are used in determination of species diversity (Krebs, 1989). Although the most widely used index of diversity, which combine species richness and evenness and also not affected by sample size, is the Shannon-Wiener index of diversity. According to Krebs (1989) Shannon-Wiener index is a measure of information content in the sample and increases with the number of species in a community. The woodland data intended to determine the extent of woodland tree species and ecosystem resilience as measured by tree species richness, relative abundance and regeneration potentials.

Bereku miombo woodland has total area of 5,373ha which is divided into five management blocks based on the surrounding villages. But for the purpose of this study two blocks were selected for woodland tree species survey. These are blocks adjacent to Ayasanda village (1,025.8ha) and Haraa village (469.6ha), forming an area of 1,495.4ha corresponding to 30 percent of the total woodland area. Systematic transects of 450m interval were established to cover the selected area and concentric circular sample plots laid at the distance of 450 m (Fig.6). According to Howard & Davenport (1996) systematic sampling in forest biodiversity survey is adopted in order to have easy replication. Also circular plots were convenient in woodland tree species survey due to easy plot layout, it has single central marker and minimize the number of edge decisions.

In concentric sample plots radius were established depending on the diameter at breast height (DBH) of the trees to be measured. Measurements were taken, within 5 m radius; all trees with dbh ≥ 4cm were recorded; within 10 m radius, all trees with dbh ≥ 10 cm were recorded and within 15 m radius, all trees with dbh ≥ 20 cm were also recorded. In total 40 circular concentric sample plots were laid down along 10 established transects (Fig.6).

Fig.6: Sketched layout of transects and sample plots used in woodland tree species survey (not drawn to scale)



In each sample plot, individual tree species were identified in the field by a locally experienced botanist (Mr Richard Alphonce). Two botanical books were also helpful in identification of woodland tree species, trees of Southern Africa (Palgrave, 2002) and useful trees and shrubs of East Africa (Ruffo et al., 1994). Members from Village Conservation Committees and experienced resource assessment person were among the crew. For the case of unidentified tree, sample was collected for further identification outside the field. Illegal activities were recorded using disturbance indicators such as burn mark on trees, traps and snares, charcoal production pits, cuts, pit sawing sites, farming (both old and recent) indicating encroachments, mining, debarking and evidence of grazing was also checked beyond the sample plots and transects and if possible photography was taken.

Data analysis techniques

Analysis of socio-economic data

Different approach and techniques were used to analyze socio-economic data and information collected. The techniques varied from qualitative and quantitative data, since each data have different techniques of analysis. However the analyses were kept simple to attain the purpose and scope of the study.

For qualitative data analysis, categorization (grouping) of data and information carried out and analyzed according to category; the categories were inclusive and mutually exclusive. Moreover, data was coded according to inclusive category (for open-ended answers) and deductive category (for closed ended answers). This is content analysis techniques; content analysis is a set of methods to analyse symbolic content of any communication for the intention of reduction of total content of communication to some set of categories that represent research interest (Singleton et al., 1993; Frankfort-Nachimias, 1997). In addition, structural-functional analysis techniques also used to explain the way social facts related to each other in a social system and the manner in which they related to the physical environment (Frankfort-Nachimias, 1997). The technique was helpful to distinguish between obvious and concealed function.

In addition, quantitative data were analyzed using simple statistic techniques such as mean, mode and median (measures of central tendency), range, variance and standard deviation (measures of dispersion), frequencies and percentages. Mann Whitney and Chi-square test was conducted to check the associations from different variables. All quantitative analysis performed with the help of Microsoft excel 2003 and SPSS version 15 spreadsheet computer programs.

Analysis of ecological parameters

In order to achieve profound description of tree species diversity, distribution and abundance, the important ecological index, referred to as important value index (IVI) was used. The IVI was calculated by adding up three important characteristics of a particular tree species. Relative frequency (how many plots a species occurs, in percentage), relative abundance (density of identified tree species) and relative dominance (density of stock expressed as basal area). Therefore, the IVI provides a summary of all three indicators of ecosystem importance and is frequently used quantifier for vegetation studies (Ambasht, 1990; Ribeiro et al., 2008).

Basal area for all tree species in each plot was summed and divided by the size of the plot to give basal area per hectare, while volume was determined using the equation by Frost (1996), which converts basal area/ha to volume/ha;

$$V = 6.18 * Ba^{0.86} \qquad (1)$$

Where:
V= Volume/ha (m^3/ha)
Ba = basal area/ha (m^2/ha)
Area of sample plot (a) (for 5 m radius=0.00786ha,
For 10 m radius=0.0314ha and for 15 m radius=0.07069ha.

More over, diversity indices were calculated to provide information about rarity and commonness of tree species in the woodland. The following diversity indices were calculated: - Shannon Weiner's diversity index (H') (Kent and Coker, 1992), this index accounts for both abundance and evenness of the species present.

It is computed as proportion of species (i) relative to the total number of species (pi) and then multiplied by the natural logarithm of this proportion (lnpi) and resulting product summed across species and multiplied by -1, i.e.

$$SD = -\sum pi \ln pi \qquad (2)$$

Also, Species Diversity Index (SDI) (Kohli et al., 1996), i.e.

$$SDI = -\Sigma \log 10(pi) / \log 10(1/s) \qquad (3)$$

$$Pi = (\frac{ni}{N}) \qquad (4)$$

Where: S= the number of species at that site,
ni= total number of individuals in the i^{th} species,
N= total number of individuals of all species.

Results

The results have been presented in line with socio-economic findings and the woodland ecological perspectives based on the focus of the study. The socio-economic results are first presented, followed with ecological findings.
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Results based on socio-economic part of the study

Households socio-economic characteristics

The household respondents represented both gender, with males headed households dominating (fig. 7). This was expected because of patriarchal system of life, where a husband (usually men) is the head of household and wife (female) take position in the absence of husband. But in matrilineal society, female is usually a head of family. For the women headed households there could be issues of divorce, separation, widows and absence of husband in the house. However this study adopted little bias to women household respondents in case of male respondent's domination. Haraa village had small female households' respondents compared to Ayasanda and Boay villages.

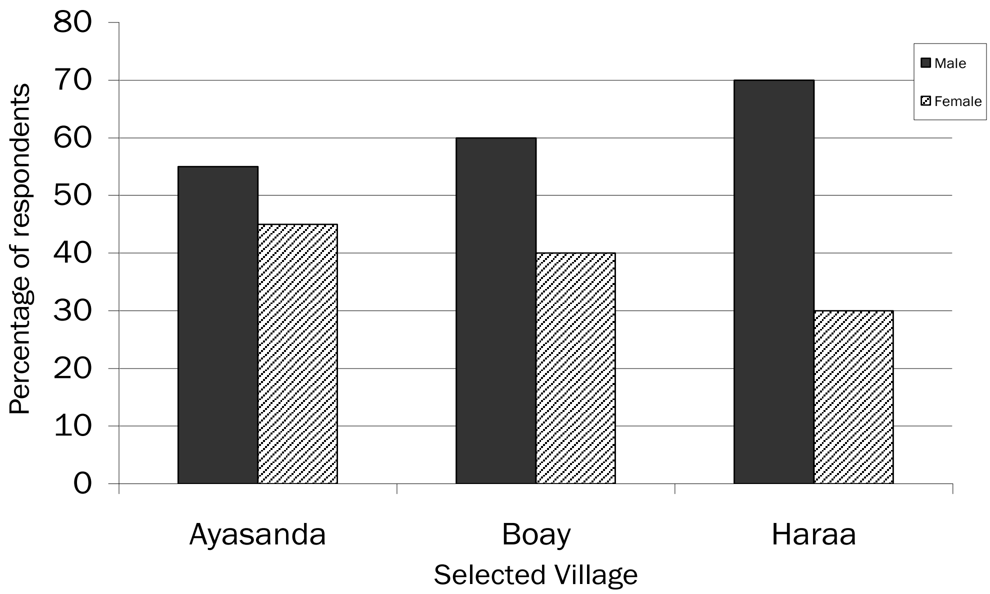


Fig.7. Percentage of respondents of the two genders in three study villages, Ayasanda, Boay and Haraa

This shows socially and economically differentiation in the community which might have influencing access and use of woodland resources. It is known that, women headed households are more often dependent on the natural resource base (Shackleton and Shackleton, 2006). Number of studies across the tropics has demonstrated that it is generally the poorest households who are more directly reliant on woodland products for both subsistence and cash income (Campbell et., al 1997; Clarket et., al 1996; Cavendish, 2002).

Nevertheless, the summary statistics related to socio-economic characteristics of households revealed that, on average each household consist of six members (Table 2). The household's family composition may sometimes involve relatives living together because of other socio-economic to cultural reasons. The most dominating reasons nowadays include disintegration of family due to death of parents; children usually are taken by other family relatives and friends. The observed household's characteristics (Table 2) do not indicate remarkable difference among the studied villages. This can be related to the existing similarity in livelihood style and contextual factors such as number of children in a family and farm size.

Table 2: The household's characteristics showing mean age, size of household and farm size in Ayasanda, Boay and Haraa villages

Variable	Ayasanda	Boay	Haraa	Overall
Sample size	40	40	40	120
Mean age (years)	43.7 (8.02)	44.7 (7.90)	43.3 (7.60)	43.9 (7.80)
Average size of household (person)	6.58 (2.82)	6.34 (3.03)	5.62 (3.14)	6.18(2.99)
Average number of females (person)	3.48 (1.82)	3.37 (1.69)	2.90(1.59)	3.25 (1.70)
Average number of males (person)	3.10 (1.79)	2.97 (1.58)	2.72(1.41)	2.93 (1.59)
Average farm size (ha)	3.65 (1.36)	3.45 (1.54)	3.92 (1.76)	3.68 (1.56)

*Number in parenthesis is standard deviations

The average size of land under cultivation by household was about 3.68 ha with an overall standard deviation of 1.56. This land is not enough for the household farming demand because sometimes they are forced to set aside land for grazing or for fodder production. The land pressure will continue increasing from increasing population due to immigration and birth rate (3.6), taking into account ethnical mixture of communities which have different livelihood strategies.

Management regime for Bereku miombo woodland

In Babati district, forests and woodlands are categorized by the local community based on type of management regime in practice. Three types of forests and woodland exist in Babati district, community based forest and woodland management (misitu ya jamii in Swahili language) forest and woodland managed in joint forest management (Misitu ya ushirika) and forest and woodland on general land/common land (Misitu ya kawaida) (Fig. 8). The study revealed that Bereku miombo woodland is practising joint forest management (JFM) category. This implies that the woodland is owned by the central government and managed through collaboration with adjacent communities.

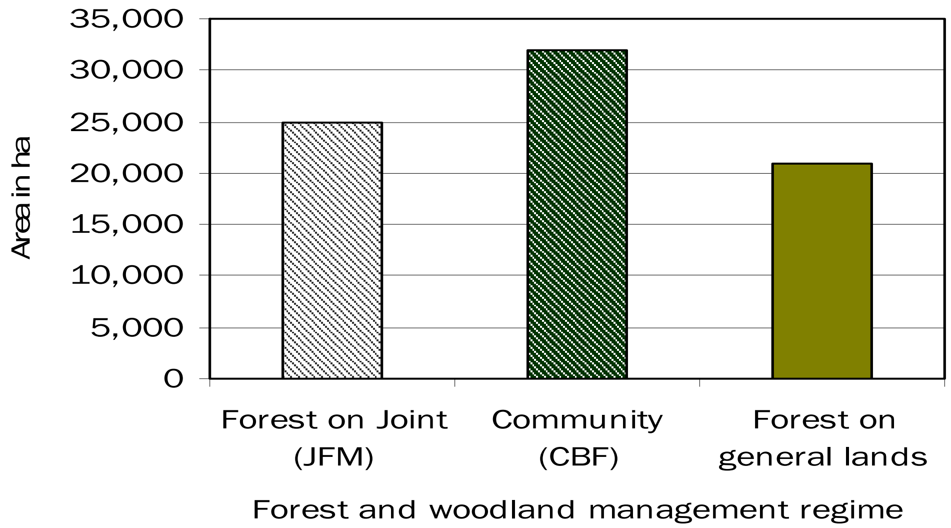


Fig. 8: Forest and woodland area (ha) in Babati district divided between different management categories as per expert interview.

Significant number of respondents (96 percent) acknowledged Bereku woodland to be managed in joint forest management style, which indicates the degree of awareness in the community. The forests and woodland areas which used to be on common property characteristics are now turned into reserve forest, largely in community management category (MNRT, 2008). According to the expert interview, the historic perspective of Bereku miombo woodland emanate from colonial period or before. The hamlet elders were regulating the use of Bereku woodland resources through number of socio-environmental rules.

For example, one part called Quaymanda was completely protected for spiritual and cultural purposes, some tree species such as Ficus sp., were also completely protected from use. After independence (1960s), the government through its forest bodies protected Bereku woodland through complete restriction to local community. There were no community considerations, the practice resulted into severe woodland degradation from illegal activities. Also there was significant community resistance against this 'fences and fines' management to their resources. The situation became worse due to ineffective of the government to manage the woodland from personnel to financial difficulties.

Majority of respondents (81.9 percent) mentioned that the woodland was severely degraded before joint management regime. The respondents mentioned that joint management regime started in Bereku woodland from year 1994 after extensive debate with the government. They pointed out that, forest fires were very common, areas had no forest cover and soil erosion was very severe, soil productivity and stream water disappeared before the commencement of joint forest management regime.

It is now more than 15 years since the implementation of participatory forest management regime in Bereku woodland. This study revealed significant understanding of the management regime in the community at different level of respondents in different villages. In Ayasanda village 90 percent of respondents were aware of the management regime, Haraa village 80 percent of respondents and Boay village 75 percent of respondents. The woodland area for joint management was divided among the surrounding villages based on traditional boundaries and each village have been allocated management area (Fig.9).

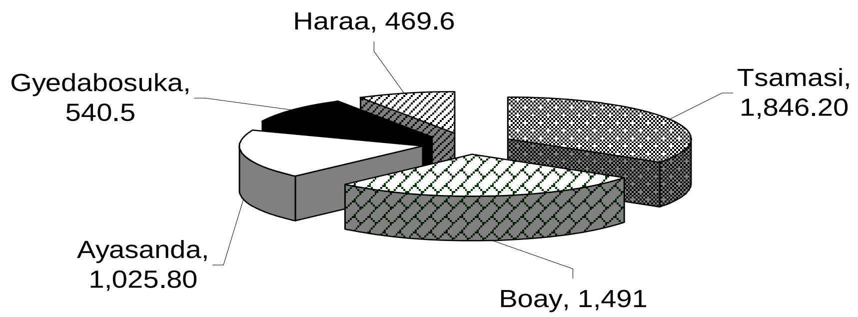


Fig. 9: Woodland management area (ha) divided between five different villages in Bereku Reserve

Locally based practical management plans and bylaws have been laid down, incorporating the following characteristics. Definition of woodland resource uses which permits need to be issued by village government (e.g. collection of poles which is limited by area, species and number of poles). Woodland uses which can continue, given the non-damaging nature (e.g. spiritual and cultural, collection of wild fruits and deadwoods). Woodland uses which no longer carried out and major fines and punishments are imposed (e.g. burning forest, charcoal making, pit-sawing and grazing).

This study covered Ayasanda, Boay and Haraa villages in socio-economic survey and for woodland tree species survey the block of Ayasanda and Haraa villages (Appendix 8). In the management arrangement, communities share responsibilities and accrued benefits from the woodland management, which is clearly spelt out at the beginning of the regime. The regime relies on experience and knowledge from both forest managers and local people in partnership arrangement that may also involve other stakeholders.

Local people satisfaction in management regime

The study found high level of satisfaction among respondents with joint management practiced in Bereku miombo woodland (Fig.10) and Chi-Square test (Table 3). Small number of respondents showed not fully satisfied or indicated to be not satisfied at all. The large number of respondents, who are satisfied, mentioned the locally control and access to the resources was important. For the those who mentioned not satisfied, the prominent reasons includes seeking more power and control over resources, and more tangible benefits accrued from the management.

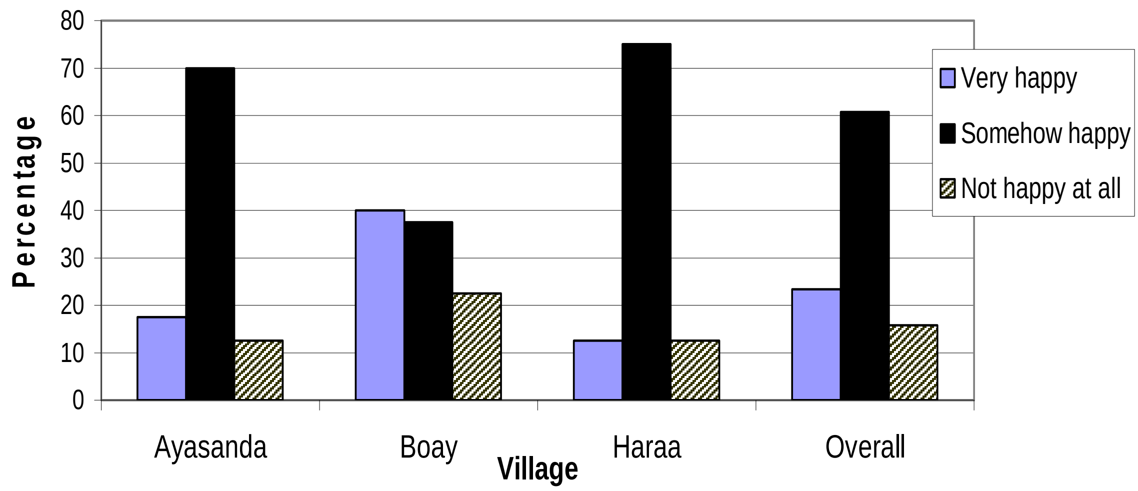


Fig. 10: Percentage of respondents indicated to be very happy, somehow happy and not happy with practiced management regime in Ayasanda, Boay and Haraa villages of Bereku woodland, Babati district.

Table 3: Chi-Square test on satisfaction with management regime

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.493(a)	4	.006
Likelihood Ratio	14.483	4	.006
Linear-by-Linear Association	.128	1	.720
N of Valid Cases	120		

*a0 cells (.0%) have expected count less than 5. The minimum expected count is 6.33.

Local participation in woodland management activities

There was significant participation in different woodland management activities (Table 4). Households participate in various woodland management activities, based on their socio-cultural context. For example, there was activities performed by all households and some activities specialized for youth, elders and women.

Participation in meetings was observed to be a norm for all respondents, which can be related to social political settings of Tanzanian village. In Tanzania villager's attendance in the meeting was compulsory during socialism history. This has grown to be common practice in most part of rural area of until recent. Village natural resources management committee members are usually the leader and actively participating in all activities

Table 4: Percentage respondents and participation in different activities (n=120)

Woodland Management Activities	Percentage Respondents
Meeting alone*	6
Meeting and off fire	1.70
Meeting and tree planting	40
Meeting, tree planting and off fire	5
Meeting and forest patrol	5
Meeting, forest patrol and off fire	21.70
Meeting, patrol,tree planting	20

*Some households participated in meeting only, due to age, or other disabilities, but the rest where also involved in other woodland activities

The socio-economic synergies accrued from woodland management

There are many socio-economic synergies essential for well-being of local community accrued from Bereku miombo woodland as results of increased access and participation in woodland management. The synergies range from households level to village levels and they have been made accessible through joint forest management practised. In terms of direct household level synergies, the woodland provide three most important benefits, namely (i) the supply of basic needs (ii) a saving of cash resources and (iii) safety-net during difficulty times. Some of the synergies act as subsidies to crop production, village development and others provide materials for survival and as insurance systems. Include fuel wood, construction materials, food, medicines, and fodder materials for livestock and beekeeping as well as environmental goods and services. These socio-economic benefits are presented and described starting with household based benefits to village level benefits.

Potential benefits at household level

There were profound socio-economic benefits attained by households as regards to the management of Bereku miombo woodland. The potentials categorized into two distinctive parts, non-income and income based portfolios

Non-income portfolios from woodland beneficial to households

The portfolio involves mainly the collections of woodland based products to be used for family consumption. Fuel wood and construction materials revealed most significant compared to other products (Fig.11). Fuel wood energy is the main sources for domestic energy in Ayasanda, Boay and Haraa villages. The observation is not surprising, as it is common in most rural areas of Tanzania which are not connected to national electricity system to rely on fuel wood as the only sources of domestic energy.

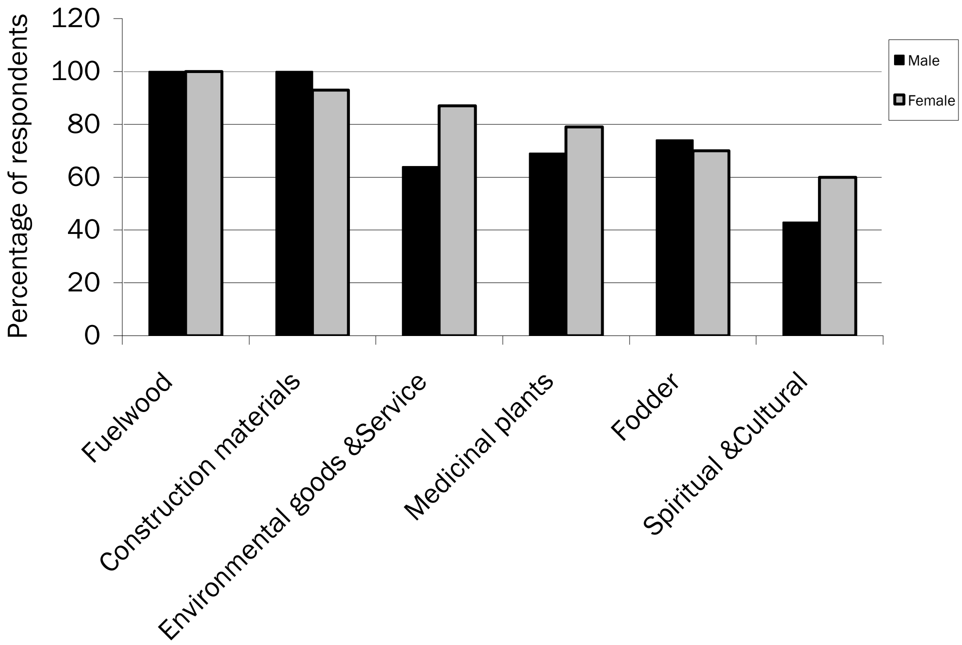


Fig. 11. Percentage of respondents by gender with regards to the benefits of woodland at household

Environmental goods and services were acknowledged to be very significant (80 percent of household respondents). This indicates the degree of environmental knowledge among the households in Babati district. Miombo woodland has important environmental role ranging from soil erosion control, modifying hydrological cycle and maintaining soil fertility.

In addition, this study revealed households respondents to be benefiting from medicinal, animal fodder for livestock keeping well as spiritual and cultural potentials from the woodland (Fig. 11). Among respondents, 80 percent of female household's respondents mentioned medicinal plants to be beneficial for their households and 65 percent male respondents are collecting medicinal plants for either sell or family self medications.

Furthermore, this study found small number of respondents (42 percent male and 60 percent female) (Fig.11), to be benefiting from cultural and spiritual uses of Bereku miombo woodlands. The benefits could be more, but fear from the notion of non-religious might made respondents not to show up their cultural and spiritual affinity to woodland. Although focused group discussion mentioned the use of some tree species to be associated with specific rituals and ceremonies. For example in Boay village species of *Dalbergia melanoxylon* not frequently used for fuel wood due to cultural and spiritual reasons.

Income based livelihoods portfolios at household level

Local communities surrounding Bereku miombo woodland earn their livelihoods from subsistence agriculture, rearing livestock, collecting woodland products and doing small scale business (Table 5). Based on number of household respondents, few households indicated to have formal employment for monthly salary, mostly were school teachers and health workers. Moreover, there was some sort of diversification of activities which provides income for the household livelihoods. This study identified income sources based on qualitative village level data (Table 5) as well as quantitative household level information.

Table 5: itemized Households livelihood sources in different source and categorical items within such sources

Sources	Categorical items						
Others	salary	Casual wage	remittance	In-kind support			
Petty business	Agric. products	Woodland products	Livestock products	Industrial products			
Livestock	Cow	goats	Donkeys	Sheep	Pigs	chicken	
Woodland products	firewood	Charcoal	Honey & Beeswax	Medicinal herbs	fruits	Vegetables & mushrooms	Bush meat
Agriculture	Maize	Cassava	Coffee & Sunflower	Beans &peas	Rice	Yams	Banana

Agriculture, livestock and woodland related activities dominates as a major livelihood sources, including household income. Maize, beans, rice, banana, cassava and yams production has dual function of being both a household food and cash crops. Coffee and sunflower are usually cultivated for commercial purposes. However, coffee is more cultivated in Haraa village in the form of agroforest system. Probably due to large number of chagga (people from Kilimanjaro region) who are known to be practising agroforestry system which mix coffee and other food crops within the same piece of land.

Furthermore, some respondents (69.2 percent) collect goods from Bereku miombo woodland for family consumption and sell surplus for the income. Small number of households (20.8 percent), mentioned to be collecting goods mainly for commercial purposes. Comparatively in three study villages, Ayasanda village have more households benefiting from sell of woodland goods (27.5 percent), while in Boay village (25 percent) very small number of households in Haraa village (12.5 percent). This was not expected, however high percentage in Ayasanda can be attributed to proximate to small town called Bonga, which is the business centre in the area, from Bonga town goods can be easily transported to Babati town centre. The monthly gain from the sell of woodland goods was estimated to range from 10,000 to 45,000 Tanzanian Shillings, equivalent to 8 to 38 USD per month from those households selling surplus goods. There were no records in official statistics, but the estimate provide picture of income gains from the woodland products.

However, based on household's quantitative data for comparative analysis of these income sources available in Ayasanda, Boay and Haraa study villages, the findings revealed significant share of woodland products contribution to the general livelihood portfolios (Fig. 12). Bereku woodland products have significant share of household income after agriculture, it has similar perceived contribution as livestock at households of all studied villages.

The study also found Bereku miombo woodland to be perceived as potentials for Beekeeping activities, vegetables and thatching grass (Fig. 13). The different in perceived potentials between male and female headed households do not differs significantly. This indicates the important of the woodland to both gender, and therefore an opportunity for both gender to participate in woodland management activities. Miombo woodland is well known to produce best quality honey bee and bee wax, because of numerous flowers from different plant species. Particularly, *Brachystegia microphylla* and *B.spiciformis* produce flowers which are very attractive to honey bees.

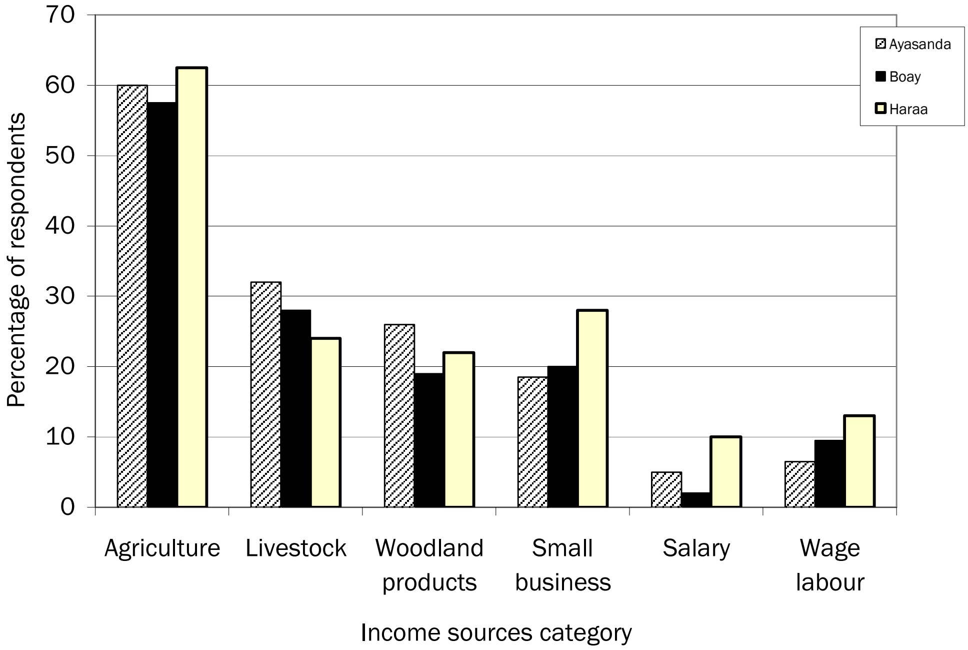


Fig. 12: Percentage respondents and annual income sources for household's livelihood among three study villages of Ayasanda, Boay and Haraa, Babati district

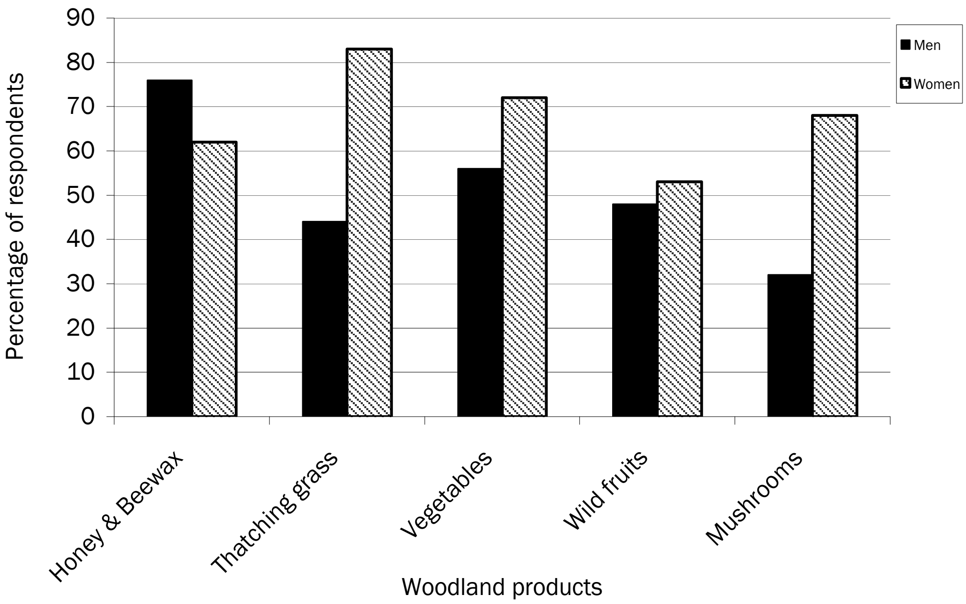


Fig. 13. Percentage of respondents by gender with regards to beekeeping, vegetable and thatching grass as benefits from woodland at household level

The study revealed beekeeping in Bereku woodland to be important socio-economic activities which provide honey and bee wax for family consumption and surplus for market (Fig.14). This potential is increasing recognized in Bereku woodland as results of increasing price of natural products in local market and global markets. Focused group discussion with beekeeping groups and district beekeeping officer (Mr. Macha) also pointed out that local and external market is growing and local communities are organized into groups and facilitated in beekeeping business.

Fig.14: Photography showing honey bee products and production in Bereku, miombo, Tanzania.

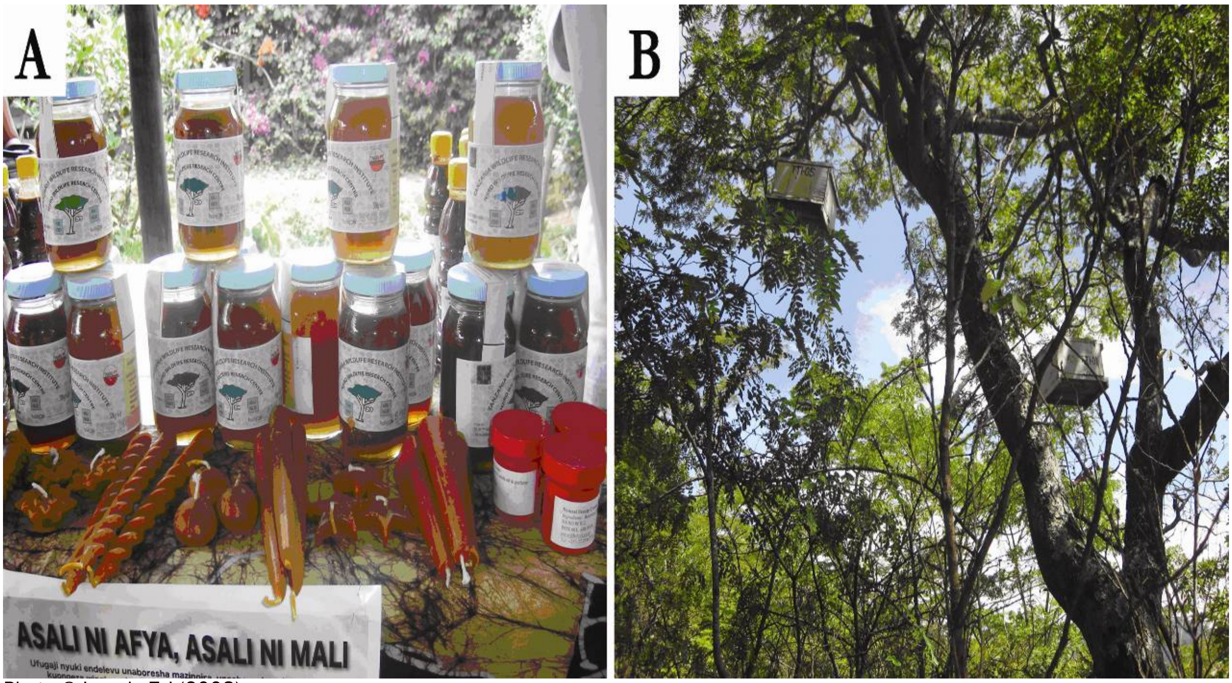


Photo © Lupala Z.J (2008)
* Plate A: Honey from miombo displayed at local market, Arusha
* Plate B: Bee hives on Bereku woodland.

Bereku miombo woodland has important bee fodder trees, for example from the identified genera of *Brachystegia, Acacia, Syzygium* and *Combretum* can be exploited for beekeeping industry. Beekeeping productivity estimates from miombo woodland of Tanzania indicates that one square mile can support 44 bee colonies producing 0.1 tons of beeswax and 1.3 tons of honey per year. Export of honey and beeswax is an important foreign currency earning in Tanzania

Accrued synergies at village level

This study have revealed number of important synergies beneficial at village level which have been grouped into four different portfolios. Namely environmental, socio-political, economic and human based portfolios.

Environmental based benefits at village level

This study revealed significant appreciation to environmental improvements associated with practised management of Bereku woodland. All households' respondents mentioned the environmental improvement as important benefits at village level. Their judgements were based on increased water sources which are flowing from Bereku woodland, increase rainfall and recovery of eroded land as results of increased woodland cover (Fig.15).

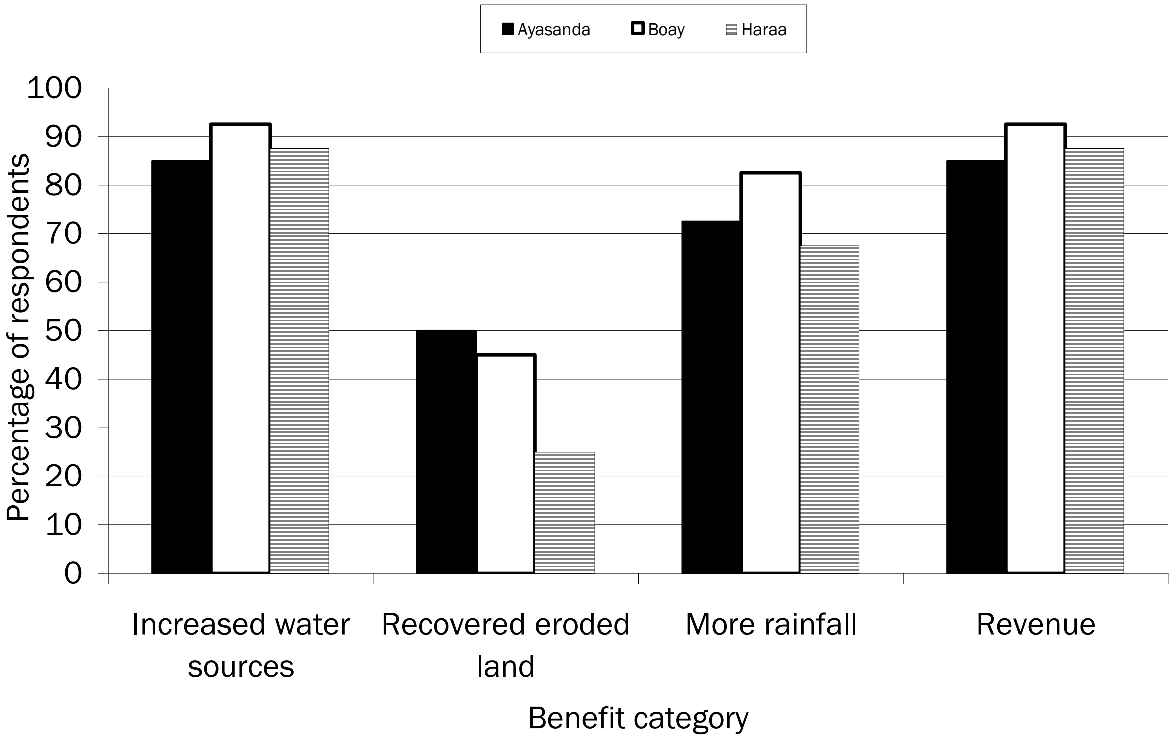


Fig. 15: Percentage respondents and perceived benefits from woodland management at village level, between three studied villages of Ayasanda, Boay and Haraa

The respondents were attributing the change with reduced illegal activities and disturbance to the woodland. They mentioned that joint forest management regime for Bereku woodland started in 1994. These perceptions were supported by expert interview from Babati catchment forest office, district natural resources officer and village natural resources conservation committees (VNRCs).

Socio-political based portfolios

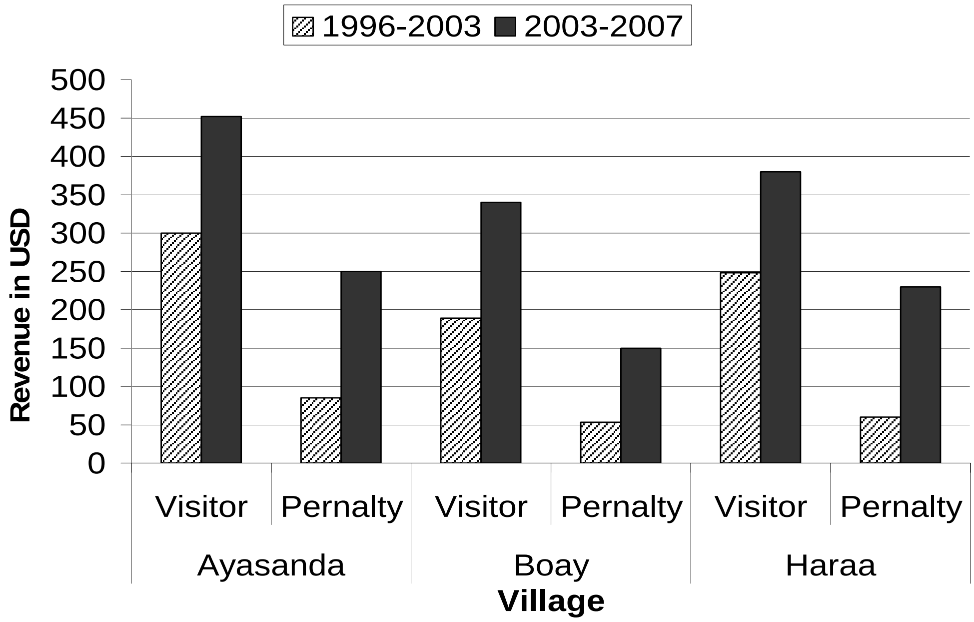
The socio-political portfolio refers to the level of networking in the village from formal organization to informal working. It involves networks among the community and how well villages are able to negotiate with external environment (Vyamana et al., 2008). The discussion with the village chairpersons and district catchments and natural resources officers acknowledge the increased socio-political attributes in their village. They mentioned that, the practiced management have strengthened local institutions, such as village governments and religious organizations. Also the formulation of village natural resources management committees (VNRCs) which have been able to negotiate, formulate and enforce forest by laws and local management plans.

Focused group discussion mentioned the introduction of savings and credit co-operative society (SACCOS), which provide loans to villagers. Also there is village cooperative bank (VICOBA) working to help villagers with capital to initiate agricultural based projects and also facilitate different village development projects. The village natural resources management committees have been linked with national wide network, called network for the society of collaborative forest management of Tanzania (Translated from Swahili: Mtandao wa Jamii wa Usimamizi wa misitu Tanzania (MJUMITA). The network has a vision of sharing experiences and best practice in conservation and management of forest and woodland in the country.

Economic based portfolios

Based on the practiced joint forest management regime there is revenue sharing mechanism between central government and village governments. The study noted significant number of respondents to be aware of the revenue sharing mechanism between central government and their villages. It was found that 93 percent of respondents to be informed in Boay village, 87.5 percent in Haraa and 85 percent in Ayasanda villages. This shows the degree of awareness and participation, communication and transparency in local woodland management systems in all villages.

The village governments were benefiting from economic gains related to both consumptive and non consumptive activities which are carried out in the Bereku woodland. According to village natural resources management committees, fees are charged from consumptive use of woodland resources such as commercial harvesting of firewood and charcoal marking in controlled manner. Also the income is generated from non-consumptive activities, notably research and eco-tourism activities for the members coming out of participating villages. As noted from their records, considerable revenue was generated from visitors (researchers and tourists) and penalty due to illegal activities in the woodlands (Fig. 16). These records also indicate the trends of visitors and illegal activities in the study villages which seem to be increasing from 1996 to 2007 years.



*Tanzania Shillings 1200= 1 USD in 2008

Fig. 16: Revenue collection from management of Bereku woodland between 1996 and 2007 in the three study villages

The revenue from ecotourism and consumptive use of woodland do not exist yet, but the process to institutionalize ecotourism is ongoing. It is important to mention that, Ayasanda village have been selected as pilot village benefiting from carbon funds, for the first phase, the village committee secretary reported to receive 2,566,000 Tanzanian shillings (=$2,138) in year 2007. This is very significant benefit and has increased the motive for community conservation effort. The collected income is being used in different village development projects. For example, to improve school and health services, woodland management activities such as patrol costs and costs associated with facilitation of woodland management meetings.

Benefits from improved human capital at village level

Human capital refers to the issues of education and skills accrued by members of community pertaining to the woodland management activities. In all study villages environmental committees reported to have benefiting from various training in relation to woodland management. For example some members have received training in tree nursery, beekeeping activities, mat making and entrepreneurship skills. Some members of the communities have also benefits from agroforestry training courses particularly in Haraa village. This indicates that the practiced management regime is also improving human capital through various training which was not provided before the existing management regime. Different governmental and non-governmental organizations (NGOs), particularly FARM Africa and Forestry Training Institute Olmotonyi Arusha, have been facilitating community based training and capacity building in the area.

Results based on ecological part of the study

This sub-section presents the findings and brief discussion on the ecological based results. It start by presenting the findings from woodland growing stock, diameter distribution of identified tree species, regeneration potentials, observed ecological diversity indices, species utilization matrix and disturbances as found in Bereku woodland reserve.

The existing woodland growing stock in Bereku woodland

The calculations of basal area and volume of the identified woodland tree species provided an overview of woodland growing stock. Both basal area and volume estimations are used to provide harvestable volume and above ground woody biomass of miombo stands (Lowore et al., 1994). This study found Bereku woodland to be growing with a basal area and volume increasing from smaller diameter trees to large diameter as expected (Fig. 17 & Appendix 7). The basal area varied between 7.7 and 20.9 m^2/ha with an overall mean basal area of 13.24 m^2/ha. The volume ranged between 41.0 and 96.9 m^3/ha with a mean of 64.76 m^3/ha.

The observed stocking in Bereku woodland can be attributed to existing management practices which strives to control illegal activities in the reserve. Various activities have been harmonized in the woodland. Neither encroachments nor bush fire has been happening under the joint forest management regime. This also indicates the woodland ecological factors and management practices have played very significant roles (Campbell, 1996). These also might have lead to the increased woodland ability to recover from the previous disturbances. The woodland seems to be dominated by massive regeneration that consists of sprouts from coppicing stumps, vegetative regrowth from roots, suckers and some fallen tree branches, as well as seedlings from soil seed banks.

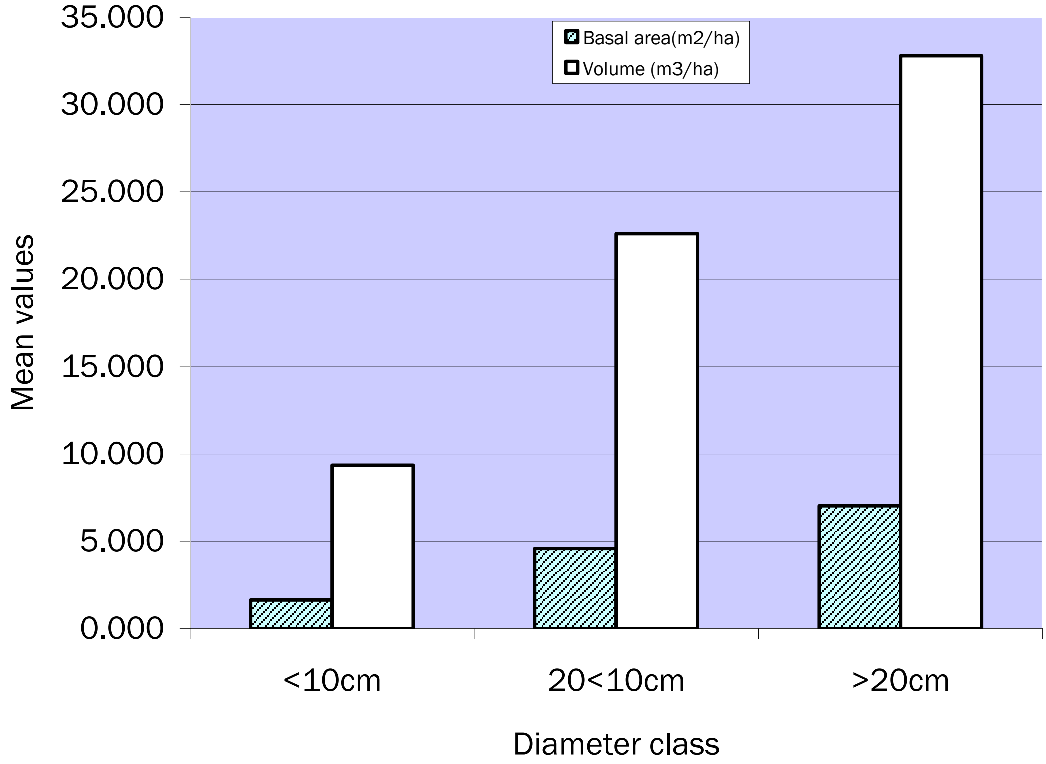


Fig. 17: Mean basal area and volume distribution by diameter classes, increases with increasing diameter as expected

Diameter class distribution of the woodland growing stock

Bereku miombo woodland have stems ranging from 682 to 1,531 stems/ha with an overall mean of 981 stems/ha. The diameter distributions of woodland tree species have shown the presence of more regeneration. There were successively fewer individuals with increasing diameter (Fig. 18 & Appendix 6). Trees individuals of less than 10cm include saplings and coppices, which was regenerating from the stumps and from some seedlings germinating after natural falls, or vegetative regrowth as stump sprouting and siblings.

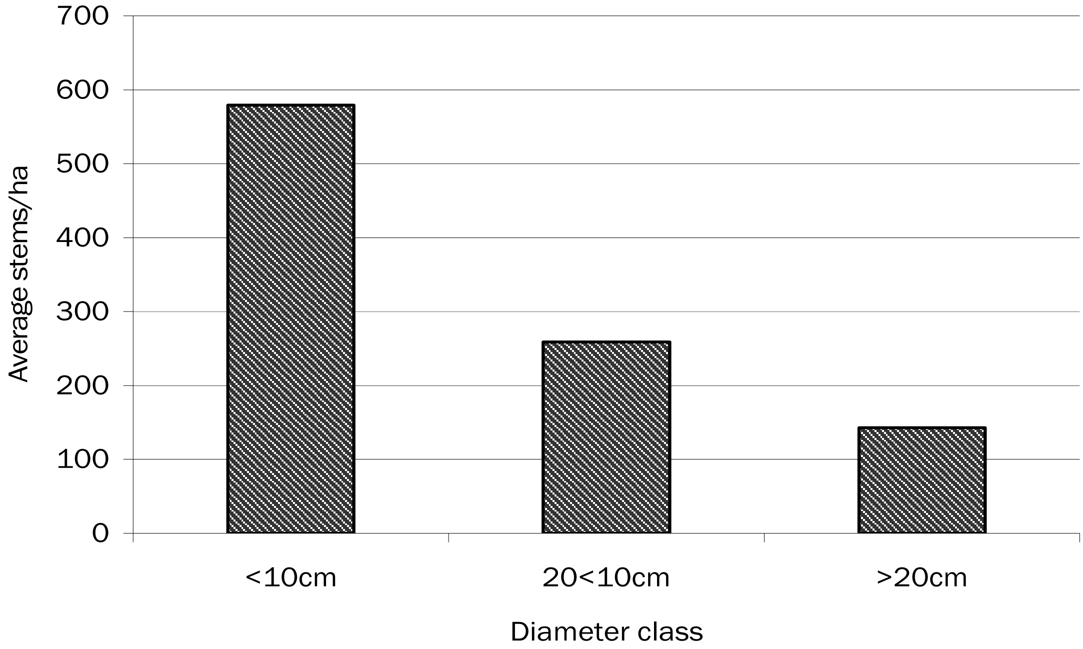


Fig. 18: Average stems (ha^{-1}) of three diameter classes in Bereku woodland, showing many tree of smaller diameter compared to larger diameter classes, depicting inverse-J shaped curve.

Previous disturbances from bush fire, over harvesting and grazing opened the woodland canopy and given the way for more regeneration in the woodland. Miombo woodland trees colonize faster and densely after disturbances. This happens due to the exposure of forest floor to sunlight and reduced competition among woody plants (Campbell, 1996). The observed distribution of tree species follows an inverse J-shaped trend (Fig. 18), showing tree frequency decreases with increasing diameter.

Trees of larger diameter class >20 cm observed to be less dominant in the woodland, this diameter class most probably suffered from the past degradation and disturbances from anthropogenic activities. Trees of larger diameter classes are more suitable for commercial timber extractions, charcoal marking and firewood or construction materials. This diameter class seems to be over exploited in the past with few remaining trees or limited recruitment from lower diameter classes.

The status of woodland tree species diversity

Woodland tree species diversity as measured by species richness and family richness was observed to be remarkably higher than expected in Bereku miombo woodland. In overall, 912 individuals were found belonging to 87 tree species in 37 families and 63 genera (Appendix 4) within 40 sample plots covering about 1,500 ha. This indicates very high tree species diversity in Bereku miombo woodland. Probably due to previous disturbances which opened the canopy and enabled regeneration of light tolerant genus like *Combretum*. Likewise, the existing management practiced have reduced disturbances and therefore probably made regenerating species to come up vigorously.

The analysis for tree species diversity index had the following ecological results were found:- Shannon-Wiener index of diversity (H') equal to 3.83, Species Diversity index (SDI),96 and Species richness (SR), 29.054 (Appendix 5). This indicates Bereku miombo woodland tree species are very diverse. Furthermore, the Importance Value Index (IVI) have indicated *Brachystegia microphylla, B. spiciformis,* and *Julbernardia globiflora* to be the most important ecologically miombo tree species in Bereku reserve, reaching about 27 percent of the total IVI (Table 6 & Appendix 5).

The highest number of taxa is found in the sub-family Caesalpinioideae with identified tree species of *Brachystegia microphylla*, *B. spiciformis, B. utilis* and *Julbernardia globiflora* (Fig.19). These tree species normally characterize miombo ecosystems. The genus of these tree species which includes, *Brachystegia* and *Julbernardia* from the family Fabaceae, sub-family Caesalpinioideae, might have made the Bereku woodland floristically rich. According to Högberg and Nylund (1981) in Campbell et al., (1996), *Brachystegia spiciformis* have ability to out compete other deciduous tree species on infertile, porous soils.

Table 6: Relative frequency, density, dominance and importance Value index of most dominant tree species in Bereku woodland

Species code	Scientific name	Relative frequency	Relative density	Relative dominance	Importance Value Index (IVI)
10	*Brachystegia microphylla*	7.092	13.816	13.223	11.377
9	*Brachystegia spiciformis*	6.383	11.404	9.304	9.030
42	*Julbernardia globiflora*	5.674	6.689	6.895	6.419
27	*Dalbergia boehmii*	2.482	1.974	1.835	2.097
11	*Brachystegia utilis*	3.901	2.303	6.049	4.084
73	*Senna septemtrionalis*	3.014	2.083	3.066	2.721
26	*Cursonia kirkii*	2.837	2.412	4.697	3.315
20	*Combretum molle*	2.837	2.083	5.528	3.483
8	*Brachystegia glaucescens*	0.532	0.439	0.121	0.364

This characteristic feature is probably linked to its extensive ectomycorrhizal (Frost, 1996). This is a fungus which forms symbiotic relationship with tree species through gaining essential organic substances from the tree and in turn helps the tree take up water, mineral salts and metabolites. It can also fight off parasites, predators such as nematodes and soil pathogens

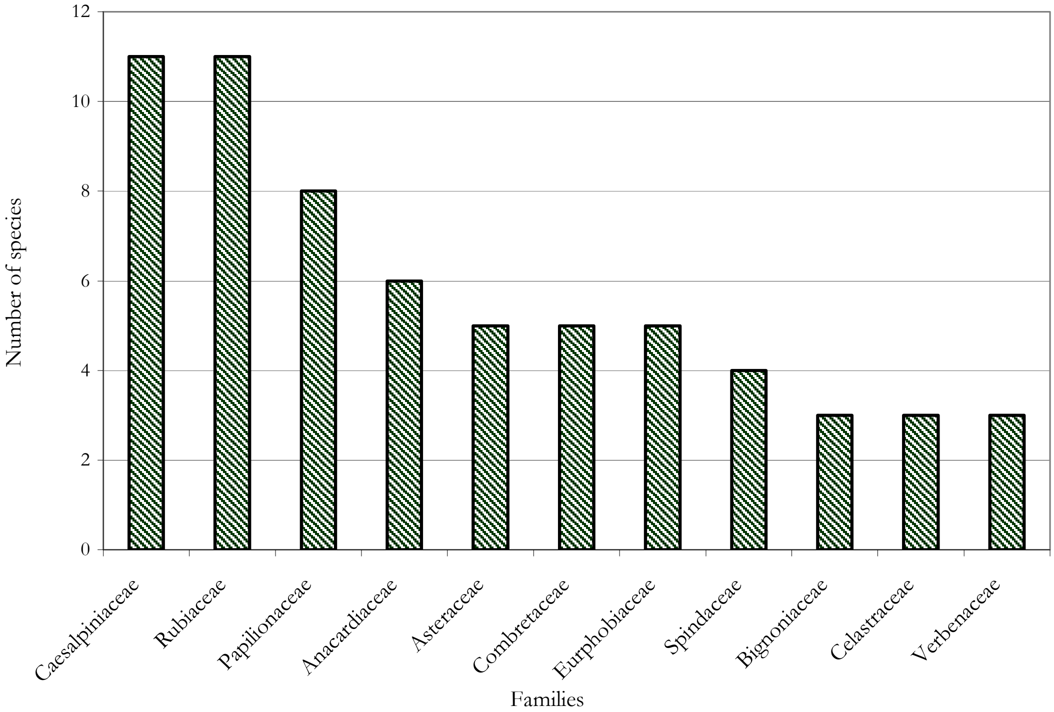


Fig. 19: Number of tree species from family of most abundant woodland species in Bereku

The interesting results are also found in analyzing for most dominating genera in Bereku miombo woodland. The genera with the highest number tree species were found to be *Combretum* (5 species), *Brachystegia* (4 species) and *Dalbergia* (3 species) (Table 7). The presence of *Combretum* shows that the woodland was previously disturbed and the tree canopy opened. *Combretum* is usually dominating in disturbed and open canopy of miombo woodland and sometimes in open undisturbed woodland. This can be associated with the abandonments of the fields from previous shifting cultivation, grazing and bush fires dominated in Bereku miombo woodland as results of past centralized management.

Table 7: The genera and their tree species most dominated in Bereku miombo woodland

Genus	Species				
Dalbergia	*D. nitidula*	*D.melanoxylon*	*D. boehmii*		
Brachystegia	*B. microphylla*	*B. spiciformis*	*B.utilis Burtt*	*B. glaucescens*	
Combretum	*C.zeyheri*	*C. schumannii*	*C.sericeum*	*C. molle*	*C. fragrans*

Similar transformation has been reported in woodlands of the Zambezi Valley, from *Brachystegia* dominated woodland to grassland and bush land dominated by *Combretum apiculatum* due to elephants and fire (Starfield et al., 1993). It was noted from the focus group discussion that, species such as *Dalbergia melanoxylon* (Mpingo in Swahili) and *Pterocarpus angolensis* (Mninga in Swahili) was previously over exploited to extinction in Bereku miombo woodland.

This study have observed number of *Dalbergia* species, including *D. melanoxylon* regenerating back in the woodland and therefore close monitoring might be advisable for the species not to be illegally harvested at their juvenile stage.

The woodland tree species regeneration potentials

The analysis of results from focus group discussion, household questionnaire and transect walk, indicated that Bereku woodland tree species diversity is well performing. The results pointed out that before joint management adoption in 1994, the woodland was heavily degraded. Most of the respondents mentioned that they could hardly imagine whether the woodland would rehabilitate into the present state. Ecological data analysis shown some of the tree species are only available in lower diameter classes (Table 8). These woodland tree species seem to be colonizing back the woodland very rapidly. For example, 32 percent of all identified woodland tree species were in the diameter class below 10 cm and between 10 and 20cm.

The most utilized woodland tree species from Bereku reserve

The local community utilizes woodland tree species in various ways depending on the suitability and availability of most preferred species. In case the preferable species with desirable characteristics not available in the woodland (local extinction); they usually shift to alternative tree species with lesser preference and suitability. Based on focused group discussion, most frequently utilized woodland tree species were identified (Table 9), and set into different use categories. The species categorized by structural uses, fuel energy, medicinal and foods including fruits.

Bereku miombo woodland seem to be composed of many species which are useful for medicinal and fruits. This study revealed 10 percent out of 87 identified species are useful for medicinal purposes and other 9 percent were useful for fruits and food materials for local community. However, the importance of miombo woodlands in provision of medicinal materials, food and fruits can be under estimated by this study. There is need for further research to determine the ethno botanical of Bereku miombo woodland. But generally this study also provided a snap short and importance of Bereku miombo woodland tree species in medicinal materials, food and fruits to local communities.

Table 8: Number of individual tree species in two class categorises which were probably newly growing in Bereku miombo woodland as observed during field survey

Re-growing species	Individuals in <10cm dbh	Individuals in 10cm ≤ 20cm dbh
Rhus longipes. Engl.	2	1
Maytenus angolensis. Exell & Mendonça	3	2
Pseudolachnostylis maprouneifolia. Engl.	2	0
Tarenna graveolens S.Moore	3	1
Allophylus sp.	3	1
Vernonia amygdalina L.	1	1
Schrebera alata Welw.	2	1
Indigofera rhynchocarpus Less	2	1
Turraea robusta Gurke	1	1
Parinari curatellifolia Benth.	3	2
Faurea rochetiana Pic. Serm.	3	2
Rhus natalensis C. Krauss	3	2
Protea gaguedi J.F. Gmel.	2	1
Phyllanthus sp.	4	1
Schrebera trichoclada Welw.	2	1
Vangueria infausta Burch.	3	2
Entada abyssinica A. Rich.	2	1
Pleurostylia africana Loes.	2	0
Bridelia spp	1	0
Erythrina caffra Thunb.	2	1
Euphorbia candelabrum Kotschy	2	1
Markhamia acuminata K.Schum.	3	2
Dichrostachys cinerea (L.) Wight. & Arn.	2	1
Ozoroa obovata (Oliv.) R. Fern. & A. Fern.	1	1
Lannea humilis (Oliv.) Engl.	2	0
Brachiaria brizantha (A. Rich.)Stapf	4	1
Melanthera scandens(Schum & Thonn)Roberty	4	2
Pentas decora S. Moore	1	1
Richardia scabra L.	2	1
Total	65	32

Table 9: Stated local uses (mainly fuel energy, structural, medicinal and fruits or foods) of miombo woodland tree species of Bereku, Babati district

Fuel energy	Structural uses	Medicinal uses	Fruits and foods
Brachystegia boehmii	*Pterocarpus angolensis*	*Zahna africana**	*Annona senegalensis*
B. microphylla	*Dalbergia boehmii*	*Lannea schimperi*	*Lannea humilis*
B. spiciformis	*Dalbergia nitidula*	*Entada abyssinica*	*Vitex doniana*
Julbernardia globiflora	*Dalbergia melanoxylon*	*Combretum molle*	*Vitex mombassae*
Acacia spp	*Julbernardia globiflora*	*Erythrina abyssinica*	*Azanza garckeana*
Combretum spp		*Cassipourea mollis*	*Strychnos potatorum*
		Commiphora eminii	*Zahna africana**
		Acacia nilotica	*Vangueria infausta*
		Combretum zeyheri	*Ximenia caffra*
		Dalbergia melanoxylon	

* Produce edible leaves which is used as both vegetables and medicinal

According to structural uses of Bereku woodland tree species, the study observed preferences in few species with desirable characteristics and quality. For example *Pterocarpus angolensis* is most preferred for timber due to durability and resistant to acid corrosion, but due to scarcity in the reserve, they usually diversify to other species like *Julbernardia globiflora. Pterocarpus angolensis* have been reported to be rapidly dwindling in other parts of Tanzania (Mbwambo et al 1995) and elsewhere in miombo woodlands (Clarke et al., 1996). There are other woodland tree species with such characteristics and preference and get local extinct due to the utilization pressure. Close monitoring and special conservation should be directed to such type of tree species to avoid the risk of extinction. Other conservation means can also be thought, for example ex-situ conservation and integrating such trees in on farm agroforestry trees to ensure their accessibility to households.

Fuel wood supply is among of the most important use of miombo woodland tree species, in Bereku woodland, the most frequently collected woodland tree species include, *Brachystegia* spp, *Combretum* spp and *Julbernardia globiflora*. According to expert discussion, fire wood collection does not cause problem to the Bereku woodland. Since the collection is done at subsistence level and only dried wood materials either from dead branches or wood materials left from cut trees for other uses. Moreover, some of the fuel wood collection is done from their farm trees adjacent to the homesteads. The frequently collected tree species of *Julbernardia globiflora*, *Brachystegia* spp and *Combretum* spp are present in abundant and these tree species regenerate very vigorously.

Illegal activities and disturbances in Bereku miombo woodland

Disturbances in miombo woodlands may manipulate the composition and structure of tree species diversity. This study found modest disturbances in Bereku woodland (Fig.20) which were probably linked with illegal activities or other causes. All activities carried out in the woodland were under the supervision of village natural resource committees. However absolute protection from illegal activities seems to be difficult, because of big demand of the wood land products for their livelihoods. According to committees, few illegal activities still exist and usually are caused by people coming from non participating villages and near by Kondoa district which is known to have problem of fire wood, charcoal and grazing pasture as result of its semi-aridity.

Fig. 20: Photographs showing disturbances as observed during woodland survey in Bereku woodland

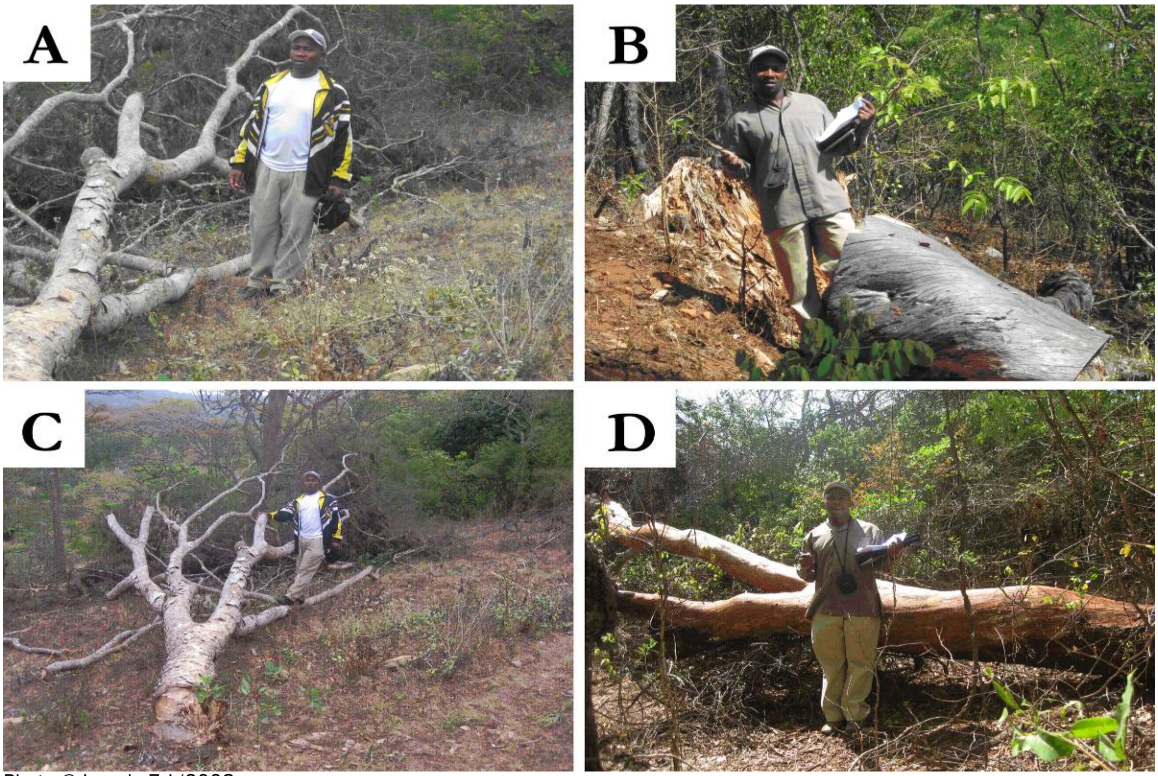


Photo © Lupala Z.J (2008

* Plate A & C: shows probably illegally cut down *Brachystegia* tree in Bereku woodland;
* Plate B: shows remnant of large log cut by pit sawyers in the past before new management regime
* Plate D: shows naturally fallen down miombo tree from which fuel wood was collected

During woodland tree species survey and personal observations, very little disturbances were observed (Fig. 20), and some dead tree crops naturally falling down. Most of stumps and fire burns appeared to be very old, there were no signal of recent fire burns. More over, in the past cattle grazing was permitted during the dry seasons and closed during the rain season, but not on steep slopes and water catchments areas. The cattle owner on other hands helped to clear the forest boundary and fire lines. This practice helped to reduce grass cover and therefore reduced fire incidences. Currently, activities carried out in the woodland are through local licensing system which provides minimal disturbances. For example, cutting of building poles carried out selectively from authorized tree species. Authorization depends upon species regeneration potential and stocks. In addition, dry fire wood collection from dead wood and beekeeping activities. Gathering of mushrooms, wild fruits and medicinal herbs are also done under special permission and control to prevent fire.

Discussion

Participatory management in Bereku Miombo woodland

There is promising results indicating participatory management practised in Bereku woodland enhance tree species diversity, woodland resilience and local livelihoods. This study has revealed Bereku miombo woodland has potential to recover from previous degradation through practiced joint forest management regime. The results were observed based on tree species diversity, stocking, regeneration potentials and regrowth of previous threatened species and socio-economic portfolios. This might be due to the integration of household's contextual factors such as cultural norms and practise to livelihood needs in their locally based management plans and by laws. In so doing woodland management benefits spill over to household's needs or income to the village levels revenue and intangible synergies.

Participatory management practised in Bereku woodland provided opportunities to local communities to take direct control of the woodland resources they use and co-manage with the state. This is based on some agreed benefits and responsibility sharing mechanisms. The practice concurs with global arrangements towards devolution of resources management from state authorities to local communities (FAO, 2003). Local communities in Babati district were previously considered as criminals and squatters, but this study has found to be seen as legitimate woodland resources managers and users.

The study indicated significant number of households was satisfied with joint management practised in all study villages with small variation of responses. There was no difference in satisfaction between genders. This can be due to the similar mode of implementation, strong and effective management committees which are responsible for rule enforcement and believed to be gender sensitive. The small variation between villages could be due to socio-cultural differences. Those who were not satisfied with management regime mentioned to demand more power in resource ownership and user rights or seeking for more tangible benefits. It indicated the way local people realize the benefits of devolution which may differ widely, however trade offs are expected (Shackleton, 2005). Local community may have different visions on woodland management and its model of implementation. Contrary, it can be argued that giving full ownership to local communities should not be main concern currently in Bereku woodland. Instead efforts have to be focused more on enhancing institutional capacity and clearly define resources right, including village land tenure systems.

Bereku woodland being surrounded by more than five villages and all depending on the woodland resource for their livelihoods, unclear tenure and resource right might cause dispute among the villages in the future. Although the socio-political, human and economic benefits have been revealed at village levels, more strengthening of institutional capacity could be necessary. This should take precedence to avoid possible domination of few elites who might use the echo of local communities to exploit the woodland resources. It is also worthy to note that Bereku woodland have potential catchment role in Babati district apart from significant biodiversity value. Therefore require close supervision and technical management to enhance its ecological role while boosting local livelihoods.

The practising joint forest management regime has defined rights and responsibilities for the participating villages. The woodland resource ownership remained on the hands of government and the communities shared only the management responsibilities and the accrued benefits. Contrarily to community based management style, where the resource ownership and management responsibilities are solemnly tackled by the local communities (Wily and Dewees, 2001).

The study revealed significant role the woodland resources have to the overall household's annual livelihoods. The woodland is almost the second livelihood source after agriculture which is major occupation by households. It is therefore, fundamental in boosting local community livelihoods and backbone for their existence in the area. The woodland seems to compliment the low agricultural production due to aridity and acidity characteristic of miombo soils and decreased livestock from tsetse fly infestation and limited grazing land.

The significance of miombo woodlands to local livelihoods are comparable throughout Miombo regions (Strömquist and Backeus, 2009; Campbell et al., 2007; Simonsson, 2004; Cavendish, 2002; Luoga et al., 2000). The finding also is comparable to the argument by Sunderlin et al., (2005), that forest products is not primary source of livelihoods but is a complimentary to others. However, this should not be generalized because the value and function of forest or woodland products might be influenced by spatial and temporal circumstances facing the households. The products can act as safety net to cope in time of adversity (McSweeny, 2004) and therefore act as primary source of livelihoods.

Nonetheless, the observed local participation and awareness on various management arrangements such as attending meetings for woodland matters, forest patrol operations and prevention of woodland fire incidences were fascinating. The management has opened channels for local community to communicate their priorities to the government decision makers. In addition this improved government and people's relationship in conservation and development arenas.

The study revealed increased access to products and services from the woodland which was essential for community well-being as a result of practised management. The products included fuel wood, construction materials, environmental goods and services, food materials and medicine. There were no remarkable differences in perception across studied villages. However, as general tendency female headed households were outstanding in thatching grasses, vegetables including mushrooms potentials. Moreover, the respondents have associated the well managed Bereku woodland with improved agricultural productivity through controlling soil erosion, enhancing hydrological cycle and increased rainfall, which is also comparable to the observations made elsewhere (Clarke et al., 1996).

Woodland stocking and regeneration potentials

The observed woodland stem density and high proportion of stems in the smallest size class (<10cm) implied that there was ongoing woodland tree species recruitment. This findings supported by the observed diameter class distribution of inverse J-shaped curve (negative exponential) indicating woodland is vigorously growing. The result is comparable to De iocourt's q factor procedure of stem frequencies decreasing with increase in diameter for natural forests (Goodburn and Lorimer, 1999). This indicated that the woodland tree species was recovering. Elsewhere, inverse J-distribution has been used as indicator of good regeneration and recruitment in woodland (Philip 1983, in Nduwamungu, 1996).

Despite the use of inverse J-distribution in natural forest stands as indicator for regeneration and therefore used as management tool (Isango, 2007), it should be taken together with other considerations. It is important to consider those factors which influence woodland tree species composition and growth patterns. For the case of miombo woodlands which do not have stable state, environmental factors such as soil conditions and rainfall pattern can influence woodland tree species composition (Campbel et al., 1996; Backeus et al., 2006) as known for dynamic factors like fire and succession status (Frost, 1996; Backeus et al., 2006). However, cautions are needed because little is still known about woodland vegetation structure and domination in relation to edaphic influences (Cambpell et al., 1996).

The observed stocking, mean basal area and mean volume, were comparable with other studies done in Tanzania (Nduwamungu, 1996; Backeus et al., 2006; Isango, 2007). There were considerable high number of small trees and low number of trees from large diameter (>20cm) class in Bereku woodland. Low number of large diameter trees can be explained from the over exploitation of the woodland before the current management regime. The past over exploitation exerted enormous disturbances in the woodland whilst the current management regime sought as mitigation. Existing management are likely the key to the recovery of woodland as shown by domination of juvenile tree species. Elsewhere disturbances in miombo woodlands reported to be the cause of increased regeneration potential (Ghermandi et al., 2004; Reinhart and Mengers, 2004). This also implies that miombo woodlands have high resilience capacity after temporary disturbances.

Miombo woodland trees invest large resources in different kinds of stress adaptation (e.g. drought, nutrient poor soil and fire), which provide security during catastrophic events (Wiegand et al., 2006). Normally the woodland tree density increases with increasing rainfall and moisture availability in the soil (Frost, 1996). But the presence of seasonal water logging and late fires may reduce the tree components and increase the herbaceous components which in turn reduce the stocking density of the woodland.

Bereku woodland tree species diversity

The observed number of woodland tree species, family and genera as well as diversity indices revealed significant high tree species diversity in Bereku woodland. The results are comparable to other miombo woodlands of Tanzania and elsewhere. For example this study was able to identify about 87 woodland tree species within 40 sample plots covering 1,495.4 ha. Similarly, most of Tanzanian miombo woodland has number of tree species ranging from 79-95 and few cases up to 102 species (Isango, 2007). Backeus et al., (2006) identified 86 species, Malimbwi et al., (1998) 95 species and Luoga (2000) 79 species. The trend provide clear picture of tree species composition in miombo woodland of Tanzania.

The findings based on calculated Shannon diversity index (H') attracted more attention on Bereku woodland tree species diversity. According to Isango (2007), Tanzanian miombo woodlands has Shannon index ranging from 1 to 2.29. This disagree from the observed Shannon diversity index in this study (3.8), which indicated more tree species diversity in Bereku woodland than other miombo woodlands of Tanzania. Similar tendency was observed by Nduwamungu (1996), who found Shannon diversity index of 3.7 for Kitulangharo miombo woodland of Morogoro, Tanzania which was recovering from disturbance. It likely imply that miombo woodland recovering from temporary disturbance create more tree species diversity that others. The study provides interesting findings, because the extent of tree species diversity in the woodland implies more ecosystem resilience capacity (Kohli et al., 1996). Particularly, Shannon diversity index, increases with the number of species in the community and in practice, for biological communities this index does not exceed 5.0 (Krebs, 1989).

The finding was likely associated with high regeneration potential observed in Bereku woodland. Regeneration has enabled re-colonization of previous threatened tree species in the area, for example *Pterocarpus angolensis* and *Dalbergia melanoxylon* among others which where locally extinct. Moreover, the observed higher number of tree species from genus *Combretum* indicated the woodland was previous disturbed, because species from this genus have characteristic of dominating the previous disturbed miombo woodlands.

Implications to sustainable woodland management

The important challenges in managing miombo woodlands sustainable are trying to make them socio-economically and ecologically viable. Participatory woodland management has been driven by the government in response to conservation problems (Wily and Dewees, 2001). The management regime can be a way of forestalling community pressure on protected forests (FAO, 2003). But there still questions whether local people in different context are genuinely conferred rights to jointly manage resources with government and which right were previously disenfranchised (Murombedzi, 2000; Dzingirai, 2003). However, the rights are shaped by *de jule* legal provisions and access is concerned with the *de facto* situation on the ground and underlying factors shaping it (Lund and Treue, 2008).

The results from this study have found that, participatory management practiced in Bereku woodland provided room for sustainable management of woodland resources in different respects. From existing policy framework which empower local community to co-manage the woodland and implement management activities based on local management plan while improving access to socio-economic returns. Implicitly, the sustainability can be signified also from established structural aspects, such as village bylaws and effective management committees which might increase accountability in woodland management with outcome on improving local livelihoods. The practised management regime seemed to offer significant returns either in cash, consumptive use or indirect use synergies and hence poses an opportunity to meet both developmental and conservation goals. This is comparable to Walters et al., (2008) and Kareiva et al., (2008) who reported that conservation can enhance economic development because un-degraded ecosystems supply valuable goods and services.

Conclusion and recommendations

Conclusion

Enabling local community participation in management is a key to stop alarming degradation in the Miombo woodlands. This is a win-win situation; the woodland is better protected and the local people have better access to the woodland resources they need for their own welfare and survival. The observed status of Bereku miombo woodland tree species diversity and the results from socio-economic study are promising to enhance woodland tree species and local livelihoods. Despite the lack of comparative data from the past management and local livelihoods history, a snapshot from this study have found joint forest management practised is likely to enhance miombo woodland tree species diversity and resilience. It also enhances access to wide varieties of products and services beneficial to local communities. The woodland offer returns either in cash, consumptive use, to indirect use synergies which act as motivation for conservation. The study provided bench mark information which might be useful to support sustainable management of Miombo woodlands and local livelihood improvement, in Babati district and elsewhere.

Recommendations

Even though socio-economic benefits and woodland tree species diversity have shown promising results through joint forest management regime, more efforts still are needed to increase tangible benefits to the household level. This can be done through encouragement of alternative income generation activities such as supporting household agricultural production, beekeeping projects, agroforestry and value adding to the woodland and agricultural products. At village level, the findings suggest strengthening of local institutional capacity to implement locally based goals and objectives as well as to negotiate better benefits from conservation. However intensive ecological and livelihood study to track the trend of change over time is recommendable. This can be useful for comparing performance and monitoring of the woodland ecosystem, in terms of tree species diversity, dynamics, stocking and local livelihoods at different periods.

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Appendix 1: Household questionnaire

Part I: Factual information

1.1 Questionnaire number ....Name of Enumerator..........................
1.2 Village...
1.3 Date...
1.4 District...
1.5 Name of Respondent...
1.6 Age...
1.7 Sex...
1.8 Educational level...
1.9 Occupation..
1.10 Total farm size (ha)...
1.11 Marital status:-
a. Single ( )
b. Married ( )
c. Separated ( )
d. Divorced ( )
e. Widowed ( )
1.12 Household composition

Age	Number		
	Male	Female	Total
1. Up to 15 years			
2.16- 30 years			
3. 31- 45 years			
4. 46- 61 years			
5. 62 and above			

PART 2: Woodland biodiversity management regimes for local livelihood.

2.1 Is there any miombo woodland forest around your village?
a.YES ( )
b.NO ( )
2.2 If yes, who owns and manage it?
a. Central government owned and management only.
b. Local government owned and management only
c. Owned by government and managed jointly by local community through JFM
d. Owned by local community and managed by CBFM
e. Don't know
2.3 When did this management regime started in Bereku woodland biodiversity reserve?

2.4 What was the condition/status of woodland biodiversity before this regime?

a. Very degraded ( )
b. Moderately degraded ( )
c. Slightly degraded ( )
d. Not degraded at all ( )
e. I have no idea ( )

2.5 If it was degraded, what activities led to these degradations?
a. Frequently occurred bush fire from various causes ( )
b. Over harvesting and grazing dominated in the woodland ( )
c. Encroachment for shifting cultivation and settlements ( )
d. Intensive and unregulated fire wood and charcoal production ( )
e. All of the above were common phenomenon in Bereku woodland ( )

2.6 Can you claim that after co-management (JFM) regime the condition of the woodland biodiversity have been improved?
a. YES ( )
b. NO ( )

2.7 If yes, what are the indicators of the improvement?
a. The woodland growing stock is dense and species regenerate vigorously
b.Iligal activities i.e grazing, cutting, encroachment and fire are totally controlled
c. Both a and b are true
d. Others, please specify ....

2.8 What specific activities do you perform to attain this improvement?
a . Effective protection i.e. intensive patrol and boundary demarcation ( )
B.Woodland management operations are jointly conducted ( )
c. Local people are fulfing their need from the woodland in a regulated manner ( )
d. Others, please specify ( )
e. Dont know ( )

2.9 How do you participate in woodland management activities?

2.10 Are you happy with the current woodland management regime?
a. Very happy, no need for improvement ( )
b. Somehow happy, need some more improvement ( )

c. Not happy at all, need major improvement
( )
2.11 If the answer is b/c what do you need to be improved or change
a. More incentives/Revenue to village
( )
b. More access and control over resources by local
( )
c. Local institutions empowerments
( )
d. More communication, transparency and accountability
( )
e. All of the above are needed
( )

PART 3: Socio-economic synergies in woodland biodiversity

3.1 Is this woodland biodiversity important for your livelihood support?
a. YES
b. NO

3.2 If YES, please rank according to important in livelihood support beneficial at household level
a. Fuel wood energy
b. Medicinal
c. Construction materials
d. fodder
e. Food and fruits...................
f. beekeeping activities
h. spiritual and cultural services
i. Environmental goods and services.

3.3 Does this management practice give you a room to access this livelihood support?
a. Yes
b. No
3.4 If yes, Please explain how?
3.5 Do you sell some of the collected woodland biodiversity produce?
a.YES ( )
b. NO ()

3.6 If yes, please estimate how much can you get per month in total.............................

3.7 What is the most important tree species utilized to support your household needs for
a. medicinal........................,.................................,................,
b. Construction................................,.............................,...........................,
c. Fuel wood................,.......................................,...............................

d. Food/ fruits.......................,.................................,...........

3.8 What other sources of your household livelihoods apart from woodland biodiversity?
a. Farming and livestock keeping
b. Farming and small scale busness
c. Salary and farming
d. Casual wage and farming
e. Other sources please specify......
3.9 Are there any other benefits accrued from the woodland biodiversity management at village level?
a. YES
b. No
c. I have no idea

3.10 If yes, please mention these benefits at the village level.............,....................
3.1 1 Are there any woodland biodiversity revenue/benefits sharing mechanism between village and government?
a. YES
b. NO
c. I don't know
3.11 If yes Please explains

. **THANK YOU/ASANTE SANA**

Appendix 2: Checklist for the focused group discussion

1. Type of woodland biodiversity management regime?

2. People's involvement in woodland biodiversity management

3. Benefits Households and village get from management regime

4. What are the conditions of miombo woodland biodiversity in your village?

5. How was the situation of woodland biodiversity and local livelihoods before the Commencement of this regime?

6. Woodland biodiversity and disturbance activities i.e. fire, encroachments etc

7. Miombo woodland biodiversity management, gender and empowerments Mechanisms

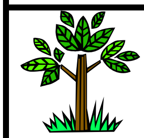
8. Tree species most exploited from the reserve

9. Threats to woodland biodiversity management and local livelihoods

10. The state of tree species diversity, regeneration and ecosystem dynamics

11. Possible interventions to enhance woodland biodiversity and improve local Livelihoods

Appendix 3: Woodland tree species survey, sample plot field form

(1)Form number................. (2) Recorder... Date................................							
NS	Scientific name of species	Local name	DBH (cm)	NS	Scientific name of species	Local name	DBH (cm)
							

Appendix 4: List of individual tree species (ni) their scientific, local and family names as identified in Bereku woodland

Spp Code	(ni)	Scientific Name	Local Name*	Family
1	15	*Acacia sp*	kambale	Mimosaceae
2	17	*Albizia petersiana*	Msaamaji	Caesalpiniaceae
3	18	*Albizia versicolor* Welw.ex Oliver	Moi	Caesalpiniaceae
4	4	*Allophyllus sp*	Ama-aanta	Spindaceae
5	12	*Annona senegalensis* Pers.	Mtomokwe	Annonaceae
6	29	*Azanza gareckiana* (F.Hoffm.) Exell & Hillcoat	Thogi	Malvaceae
7	5	*Brachiari brizantha*	Mpangwe	Poaceae
8	4	*Brachystegia glausences* Burtt Davy & Hutch	Mguji	Caesalpiniaceae
9	104	*Brachystegia spiciformis* Benth	Nafumo	Caesalpiniaceae
10	126	*Brachystegia microphylla* Harms	Hhewasi	Caesalpiniaceae
11	21	*Brachystegia utilis* Burtt Davy & Hutch	Mufumbo	Caesalpiniaceae
12	1	*Bridelia canthratica*	Tsarmo	Eurphobiaceae
13	7	*Bridelia micranthra*	Isalmo	Eurphobiaceae
14	3	*Canthium burtii*	Kiviruviru	Rubiaceae
15	14	*Carissa edulis*	Wahawi	Apocynaceae
16	6	*Cassipourea mollis*	Mube	Rhizophoraceae
17	13	*Clausina anisata*	Meetlakwi	Rutaceae
18	16	*Combretum ceriseya* Wall	Mlama gombe	Combretaceae
19	9	*Combretum fragrans* F.Hoffm	Mgombogombo	Combretaceae
20	19	*Combretum molle* R.Br.ex G .Don	Mototi	Combretaceae
21	7	*Combretum stuhlmanii* Engl.	Mulama	Combretaceae
22	12	*Combretum zeyheri* Sonder	Mulama	Combretaceae
23	8	*Commiphora eminii*	Madawiri	Burseraceae
24	7	*Commiphora mossambicansis*	Intiwi	Burseraceae
25	6	*Crossopteryx febrifuga* Benth.	Mdumwa	Rubiaceae
26	22	*Cussonia kirkii*	Mnaneh	Araliaceae
27	18	*Dalbergia boehmii* Taub	Menday	Papilionaceae
28	6	*Dalbergia melanoxylon* Guill & Perr	Tamumu	Papilionaceae
29	7	*Dalbergia nitudila* Welw.ex Baker	Guadi	Papilionaceae
30	4	*Deinbolia kilimanidscharica*		Spindaceae
31	3	*Dichrostachys cinerea* (L.) Wight & Arn	Gewawu	Mimosaceae

32	4	*Diospyros kirkii* Hiern	Kharkhantu	Ebnaceae
33	11	*Dodonea vescosa*	Berimi	Spindaceae
34	3	*Entada abyssinica* Steud.ex A.Rich.	Msaningala	Caesalpiniaceae
35	7	*Erythrina abyssinica* Lam	Angal	Papilionaceae
36	3	*Erythrina caffra*	Qanguzi	Papilionaceae
37	4	*Euclea divonorum*	Sinyanyi	Ebnaceae
38	3	*Eurphobia candelabrum*	Mwasa	Eurphobiaceae
39	5	*Faurea rochetiana*	Kakta	Protaceae
40	5	*Glycine wightii*	Sa-aam	Papilionaceae
41	3	*Indigofera rhynchocarpus* Less	Amaari	Papilionaceae
42	61	*Julbernardia globiflora* (Benth.) Troupin	Hewasi	Caesalpiniaceae
43	6	*Kigelia africana* (Lam.) Benth	Dati	Bignoniaceae
44	2	*Lannea humilis*	Intiwi	Anacardiaceae
45	5	*Lannea schimperi* Engl.	Tsarmai	Anacardiaceae
46	3	*Maerua angolensis*	Mutungulu	Capparaceae
47	6	*Manilkara sp*	Hiiti	Spotaceae
48	5	*Markhamia acuminata* K. Schum	Mtalawanda	Bignoniaceae
49	7	*Markhamia obtusifolia*	Itunene	Bignoniaceae
50	7	*Maytenus acuminata*	Ako-awak	Celastraceae
51	5	*Maytenus angolensis* Exell & Mendonca	Mummi	Celastraceae
52	5	*Ochna holstii* Engl.	Flamno	Ochnaceae
53	5	*Osyris lanceolata*	Kipaa-tu	Santalaceae
54	6	*Oxyanthus speciosus*	Muvabahi	Rubiaceae
55	2	*Ozoroa obovata*	Burthi	Anacardiaceae
56	5	*Parinari curetifolia*	Mafaa	Rosaceae
57	6	*Pavetta dolichantha*	Naleechan	Rubiaceae
58	8	*Pavetta schumanniana*	Uluahhoki	Rubiaceae
59	5	*Phyllanthus sp*	Mubuntuwa	Eurphobiaceae
60	4	*Piliostigima thonningii*	Galapi	Caesalpiniaceae
61	2	*Pleurostylia africana* Loes	Da-aatenimo	Celastraceae
62	3	*Protea gaguedi*		Protaceae
63	2	*Pseudolachnostylis maprouneifolia*	Ghaghari	Eurphobiaceae
64	7	*Psorospermum febrifuga*	Goroghori	Clusiaceae
65	14	*Pterocarpus tinctorus*		Papilionaceae
66	12	*Rauvofia caffra*	Hareie	Apocynaceae
67	3	*Rhus longipes* Engl.	Datei	Anacardiaceae
68	5	*Rhus natalensis* Bernh	Sirongi	Anacardiaceae
69	3	*Schrebera alata* Welw.	Pararumo	Oleaceae
70	3	*Schrebera trichoclada* Welw	Kiseresere	Oleaceae

71	10	*Sclerocarya birrea* (A.Rich.) Hochst.	Muaangu	Anacardiaceae
72	6	*Senna obtusifolia*		Caesalpiniaceae
73	19	*Senna septemfirionalis*		Caesalpiniaceae
74	4	*Strychnos innocua* Delile	Mkomu	Loganiaceae
75	12	*Strychnos potatorum*	Itoto	Loganiaceae
76	5	*Tarenna graveolens*	Songi	Rubiaceae
77	4	*Thylachium africanum*		Capparaceae
78	5	*Vangueria infausta* Burch.	Barangu	Rubiaceae
79	7	*Vangueropsis lanciflora*		Rubiaceae
80	2	*Vernonia amygdalina*	Baraii	Asteraceae
81	4	*Vernonia poskeana*	Pungani	Asteraceae
82	8	*Vitex doniana*	Mfulu	Verbenaceae
83	9	*Vitex mombassae* Vatke	Mchambali	Verbenaceae
84	6	*Ximenia americana*	Mtundwe	Olacaceae
85	2	*Ximenia caffra* Sonder	Mjengu	Olacaceae
86	7	*Zanha africana* (Radlk.) Exell	Mnughumo	Spindaceae
87	4	*Zizyphus mucronata* Willd	Ghal-landi	Rhamnaceae
Total	912	Genus=63		37

*Local names are Iraqw, Gorowa, Barabaign, Gogo and or Nyatulu languages, spoken in Babati

Appendix 5: Ecological parameters for identified woody species in Bereku miombo woodland

Spp Code	ni	Freq.	Rel.fr	pi	pi*lnpi	RDO	RD	IVI	SDI
1	15	7	1.241	0.016	0.068	1.012	1.645	1.299	0.920
2	17	7	1.241	0.019	0.074	0.393	1.864	1.166	0.892
3	18	12	2.128	0.020	0.077	0.483	1.974	1.528	0.879
4	4	3	0.532	0.004	0.024	0.325	0.439	0.432	1.216
5	12	9	1.596	0.013	0.057	0.551	1.316	1.154	0.970
6	29	12	2.128	0.032	0.110	1.782	3.180	2.363	0.772
7	5	3	0.532	0.005	0.029	0.619	0.548	0.566	1.166
8	4	3	0.532	0.004	0.024	0.121	0.439	0.364	1.216
9	104	36	6.383	0.114	0.248	9.304	11.404	9.030	0.486
10	126	40	7.092	0.138	0.273	13.223	13.816	11.377	0.443
11	21	22	3.901	0.023	0.087	6.049	2.303	4.084	0.844
12	1	1	0.177	0.001	0.007	0.045	0.110	0.111	1.526
13	7	4	0.709	0.008	0.037	0.989	0.768	0.822	1.090
14	3	2	0.355	0.003	0.019	0.430	0.329	0.371	1.280
15	14	12	2.128	0.015	0.064	2.620	1.535	2.094	0.935
16	6	4	0.709	0.007	0.033	0.551	0.658	0.639	1.125
17	13	10	1.773	0.014	0.061	0.959	1.425	1.386	0.952
18	16	11	1.950	0.018	0.071	1.238	1.754	1.648	0.905
19	9	7	1.241	0.010	0.046	1.110	0.987	1.113	1.034
20	19	16	2.837	0.021	0.081	5.528	2.083	3.483	0.867
21	7	9	1.596	0.008	0.037	0.355	0.768	0.906	1.090
22	12	10	1.773	0.013	0.057	0.695	1.316	1.261	0.970
23	8	4	0.709	0.009	0.042	1.329	0.877	0.972	1.061
24	7	5	0.887	0.008	0.037	1.933	0.768	1.196	1.090
25	6	4	0.709	0.007	0.033	2.734	0.658	1.367	1.125
26	22	16	2.837	0.024	0.090	4.697	2.412	3.315	0.834
27	18	14	2.482	0.020	0.077	1.835	1.974	2.097	0.879
28	6	3	0.532	0.007	0.033	0.566	0.658	0.585	1.125
29	7	5	0.887	0.008	0.037	0.430	0.768	0.695	1.090
30	4	2	0.355	0.004	0.024	0.884	0.439	0.559	1.216
31	3	3	0.532	0.003	0.019	0.279	0.329	0.380	1.280
32	4	4	0.709	0.004	0.024	0.438	0.439	0.529	1.216
33	11	9	1.596	0.012	0.053	0.702	1.206	1.168	0.989
34	3	2	0.355	0.003	0.019	0.174	0.329	0.286	1.280
35	7	5	0.887	0.008	0.037	0.325	0.768	0.660	1.090

36	3	3	0.532	0.003	0.019	0.060	0.329	0.307	1.280
37	4	3	0.532	0.004	0.024	0.483	0.439	0.485	1.216
38	3	2	0.355	0.003	0.019	0.091	0.329	0.258	1.280
39	5	5	0.887	0.005	0.029	0.317	0.548	0.584	1.166
40	5	3	0.532	0.005	0.029	0.506	0.548	0.529	1.166
41	3	2	0.355	0.003	0.019	0.060	0.329	0.248	1.280
42	61	32	5.674	0.067	0.181	6.895	6.689	6.419	0.606
43	6	5	0.887	0.007	0.033	0.347	0.658	0.631	1.125
44	2	2	0.355	0.002	0.013	0.174	0.219	0.249	1.371
45	5	3	0.532	0.005	0.029	0.068	0.548	0.383	1.166
46	3	2	0.355	0.003	0.019	0.408	0.329	0.364	1.280
47	6	3	0.532	0.007	0.033	0.672	0.658	0.621	1.125
48	5	2	0.355	0.005	0.029	0.264	0.548	0.389	1.166
49	7	4	0.709	0.008	0.037	0.196	0.768	0.558	1.090
50	7	5	0.887	0.008	0.037	0.370	0.768	0.675	1.090
51	5	2	0.355	0.005	0.029	0.929	0.548	0.611	1.166
52	5	3	0.532	0.005	0.029	0.083	0.548	0.388	1.166
53	5	4	0.709	0.005	0.029	0.423	0.548	0.560	1.166
54	6	6	1.064	0.007	0.033	0.068	0.658	0.597	1.125
55	2	2	0.355	0.002	0.013	0.612	0.219	0.395	1.371
56	5	4	0.709	0.005	0.029	0.461	0.548	0.573	1.166
57	6	3	0.532	0.007	0.033	1.178	0.658	0.789	1.125
58	8	7	1.241	0.009	0.042	1.238	0.877	1.119	1.061
59	5	5	0.887	0.005	0.029	0.461	0.548	0.632	1.166
60	4	2	0.355	0.004	0.024	0.264	0.439	0.353	1.216
61	2	2	0.355	0.002	0.013	0.053	0.219	0.209	1.371
62	3	3	0.532	0.003	0.019	0.113	0.329	0.325	1.280
63	2	2	0.355	0.002	0.013	0.136	0.219	0.237	1.371
64	7	7	1.241	0.008	0.037	0.838	0.768	0.949	1.090
65	14	12	2.128	0.015	0.064	0.725	1.535	1.463	0.935
66	12	10	1.773	0.013	0.057	0.317	1.316	1.135	0.970
67	3	2	0.355	0.003	0.019	0.242	0.329	0.308	1.280
68	5	4	0.709	0.005	0.029	0.060	0.548	0.439	1.166
69	3	2	0.355	0.003	0.019	0.151	0.329	0.278	1.280
70	3	2	0.355	0.003	0.019	0.211	0.329	0.298	1.280
71	10	8	1.418	0.011	0.049	1.148	1.096	1.221	1.011
72	6	3	0.532	0.007	0.033	0.279	0.658	0.490	1.125
73	19	17	3.014	0.021	0.081	3.066	2.083	2.721	0.867
74	4	4	0.709	0.004	0.024	0.536	0.439	0.561	1.216
75	12	9	1.596	0.013	0.057	2.605	1.316	1.839	0.970
76	5	3	0.532	0.005	0.029	0.536	0.548	0.539	1.166

77	4	2	0.355	0.004	0.024	0.143	0.439	0.312	1.216
78	5	5	0.887	0.005	0.029	0.649	0.548	0.695	1.166
79	7	5	0.887	0.008	0.037	0.733	0.768	0.796	1.090
80	2	2	0.355	0.002	0.013	0.166	0.219	0.247	1.371
81	4	3	0.532	0.004	0.024	0.551	0.439	0.507	1.216
82	8	7	1.241	0.009	0.042	0.204	0.877	0.774	1.061
83	9	5	0.887	0.010	0.046	0.325	0.987	0.733	1.034
84	6	5	0.887	0.007	0.033	0.476	0.658	0.673	1.125
85	2	2	0.355	0.002	0.013	0.136	0.219	0.237	1.371
86	7	4	0.709	0.008	0.037	3.950	0.768	1.809	1.090
87	4	4	0.709	0.004	0.024	0.385	0.439	0.511	1.216
Total	**912**	**564**	**100**	**1**	**3.82791**	**100.00**	**100**	**100.00**	**96.3192**

Appendix 6: Stocking (number of stems per hectare i.e. N/ha) by plot

Plot No.	Diameter at Breast Height Classes			
	<10cm	20<10cm	>20cm	TOTAL
1	382	223	85	690
2	636	350	142	1128
3	509	446	127	1082
4	509	382	212	1103
5	636	64	113	813
6	509	159	127	796
7	636	96	142	873
8	763	318	127	1209
9	636	191	85	912
10	509	223	226	958
11	636	255	71	962
12	382	159	142	682
13	891	287	156	1333
14	382	382	255	1019
15	509	510	198	1217
16	382	287	113	782
17	636	350	170	1156
18	509	223	311	1043
19	509	191	71	771
20	382	382	170	934
21	763	159	113	1036
22	382	255	85	721
23	509	318	241	1068
24	1145	191	127	1464
25	254	382	212	849
26	763	127	113	1004
27	509	223	71	803
28	382	191	127	700
29	891	64	156	1110
30	1018	255	113	1386
31	636	287	71	994
32	636	350	99	1086
33	382	223	184	789
34	891	318	85	1294
35	382	255	127	764
36	382	191	156	728
37	636	96	85	817
38	891	414	226	1531

39	509	255	170	934
40	254	318	127	700
MEAN	579	259	143	981

Appendix 7: Distribution of basal area (Gm²/ha) and volume (Vm³/ha) by diameter classes and plot

PLOT NO.	<10CM		20<10CM		>20CM		TOTAL	
	G (m^2/ha)	V(m^3/ha)	G(m^2/ha)	V(m^3/ha)	G(m^2/ha)	V(m^3/ha)	G(m^2/ha)	V(m^3/ha)
1	1.077	6.587	3.940	20.095	4.169	21.098	9.186	47.780
2	1.795	10.221	6.191	29.641	6.949	32.736	14.935	72.598
3	1.436	8.436	7.879	36.472	6.254	29.901	15.569	74.809
4	1.436	8.436	6.754	31.944	10.423	46.395	18.613	86.775
5	1.795	10.221	1.126	6.842	5.559	27.020	8.480	44.083
6	1.436	8.436	2.814	15.046	6.254	29.901	10.504	53.382
7	1.795	10.221	1.688	9.697	6.949	32.736	10.432	52.654
8	2.154	11.956	5.628	27.308	6.254	29.901	14.036	69.165
9	1.795	10.221	3.377	17.600	4.169	21.098	9.341	48.918
10	1.436	8.436	3.940	20.095	11.118	49.043	16.494	77.573
11	1.795	10.221	4.502	22.540	3.474	18.036	9.772	50.797
12	1.077	6.587	2.814	15.046	6.949	32.736	10.840	54.369
13	2.513	13.651	5.065	24.943	7.644	35.533	15.222	74.126
14	1.077	6.587	6.754	31.944	12.508	54.271	20.338	92.802
15	1.436	8.436	9.005	40.911	9.728	43.722	20.169	93.069
16	1.077	6.587	5.065	24.943	5.559	27.020	11.701	58.550
17	1.795	10.221	6.191	29.641	8.339	38.294	16.324	78.155
18	1.436	8.436	3.940	20.095	15.287	64.493	20.663	93.024
19	1.436	8.436	3.377	17.600	3.474	18.036	8.287	44.072
20	1.077	6.587	6.754	31.944	8.339	38.294	16.169	76.825
21	2.154	11.956	2.814	15.046	5.559	27.020	10.527	54.022
22	1.077	6.587	4.502	22.540	4.169	21.098	9.749	50.225
23	1.436	8.436	5.628	27.308	11.813	51.667	18.877	87.412
24	3.231	16.944	3.377	17.600	6.254	29.901	12.862	64.444
25	0.718	4.648	6.754	31.944	10.423	46.395	17.895	82.987
26	2.154	11.956	2.251	12.418	5.559	27.020	9.964	51.394
27	1.436	8.436	3.940	20.095	3.474	18.036	8.850	46.567
28	1.077	6.587	3.377	17.600	6.254	29.901	10.708	54.087
29	2.513	13.651	1.126	6.842	7.644	35.533	11.282	56.025
30	2.872	15.312	4.502	22.540	5.559	27.020	12.933	64.872
31	1.795	10.221	5.065	24.943	3.474	18.036	10.335	53.200
32	1.795	10.221	6.191	29.641	4.864	24.089	12.850	63.950
33	1.077	6.587	3.940	20.095	9.033	41.023	14.050	67.704
34	2.513	13.651	5.628	27.308	4.169	21.098	12.310	62.057
35	1.077	6.587	4.502	22.540	6.254	29.901	11.833	59.027
36	1.077	6.587	3.377	17.600	7.644	35.533	12.097	59.719

37	1.795	10.221	1.688	9.697	4.169	21.098	7.653	41.015
38	2.513	13.651	7.316	34.220	11.118	49.043	20.947	96.914
39	1.436	8.436	4.502	22.540	8.339	38.294	14.277	69.270
40	0.718	4.648	5.628	27.308	6.254	29.901	12.600	61.857
MEAN	1.634	9.356	4.573	22.604	7.036	32.797	13.242	64.757

Appendix 8: Sketched map showing village management areas in Bereku woodland reserve (not to scale)