INFLUENCE OF FORESTLAND TENURE REGIMES ON FOREST RESOURCE CONDITION AND LIVELIHOODS IN BABATI DISTRICT, TANZANIA

BY

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ABSTRACT

Forestland tenure regime has wide ranging implications on resource condition and livelihoods of forest adjacent communities. Historically, state forestland tenure regime was dominant in Tanzania, but the current move is towards allocating forests on general land to villages. However, there is little information on the influence of forestland tenure on resource condition and livelihoods. This study aimed at analysing the influence of forestland tenure regimes on forest resource condition and livelihoods in Bereku and Haraa Forest Reserves and Riroda and Bubu Village land Forest Reserves in Babati District. Specifically the study assessed the influence of state and communal tenure regimes on vegetation cover changes, forest stocking, tree diversity, removals and livelihoods. Primary data were obtained through interpretation of satellite images, forest inventory and questionnaires. The results on forest vegetation cover classification between 1993 and 2009; showed that forests under state forestland tenure regime had a higher proportion of closed woodland than communal forestland tenure regime (83 and 84% against 74 and 68% in 1993). The annual rate of change from closed woodland to other vegetation classes was higher in communal forestland tenure regime (-9.3 and -6.1% against -1.1 and -0.1% between 1993 and 2000). The findings further revealed that number of stems were higher in state forestland tenure regime with a highest mean of 1134±256 against 1015±216 stems ha^{-1}. Likewise, basal area was higher in state forestland tenure (15.0±1.8 m^2ha^{-1} against 11.35±2.13 m^2ha^{-1}) compared to communal forestland tenure. Species diversity index H’ was higher in forests under state forestland tenure regime and the index of dominance D’ was low in state tenure regime indicating a stable structure in state forestland tenure. Disturbance level was higher in communal forestland tenure regime with a mean removal of 101±28 stems ha^{-1}. Access to natural capital was highest in communal forestland tenure regime. Forestland tenure regime was found to be one of the institutional factors constraining household dependence on forest income. Albeit other factors like location of the forest, agroforestry practice and income diversification, there was sufficient evidence to support the alternative hypotheses. The study recommends creation of buffer zone forests for villagers with limited user rights.

DECLARATION

I, **Cellina Lucas Mongo**, do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my original work and has neither been submitted nor concurrently being submitted for a degree award in any other institution

______________________ ____________

Cellina Lucas Mongo Date

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DEDICATION

This work is dedicated to my beloved parents Lucas Bernard Mongo and late Theresia Bagonga Mongo (may her soul rest in eternal peace), who sacrificed much and laid down the foundation for my education and to my beloved children Theresia and Lucas for whom education is vital to their lives.

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ABBREVIATIONS AND SYMBOLS

CBFM	Community Based Forest Management
CBNRM	Community Based Natural Resource Management
CFP	Catchment Forest Project
CFRs	Catchment Forest Reserves
DFID	Department for International Development
DHFs	Duru-Haitemba Village Forest Reserves
DPSIR	Drivers-Pressures-State-Impact-Response
ERDAS	Earth Resources Data Analysis System
ETM+	Enhanced Thematic mapper plus
FAO	Food and Agriculture Organisation of the United Nations
FBD	Forestry and Beekeeping Division
FLEGT	Forest Law Enforcement, Governance and Trade
FGD	Focus Group Discussion
GPS	Geographic Positioning System
ha	Hectare
IRG	International Resource Group
ITTO	International Tropical Timber Organization
JFM	Joint Forest Management
LAFRs	Local Authority Forest Reserves
MDGs	Millennium Development Goals
MLC	Maximum Likelihood Classifier
MIR	Mid Infra-red Reflectance
MNRT	Ministry of Natural Resources and Tourism
NAFORMA	National Forestry Resources Monitoring and Assessment

NFRs	National Forests Reserves
NIR	Near Infra-red Reflectance
PAs	Protected Areas
PALI	Participatory Assessment of Livelihood Issues and Impact
PFM	Participatory Forest Management
PRA	Participatory Rural Appraisal
PRSs	Poverty Reduction Strategies
REDD	Reducing Emissions from Deforestation and Degradation
REPOA	Research on Poverty Alleviation
RRI	Rights and Resources Initiative
SACCOs	Savings and Credit Cooperatives
SFM	Sustainable Forest Management
SLA	Sustainable Livelihood Approaches
SUA	Sokoine University of Agriculture
TM	Thematic Mapper
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VFR	Village land Forest Reserve
VNRC	Village Natural Resource Committee

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

1.1.1 Forest resources and tenure status

The world has approximately 4 billion ha of forests, covering about 30% of the land area (FAO, 2007a). In the 30 most forested countries in the world, 74.3% of the forests are publicly owned under central governments (Sunderlin *et al*., 2008). Most of Africa's forest estate (95%) is under the jurisdiction of either national or local governments (FAO, 2007b; Romano, 2007). Rights and Resources Initiative (RRI) (2009) reports tenure status of 14 most forested countries in Africa to be 97.9% as public forestland managed directly by central governments.

Tanzania has about 33.5 million ha of forested land; within the following tenure categories: Forest reserves under state tenure are about 14.5 million ha which constitute about 40% of the total forest estate; these include national and local authority forest reserves. Another tenure category is communal which includes forests on village land which covers about 2 million ha whereas forests on general land cover an area of approximately 17 million ha (URT, 1998; URT, 2001; URT 2008; Zahabu and Malimbwi, 2008; FAO, 2010). Recent studies done by NAFORMA have shown that most of the land under general land has been included in the respective villages (NAFORMA, 2013). Forest resources in Tanzania, have for many decades been controlled by the state characterized by central decision-making (Ylhäisi, 2003; Shahbaz *et al*., 2008). This type of management did not involve local communities and mostly was applied in gazetted forest reserves, which accounted for 30% of total land area. The remaining 70% are in village and general lands with little de facto protection (Luoga *et al*., 2005).

There is an increasing awareness that insecure tenure is a primary factor to forest degradation (Talwar and Ghate, 2004). This insecurity weakens sound forest management, for without secure tenure and legal status, communities have few incentives to invest in managing and protecting forest resources (White and Martin, 2002). Clarification of tenure rights is a fundamental component of forest-based approaches to mitigating climate change; hence, the reasons for giving serious attention to the issue of forestland tenure are now more compelling than ever (Romano and Reeb, 2006). Besides, understanding forestland tenure issues is essential to promote sustainable use of forest resources and formulate satisfactory policies (FAO, 2011). Larson *et al*. (2008) concluded that better forest condition could be achieved through an enabling policy and legal framework that safeguard community tenure rights. However, forest policies in developing countries face many challenges which can be met by vigorous social science research (Vincent, 2009). Researches will provide explanations for the reasons of successes and failures in various attempted forestry initiatives.

1.1.2 The role of forests in peoples' livelihood

Forests play a vital role in the lives of forest adjacent communities, which for generations have utilized the resources to meet their ecological and subsistence needs (FAO, 2006a; Larson *et al*., 2008). As population increased, livelihood pressure led to over exploitation, hence a threat to forest quality (Chileshe, 2005; FAO, 2006a). Apart from population increase, another principal factor affecting the way in which forest resources are used and managed is forestland tenure (Talwar and Ghate, 2004; FAO, 2006b).

Sustainable forest management requires conservation and maintaining forest cover. However, increasing levels of anthropogenic disturbances have increased tremendous pressure on the forests (Mishra *et al*., 2004; Panigrahy *et al*., 2010). Forest disturbances which lead to degradation affects many social, economic, and ecological performances including loss in income to forest adjacent communities, soil erosion, loss of biodiversity and eventually global warming. Due to these enormous pressures on forests and the failure of centralised forestland regimes to prevent forest loss in many parts of the world, a strategy of people's participation emerged (Iddi, 2002; White and Martin, 2002; Wily, 2004; Matose, 2006; FAO, 2008; Semwal *et al*, 2010). In this strategy, communities with direct stake become part of decision making in forests under state and communal forestland tenure (Iddi, 2002; Wily, 2004). Currently, the world is experiencing a forestland tenure transition and this strategy has been embedded in revised forestry policies (Odera, 2004; Wily, 2004; Sunderlin *et al*., 2008).

Management of forests involve periodic inspections of structural stand parameters (Mishra *et al*., 2004). Since the traditional inventory strategies which include field observations are cost-intensive and time-consuming, remote sensing data collection seems to be attractive to complement and optimise forest inventories (Vohland *et al*., 2007). An accurate and continuously updated resource data is a prerequisite for the present-day forest ecosystem management (Panigrahy *et al*., 2010). Satellite-based sensors have the potential to detect, identify and map vegetation changes that are important to the forest ecosystem managers (Vohland *et al*., 2007; Panigrahy *et al*., 2010). The change maps can be used to support ecological research and socio-economic studies (Panigrahy *et al.,* 2010). Remotely sensed data combined with ground measurements are believed to contribute substantially to increasing quality and precision of estimates (Vohland *et al*., 2007; Kumar, 2011).

As institutional rearrangement gets under way, communities and governments increasingly debate about the incentives needed to support community roles in forest management. One of the incentives is the right to own the forest itself since secure tenure ensures protection of the resources (Wily, 2004). In any case, clarification of tenure rights is a crucial component of forest-based approaches to abate forest degradation (Nagendra, 2002a; Hayes, 2007; Sunderlin *et al*., 2008; RRI, 2009).

1.1.3 Forestland tenure in Tanzania

In order to understand forestland tenure system in Tanzania, it is important to understand the basic land tenure system. Before colonial era, landholding was based on customary laws of different tribes in the country. Under the Germans colonial era, all lands whether occupied or not, were regarded as crown land (MNRT, 2001; Lange, 2008; Zahabu *et al*, 2009; Myenzi, 2010). However, there was an exception to this general rule where private persons or communities could prove ownership. Settler's ownership was recognised but that law did not recognised traditional or customary users (Olenasha, 2005).

The British made few modifications and came up with a framework legislation in 1923, which regulated the German land tenure rules. Their main concern was to recognise and safeguard interests and titles to lands that were granted to immigrant settlers during the German period (Olenasha, 2005; Lange, 2008; Myenzi, 2010). This Land Ordinance was amended in 1928 to recognise customary law titles under the chiefs (Olenasha, 2005). The independent Tanzanian Government maintained the same colonial land policy and practices up to 1995 when some reforms were made (URT, 1995; MNRT, 2001). The fundamental principles of the new national land policy were incorporated in the new land laws - Land Act No.4 and Village Land Act No.5 passed by the Parliament in 1999, which have become operational as from May, 2001 (MNRT, 2001; Myenzi, 2010). These Acts encourages individuals, companies, communities and villages to acquire title deeds for customary land and forest occupation.

According to Lange (2008) and FAO (2008), Tanzania recognizes three categories of land tenure namely: reserved land, village land and general land. Reserved land under central government is set aside for special purposes such as forest reserves, game reserves, national parks, land reserved for highways and public utilities and other reserves, managed according to the defined parent laws for example forest reserves are managed according to the Forest Act. Village land includes all land within the boundaries of registered villages whereby village councils are given power to manage this land. The village land is divided into occupied land, communal land and future land. The communal land include grazing, pastures, forests or other areas with natural resources. General land is the land that is neither reserved nor in village land. The commissioner of lands manages it on behalf of the central government (Myenzi, 2010; FAO, 2008; Lange, 2008).

Forestland tenure has been categorized according to the land tenure of an area. Odera (2004) categorised three common types of forestland tenure in sub-Saharan Africa, these falls under: i) Forests on state land usually controlled by central government. ii) Forests on customary and trust lands managed with agreements by local councils on behalf of communities and iii) Forests on private land: owned by local or multinational companies. In Tanzania, forestland tenure falls within the defined land categories whereby (i) Reserved land under state tenure encompass national forests reserves (NFRs) managed centrally or by the local government authority known as local authority forest reserves (LAFRs) within district councils as production and protection forests. (ii) Village land includes village land forest reserves (VFRs), community forest reserves which are found on village land and are similar in all respects to VFRs, except that the village council delegates their management to a group of people within the community. Other forests found in village land include sacred and traditional forests often governed by clan or village elders and private forests. (iii) General land contains all forests on non-gazetted, non-village or non-reserved land and sometimes may contain private forests owned by individuals and companies (MNRT, 2001; FAO, 2008).

Babati District in this study with a long history of forestland tenure; is one of the earliest examples for implementing community based forest management in Tanzania. Some of the forests in Babati District, are under state tenure managed by central government (managed mainly for catchment purposes), private forests and forests under village forestlands whereas traditional forest reserves (Qaymanda) are found on the village land and in state forestland reserves. Forests on general land have been allocated to corresponding villages and processes are underway to make them village land forest reserves. The forests are source of rivers and other forest products consequently they are important for the livelihoods of the surrounding communities.

1.2 Problem Statement and Justification

1.2.1 Problem statement

Tanzania assumed state controlled forest resource tenure as a consequence of colonial legacy, whereby forest reserves were the main focus for protection and conservation of forestlands (MNRT, 2001). Forests and woodlands on general lands were mainly open access; hence, the resources were and still are available to anyone and therefore unlikely to elicit investment in maintenance or protection. Thus, these forests and woodlands are subject to conversion to other land uses such as shifting cultivation, and also suffer from repeated fires since security of tenure or formal user rights are lacking (Ellsworth and White, 2004; Odera, 2004; Abdallah and Monela, 2007).

Internal and external factors such as public pressure and economic realities influenced changes in the forestry sector (Wily, 2002; ITTO, 2006; FAO, 2007a). A major milestone was reached in 1998 with approval of the revised national forest policy, which completely reframed the state controlled and protectionist nature of forest policy in Tanzania. According to the new forest policy (URT, 1998), clear ownership of forests in general lands need to be defined. Generally, tenure security is accepted as being important for the development of the forest sector. Some conservation biologists argue that successful conservation is found under strict conservation to enable protection of forest habitats (Naughton-Treves, *et al*., 2005). Other studies compare strict government protection with other tenure arrangements and point out that management by local communities can be just as effective although all communities are not equally efficient (Wily, 2004; Nagendra, 2007).

Blomley and Ramadhani (2006) argued that, forest reserves on state land, while providing valuable services at the national and even international level, generate few concrete returns to villagers. In the review of forestland tenure in Tanzania, Akida and Blomley (2007) expressed their opinion that when forestland tenure is under community, group or individual levels, the potential for achieving the goals of improved livelihood and sustainable forest management is maximized. However, there is little information on how different tenure regimes have influenced forest resource condition and livelihoods of the adjacent communities. With the broad participatory forest management (PFM) policy objectives of rehabilitation and maintenance of forest quality, improved livelihoods for forest-dependent communities and improved local governance (MNRT, 2001); it is important to have empirical evidence as to whether forestland tenure regime matter in maximizing the three objectives.

Forests in Babati District as elsewhere in Tanzania have been faced with unrestricted grazing and uncontrolled forest harvesting as part of livelihood strategy (LAMP, 2002). Forests on state forestland tenure with high biodiversity and catchment value in Babati District are under co-management regime (Joint forest management - JFM) (e.g. Nou, Ufiome, Haraa and Bereku forests) and communities have been assisted to manage forests in general lands (falling under respective village lands, e.g. Duru-Haitemba village land Forest Reserves). Several studies have been conducted in different forests in Babati District (Chamshama and Nduwayezu, 2002; Malimbwi, 2003; Kajembe *et al.*, 2003a and Backlund, 2006) but none of these studies investigated the influence of forestland tenure regimes on forest resources and rural livelihoods. Therefore, this study intended to fill this knowledge gap by assessing the way forestland tenure regimes have influenced forest resource condition and livelihoods of the adjacent communities.

1.2.2 Justification

Global attention is focused on poverty reduction as articulated in the Millennium Development Goals (MDGs) and in the Poverty Reduction Strategies (PRSs) (Roe, 2003; Narain *et al.*, 2005; FAO, 2007b). Forests have been identified as one of the vehicles to improve the livelihoods of the rural poor (FAO, 2007b). Deforestation and forest degradation are becoming a major concern of the government and some attempts have been made at policy-making levels to reduce this trend. Policy-makers are aware of the important role being played by forests and they are faced with the challenge of identifying conservation strategies that favour livelihoods, while achieving conservation. However, assessment of past and ongoing strategies suggest that tenure is one of the root causes of poor performance in the forestry sector (Romano and Reeb, 2006; FAO, 2008; FAO, 2011). Forestland tenure has complex and wide ranging implications on resource condition and livelihoods of the adjacent communities. The current move in Tanzania is towards allocating forests on general land to villages (Wily, 2002; Blomley and Ramadhani, 2006; FAO, 2008). However, there is little information on the influence of forestland tenure on resource condition and rural livelihoods. With the broad PFM policy objectives (URT 1998); there is therefore a great need to improve understanding of the implications of forestland tenure and raise awareness of policy-makers, providing them with arguments and evidences that can lead to forestland tenure system reform.

This study on influence of forestland tenure regimes on forest resource condition and livelihoods is important in the process of reconciling the role of forests in providing local livelihoods and sustainable forest management. The findings are anticipated to form the basis for policy recommendations for forestland tenure reforms; especially on general lands due to the current shift of tenure from general land to village land in Tanzania. The results can also form a basis for study of changes as far as National Forestry Resources Monitoring and Assessment (NAFORMA) work is concerned. Babati District being the pioneer for community based forest management (CBFM) implementation with the first village managed forest reserves (Duru-Haitemba village forest reserves) was selected for the study.

1.3 Objectives of the Study

1.3.1 Overall objective

The overall objective of the study was to analyse the influence of forestland tenure regimes on forest resource condition and livelihoods in selected forests in Babati District, in order to support decisions in forestland tenure reforms for sustainable forest management.

1.3.2 Specific objectives

To meet the overall objective, the following specific objectives were addressed:

(i) To assess forest vegetation cover change in state and communal tenure regimes in the study area.

(ii) To compare forest stocking level and tree diversity in state and communal tenure regimes in the study area.

(iii) To assess forest disturbance levels and main causes of forest pressure in state and communal tenure regimes in the study area.

(iv) To determine the influence of state and communal tenure regimes on rural livelihoods in the study area.

1.3.3 Hypotheses

The following hypotheses were tested:

(i) H_o: Forests resource condition is not influenced by forestland tenure regimes and the alternative hypothesis

H_1: Forest resource condition is influenced by forestland tenure regimes.

(ii) H_o: Forest based livelihood is not influenced by forestland tenure regimes and the alternative

H_1: Forest based livelihood are influenced by forestland tenure regimes.

1.4 Conceptual Framework

A conceptual framework is a set of broad ideas and principles used to structure the research; it outlines possible means of action and presents a preferred approach. It is presented diagrammatically and/or in a narrative way (Smyth, 2004). In this study, the conceptual framework has been derived from the drivers-pressures-state-impact-response (DPSIR) framework (Tapio and Willamo, 2008). It is an interdisciplinary model used to analyze reasons for environmental problems, their characteristics, and ways to mitigate them. In this study, the framework has been modified to suit the situation of the study (Fig. 1). The driving force (the need) in this study is reforms in forestland tenure regime. At present tenure regime dictates management regime of forests and controls the way resources are being utilized by adjacent communities. Forests on state land are hypothesized to offer maximum protection of the resources while giving less in terms of livelihood provision; meanwhile forests on village land are hypothesized to offer maximum on livelihood provision and less protection of the resource. It is further hypothesised that different forces for livelihood sustenance (logging, commercial fire wood collection, charcoal making, grazing, annexing land for agriculture, and wild honey collection) are likely to create pressure (stress) on the resources in the corresponding tenure regimes. In due course, the status (condition) of the forest is subjected to change in terms of forest cover, stocking, diversity, disturbance level and the extent of livelihood provision. The status of the forest under different tenure regimes was the basis for developing analytical model for this study. It was further anticipated that forestland tenure would influence (affect) livelihood provision and the resource base whereby positive influence would lead to sustainability. On the other hand, it is important to have right information to bring about changes (response) in policy reforms and institutional rearrangements that will enhance decisions on appropriate tenure regime.

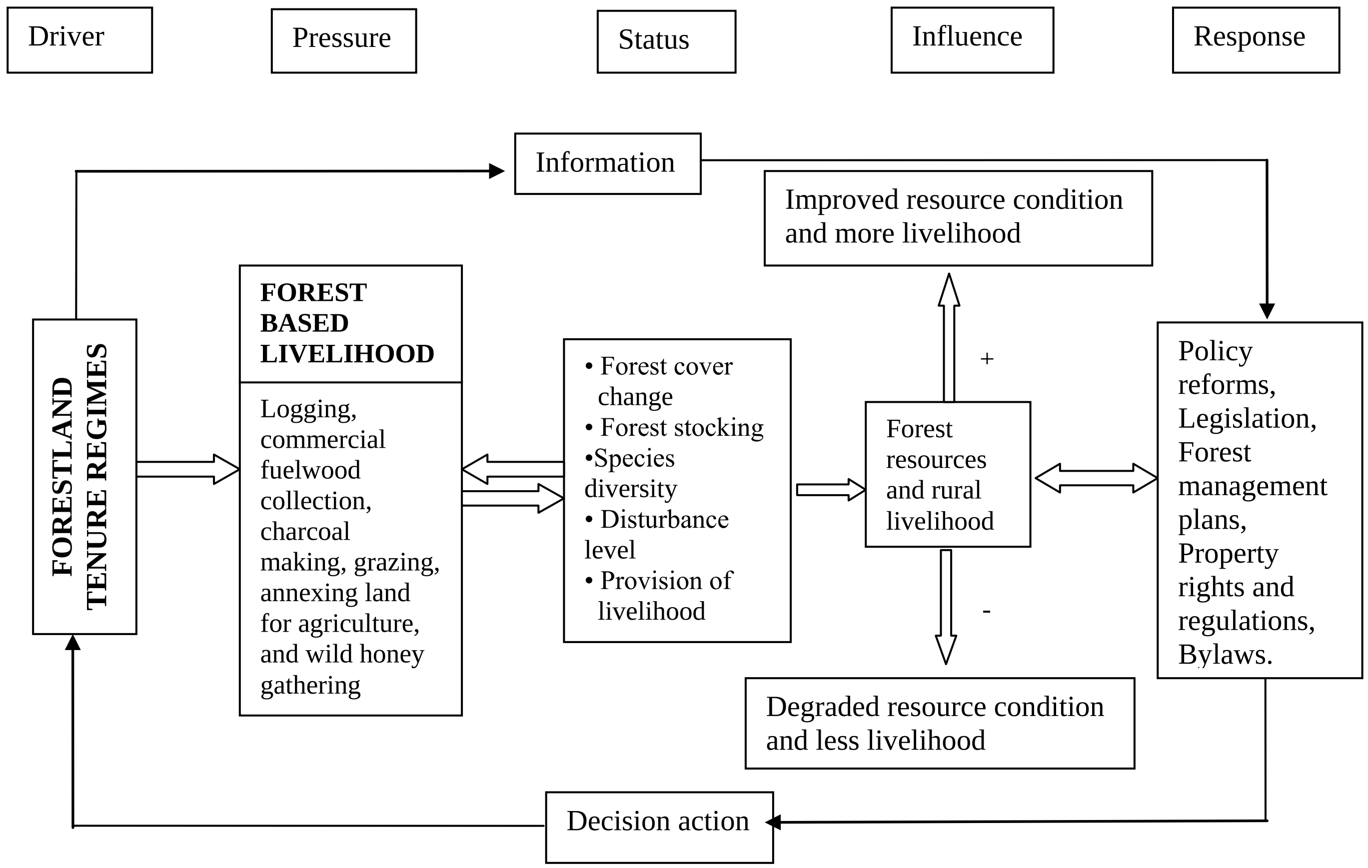

Figure 1: Conceptual framework for the study

Source: Modified from Tapio and Willamo, (2008).

1.5 Limitations of the Study

Some limitations were encountered during the study, including:

i) Reluctance to give information

Some of the key informants residing in villages near forests under state forestland tenure were not willing to give information on harvesting procedures and permits to collect forest products since it was regarded illegal. The same problem was encountered on household income due to the fact that matters related to cash income are regarded as private and sensitive. Most interviewed heads of households were unwilling to disclose their real household incomes. In most of the cases, there was a tendency of lowering the income hoping to get some form of aid from the researcher. These limitations were minimised through triangulation technique and the data obtained were sufficient to allow for the inference made from the study results.

ii) Poor recall memory by the respondents

In some cases, the respondents were getting difficulties in recalling the past when historical information was required. The shortfalls were reduced by breaking down the questions into manageable, meaningful and easily recalled components. Furthermore, this problem was reduced through additional information obtained from key informants, actual field observation and researcher’s experience and exposure in the study area.

iii) Difficulty in identifying some plant species

Some plant species were not easily identified in the field. However, this problem was resolved by collecting specimens for identification by a taxonomist at Olmotonyi Forest Training Institute, Arusha.

iv) Difficulty in obtaining image from the same season

Availability of cloud free images of the study area for the dry season (May-October) for all the three epochs (1993, 2000 and 2009) was not possible, as a consequence satellite images from different seasons were used, this might have contributed to inaccuracy in vegetation cover classification. This problem was resolved by crosschecking classified areas with ground truth points.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Background on Forestland Tenure and Property Rights

2.1.1 Forestland tenure definition and tenure coverage

Forestland tenure is the combination of legally or customarily defined forest ownership rights and arrangements for the management and use of forest resources (Romano, 2007). It determines who can use what resources, for how long and under what conditions (FAO, 2009b). Legally, tenure is a bundle of both rights and obligations: the rights to own, hold, manage, transfer or exploit resources and land, but also the obligation not to use these in a way that harms others (MNRT, 2001; Romano, 2007). These rights are fundamental to determine how forests will be protected or neglected. The rights are often, but not always, exclusive and secure only if others respect the protection of that stream benefits (Siry *et al*., 2009; Atzenhoffer, 2010).

Forestland tenure in the world is characterized mainly by public ownership with most forests under the direct control and management of the state (FAO, 2007b; FAO, 2008; Siry *et al*., 2009). This has been confirmed by the results of the survey of 17 countries that the tenure system in forestry remains chiefly dominated by the state (Romano and Reeb, 2006). The survey further clarified that at global level, the state retains management responsibilities in about 80% of public forests while private forests were recorded to be about 10% and communities between 4 and 7% (FAO, 2010). However, changes are taking place, in particular to locally rather than state-run forest management (Willy, 2002; Talwar and Ghate, 2004; Romano, 2007).

2.1.2 Forest land tenure regimes, definition and categories

Forest tenure regime is defined as a system of rights and duties characterizing the relationship of individuals to one another with respect to forest resources (Bromley and Cochrane 1994; Bromley, 2008). Resource tenure regimes evolved overtime to mediate conflicting interest among users (Bromley, 2008). In previous studies it was found that the uses of forests and other natural resources in general are regulated by tenure and management regimes (FAO, 2011).

Forest tenure regime, suggests social relations which provide a fairly consistent and stable pattern to govern behaviour on forest resource (Romano and Reeb, 2006; Bromley, 2008). In addition, tenure regime regulates the actual functioning of tenure in local situation (Bromley, 2008). There are many potential tenure regimes globally, and within each regime there are many possible results (Acharya *et al*., 2008; Barrow *et al*., 2008). Moreover, tenure regimes are changing as coping and adapting strategies, depending upon the needs of the community.

So far, the following tenure regimes (which are also property regimes) have been identified: (1) state-property; (2) private-property; (3) common-property; and (4) non-property (known as open access) (Bromley and Cochrane (1994); Barrow *et al*., 2008). State-property regime is whereby ownership, control and management rest in the state through various government agencies (Bromley and Cochrane, 1994). Individuals and groups may have user rights, but only with the approval of the administrative agency of the resource. Private property regime is whereby a range of discretions are open to the owner(s) and includes the right to control and transfer (Ostrom and Hess, 2007). Private property regime includes corporate property, which is administered by a group; similarly, marital property is often the joint property of the spouses (Ostrom and Hess, 2007; Bromley, 2008).

Common property regime is a shared resource use which at the most basic level is similar to private property in the sense that non-owners are excluded from use and decision making (Bromley and Cochrane 1994; Gibson *et al.*, 2005; Bromley, 2008). Along with this exclusionary similarity, it is also found that each of the co-owners in a common-property regime have duties and rights inside the regime. Open-access regimes lack any property rights; they represent situations of un-owned resources (Bromley and Cochrane 1994; Ostrom and Hess, 2007; Larson *et al*., 2008). Under open access, the first individual to make use becomes the beneficiary of streams of benefits arising from the resource (Bromley, 2008).

2.1.3 The rise of forestland tenure

Forests all over the world have been under diverse tenure regimes and communities adjacent to forests have been utilising the forests for many generations (Talwar and Ghate, 2004). Historically, customary tenure rights were the first ones to be implemented in many parts of the world (Ellsworth and White, 2004; RRI, 2009). The major drawback in customary tenure was lack of written principles; mainly the elders of the tribe understood them and it had no time limit (MNRT, 2001). Statutory tenure rights started in the colonial era, where the rights were controlled by the government and were granted to companies, individuals or associations, and were supported by documentary evidences such as title deeds or lease certificates (Chileshe, 2005; Lange, 2008; Myenzi, 2010). Right now, customary tenure is acknowledged as legitimate means of managing land relations, although with decision-making now supported by modern parameters of justice (Wily, 2002; Ellsworth and White, 2004; Myenzi, 2010).

The practice of modern forestland tenure and management had its roots in medieval Europe where land and forests were the properties of the lords of the manors as rulers (White and Martin, 2002: Larson and Puhlin, 2012). This tradition was transferred to many colonies making the independent governments the legally owners on most forests (*ibid*). Community claims to forest ownership are finally gaining momentum and acknowledged; marking a historic forestland tenure transition (IRG, 2000; Wily, 2002; White and Martin, 2002; Kajembe *et al*., 2003a; Sunderlin *et al*., 2008). Many governments are beginning to recognize the ownership of forest adjacent communities and to grant access to forests, however, these recent changes have not been adequately assessed (White and Martin, 2002; FAO, 2009a).

Recently, forestland tenure has raised the attention of the international community, particularly in the context of initiatives such as forest law enforcement, governance and trade (FLEGT) and efforts to reduce greenhouse gas emissions from deforestation and forest degradation (REDD) in contrary to land tenure issues which have been investigated and debated for a long time (FAO, 2009b). So far, limited information on forest ownership (public/private) and its implication for sustainable forest management is available (Siry *et al*., 2009). Forestland tenure importance is based on cultural survival for some communities and to others it is a structure of incentives that motivate protection of forests (FAO, 2009a; RRI, 2009).

2.1.4 Property rights and its significance in collective management

Property right is defined as a claim to a benefit stream while a property is said to be a right to a benefit stream (Bromley, 2008). Moreover, a property is considered as a social agreement between an individual and an item of value in relation to all other individuals (Bromley, 2008; Atzenhoffer, 2010). Property rights play a significant role in sustainable management of natural resources and have been regularly changing over time (Schlager and Ostrom, 1992). The changes are usually connected to exploitation and degradation of forests and biological diversity of forested lands (Bouriaud and Schmithüsen, 2005).

Property rights theory defines the nature of sanctioned human behaviour (norms of behaviour) which allows people the right to use resources within the 'class of non-prohibited uses' (Demsetz, 1967). Early debates on the property rights theory started with the well-known "tragedy of the common theory" presented by Hardin (1968). Under this theory, it was visualized that resources owned in common would eventually be overexploited. The theory speculated that when resources such as grazing land or forests are free to everyone, costs arising from their use and abuse can be passed on to others (Hardin, 1968; Demsetz, 1967, Sjaastad and Bromley, 2000). This theory discouraged collective action in natural resources management and forests being among them.

Several other studies (Rapoport and Chammah, 1965 cited by Soroos, 1994; Olson, 1965) had the same opinion as Hardin (1968). Whereby, in the game theory of the prisoner's dilemma, Rapoport and Chammah, 1965 cited by Soroos (1994) speculated that all stakeholders in a group would try to maximise their own benefit in the short term, but in the long term, the resource would be degraded. The game theory suggested that the group would need either coercion from outside (to enforce the rules), or change the tenure to a private property regime. The "Free riding" theory developed by Olson (1965) accounts on a situation where initially the benefits of collective goods will be available to all but individuals will base their decisions on self-interest. Like the prisoner's dilemma and the free riding theory, tragedy of the commons had a pessimistic view of the future of natural resources, implying that collective action is impossible. The only solution to secure resource tenure suggested by the earlier studies was nationalization or privatization of forests, ranges and other natural resources (Rapoport and Chammah, 1965 cited by Soroos, 1994; Olson, 1965; Hardin, 1968; Bromley and Cernea, 1989).

From the time of the publication of Hardin's articles of the 'Tragedy of the Commons' there has been an increasing debate on common pool resources, property rights, and resource degradation (Ostrom and Hess, 2007). A number of other studies have challenged the "tragedy of the commons" theory (Feeny *et al*., 1990; Gibson *et al*., 2005; Agrawal and Chhatre, 2006; Ostrom and Hess, 2007). According to these studies, common property and open access were treated as similar in the theory for a long time, which resulted into incorrect conclusion that collective ownership was also connected with over exploitation of natural resources as stated by Hardin (1968). These counter arguments to Hardin's analysis reached a conclusion that common property is a viable form of resource tenure (Bromley and Cernea, 1989; Feeny *et al*., 1990; Gibson *et al*., 2005; Agrawal and Chhatre, 2006; Ostrom and Hess, 2007). On the other hand, when property rights are well defined, users would take the consequences of their decisions into account, making it possible to structure the rights to natural resources.

2.1.5 Forest policy and legal framework for sustainable forest management

Forest policy is concerned with the manner in which forests should be managed to meet society's forest goods and services demand at national and global levels (Petersen and Sandhövel, 2001). The national policy together with the legal frameworks guide decision-making and constitute the basis for sustainable forest management (Dewees *et al*., 2010; FAO, 2010). Although respective governments pronounce the need for forest policies, usually it is a dynamic process based on participation and must balance the fates of people and forests (Petersen and Sandhövel, 2001, FAO, 2010). FAO (2010) further emphasised the need for frequent revision of forest policies for increased effectiveness.

In Tanzania, a forest policy issued in 1998 initiated community participation (under participatory forest management - PFM) in the management of reserved and non-reserved forestland (Petersen and Sandhövel, 2001; Iddi, 2002). PFM is a strategy to achieve sustainable forest management by encouraging the management or co-management of forest and woodland resources by the communities living closest to the resources (MNRT, 2006; Vyamana, 2009). PFM is a central strategy of Tanzania's Forest Policy (1998), Forest Act (2002) and National Forest Programme (2001) and has been facilitated by the enactment of other laws and policies that provide an enabling legal environment. These includes the Land Act No. 4 (1999) and the Village Land Act No.5 (1999), which all provides legal tenure rights and provisions at the grass-root level (Blomley and Ramadhani, 2006; Blomley and Iddi, 2009). Before the Forest Policy of 1998, there was no legal access to forest reserves by local communities.

In Tanzania, two forms of PFM are recognized including Joint Forest Management (JFM) and Community Based Forest Management (CBFM) – which differ in terms of forest ownership and cost/benefit flows (Hamza and Kimweri, 2007; Blomley and Ramadhani, 2006; Vyamana, 2009; Blomley and Iddi, 2009; Kajembe *et al*., 2009). In JFM, local communities are involved in the management and conservation of state forest reserves. It entails sharing forest cost/benefits and forest management responsibilities between the state and the communities. CBFM takes place on village land or private land, with the trees being owned and managed by the villagers through a Village Natural Resource Committee (VNRC) (Wily, 2002; Blomley and Ramadhani, 2006; Hamza and Kimweri, 2007; Blomley and Iddi, 2009; Kajembe *et al*., 2009; Vyamana, 2009).

2.1.6 Participatory forest management initiatives in Babati District

Tanzania established its first three community-owned and managed forest reserves in 1994 (Wily, 2002). These were among the forests that compose the Duru-Haitemba village forest reserves (DHF) of which Bubu and Riroda villages in this study belong. The DHF are a series of linked ridges of high woodland characterized by an open canopy of trees of usually medium height, interspersed with grassland (Malimbwi, 2003). These miombo woodlands are highly valued for products and services ranging from timber, fuel wood, catchment, grazing and medicinal plants.

CBFM initiatives in Duru-Haitemba village forest reserve (DHF) were a result of dissatisfaction by the local communities (Wily, 2002; Kajembe *et al*., 2003b). The decision to gazette DHF and withdraw it from the public sphere was highly contested by the local community (Wily, 2002; White and Martin, 2003). A conflict emerged and consequently, they deliberately exploited the woodlands as quickly as possible before gazetting, with the result that by 1994 the woodlands were heavily degraded (Kajembe *et al*., 2003b; White and Martin, 2003). By 1995, all 9000 ha of the DHF were under the management of the corresponding villages. By-laws were formulated and since then DHF management rules were continually modified and updated (Wily, 2002; Kajembe *et al*., 2003b).

JFM has been strongly promoted by the Forestry and Beekeeping Division (FBD) as a forest management strategy in montane catchment forests with high biodiversity values (MNRT, 2006). Traditionally, no extraction from Tanzania's Catchment Forest Reserves (CFRs) has been allowed (MNRT, 2003a; Vyamana, 2009). However, following recent changes, limited access is granted to adjacent communities (Petersen and Sandhövel, 2001; MNRT, 2003a). JFM process in Bereku and Haraa FRs was introduced in 2000 although the forests were gazetted in 1941 and 1970 respectively (Lovett and Pócs. 1993). After introduction of JFM the communities have been involved in the management of these state forest reserves based on forest management plans. Literally, the forest has been divided into village management areas, where each village has set up its own by-laws on how to protect and use the forest resources.

2.2 Forest Cover Change Concepts

2.2.1 Forest cover and its relationship to forest dependent communities

Forest cover is one of the types of land cover. A forest cover may consist of closed or open forest pattern with trees of different storeys and thick or open undergrowth (Neumann and Starlinger, 2001; Nagendra, 2002b; Namaalwa *et al*., 2007). As part of forest condition, forest cover provides the first indication of adequate or inadequate forest resources in a country or region (FAO, 2010; Ismail and Kamarudin, 2011). An adequate forest cover ensures high capacity production of goods and services from the forests including watersheds protection and maintenance of biological diversity without overlooking amenity and recreation (Kumar, 2011).

Forest adjacent communities have been linked to the forest due to their highly dependence on forest resources for their livelihoods. This has been observed since the hunting and gathering era to sedentary agriculture. Since then forests tend to become less dense and forest cover decreases due to increased population densities, higher market demands and changing types of forest use by local communities (Sunderlin *et al*., 2008; Harun *et al*., 2010; Kumar, 2011). Above all, developments in the forest areas have seen dramatic change on the forest ecosystem which has created many impacts on livelihoods of forest adjacent communities depending on them (Gautam *et al*., 2004). Sunderlin *et al*. (2008) had the opinion that, areas of poverty and forest cover extent overlap. Maintaining forest cover is important for people who gains livelihood from the forest (Naughton-Treves *et al*., 2005). Adequate or better forest cover can overcome vulnerability and is associated with better welfare of forest adjacent communities. Decreased forest cover has direct impact to important livelihood services of forest adjacent communities (Harun *et al*., 2010; Lugandu, 2010).

2.2.2 Forest cover change estimation

Monitoring forest cover is important in sustainable development and management of forest ecosystems (Çakir *et al*., 2008). There are different methods used in estimating and analyzing forest cover and cover changes. Remote sensing technologies have been found to facilitate the process (Gautam *et al*., 2004). Remote sensing provides an opportunity of examining vast areas at frequent intervals, and also has an advantage of detecting and delineating major changes (Couteron *et al*., 2005). Change detection is a method of identifying differences of a phenomenon by observing it at different epochs (Lu *et al*., 2004).

Forest cover conditions are not static; they are unstable due to constant changes that may be abrupt or gradual, from natural and/or anthropogenic forces (Hayes and Cohen, 2007). These forest cover changes are complex patterns ranging from simple degradation to total deforestation (Geist and Lambin, 2002). Information on the condition and change trends of forests is crucial to forest policy decisions and the data can act as early warning systems (Madoffe *et al*., 2006; Nagendra and Gokhale, 2008). On-time and accurate change detection provides a basis for improved understanding of relationships and interactions between forests and adjacent communities (Panigrahy *et al*., 2010).

Forest cover and change detection data are an important feature of forest inventory in which remote sensing technique play a role in keeping the inventory up-to-date (Pérez *et al*., 2006). From remotely sensed data, forests stand structure parameters can be retrieved whereby estimation on volume of the stand, biodiversity and carbon stocks can be done (Fuller *et al*., 1998; Tomppo *et al*., 2008). These stand structure parameters also provide spatial information on potential determinants of plant species distributions (Couteron *et al*., 2005).

2.2.3 Accuracy assessment in image analysis

Accuracy assessment is the process of estimating the accuracy of the classification in a map, by comparing the map with reference information believed to accurately reflect the true land-cover (Çakir *et al*., 2008). Sources of reference data include ground truthing, higher resolution satellite images and maps. Accuracy assessment is an important element of any land or vegetation cover classification derived from remotely sensed data, since some errors may occur due to thematic error, positional errors, land cover mixtures (mixed pixels) or human errors (Congalton, 2001). Accuracy assessments determine how useful the classified maps are to the user.

The most effective way to represent classification accuracy is through an error matrix. It is a square array of numbers laid out in rows and columns that express the number of sample units assigned to a particular category relative to the actual category as verified in the field (Congalton, 2001). The columns normally represent the reference data, while the rows indicate the classification generated from remotely sensed data. The common used indices for accuracy assessment are overall accuracy, producer's accuracy, user's accuracy and Kappa (κ) coefficient (Zãvoianu *et al*., 2004; Lu *et al*., 2004; 2008; Sullivan, 2008). It is useful for statistically measuring and visualizing image classification results (Congalton, 2001; Lu *et al*., 2004; Zãvoianu *et al*., 2004; Çakir *et al*., 2008).

The overall accuracy is the sum of correctly classified samples represented in percentage. Producer's and user's accuracies represent percent of individual class accuracies based on commission errors (including an area into a category when it does not belong to that category) and omission errors (exclusion of an area from the category to which it belongs) (Congalton, 2001, Çakir *et al*., 2008). The results of performing Kappa (κ) analysis, generates a K_{HAT} statistic that measures the difference between actual and chance (or random) agreement between the map and reference data (Congalton, 2001). Landis and Koch (1977) characterized the ranges for K_{HAT} statistic into three groups: a value greater than 0.80 represents strong agreement; a value between 0.40 and 0.80 represents moderate agreement and a value below 0.40 represents poor agreement. These indices are important to be able to use the information resulting from the spatial data analysis in some decision-making process.

2.2.4 Application of remote sensing technology in forest cover change assessment

Remote sensing technologies are widely used to monitor landscape and vegetation change in many parts of the world (McRoberts and Tomppo, 2007; Panigrahy *et al*., 2010). While the availability of extensive and timely images from various satellite sensors can assist in identifying the rates and patterns of deforestation, modelling techniques can evaluate the socioeconomic and biophysical forces driving deforestation processes (Couteron *et al*., 2005; Chowdhury, 2006).

With time, monitoring rate of deforestation and forest degradation can be done through analysis of remotely sensed data. In Kenya for example, Ochego (2003) applied remote sensing in deforestation monitoring in the Aberdare range mountains which are important water catchment areas for many rivers and streams in Kenya. When using GIS to measure changes in temporal and spatial dynamics of forestland in north-west Spain, Pérez *et al*. (2006) discovered an increase in the forest cover in Galicia region. In Tanzania, a study tracked forest cover changes in the Eastern Arc mountain forests and calculated that approximately 70% of the original forest cover has been lost and the remainder is retreating towards the boundaries of National Forest Reserve (NFR) (Mbilinyi and Kashaigili, 2005).

2.3 Forest Resource Condition

2.3.1 The need for forest resource assessment

Forests are important natural resources base, which need priority action for their utilization, management and protection at local or global scales (Panigrahy *et al*., 2010). FAO, (2006b) identified six important themes representing sustainable forest management: extent of forest resources, biological diversity, forest health and vitality, productive functions of forest resources, protective functions of forest resources and socio-economic functions of the forests. Assessment of information on forest condition over time enables a comprehensive monitoring of forest resources (Higgins and Ruokolainen, 2004).

Forest resources assessment involves gathering information on forest area and on forest stock (Higgins and Ruokolainen, 2004). Forest area and vegetation types are easily understood baseline variables. Carbon storage is an equally important parameter, as it is an indication of whether forests are degraded or not, and the extent of the forests to mitigate climate change (Higgins and Ruokolainen, 2004; FAO, 2006b). Since trends are more useful than one time measurements in determining sustainability, the assessment of sustainable forest management (SFM) requires periodic and long-term monitoring of forest values (FAO, 2009a).

2.3.2 Forest inventory to determine stocking

2.3.2.1 Background on forest inventory

Forest inventory is an accounting of trees and their associated characteristics of interest over a well-defined area; it involves gathering information on timber location, quality and quantity as well as the quantification of non-timber forest products (Scott and Gove, 2002). Professional foresters have a long tradition of monitoring forest resources to ensure their sustainable use through inventory (Scott and Gove, 2002; Couteron *et al*., 2003). Inventories may be conducted to estimate growth, stand density or volume and the information may form a basis for management planning (Arnold and Pérez, 2001; Couteron *et al*., 2003). Traditionally, forest inventories aimed for timber estimates; due to the adoption of industrial tree plantation approaches from large forest management units (Arnold and Pérez, 2001). It is however realized that non-timber forest products may be equally important to the local community (Arnold and Pérez, 2001; Gong *et al*., 2005). The sampling design and plot design used are key features to precise estimates of forest condition. In SFM and livelihood provision the following could be essential key elements to be observed at regular intervals in populations making up forests: i) Volume/ha, ii) Basal area/ha, iii) Mean height, iv) Mean diameter at breast height (dbh) and v) Stems/ ha of the forest (Guy, 2000; Couteron *et al*., 2003).

2.3.2.2 Inventory types and relevance of inventory

In most cases, the type of inventory to be executed depends on defined objectives, forest type (whether natural or plantation), precision wanted, available funds and time limitation among the few (Scott and Gove, 2002. However, three main types of inventories are common, namely: Reconnaissance forest inventory for producing general forest information, another one is management inventory, which is more intensive and provides adequate data for preparation or compilation of forest management plans. The last one is operational inventory whose main purpose is obtaining information on harvesting activities, sales of standing volume of timber or construction forest roads (*ibid*). But all in all, the main reason for conducting a forest inventory is to make informed decisions about forest management (Scott and Gove, 2002; Higgins and Ruokolainen, 2004).

Observations and measurements in the field are still the best ways of ensuring a good result in terms of precision on the variables to be collected. However, the use of remote sensing is an increasingly useful tool (McRoberts and Tomppo, 2007). Efforts to check cover and vegetation classification is frequently associated with remote sensing through image processing (Higgins and Ruokolainen, 2004). These efforts are significant in development of characteristics and checking accuracy of maps relative to ground truth.

Chazdon *et al*. (2009) emphasised the need for long term monitoring, as they provide information and characteristics of forests that are crucial for conservation and management of forests and woodlands. Most important characteristics used as indicators of status and condition of the forest ecosystem are vegetation cover, stocking, biomass and biodiversity (Lindenmayer *et al*., 2000). Long-term research serves as a research base for diverse aspects of ecology when investigating forest composition, structure and dynamics of forests.

2.3.3 Biological diversity values of the forests

2.3.3.1 Forestland tenure and forest biodiversity conservation

Biological diversity or biodiversity describes the variety of biotic forms from genetic to ecosystem (Martens *et al*., 2003). Biodiversity provides resilience to our lives at household level (Naughton-Treves *et al*., 2005). Conserving forest biodiversity means maintaining a forest cover with ecological conditions suitable to provide food, shelter, energy and income for the community (Lupala, 2009). Understanding the context of the biodiversity status of a particular forest provides an important key to management strategies that should be adopted under different circumstances.

Ecologists often use biodiversity measurements to determine the health of an ecosystem (Martens *et al*., 2003; Lupala, 2009). In this case, a declining biodiversity indicates a declining ecosystem and is a sign of some environmental stress (Martens *et al*., 2003). Forestland tenure appears to be a powerful determinant factor in the conservation of forest biodiversity (Mwase *et al*., 2007). So far, two schools of thought dominate the literature (Baird and Dearden, 2003; Bhuyan *et al*., 2003). One supports total protection of biodiversity under state tenure regime where there is prevention of human interference and another supports biodiversity protection under local community (villagers) tenure regime as part of the search for sustainable development (Baird and Dearden, 2003).

2.3.3.2 Estimation of forest biodiversity indicators

There are different ways in which biodiversity can be estimated. One of which is from the structure of a forest stand, this can provide a useful indicator of the ecosystem function and changes through time (Huang *et al*., 2003). Different ways of measuring forest structure include stem density and forest basal area. These have direct responses with human impact (Bhuyan *et al*., 2003). For example, mean basal area in a stand may decrease as a consequence of increasing disturbance pressure, whereas stem density of smaller trees may increase after disturbance (Ingram *et al*., 2005). The density and size distribution of trees contributes to the structural pattern characteristic of forests and woodlands, and there is a positive relationship between species diversity and forest structural features (Huang *et al*., 2003).

Species composition is another measure of diversity in a forest. Species composition is the assemblage of plant species that characterize the vegetation (Isango, 2007). It is one of the major components of biologically spatial structure (Ingram *et al*., 2005). The most common measure of composition is richness (the number of different species) and abundance (the number of individuals per species found in specified area). Species richness can be documented by calculating its relative density (RD), while the distribution of species is shown by relative frequency (RF). The abundance is calculated as relative dominance (RDo) whereas the importance value index (IVI) is the sum of relative density (RD), relative frequency (RF) and relative dominance (RDo) of species (Evariste *et al*., 2010). The IVI of a species in the community gives idea of its relative importance in the community (Banerjee and Srivastava, 2010).

Within biodiversity conservation, there are other ecologically-oriented valuation measures (Backéus *et al*., 2006). Lindenmayer *et al*., (2000) and Munishi *et al*., 2011 for example, discussed the use of indicator species in ecological valuation which is important for application in ecologically sustainable forest management whereas in biological richness; genetic, species and community diversity are important measurements used (Lindenmayer *et al.*, 2000; Martens, *et al*., 2003; Sigdel, 2008). Ecosystem health or quality approaches are equally important in valuations when viewing ecosystem functioning and services, as they assess ecosystem performance and quality (Sigdel, 2008). In general, biodiversity valuation can help decision makers to protect species and other biological values of a forest (Couteron *et al*., 2003; Mertz, 2007).

2.3.3.3 The need for biodiversity valuation and monitoring

Monitoring and valuing of forest biodiversity and ecosystem services is essential not only for assessing the relative importance of different components in the system, but also for informing decision-makers, who are often unaware of the value and importance of biodiversity and its accompanying ecosystem services (Yoccoz *et al*., 2001; Mertz, 2007; Chazdon *et al.*, 2009). A significant proportion of the world's population directly depends on forests and the surrounding environment for livelihood support (Shackleton *et al*., 2007; FAO, 2007a; Munishi *et al*., 2011). The correlation between forests and livelihoods is strongest for poor and rural community who have the least or limited influence in key decision-making concerning their adjacent forests and environments (Wily, 2002; Sunderlin *et al*., 2008). There is, therefore, a growing need to better understand the association between livelihoods and the conservation of forest biodiversity resources (FAO, 2007a).

Biodiversity provides a range of services, including aesthetic, cultural and recreational values as well as goods that have direct use values (FAO, 2006a). Apart from that, it enhances many other ecosystem services including carbon storage, water supply and soil fertility (Shahbaz and Suleri, 2009; Munishi *et al.*, 2011). Ecosystem services concept is of significant importance in appreciating the role of nature for sustaining human livelihoods (Mertz *et al*., 2007). Therefore, there is a need for effective valuation of biodiversity for ecosystem services (FAO, 2006a; Mertz *et al*., 2007).

Species diversity measurements allow objective assessment of level of biodiversity and the effects of tenure regimes on ecosystems (Magurran, 1988). Forestland tenure regime may affect site, and the use of diversity indices can help identify negative and positive trends for plant diversity. In ecological studies, diversity indices are used to understand the structure of a population by measuring species numbers, species abundances, and proportional abundances across species (Magurran, 1988). It is more effective and scientifically accepted to use a combination of indices or measures to assess plant diversity so as to combine separate aspects of diversity for example richness and evenness (Nagendra, 2002b). The scale, design and intensity of monitoring programmes vary to a great extent. Fuller *et al*. (1998) and McRoberts and Tomppo (2007) explained how combination of field survey and remote sensing could improve results of monitoring biodiversity of a particular area.

2.3.3.4 Biodiversity of the miombo vegetation

Most miombo woodlands have been heavily disturbed precisely because they have great local value (Gambiza *et al*., 2000; Campbell *et al*., 2007; Dewees *et al*., 2010 Munishi *et al*., 2011). They provide dry-season fodder for large livestock populations and fuelwood for domestic and rural industry uses. They offer construction material for farm structures and homes for millions. They are rich source of wild foods and fruits, reducing the vulnerability of poor rural households from the risks of crop failure. Although miombo woodlands are disturbed, the species composition is virtually unchanged because regeneration is easy through stump or root sucker shoots (Luoga *et al*., 2004; Timberlake *et al*., 2010). Dorren *et al*. (2004) argued that the composition of species should be characteristic for an ecoregion.

Miombo woodlands are characterized by the three Caesalpinoid genera: *Brachystegia, Julbernardia* and *Isoberlinia* (Gambiza *et al*., 2000; Backéus *et al*., 2006; Banda *et al*., 2006; Campbell *et al*., 2007; Munishi *et al*., 2011). These species produce hard timber, and have fibrous, tannin-rich barks used by local communities. Both - species structure and composition in miombo ecoregion are sensitive to environmental impacts (pressure) thus they can be used as indicators for degradation of forests (Chamshama and Nduwayezu, 2002; Backéus *et al*., 2006).

2.4 Forest Disturbances

Forest disturbances is viewed as uncommon, irregular events that cause abrupt structural changes in natural communities, move them away from near equilibrium condition, and affect landscapes in disruptive ways (Orzell and Platt, 2008; Frolking *et al*., 2009; Noone *et al*., 2012). Disturbances are major sources of temporal and spatial heterogeneity in the structure and dynamics of natural communities (Frolking *et al*., 2009; Noone *et al*., 2012). Scientists categorized two main types of ecological disturbances which are natural and man-made (Orzell and Platt, 2008). Natural disturbances, which include floods, strong winds, lightning and landslides are considered non-catastrophic by many ecologists, however natural landscapes can be greatly affected by anthropogenic disturbances (Orzell and Platt, 2008; Frolking *et al*., 2009). Anthropogenic disturbances reduce standing biomass and changes ecological communities (Mitchell and Schaab, 2008; Frolking *et al*., 2009; Noone *et al*., 2012).

Forest disturbances can be in a large or small scale. Disturbances at smaller scales tend not to affect landscapes; nonetheless, these disturbances may be important as a result of their combined effects over space and time (Frolking *et al.*, 2009: Noone *et al.*, 2012). Large-scale disturbances are those that affect entire landscapes and ecological systems and cause deforestation (Ismail and Kamarudin, 2011). Forests face different pressures which are part of processes of acquiring livelihood provisions. The pressures that forest adjacent communities puts on the forests are in the form of demands on resources (leading to resource depletion) and demands on ecological processes (leading to pollution) (Geist and Lambin, 2002).

2.4.1 Forest degradation and deforestation as constituents of disturbances

Forest degradation is the reduction of stocking level within the forest while deforestation has been defined as the change of tree crown cover to less than 10 percent (Acharya and Dangi, 2009; FAO, 2006b). Forest degradation cause significant impacts on ecosystem function, biodiversity, changes in forest micro-climate and livelihoods although some degree of disturbance can increase biodiversity (Mitchell and Schaab, 2008).

Present discussions on forest degradation are focused on reduction of emissions from source under reduced emissions from deforestation and degradation project (REDD) (Unruh, 2008; Acharya and Dangi, 2009). Apart from that, the role of other ecosystem services such as water, soil and biodiversity conservation have equally been given the accorded importance in sustaining rural livelihoods.

2.4.2 Causes of anthropogenic forest disturbances

Causes of anthropogenic forest disturbances which create pressures to the forests have been classified into three categories (Geist and Lambin, 2002): source (proximate), predisposing and underlying causes.

2.4.2.1 Source (proximate) causes

Sources or proximate causes are immediate means used to clear forests. Proximate causes include human activities which directly affect the environment and thus constitute direct source of change in forest cover (Geist and Lambin, 2002). In literature (Laurance, 1999; Contreras-Hermosillo, 2000; Rudel *et al*., 2000; Geist and Lambin, 2002), proximate causes are grouped into three categories: expansion of cropped land and pasture (agricultural expansion), harvesting or extraction of wood (wood extraction), and expansion of infrastructure. Proximate causes operate within sites of the respective case studies at local level.

2.4.2.2 Predisposing factors

Predisposing factors are geo-ecological factors recognized to shape forest disturbances such as land characteristics composed of soil quality, rainfall, fire, temperature, topography and forest fragmentation (Geist and Lambin, 2002). Among the pre-disposing environmental factors soil-related features (e.g. erosion due to grazing) are most frequently cited although they do not operate in many areas (Geist and Lambin, 2002; Mitchel and Schaab, 2008).

2.4.2.3 Underlying causes

Underlying or ultimate causes are primary forces that support the more obvious or proximate causes of deforestation. They are complex social, political, economic, technological and cultural variables that constitute initial conditions in the human-environmental relations (Laurance, 1999). Underlying causes operate mainly at the macro level related to social processes such as population pressure, land tenure, income distributions, national and regional development strategies, agricultural research and technological change as well (Geist and Lambin, 2002).

Underlying causes may operate directly at the local level, or indirectly from the national or even global level (Laurance, 1999). In literature (Laurance, 1999; Contreras-Hermosillo, 2000; Rudel *et al*., 2000; Geist and Lambin, 2002), underlying causes are grouped into five categories. These are demographic factors (human population dynamics, sometimes referred to as population “pressure“), economic factors (commercialisation, development, economic growth or change), technological factors (technological change or progress), policy and institutional factors (tenure change, impact of political-economic institutions, institutional change), and a complex of socio-political or cultural factors (values, public attitudes, beliefs, and individual or household behaviour).

2.4.3 Drivers of forest disturbances

In developing countries, population pressure has been termed as the major driver of anthropogenic forest disturbance (Backéus *et al*., 2006; Abdallah and Monela, 2007; Duveiller *et al*., 2008; Blomley and Iddi, 2009). The growing populations need food, so forest is cleared to provide space for cultivation and more is extracted from the forest to fit the increased population.

Another driver is uncontrolled logging which permanently or temporarily diminish forests (Semwal *et al*., 2010). Fuel wood removal is yet another common driver, as narrated by Agrawal and Chhatre (2006), fuel wood collection is assumed to be a critical factor since fuel wood collection, regardless of the size of the trees, may be repeated too frequently and intensively. Forest fires and animal grazing have the same effect on the forests since both reduce the natural regenerative ability of the forestland though grazing can reduce fire intensity (Topp-Jørgensen *et al*., 2005; Sharam *et al*., 2006).

General forest management is another cause whereby forestry policies in developing countries have been reviewed to be able to deal with the major causes of deforestation and forest degradation (Saunders *et al*., 2008; Lubna, 2008). Previous policies and institutional arrangements lead to forest degradation and deforestation when tenure of forestland was not well defined in some of the forests (Angelsen and Kaimowitz, 2001).

2.4.4 Forest disturbance indicators and assessment

In general, decreased productivity of the forest ecosystem is the major indicator of forest disturbance (Ismail and Kamarudin, 2011). Anthropogenic impact can be checked through the structure of a forest, since measures such as forest basal area and stem density have documented responses to disturbances (Ingram *et al*., 2005). Species diversity and forest health are also reduced after disturbance though it depends on time elapsed and degree of disturbance (Mitchell and Schaab, 2008).

The continuing pressures on the forest resource base have promoted much debate over how best to manage forests and woodlands for the future (RRI, 2009). An important component of this debate is the need for reliable information on the status of forests and, in particular how they change over time (Angelsen and Kaimowitz 2001; Duveiller *et al*., 2008). This information is required at a range of spatial and temporal scales and from local to global scale (Scott and Gove, 2002; Duveiller *et al*., 2008).

Acharya and Dangi (2009) recount the complexities in measuring forest disturbance in terms of degradation. It is more difficult than measuring deforestation since deforestation occurs in a large scale while degradation is a gradual reduction of stocks of biomass. Despite this fact, a wide variety of methodologies have been used. Some of the methods include transect observation of ‘direct’ disturbance indicators such as tree-stumps and charcoal kilns, sight surveys of on-going forest uses, archival research, the use of species-abundance models as indicators of ecosystem disturbance and remote sensing technology (Mitchell and Schaab, 2008; Acharya and Dangi, 2009).

2.5 Community Livelihoods and Forest Resources Dependence

The majority of the people in sub-Saharan African countries live in rural areas and largely depend on access to natural resources for their livelihoods (Babulo *et al.*, 2009; Chileshe, 2005). Rural and urban communities as well rely on the forest and also expects to benefit from other ecosystem services (Angelsen and Kaimowitz, 2001; FAO, 2006a; Shackleton *et al*., 2007; Williams *et al*., 2007). The basic concern is securing improved livelihoods for present generations while maintaining the forest heritage and its future potential (Nagendra, 2002a; FAO, 2006a).

The main occupation in rural areas is small-scale agriculture. Agricultural activities involve an extensive use of forest resources for its production comparing with secondary and tertiary economic activities (Babulo *et al.,* 2009). Livelihoods of rural communities with limited or no access to forest resources are vulnerable since they have difficulty in obtaining adequate food, accumulating other assets, and recovering from natural or market shocks (Romano and Reeb, 2006).

2.5.1 Livelihood components

Livelihood is a means of securing the necessities of life, it consists of the capabilities, assets (including both material and social resources) and activities required for a means of living (Ross-Tonen and Dietz, 2005; Shackleton *et al*., 2007). According to the Department for International Development (DFID, 1999), a livelihood is socially sustainable when it can cope with and recover from shocks, and provide for future generation, while not undermining the natural resource base (Ross-Tonen and Dietz, 2005).

Furthermore, DFID’s livelihood framework (1999) identified five basic types of capital assets whose access, when combined with household’s internal and external factors contributes to household income generating activities (Barrett *et al*., 2001). These are human, natural, physical, financial, and social capitals. These capital assets and their activities are the basic livelihood building blocks, upon which livelihoods are built (DFID, 1999; Soini, 2005; Malleson *et al*., 2008). For each capital asset there are sets of key indicators reflecting the asset and a single asset can generate several returns (Malleson *et al*., 2008).

2.5.2 Access to livelihood capital assets

Access to livelihood capitals is important when household livelihood has to be attained. The capitals constitute a stock of assets that can be stored, accumulated, exchanged or allocated to activities to generate a flow of income for the desired livelihood outcomes (Soini, 2005). Households with better access to resources, have more advantages in choices of household activities.

The five capital assets do not work in isolation and one capital asset may generate multiple benefits. Furthermore, households can convert natural capital into financial, physical, and human capital in order to improve the long-term possibility of livelihood sustenance (Angelsen *et al*., 2008).

2.5.2.1 Physical capital

Physical capital assets are created by economic production; they refer to basic physical infrastructure usually provided to enhance livelihoods (Kamanga, 2005, Tumusiime, 2006; Hassanshahi *et al.,* 2008). Physical capital is composed of infrastructures, such as roads, irrigation works, transport, shelter, affordable energy, communication and water supply also producer goods such as machinery (Hassanshahi *et al.*, 2008). Inadequate access to physical capital assets can have negative effects on productivity and income generating opportunities in general (Lugandu, 2010).

Physical assets are very important in livelihood support, for example, without transport services inputs for agriculture may not be easily available for farming and this may result in a decrease in agricultural yield, it is then difficult to transport agricultural products to the market. Forests are expected to offer means of improving physical assets for example providing affordable household energy or building materials for housing.

2.5.2.2 Human capital

Human capital asset is the collective sum of life experience, knowledge, inventiveness and enthusiasm that people choose to invest in their work (Weatherly, 2003). Human capital is composed of people's knowledge and skills, labour, education, household size, age and gender. It is also represented by good health and physical capability important for pursuit of different livelihood strategies to achieve livelihood outcomes (Soini, 2005; Tumusiime, 2006).

Hassanshahi *et al*. (2008) argued that human capital when developed contributes to the quality of life with improved production, more efficiency and capability to engage more fruitfully to livelihood activities. In day-to-day production, labour is important in terms of its quality and quantity (Tumusiime, 2006). Quantity relates to the household size, gender and age composition; and quality relates to the skills possessed, often developed through education and experience through age. Forest conservation strategies geared towards sustainability believes in conducting a number of trainings, workshops and exposure visits for increased knowledge and skill related to forest silviculture, community development, organisational management and leadership development, all of which are basically human capital.

2.5.2.3 Social capital

Social capital refers to the internal social and cultural coherence of society, including norms and values that govern interactions among people and institutions in which they are embedded (Pretty, 2003). Social capital is the glue that holds societies together and is based on practice of exchanging things within the community and between households (Pretty, 2003; Tumusiime, 2006). Social capital is composed of networks, group membership, social relations, claims and associations within the same village or other villages (DFID, 1999; Malleson *et al*., 2008). Access to social capital is said to be influenced by migration status, ethnicity and duration of stay in that community (Tumusiime, 2006).

Within social capital, the important idea in a community is norms and social bonds that bring social cohesion, cooperation and confidence to invest in collective activities under same rules (Soini, 2005; Lugandu, 2010). Likewise, economic and social homogeneity with respect to kinship, ethnic and cultural background are perceived to support collective action (Pretty, 2003). For an equitable livelihood provision, social cohesion is important to enhance social capital of those who have been powerless, left in isolation and excluded from mainstream social and political processes.

2.5.2.4 Natural capital

Natural capital consists of natural resource stocks from which people derive resources through resource harvest, extraction and the ecosystem services (Malleson *et al*., 2008). These are natural resource assets like land, forests, water, fisheries, pastures, soil, water, air and environmental services like nutrient cycling and hydrological cycle (Ellsworth and White, 2004). Natural resources may provide inputs in production activities including agriculture.

Two of the most valued natural capitals are land and forest resources (Barret *et al*., 2001b). Land is very important asset for rural communities whose main occupation is agriculture (FAO, 2006b). Households with little or less access to land are pushed into other livelihood activities such as collection of forest products as an alternative activity. However, households with better land access, may also diversify due to pull factors but usually they are attracted by better paying alternatives (Angelsen and Wunder, 2003).

Forest activities play the functions of supporting current consumption, safety nets in time of hardships like drought or crop failure and as a pathway out of poverty (Zewdie, 2002; Mamo *et al*., 2007). In many parts of the world local forest resources often are freely available and require little financial and physical capital (Malleson *et al*., 2008; Angelsen *et al*., 2008). Generally, it is known that poor households rely more heavily on natural resources for their basic needs which often contributes highly to the household economy, but the wealthy households are said to be greatest users of natural resources quantitatively (Mamo *et al*., 2007; Shackleton *et al*., 2007). Access to forests and forest conditions are essential features for livelihood sustenance.

2.5.2.5 Financial capital

Financial capital denotes the financial resources that people use to achieve their livelihood objectives (DFID, 1999). It consists of stocks of money or other savings in liquid form and includes easily disposed assets such as livestock, which in other senses may be considered as natural capital. Financial capital assets may be regular inflow of money like salary, credit, savings and marketable securities (Hassanshahi *et al.*, 2008). Among the five capitals, financial capital is probably the most versatile as it can be converted into other types of capital or it can be used for direct achievement of livelihood outcomes (DFID, 1999). Although financial capital is the most crucial, it is the least available and when available, it is still inaccessible due to low return activities undertaken by rural communities (Soini, 2005; Tumusiime, 2006). Nevertheless, the microfinance revolution underway shows some promise in extending financial capital to rural communities (Barrett *et al.*, 2001).

Binding working capital constraint traps rural communities (Chileshe, 2005). The communities have limited ability to invest and may thus depend on such activities as collection of forest products. Funds generated from the sale of forest products and levies are the financial capital created through forestry and is expected to benefit the communities; although there is a concern that the interest in generating cash income from sale of forest products might put at risk the sustainability of the forest livelihood system (Zewdie, 2002). Forests represent important livelihood resources for the rural community but several operational constraints like tenure hinders the success of the forest use system, which calls for informed institutional interventions (Ellsworth and White, 2004).

2.5.3 Vulnerability

Vulnerability can be described as insecurity in the well-being of individuals, households and communities when they are faced with changes in the external environment that affects a household's assets (DFID, 1999). People's livelihoods and the availability of assets are fundamentally affected by critical trends known as shocks and seasonality – over which they have only limited or no control (Paavola, 2008). The vulnerability contexts are important because they have a direct impact on people's asset status.

The vulnerability context encompasses the external environment like drought, floods, climate change and wild fires in the forest (Williamson *et al*., 2007). Others are policies, formal and informal institutions and processes that constitute people's everyday life like lack of assets (DFID, 1999; Shahbaz and Suleri, 2009). Communities adjacent to forest reserves face multiple stresses such as droughts, climate variability, policy changes and market fluctuations, which directly affects agriculture and forest productivity, biodiversity, water quantity and quality (Paavola, 2008). Following this, the ultimate objective of policy is therefore the promotion of sustainable livelihoods, particularly for the poorest and most vulnerable in forest adjacent communities (Chambers, 2006; Paavola, 2008).

2.5.4 Livelihood strategies and diversification

Livelihood strategies are the range and combination of various activities and choices that individuals or households undertake in order to meet their livelihood goals or outcomes at different time (DFID, 1999). Livelihood strategies encompass productive activities, investment strategies and reproductive choices, among other things (Ellis, 1999; Babulo *et al*., 2009). These strategies enable them to try to meet the challenge of existing vulnerability, while using such strategies to deal with the positive and negative effects of policies, institutions and other processes (Hassanshahi *et al*., 2008). Ellis (1999) defines rural livelihood diversification as the process by which households construct an increasingly diverse activities and assets in order to survive and to improve their standard of living. It includes both on and off-farm activities undertaken to generate additional income to that from the main household agricultural activities (*ibid*). Livelihood strategies may use natural resource or non-natural resource based activities.

Rural households' livelihood strategies throughout the world rely on subsistence agriculture and other small-scale activities (Ellis and Mdoe, 2003). Choice on strategies brings diversification or intensification of activities which might have short-term or long-term outcomes (Barrett *et al*., 2001; Babulo *et al*., 2009). Some of the activities apart from agriculture and livestock keeping include vegetable gardening, beer brewing, brick making, basket weaving and other handicrafts. Others are labouring (that is selling one's labour by engaging in waged labour), selling of timber and fuel wood, petty business, building work and charcoal making, depending on the objectives and priorities of household (Ellis and Mdoe, 2003; Sullivan *et al*., 2009). These activities provide the needed source of income used to support household's needs such as education and health (Sullivan *et al*., 2009).

Rural communities engage in multiple activities and rely on diversified income since they cannot get as much as desired from subsistence farming alone which has low returns. Livelihood diversification has the advantage of using seasonality hence utilizing labour and generating alternative sources of income in off-peak periods (Ellis, 1999). Another advantage is that it minimizes risk since it comprises more activities with uncorrelated risks between them. Lastly, livelihood diversification ensures continuous employment, whereby cash resources obtained from diversification may be used to invest in other activities to improve the quality of any or all of the five capitals (Babulo *et al*., 2009).

2.5.5 Livelihood outcomes

Livelihood outcomes are the achievements through livelihood strategies. They are the goals reached by individuals or households in a certain period (DFID, 1999). The outcomes are likely to vary according to place, time, individual and situation, which make them extremely complex. Individuals and households will usually try to achieve multiple outcomes, which include: increased well-being, higher or more income, reduced vulnerability, improved food security, more sustainable use of natural resources, protected rights of access and recovered human dignity (Sullivan *et al*., 2009).

Among the most commonly cited expected outcomes of forest sector are improved livelihoods for rural people living in or near forests and sustainable management of forests (Meinzen-Dick and Adato, 2001; Shackleton *et al*., 2007; Paavola, 2008). Considering rural communities, outcomes from livelihood strategies and diversification should be featured well in access to the five livelihood capitals (DFID, 1999). However, the specific outcome of any intervention depends on structures like tenure of a resource as well as the existing stock of livelihood assets and the vulnerability context (Paavola, 2008). The opportunities for achieving outcomes are different for forests on private and customary lands as opposed to gazetted forests in state forest reserves (Ellsworth and White 2004; Paudel *et al*., 2007; Acharya and Dangi, 2009).

2.6 Knowledge Gap

Forest dependence and sustainable livelihoods issues have been ranked high on the international discussions (Shahbaz *et al*., 2007). This is due to the fact that forest conservation is perceived as a component of livelihood insurance (Ross-Tonen and Dietz, 2005; Naughton-Treves *et al*., 2005; Pathak *et al*., 2005). In order to utilise the potential of forests, forest policies of many countries have been revised to be more on forestry for rural development and poverty alleviation (Shackleton *et al*., 2007; Larson *et al*., 2008). So far many countries in the world have changed ownership pattern of the forests. Tanzania is one of the good examples of countries which have laid emphasis on conservation of its forest resources (Wily, 2002; Ylhäisi, 2003).

The existing literature on tenure mainly contains literature research from agricultural land due to its importance as a basic production factor (FAO, 2009a; FAO, 2009b; RRI, 2009; Siry *et al*., 2009). Recently it has been found that understanding forestland tenure issues is essential for sustainable use of forest resources (RRI, 2009). Previous researches on forestland tenure were focused on tenure rights, challenges and opportunities, reforming and strengthening tenure, and few on role of tenure in either forest condition or livelihood provision (White and Martin, 2002; Sunderlin *et al*., 2008; FAO, 2009a; FAO, 2010). Many of these literatures were drawn from Asia, Latin America and a some from Africa (Ellsworth and White, 2004; FAO, 2006b; FAO, 2007b; Mwase *et al*., 2007; Romano, 2007; Acharya *et al*., 2008; Larson *et al*., 2008; FAO, 2008; RRI, 2009; FAO, 2011, Larson and Puhlin, 2012). The few studies in Tanzania explored on trends, systems and institutional arrangements in forestland tenure (MNRT, 2001; Akida and Blomley, 2007). The implications of the researches on forestland tenure (reform) have been based on the theory that communities are good stewards in practice but this does not always happen. Nevertheless, very little empirical evidence exists on how tenure regimes have influenced forest resources and also the extent of forest products contribution to total household income in different forestland tenure regimes remains unknown (Tumusiime, 2006).

The question of forestland tenure in Tanzania seems to be imperative especially when moving towards REDD and REDD+ programmes which require clear tenure as well as strict regulations if carbon emission reduction and sustainable forest management is to be met. Policymakers are faced with a difficult trade-off between local livelihoods and forest conservation, hence the need for valuing forest resource use by rural households (Mertz *et al.*, 2007). With the use of a combination of spatial data (GIS), field samples for bio-physical data and socioeconomic data, this study will fill the knowledge gap on the role of forestland tenure on forest condition and household access to the five livelihood assets.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

3.1.1 Geographical location

The study was conducted in four forests in Babati District namely Bereku (6111 ha) and Haraa (605 ha) which are under state forestland tenure regime and two forests under communal forestland tenure, Riroda and Bubu with areas of 1800 ha and 2300 ha respectively (Fig. 2). Babati District is in Manyara Region in northern Tanzania, located between 4° 13' and 4°22' South, and between 35° 45' and 35°75' East. The four forests under state and communal forestland tenure regimes are on the same ecological zone (Table 1).

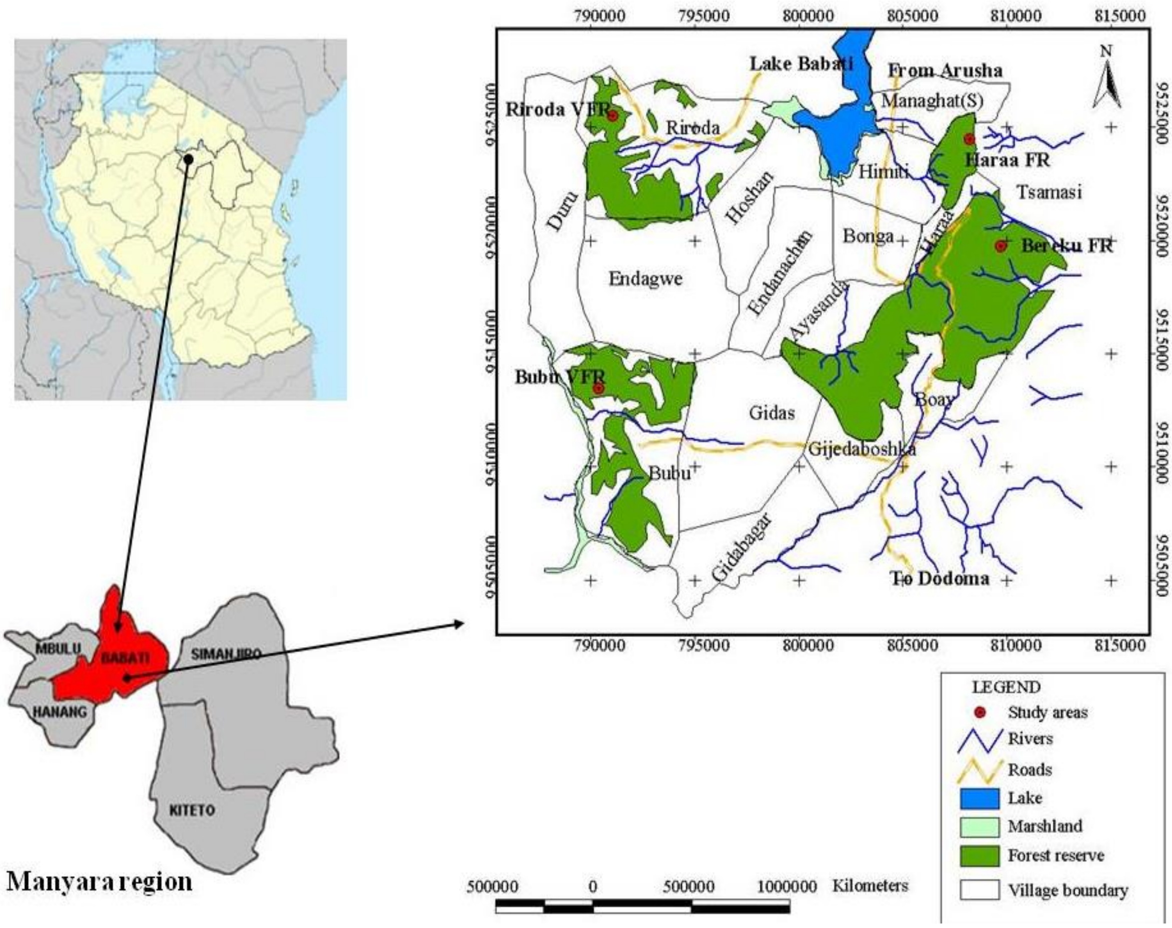

Figure 2: Map showing location of the study area

Table 1: Forests description

Forest name	*Area (ha)	*Type of vegetation	*Elevation (m)	Previous tenure regime	Current tenure regime	Management regime	Year of regime change
Bereku	6111	Miombo and dry montane	1280-1810	State	State	JFM	2000
Haraa	605	Miombo and dry montane	1600-1830	State	State	JFM	2000
Riroda	1800	Miombo	950-1800	Open access	Communal	CBFM	1994
Bubu	2300	Miombo	950-1800	Open access	Communal	CBFM	1994

* Source: Lovett and Poćs, 1993.

3.1.2 Bereku forest reserve

Bereku forest reserve is situated 30 km south of Babati Township and can be accessed through Babati to Kondoa road; the road form part of the north-western boundary. The reserve covers Bereku ridge and Gedabosh mountain north-west of Babati and Kondoa district borders and south of Haraa FR.

(i) Soils and climate

The soil is red to red-brown and sandy, with more fertile and humic soils in the valleys and areas of seasonally waterlogged depressions. The climate is characterized by oceanic rainfall with continental temperatures. Estimated rainfall is between 750 and1200 mm/year; with a mist effect on the higher ridges. Dry season is between June and October. The maximum temperature is 21^{o}C in November and December while the minimum is 16.5^{o}C in July at lower altitudes.

(ii) Vegetation

The reserve is covered by woodland dominated by *Brachystegia microphylla* with occasional small clumps of dry montane forest in the higher north-western part. With the exception of erosion caused by cattle on slopes near villages, the vegetation of the reserve is in relative good condition. The woodland's main species include *Acacia* spp., *Albizia versicolor*, *Brachystegia microphylla*, *Brachystegia spiciformis*, *Cussonia arborea*, *Markhamia obtusifolia*, *Parinari curatellifolia*, *Strychnos* sp., *Syzygium guineense* subsp. *guineense*, *Vitex* sp. On the seasonally waterlogged grassland area, available species include *Bridelia micrantha* and *Syzygium cordatum*. The dry montane forest is composed of *Croton macrostachyus* and *Rauvolfia caffra*. *Podocarpus* sp. is also spotted at Buai peak. The importance of the reserve as a catchment forest is of prime importance as water is piped from the permanent Matsi stream to Bonga village, on the western side, Kikore and Madege Rivers supply permanent water while other streams being seasonal (Lovett and Poćs, 1993).

3.1.3 Haraa forest reserve

Haraa forest reserve is situated 35 km south of Babati Township; access is through the Babati to Kondoa road above Bonga village and then north to Haraa village. The reserve covers Ipini Hill and is separated from Bereku FR to the south by a cultivated valley.

(i) Soils and climate

The soils in the dry montane forest is light brown, sandy with humus and in the wooded grassland it is light brown with quartzite stones on the south east side. The climate is composed of oceanic rainfall with continental temperatures and rainfall ranging between 1200 and1500 mm/year in the forest and 750 mm/year on the grasslands. The dry season is between June and October and temperatures between 16 ^{o}C in July and 21^{o}C in December (Lovett and Poćs, 1993).

(ii) Vegetation

The reserve is mostly fragmented dry montane forest with large areas of tangled secondary growth. The lower slopes of the reserve are dominated by miombo woodland with *Brachystegia microphylla* as the dominating species, other species are *Combretum molle*, *Cussonia arborea*, *Dodonea viscosa*, *Dombeya rotundifolia*, *Erythrina abyssinica*, *Osyris lanceolata* and *Bridelia micrantha*. The dry montane forest is composed of species including *Albizia gummifera*, *Calodendrum capense*, *Cassipourea malosana*, *Clausena anisata*, *Cordia abyssinica*, *Croton macrostachyus*, *Diospyros abyssinica*, *Dombeya torrida*, *Ficus thonningii*, *Prunus africana*, and *Rauvolfia caffra*. The reserve has an important catchment value, on the forest edge and just inside the forest there are small permanent springs and seasonal streams used for local water supply and irrigation (Lovett and Poćs, 1993).

3.1.4 Riroda Village land Forest Reserve

Riroda village land forest reserve is part of the forest patches which forms the Duru-Haitemba forest reserve and is located 29 km from Babati Township. Local communities living adjacent to the forest reserve derive a number of benefits from the forest which is also a source of springs.

(i) Soils and climate

The soils have low organic matter content and poor availability of phosphorus (Lovett and Poćs, 1993; Malimbwi, 2003). The forests are relatively dry with bimodal rainfall which is irregular. The rain ranges from 300 - 1200 mm per year. Short rains occur between

October and January while long rains duration is between February and May (Kajembe *et al.*, 2005). Occasionally the area experiences extended dry season for six months in a year and might have drought (LAMP, 2002). The temperature ranges between 12^o and 25^oc.

(ii) Vegetation

The forest is dominated by *Brachystegia microphylla* confirming being typical miombo woodland. *Combretum molle* also appear to be dominant species in this woodland (Malimbwi, 2003). The woodland comprise of distinct two layers of vegetation: the upper canopy of umbrella shaped trees and sub canopy trees with shrubs and saplings (Lovett and Poćs, 1993). There is considerable degradation in the reserve due to overgrazing.

3.1.5 Bubu Village land Forest Reserve

Bubu village land forest reserve is among the nine village forest reserves which form the Duru-Haitemba forest reserve. It is situated 60 km from Babati Township and can be accessed through Babati to Kondoa road; the forest reserve consists of four mountain ridges (Singe, Endarbo A, Endarbo B and Endadu) (Malimbwi, 2003). The forests are important for timber and non-timber products available in the forest.

(i) Soils and climate

Soils of the area are vertisols which have poor availability of phosphorus and low organic matter content. Rainfall pattern is characterized by bi-modal and irregular rains ranging from 300-1200 mm per year. Short rains are in October to January while long rains start in February to May. The dry season is from May-October when there is little or no rain at all (Lovett and Poćs, 1993; Malimbwi, 2003).

(ii) Vegetation

Being part of Duru-Haitemba forests, it is composed of typical dry miombo woodlands. The vegetation is dominated by *Brachystegia microphylla* and *B. spiciformis*. Grazing has been observed in all the four ridges (Malimbwi, 2003).

3.2 Methodology

3.2.1 Research design

This study employed a cross sectional research design ; whereby data were collected at a single point in time. A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the purpose with economy in procedure (Kothari, 1985). Cross-sectional study design was chosen due to the fact that this study involved studying variables within a given population without manipulating the study environment, i.e. forestland tenure alongside forest condition and livelihood variables. The design involves measuring differences between or among a variety of phenomena rather than changes and establishes associations. It involves special data collection, including questions about the past, but often the design rely on data originally collected for that purposes (Simon, 1985; Babbie, 1990).

According to Simon (1985) and Babbie (1990) a cross sectional research design, allows for collection of in-depth information on specific cases at one point in time. This design is useful in that it helps to generate in-depth qualitative and quantitative data. A mix of qualitative and quantitative methods was used in data collection and analysis in a triangulation manner. Triangulation is the use of multiple methods to study a particular phenomenon with the effect of balancing each method and giving a hopefully truer account (Olsen, 2004; Hussein, 2009). In this study, ecological data used quantitavive data collection and analysis while qualitative data collection was used in livelihood data collection. Triangulation was employed in livelihood data where different methods like PALI, PRA, observations and interviews were done and in analyzing tree diversity different analyses were done so as to come to a truer account and minimize bias.

3.2.2 Data collection and analysis

Data collection was done by blocking the two tenure regimes that is: state and communal forestland tenure and had a single replication in forests with the same tenure regimes. To reduce variation, forests with the same management regimes that is - Participatory Forest Management (PFM in terms of JFM and CBFM) were studied. Data for this study consisted of ecological and livelihoods information. Ecological data encompassed remotely sensed data and forest inventory.

3.3 Ecological Data

3.3.1 Remotely sensed data, processing and change detection

3.3.1.1 Image selection and acquisition

Remotely sensed data were collected from satellite images. Four remotely sensed images (Landsat TM and ETM+) were used to discern the forest vegetation cover changes (Table 2). The selection of the images took into account the cloud cover and the seasonality effects (Jensen, 1996) and the temporal period corresponded to the change in tenure regimes in state and communal forest lands of Bereku, Haraa, Riroda and Bubu, forest reserves.

Table 2: Landsat scenes used in the study

S/N	Satellite sensor	Path/Row	Imagery date	Season	Source
1	Landsat 5 TM	168/63	17/02/1993	Wet	http://glovis.usgs.gov
2	Landsat 7 ETM+	168/63	23/09/2000	Dry	http://glovis.usgs.gov
3	Landsat 7 ETM+	169/63	23/09/2000	Dry	http://glovis.usgs.gov
4	Landsat 5 TM	168/63	04/11/2009	Wet	http://glovis.usgu.gov

3.3.1.2 Image processing

Image processing involved three major activities, which were pre-processing, rectification/georeferencing, and enhancement (Kashaigili, 2006). Pre-processing involved band extraction from zipped files, converting bands to imagine format and stacking bands in one composite file. The images were geometrically corrected to Tanzania UTM coordinate system which is Clarke 1880 ellipsoid and Arc 1960 in UTM zone 36 south of the equator where the study area is located. Geometric correction involved modeling the relationship between the image and ground coordinate systems. Ground control points on the satellite image and on the topographic maps were identified, geometric correction was done with the help of Land Cover and Land Use map of Singida (Sheet Index SB 36- 4) of scale 1:250 000 and topographical maps of series Y742 scale 1: 50 000 of North Bubu (sheet No.85/3) and Gallapo (sheet No. 85/4), this shows the distribution of land cover and land use in Singida and some part of Manyara region (later used in accuracy assessment). Sub-setting was done to extract the study area from the full image scenes and reduce the size of the working image. A swipe command was applied for the temporal images overlaid on the same window for confirmation of the co-registration (e.g. Mather, 2004).

Image enhancement was done in order to reinforce the visual interpretability of images (Lu *et al*., 2004; Mather, 2004). A colour composite (Landsat TM bands 4, 5, 3) was prepared and its contrast stretched using a Gaussian distribution function followed by a

3 x 3 high pass filter for ease of interpretability of linear features (e.g. rivers). There are various band combinations used in remote sensing, though choice of layers should take into consideration information of classes of interest. A combination of bands 4, 5 and 3 (4-NIR, 5-MIR and 3-Red) was applied as optimal in discriminating vegetation conditions and soil moisture analysis (Her and Heatwole, 2007; Jansen *et al.,* 2008). All image processing were carried out using ERDAS Imagine Software Version 9.1 and ArcView 3.2.

3.3.1.3 Preparation of base map, ground truthing and final image classification

Both visual and digital image classification approaches were used using hybrid image classification. Firstly, unsupervised classification was performed followed by supervised image classification using maximum likelihood classifier (MLC) (ERDAS, 1999; Dougherty, *et al*., 2001). Unsupervised classification was done in order to have an insight into spectral groupings that may make physical sense and also to determine how well the intended cover classes could be defined from the image. Supervised image classification involved selection of training sites (signature) on the image, which corresponded to specific land classes to be mapped.

Training field was identified by inspecting enhanced colour composite 4, 5, 3 (for red, green and blue) in which vegetation types and condition are clear and visible than other band combination (Her and Heatwole, 2007; Jansen *et al.*, 2008). The training areas were identified with the help of topographic maps and several iterations were made to improve the classification. Ground truthing was done in order to verify and modify the initial classification in the base-map and obtain actual field information for accuracy assessment. A hand-held GPS was used to locate sampled forest vegetation types in the field.

The pre-processed multispectral satellite image classes were then merged by recoding. The final classification of the vegetation types used the following key based on the National Forestry Resources Monitoring and Assessment of Tanzania (NAFORMA) scheme of land use/cover classification (MNRT, 2010):

- Closed woodland
- Open woodland
- Bushed woodland
- Shrubs
- Grassland
- Settlements
- Water features.

3.3.1.4 Accuracy assessment

In order to assess the accuracy of the classification an error matrix was generated. This is an accuracy assessment procedure for image classification (Zãvoianu *et al*., 2004). To perform this analysis, a sample of the classified pixels from the thematic map were randomly chosen using the accuracy assessment tool in ERDAS Imagine software and then compared visually with the reference data from inventory, topographic maps and ground truthing. A total of 250 random points were generated to determine the accuracy of the classification. From the error matrix, accuracies of each category, overall accuracy and K_{HAT} were calculated following formulae provided in Congalton (2001).

Error of omission or producer's accuracy indicates the probability of the cell value in map 2 being the same as in map 1, was calculated as the percentage of correct for a given column divided by the total for that column.

$$Omission error = x_{ii} / x_{+i} \; x 100\% \qquad \text{(Equation 1)}$$

Where X_{ii} = total number of correct cells in the class

X_{+i} = sum of the cell values in the column

Commission error or user's accuracy indicates the probability of the cell value in Map 1 being the same as in map 2; this was calculated as the percentage correct for a given row divided by the total for that row.

$$Comissionerror = x_{ii} / x_{i+} \ x \, 100\% \qquad \text{(Equation 2)}$$

Where X_{ii} = total number of correct cells in the class

X_{1+} = sum of the cell values in the row

The overall accuracy is the probability that a random point in the target area is classified correctly in the map. It summarizes the total agreement/disagreement between the reference data and the interpreted land cover types; usually it is the major diagonal of the matrix. Overall accuracy was calculated by dividing the sum of all the entries in the major diagonal of the matrix by the total number of sample units in the matrix (Congalton, 2001).

$$OverallAccuracy = D / N \ x \, 100\% \qquad \text{(Equation 3)}$$

Where: D = total number of correct cells as summed along the major diagonal

N = total number of cells in the error matrix

K_{HAT} statistics measure the agreement or accuracy based on Kappa analysis, it is useful for comparing maps of similar categories to determine if they are significantly different. It was calculated as follows :

$$\hat{K} = \frac{N \sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r} (X_{i+} * X_{+i})}{N^2 - \sum_{i=1}^{r} (X_{i+} * X_{+i})} \qquad \text{(Equation 4)}$$

Where r = number of rows in the matrix

X_{ii} = total number of correct cells in a class (value in row *i* and column *i*)

X_{i+} = total for row *i*

X_{+i} = total for column *i*

N = total number of cells in the error matrix

3.3.1.5 Change detection

The purpose of change detection was to discern areas of interest with different dates on digital images; this depicted change in classified vegetation cover. This study used a post classification approach in change detection analysis where two images from different dates are classified and labelled and the area of change extracted through the direct comparison of the classification results (Mbilinyi, 2000). Post-classification comparison is a common approach and was preferred due to its capability of providing a matrix of change information and reducing external impact from atmospheric and environmental differences between the multi-temporal images (Lu *et al*., 2004).

3.3.1.6 Assessment of rate of forest vegetation cover change

The estimation for change and the rate of change for the different vegetation covers were computed based on the following formulae as used by Kashaigili and Majaliwa (2010):

$$\% \, Change_{year\ x} = \frac{Area_{i\ year\ x} - Area_{i\ year\ x+1}}{\sum_{i=1}^{n} Area_{i\ year\ x}} x\, 100$$ (Equation 5)

$$Annual\, rate\, of\ change = \frac{Area_{i\ year\ x} - Area_{i\ year\ x+1}}{t_{years}}$$ (Equation 6)

$$\% \, Annual\, rate\, of\ change = \frac{Area_{i\ year\ x} - Area_{i\ year\ x+1}}{\sum_{i=1}^{n} Area_{i\ year\ x}\, x\, t_{years}} x100$$ (Equation 7)

Where Area $_{i\ year\ x}$ = area of cover i at the first date,

Area $_{i\ year\ x+1}$ = area of cover i at the second,

$\sum_{i=1}^{n} Area_{i\ year\ x}$ = the total cover area at the first date and

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

3.3.2 Forest inventory data collection and analysis

Forest inventory was conducted to assess differences in forest resources, biodiversity and level of disturbance between state and communal forestland tenure regimes; this was preceded by a reconnaissance survey.

3.3.2.1 Sampling intensity, shape and size of the plots

Data collection was based on the normal inventory procedures as detailed by Philip (1994). Systematic sampling design with plots along transects was used. In this study, the numbers of plots for inventory were calculated using the following formula (e.g. Philip, 1994):

$$n = CV^2 t^2 / E^2 \qquad \text{(Equation 8)}$$

Where: n = number of sample plots;

CV = Coefficient of Variation (standard deviation/sample mean);

E = allowable sampling error;

t = Student's t-value at specific level of significance

The number of sample plots was determined from a pilot survey in Haraa and Bereku forest reserves while previous data from inventory done by Malimbwi (2003) were used to calculate the number of plots in Riroda and Bubu village forests. In this study, the number of plots adopted aimed for a sampling error of 15% at a 95% confidence level, and 154 plots were surveyed in the four forests (Table 3).

Table 3: Number of plots, sample size and sampling intensity in the study forests

Name of forest	Total Area (ha)	Number of plots	Sample size (ha)	Sampling intensity %
Bereku	6111	55	3.88	0.06
Haraa	605	33	2.33	0.39
Riroda	1800	36	2.54	0.14
Bubu	2300	30	2.11	0.09
Total		Total 154		

Systematic sampling design with the first plot randomly laid at 150 m from the forest boundary was employed, subsequent plots were laid along transects at 300 m interval and the transects were 500-1000 m apart. Circular nested plots with radii of 2 m, 5 m, 10 m and 15 m were used to collect ecological data in the forests. Data collected in a plot included number of regenerants, species names (vernacular and botanical) for all trees, dbh measurement of all trees ≥ 5 cm dbh in the plot, and total height of two sample trees ("in trees" nearest to the plot centre) (Table 4). Circular plots are quick and efficient in allowing accurate area sampling with minimal effort for plot layout (a single central marker for permanent location) and they reduce the number of edge effects because they minimize perimeter to area ratio (Banda *et al.*, 2006).

Table 4: Summary of data collection in sample plots

Sub plot radius	Variables to be measured
2m	Identification and count of all treeswith diameter of ≤5cm
5m	trees with dbh >5 cm ≤10 cm
10m	all trees with dbh >10 cm ≤20 cm
15m	all trees with dbh>20 cm. Grazing, grass cutting, burnt areas, basal diameter of stumps and bare ground in % of the plot area.
Other parameters	Description of the plot: slope, vegetation type, altitude and location according to Geographic Positioning System (GPS) coordinate reading and species names of all recorded trees.

Trees and plant identification in the field was done by a taxonomist and local plant identifier. The species were counter checked on a species checklist (Ruffo and Sigara, 1990; Mbuya *et al*., 1994; Ruffo *et al*., 2002) but some voucher specimens were collected for identification later by a taxonomist. A species code of trees and shrubs of the four forests was prepared by matching local names and botanical names as per available Babati checklists (Ruffo and Sigara, 1990; Ruffo *et al*., 2002). Given that measurement of height involved sample trees in a plot, height/diameter relationship, which is site and vegetation specific, was developed and used to estimate the height of trees that were measured for Dbh only (Table 5). The equations were developed in this study from a total of 356 trees; R^2 varied from 0.72-0.80 and S.E varied from 0.20-0.36.

Table 5: Equations used in height estimation

Forest name	Vegetation type	Equation	R^2	SE	N	Equation number
Bereku	Miombo	$Ln\,Ht = 0.8643 + 0.5487(Ln\,Dbh)$	0.80	0.25	133	9
Bereku	Dry montane	$Ln\,Ht = 1.54 + 0.35(Ln\,Dbh)$	0.79	0.36	51	10
Haraa	Miombo	$Ln\,Ht = 0.8611 + 0.5579(Ln\,Dbh)$	0.79	0.24	37	11
Haraa	Dry montane	$Ln\,Ht = 1.1646 + 0.4425(Ln\,Dbh)$	0.78	0.25	37	12
Riroda	Miombo	$Ln\,Ht = 0.6064 + 0.6183(Ln\,Dbh)$	0.76	0.35	70	13
Bubu	Miombo	$Ln\,Ht = 0.6184 + 0.6232(Ln\,Dbh)$	0.72	0.34	65	14

Where Ht is total tree height in meters; Dbh is tree diameter at breast height in cm; Ln is the natural logarithm; R^2 is the coefficient of determination, SE is the standard error of estimate and N is the number of observations.

3.3.2.2 Analysis of forest inventory data

Forest inventory data was used to compute stand ecological parameters (Mugasha and Chamshama, 2002; Malimbwi, 2003) so as to make comparison of current forest condition for the different tenure regimes. MINITAB software and Microsoft Excel spreadsheet were used to undertake inferential statistical analysis whereby stems ha^{-1}, basal area ha^{-1} and volume ha^{-1} were calculated as follows:

(i) *Stems (N ha^{-1})*

In each plot, the number of saplings and stems ha^{-1} (N) was determined. This was done by dividing the total number of saplings and stems by the plot area. The mean number of saplings and stems was obtained by dividing the sum of saplings and stems ha^{-1} for all plots by the number of plots. The following formula as stipulated by Philip (1994) was used:

$$N = \sum (n_i / a_i) / n \qquad \text{(Equation 15)}$$

Where N = Number of saplings or stems ha^{-1},

n_i = Tree counts in the i^{th} plot,

a_i = Area of the i^{th} plot in ha,

n = Total number of sampled plots.

(ii) *Basal area (G m^{2}ha^{-1})*

Basal area ha^{-1} (G) was determined through the following formula (Malimbwi, 2003):

$$G = \frac{\sum^{n} (\sum^{m_i} g_{ij} / a_{ij})}{n_i} \qquad \text{(Equation 16)}$$

Where G = Average basal area per ha,

g_{ij} = Basal area in the j^{th} diameter class of the i^{th} plot in m^2,

m_i = number of diameter classes in the i^{th} plot,

n = number of plots,

a = area of subplot j in i^{th} plot. Whereas basal area per tree (g m^2) was calculated from the equation $g = 0.0000785 d_i^2$ (Equation 17)

(iii) *Volume ($V\ m^3ha^{-1}$)*

The volume ha^{-1} was calculated through dividing the sum of all tree volume in the plot by plot area. Since the volume equation requires height as an input, a height diameter equation was first fitted using the data of the sample trees which were measured for height. The equation was then used to estimate the height of each tree. In the miombo forests the total volume of standing trees was calculated using the general volume equation for miombo tree species:

$$v_i = 0.0001 d_i^{2.032} h_i^{0.66} \qquad \text{(Equation 18)}$$

developed by Malimbwi *et al.,* (1994), and in the dry montane forest area the volume of standing trees was calculated from the equation:

$$v_i = 0.5 g h_i \qquad \text{(Equation 19)}$$

$$V = \sum (v_i) / a_{ij} \qquad \text{(Equation 20)}$$

Where; v_i= the volume of the i^{th} tree (m^3),

d_i = the diameter at breast height (1.3m) for the i^{th} tree (m),

h_i = the total height of the i^{th} tree (m) and g =the tree basal area (m^2).

All of the computed parameters were separated into eight size classes based on the diameter whereas class one had trees with diameter from 5-10 cm, class two 10.1-20 cm, class three 20.1-30 cm, class four 30.1-40 cm, class five 40.1-50 cm, class six 50.1-60 cm, class seven 60.1-70 cm and class eight > 70 cm.

(iv) *Level of disturbance and dominant pressure*

Level of disturbance was assessed by checking removals and calculating removals and removal/standing ratio in each tenure regime and making comparisons (e.g. Luoga *et al*., 2002). The numbers of stems, basal area and volume of removed/cut trees were determined to compare differences between state and communal tenure regimes.

Estimation of dbh for the removed trees was done by fitting an equation of relationship between basal diameter (D) of the sample trees thus:

$$Ln\,Dbh = 0.1495 + 0.8975(Ln\,D) \quad \text{(Equation 21)}$$

R^2=0.86, SE=0.33, N=43 for miombo and for dry montane the equation was:

$$Ln\,Dbh = 0.3401 + 0.9389(Ln\,D) \quad \text{(Equation 22)}$$

R^2=0.92, SE=0.55, N=39. Equations 21 and 22 were developed in the study.

Volume of removed trees (miombo) in a plot was estimated using the equation developed by Chamshama *et al.,* (2004):

$$v_i = 0.000047\,D^{2.56} \quad \text{(Equation 23)}$$

whereas in the dry montane forest, volume of removed trees was calculated using the equation: $v_i = 0.5gh_i$ (Equation 24)

Removal/standing ratio was calculated following (Luoga *et al*., 2002). The stumps were classified as old or fresh cut from the appearance of blackening.

3.3.2.3 Species diversity

Plant species diversity in state and communal forestland tenure regimes was quantified by calculating total number of species in each forest from the sampled plots. Diversity indices used were Shannon's index of diversity (*H'*) as a measure of species richness and abundance, Simpson index of dominance (*D*) as a measure of dominance and Jaccard's similarity index (*JI*) was used to measure the degree of similarity between forests in the two tenure regimes. Analysis of variance (ANOVA) was also carried out to test whether there were significant differences in tree species diversity between state and communal tenure regimes.

(i) *Index of Diversity (H')*

The species diversity was calculated using Shannon-Wiener index, which measures the value of species as a function of their frequency in the community (Yoccoz *et al*., 2001). The index values ranges from 0 – 5, the index increases with increase in number of species in the community. It was calculated by the following formula:

$$H' = -\sum pi \ln pi \qquad \text{(Equation 25)}$$

Where; H' = Shannon-Wiener value,

pi = Proportion of the i^{th} species,

ln = natural logarithm.

The species diversity was compared within and between the tenure regimes. Diversity in any vegetated system is a product of its richness and evenness (Kohli *et al*,. 1996).

(ii) *Index of dominance (D')*

The index of dominance is a measure of the distribution of individuals among the species in a community. This index is also called Simpson's Index of diversity and is equal to the probability of picking two organisms at random that are of different species (Krebs 1989) and it weights towards the abundance of the most common species. The value of *D'* ranges between 0 and 1 whereby the greater the value of the index of dominance, the lower is the species diversity in the community and vice versa (Webb *et al*., 2007; Sigdel, 2008). This index was calculated as described by Misra (1989):

$$D = \sum (n_i / N)^2 \qquad \text{(Equation 26)}$$

Where D is the Index of Dominance,

n_i is the number of individuals of species *i* in the sample;

N is the total number of individuals (all species) in the sample.

(iii) Similarity Index (JI)

This measures similarity between communities based on species composition. It is useful in comparing communities under different management. Jaccard index of similarity (JI) was used to estimate the proportion of species shared between state and communal forestland tenure regimes. The JI is a measure of similarity in species composition between two communities and is designated to equal 1 in cases of complete similarity and 0 if they are dissimilar i.e. have no species in common (Williams *et al.*, 2008). The following formula was used (Evariste *et al*., 2010):

$$JI = j/(n1 + n2 - j) \qquad \text{(Equation 27)}$$

Where, JI = Jaccard index of similarity,

j = the number of species common to the sites,

n1 and n2 = number of species occurring in site 1 and site 2, respectively.

(iv) Forest species composition computation

Composition is the assemblage of plant species that characterize the vegetation (Martens *et al.*, 2003). Composition as measured by richness and abundance can be obtained from relative density (RD), relative frequency (RF) and relative dominance (RDo) which forms the importance value index (IVI).

(v) Importance value index (IVI)

The data were quantitatively analysed for abundance, density and frequency according to the formulae given by Curtis and McIntosh (1950) cited by Evariste *et al*. (2010). Importance value Index (IVI) is the sum of relative density (RD), relative frequency (RF) and relative dominance (RDo) of a species in a community (Sigdel, 1989; Isango, 2007; Evariste *et al*., 2010). The IVI value of any species in community ranges between 0-300 and the sum of IVI of all species is 300. The following equation was used to calculate IVI as defined by Curtis and McIntosh (1950) cited by Evariste *et al*., (2010):

$$IVI = (RD + RDo + RF) \quad \text{(Equation 28)}$$

Where IVI is the Importance value Index,

RD = Relative density ,

RDo = Relative dominance and

RF = Relative frequency.

RD is a proportion of density of a species with respect to total density of all species in percentage, it was calculated using the following equation:

$$RD\ (\%) = \frac{Density\ of\ species\ A}{Total\ density\ of\ all\ species} x100 \quad \text{(Equation 29)}$$

and density which represents the numerical strength of the species in a community was calculated as:

$$Density\ (p/ha) = \frac{Total\ number\ of\ individual\ of\ species\ A}{Total\ number\ of\ plots\ studied\ x\ plot\ area} x10000 \quad \text{(Equation 30)}$$

Relative dominance (RDo) is a proportion of basal area of species in respect to total basal area of all species. Basal area is one of the chief characteristics to determine dominance. Therefore, relative dominance was determined as the relative value of basal area (Evariste *et al*., 2010).

$$RDo\ (\%) = \frac{Combined\ basal\ area\ of\ a\ species}{Total\ basal\ area\ of\ all\ species} x100 \quad \text{(Equation 31)}$$

The relative frequency (RF) and frequency was calculated as follows:

$$RF\% = \frac{Frequency\ of\ species\ A}{Sum\ of\ frequency\ values\ for\ all\ species} x100 \quad \text{(Equation 32)}$$

and the frequency was obtained from:

$$frequency = \frac{Total\ number\ of\ plots\ in\ which\ species\ A\ occured}{Total\ number\ of\ plots\ sampled}$$ (Equation 33)

3.3.3 Determination of influence of tenure on forest resources

Bonferroni t-tests for multiple comparisons (see e.g. Miller 1981) were done to compare different parameter values between the four sites. The level of significance in such tests is determined as α/(k(k-1)/2, where α = 0.05, and k number of pairwise comparisons , i.e. six with four sites was performed to compare forest parameters (basal area, volume, number of stems per ha and forest diversity) and diversity indices between state and communal tenure regimes to see if there is significant difference in the stocking and biodiversity. The confidence interval which is the range of deviation from the true mean for a given level of probability (95% in this case); was calculated based on the following equation (Philip, 1994):

$$CI = \bar{x} \pm tS_{\bar{x}}$$ (Equation 34)

where CI is confidence interval, $\bar{x}$ is the mean and tS $\bar{x}$ is the sampling error. It specifies the upper and lower levels of confidence.

3.4 Livelihood Data Collection and Analysis

3.4.1 Livelihood data collection

Based on DFID's sustainable livelihoods guidelines, livelihood data consist of assets, vulnerability and opportunities (DFID, 1999; Malleson *et al.*, 2008). Focus was on contribution of the forests to livelihood of the adjacent forest communities. Data was collected through structured interviews as well as Participatory Assessment of Livelihoods issues and Impact (PALI), which uses PRA approaches (Conroy, 2002).

(i) Sampling procedure and sample size

This study employed multi-stage and purposive sampling method to cover district, villages and hamlets (Simon, 1985). First the forests were grouped into state and communal tenure regimes, then the villages were selected to purposively fall near these forests. Four villages were selected; two villages represented villages practicing JFM near state forests while the other two represented villages practicing CBFM in village forest reserves for comparison. The sampling unit was a household in respective villages. Random sampling procedure (using random numbers) was used to select individual households in the villages. The sampling frame for each village was the list of all households in the villages and samples were drawn from sub-villages. The average sampling intensity was 10% which is higher than the recommended minimum sampling intensity of 5% that yielded less than 30 subjects that are regarded as small sample size (Boyd *et al.* 1981; Kothari, 1985). A total of 192 household' heads were interviewed in the four villages. Table 6 presents sampling intensity and sample size for each study village.

Table 6: Number of households, sample size and sampling intensity in the study villages

Forest name	Village name	Number of Households	Sample size	Sampling intensity (%)
Bereku	Haraa	451	45	10
Haraa	Managhat	484	48	10
Riroda	Riroda	498	54	11
Bubu	Bubu	446	45	10
Total		1879	192	

Source: Village governments' record 2010 *(ii) Forest pressures*

Forest pressures as part of disturbance were obtained from scoring done during PALI and PRA exercises. Identified pressures included logging, commercial fuelwood collection, charcoal making, grazing, annexing land for agriculture, and wild honey hunting. These were combined in a "composite index" for the selected households for each study forest (Appendix 4). The identified pressures were given scores which ranged from 1 to 5 and the average score was computed for each pressure. The indicators were weighted in a composite index and presented in a matrix index to get a representative of the six pressures, whereby, a cut off point for each pressure was 3.5 i.e. below 3.5 was regarded as not damaging while from 3.5 to 5 was termed as intense damage (contributed more gaps in the forest) for each forest. The conclusion was based on comparison of the cut points between state and communal tenure regimes in the four forests.

(iii) Structured interviews

Structured interviews involved the use of questionnaires with open and close-ended questions; these were administered to the selected household heads (Appendix 7). Data collected included, basic household information, economic activities, household assets and collection and use of products and services from the forest. The sample was composed of respondents between the age of 20 and 60 years and mostly (73%) have spent seven years in school. The households were composed of 1-12 members. The main economic activity of the sample households was farming, livestock keeping, horticulture, beekeeping, charcoal burning and petty business. The households owned medium and large land size (1-3 acres and > 3 acres respectively), while main crops were maize, pigeon peas, sunflower and beans.

Data on access to the five livelihood capitals was collected by using a five-point Likert scale (Shahbaz, 2009) (Appendix 6). In each capital, there were sets of indicators out of which two indicators with direct link to forest use were used in discussion. The questionnaires were pre-tested in Himiti village to check for validity and reliability. Necessary corrections were made before final administration. Secondary data were collected from villages' offices, district's authorities and from internet and libraries.

(iv) Focus group discussion (FGD)

A Focus group discussion (FGD) is a qualitative method to obtain in-depth information on concepts, perceptions and ideas of a group of approximately 6–12 persons (Corlien *et al*, 2003). The FGD was used to collect qualitative data to complement information from structured questionnaire. In each village, there were four groups of FGD. The composition of the groups were from i) women ii) youths ii) village leaders and iv) elderly men. The reason for forming four FGDs was that each group in the village has its own needs and priorities in conservation and uses in forests, this should be taken into consideration. A checklist of defined issues was prepared to guide the FGD (Appendix 5).

(v) Field observations

Field observation involved direct observation of communities and household activities, behaviour, relationship, networks, processes and their perception towards resource use and related economic returns for livelihood sustenance. Other PRA methods used included: Venn diagram drawing which showed relationship of institutions in the village, seasonal calendar, historical trend line, organizational chart, time line, simple ranking, pair-wise ranking and matrix scoring on priorities in livelihood capital asset and dominant pressure.

3.4.2 Livelihood data analysis

(i) Qualitative and quantitative data analysis

Qualitative data were subjected to content and structural-functional analysis techniques (Kajembe, 1994). Quantitative data analysis was done using the Statistical Package for Social Sciences (SPSS) computer software version 16 and MINITAB software; Descriptive and inferential statistical analyses were used in the analysis of quantitative data in which the results were presented in the form of frequencies, means, standard deviation and cross tabulation.

(ii) Analysis of capital indices and livelihood index

The capital indices of the five livelihood capital assets obtained from likert scale were calculated as follows (Rahman and Akter, 2010):

$$CI = \sum_{j=1}^{j} (y_{ij} / Y_{\max}) \qquad \text{(Equation 35)}$$

while livelihood index was calculated using the following formula:

$$LI = \sum_{i=1}^{n} (\sum_{j=1}^{j} (y_{ij} / Y_{\max})) / n \qquad \text{(Equation 36)}$$

Where: CI = household capital index,

LI = Livelihood index,

I = 1,2,.......n (n=sample size) and

j = 1,2,.........x (x=number of sub-dimensions determining factor),

Y_{ij} = frequency of score to an individual sub-dimension of the main dimension and

Y_{max} = maximum frequency of score to that sub-dimension.

The indices values ranged between zero and one where 0 – 0.3 indicated poor, 0.4 – 0.6 indicated fair or satisfactory and 0.7 – 1 indicated good. Chi square test was performed to compare the results if there was any association between forestland tenure regime and access to livelihood capital assets.

(iii) Analysis of relative forest income (RFI)

Forest income was calculated as relative forest income rather than absolute forest income since it is difficult to say what level of absolute income determines forest dependence (Lepetu, 2009).

At household level, relative forest income (RFI) was used to analyse forest dependence (*FD*) from forest income sources. RFI in this case is a proportion of the share of income in total household income accounts derived from consumption or sale of forest resources (AFI) to total household income (*AI*) per year (Kamanga, 2005; Mamo *et al*., 2007). The calculations were based on the following formula as detailed in Vedeld *et al*. (2004):

$$RFI = \frac{AFI}{AI} \qquad \text{(Equation 37)}$$

where RFI = relative forest income,

AFI = total absolute forest income and

AI = total absolute household income.

Total absolute income (AI) was the sum of absolute forest income (AFI), on-farm and off-farm income and income from livestock. Whereby, absolute forest income (AFI) included cash and subsistence returns from the forest. It comprised household firewood consumed, selling of firewood to other villagers, selling of fodder, income from charcoal burning, honey and beeswax selling, selling of burnt bricks which uses firewood from the forests and irrigation of horticultural crops by which furrows have been dug to tap water from the forest of which some were used for home consumption, however grazing could not be quantified since it was done in different areas apart from the forest. On-farm activities income was the sum of the products from different crops cultivated. It was composed by market price minus inputs costs for the sampled households. Off-farm activities income included small scale income generating activities, aids from relatives, temporary and permanent employment whereas income from livestock considered number and type of livestock, market price and medicines costs. The cost of own labour was not considered due to multiple work done at the same time which could lead to over estimation.

3.4.3 Determination of influence of state and communal tenure regimes on livelihood

A multiple regression model was developed as one of inferential statistical analysis technique; this showed the relationship between households relative forest income (RFI) as the surrogate of forest livelihood dependent variable obtained from sales of forest products from state and communal forest reserves.

Therefore, assuming linearity, the multiple regression model was as follows (Johnson and Wichern, 2002; Montgomery *et al.*, 2006):

$$RFI = \beta_0 + \beta_1 x_1 + \beta_2 x_2 \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \lambda_1 D_1 + \lambda_2 D_2 + \lambda_3 D_3 + \mu$$

(Equation 38)

Where βo is the intercept when all other factors =0,

β_1-β_6, λ_{1}- λ_3.... are regression coefficients describing the size of contribution of the factor which are independent variables.

x_1- x_6 are quantitative independent variables

x_1=age of household head (years),

x_2=education of household head (number of years spent in school),

x_3= number of livestock owned by the household,

x_4= total household income,

x_5=cropland size held (or cultivated) by the household (ha),

x_6= number of household members.

D_1-D_3 are qualitative-dummy variables; where

D_1= forestland tenure type (1=state, 2=communal),

D_2= sex of household head (1=female, 2=male),

D_3 =having savings (1=no saving, 2=have saving) and **μ** stochastic disturbance term.

The assumptions and signs of the regression coefficients are summarised in Table 7. An F-test at $p \leq 0.05$ was used to determine if the relationship can be generalized to the population represented by the sample and a t-test was used to evaluate the individual relationship between each independent variable and the dependent variable.

Table 7: Assumptions on household characteristics and size of β contribution expected to influence forest dependence

Factor	Expected β sign	Assumption and theories
Age of household head	-ve	Age capture labour, where young households head are more energetic and have more time for forest activities hence likely to get more forest income (Adhikari, 2005; Vedeld *et al*. 2004)
Education level of household head	-ve	People with more education are likely to have other sources of income, since education opens up alternative employment opportunities hence less entrance to the forest leading to low forest income (FI) (Vedeld *et al*. 2004; World Resource 2005)
Number of household members	+ve	A larger household has more labour for various forest activities and hence may derive more resources from the forest therefore more FI. (Buyinza, 2008)
Land size owned by the household	-ve	Households better endowed with land tend to obtain some of the forest products from their farms therefore small land size more utilization of forests (Adhikari, 2005)
Number of livestock owned by a household	+ve	Households with more livestock have greater need for animal fodder hence more forest utilization especially in grazing area (Varughese and Ostrom, 2001; Narain *et al*. 2005)
Total household income	-ve	Lower income high dependence on FI since forest activities have low entry costs, few requirements in terms of skills and capital and those with low income use forest products due to lack of better alternatives (Angelsen and Wunder, 2003; Vedeld *et al*., 2004; World Resource, 2005)
Forestland tenure type	-ve	There is insecurity over property rights owned by state, holders have few incentives to protect the resources hence more utilization (White and Martin, 2002)
Sex of household head	-ve	Female-headed households often have less access to labour hence lower forest income (Buyinza , 2008)
Household having savings	-ve	Households with more savings are considered wealthy hence less need for forest income since productive wealth creates more opportunities (Adhikari, 2005)

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents research results and discussions in relation to the study specific objectives. The findings include forest cover changes in the two tenure regimes, influence of forestland tenure regimes on stocking and biodiversity, disturbance and forest pressures and eventually the influence of forestland tenure regimes on rural livelihoods.

4.1 Forest Vegetation Cover Change in State and Communal Tenure Regimes

Vegetation classification and change detection have been quantified over a 16-year time period (1993, 2000 to 2009) in state and communal forestland tenure regimes. Rate of forest cover change was calculated from each forest, and then comparison between forests of different tenure regimes was done. The results are presented in the following sub-topics.

4.1.1 Vegetation classification and main forest cover types in 1993, 2000 and 2009

Results of image classification in years 1993, 2000 and 2009 produced the following maps (Figure 3, 4, 5, 6, 7 and 8) with six classification cover classes including (i) Closed woodland (ii) Open woodland (iii) Bushed woodland (iv) Shrubs and (v) Grassland found in both - state and communal land forests and (vi) some few settlements found in VFR prior to evacuation of villagers.

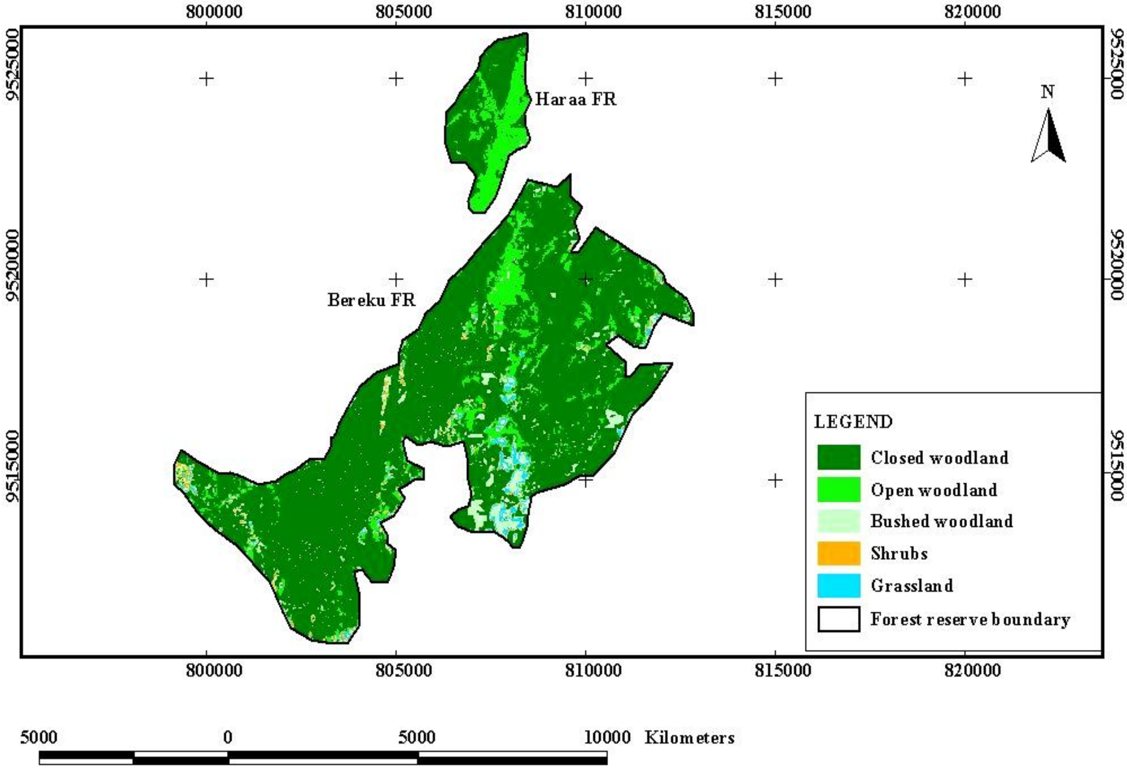

Figure 3: Forest cover types in 1993 in Haraa and Bereku state forestland tenure

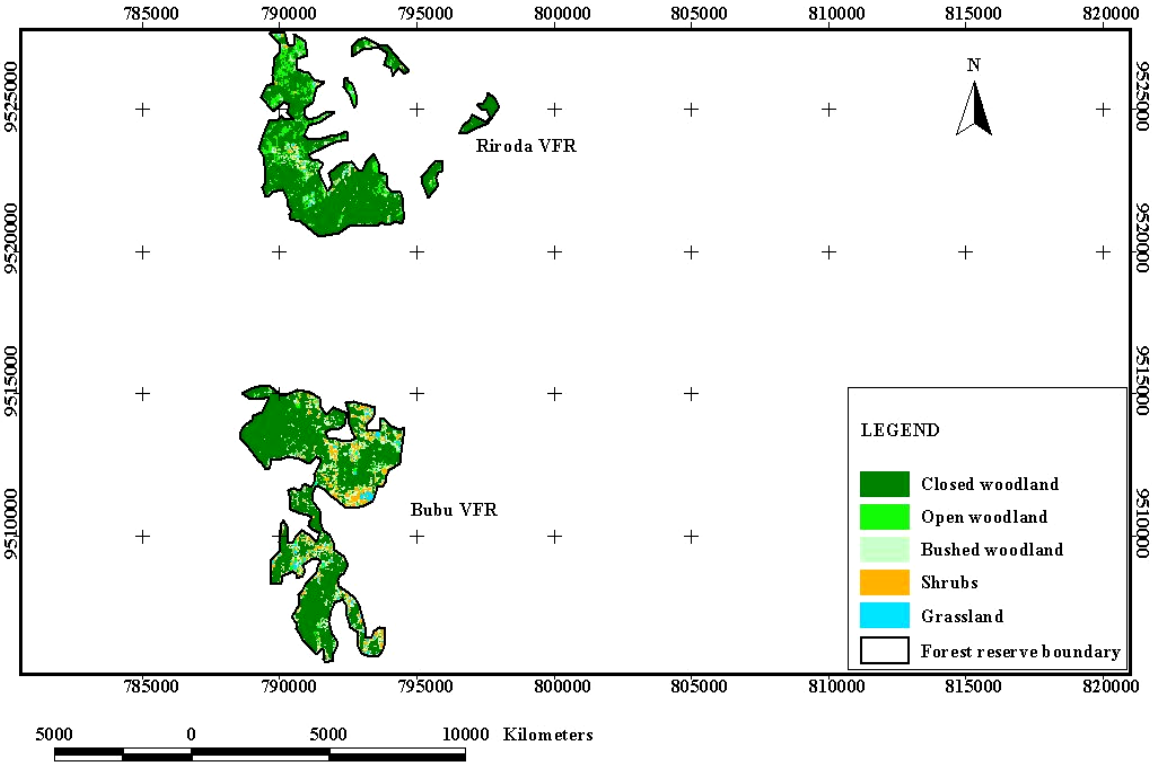

Figure 4: Forest cover types in 1993 in Riroda and Bubu communal forestland tenure

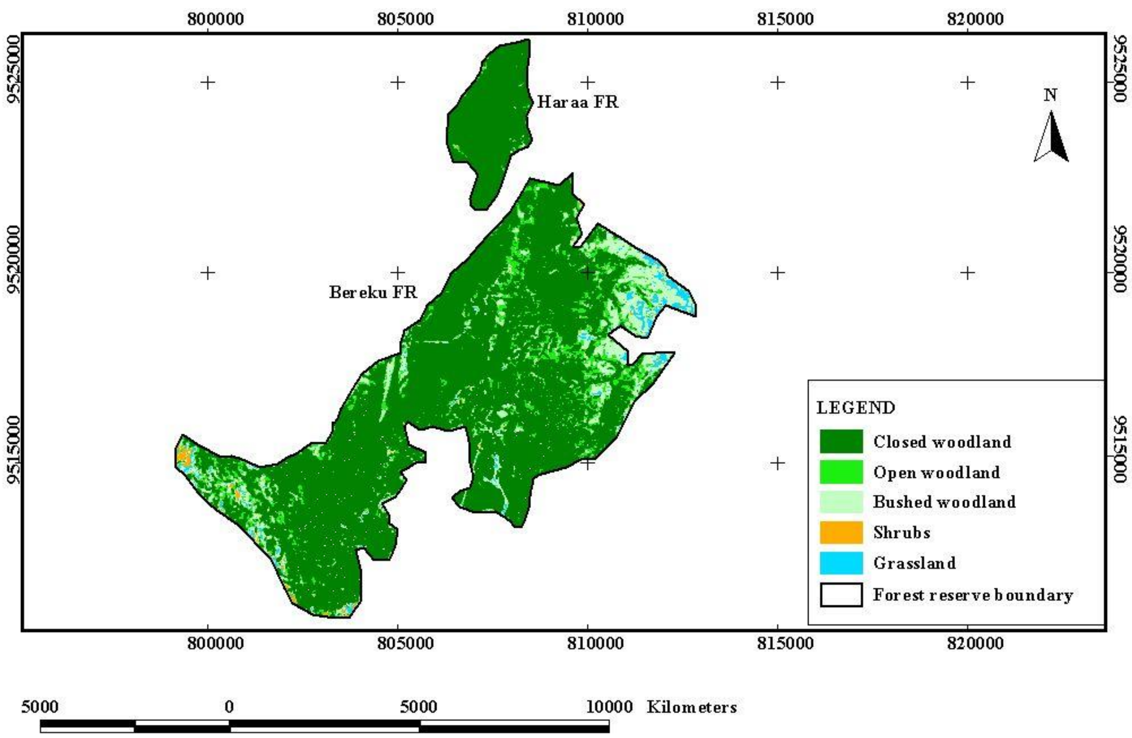

Figure 5: Forest cover types in 2000 in Haraa and Bereku state forestland tenure

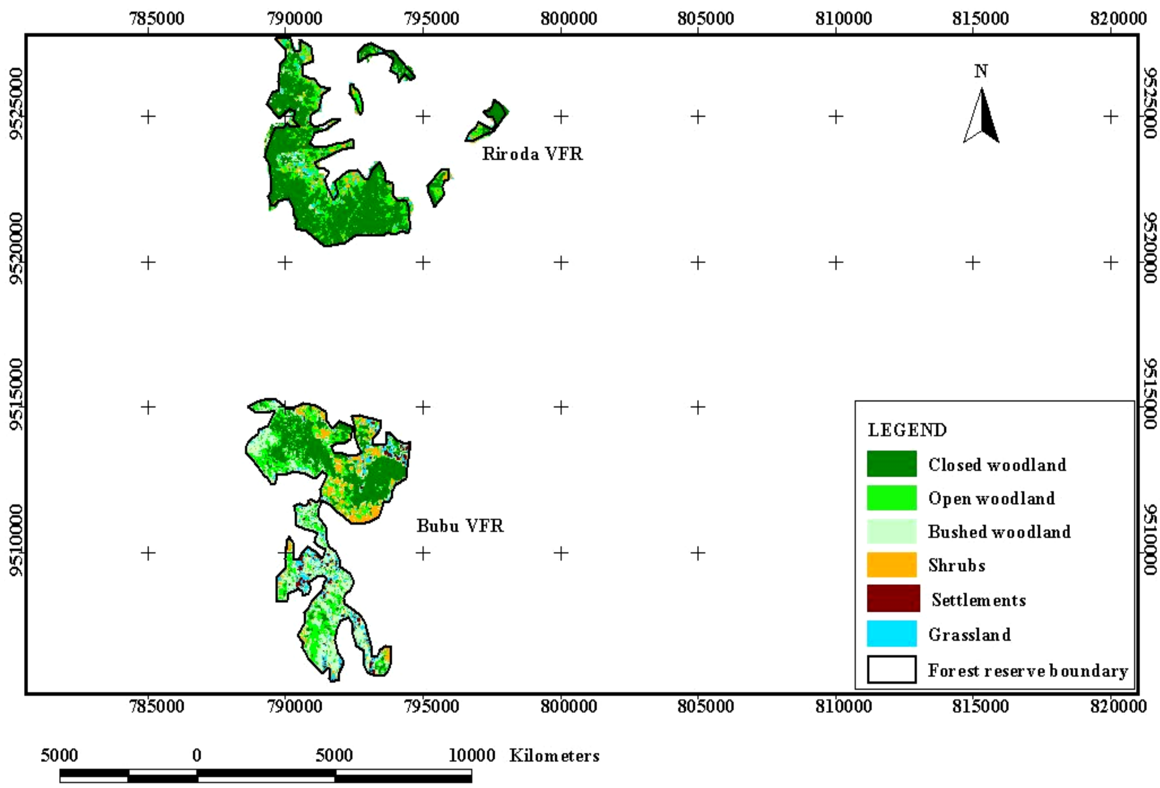

Figure 6: Forest cover types in 2000 in Riroda and Bubu communal forestland tenure

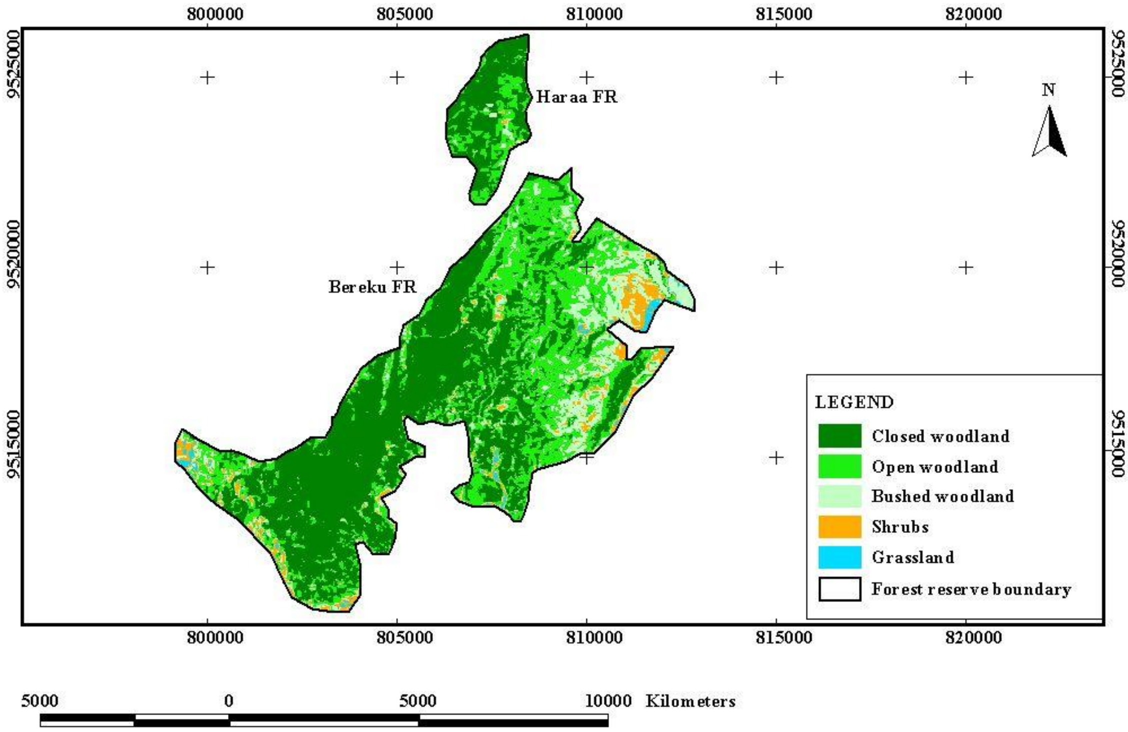

Figure 7: Forest cover types in 2009 in Haraa and Bareku state forestland tenure

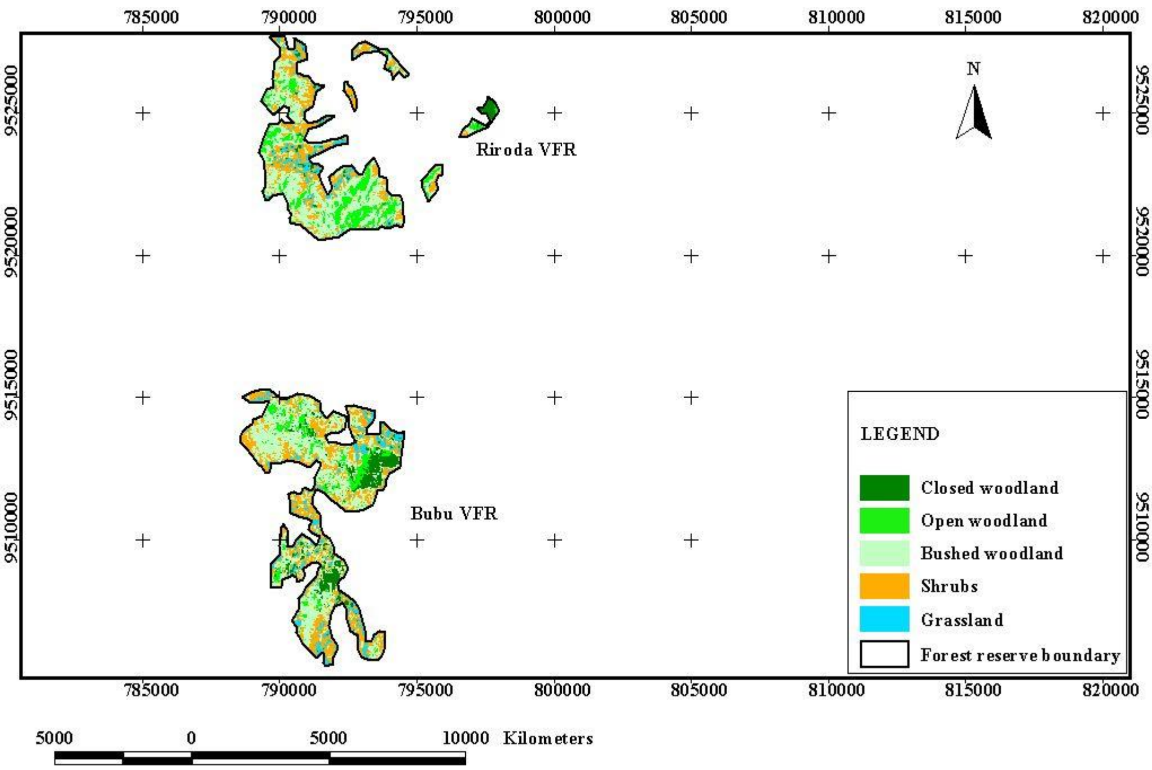

Figure 8: Forest cover types in 2009 in Riroda and Bubu communal forestland tenure

In 1993, forests under state forestland tenure regime were dominated by closed woodlands which accounted for 83.1% and 84.0% of the vegetation cover in Bereku and Haraa FRs respectively followed by a small proportion of open woodlands while shrubs and grassland covers were very few (Table 8). Vegetation cover in village land forests in 1993, comprised 74.6 and 68.0% of closed woodland in Riroda and Bubu VFRs respectively, followed by open woodland in Riroda VFR and bushed woodland in Bubu VFR (Table 8).

Results for 2000 in state forestland tenure regime showed that closed woodland still dominated vegetation cover in Bereku and Haraa FRs. In forests under communal forestland tenure regime results showed that in Riroda VFR the dominant forest cover was open woodland while in Bubu VFR it was bushed woodland (Table 8). In 2009, the dominant forest vegetation cover in state forestland tenure regime was closed woodland followed by open woodland. Results in village FRs showed a domination of bushed woodland in Bubu and Riroda VFRs.

In general, results showed that forests under state forestland tenure regime had a higher proportion of closed woodland than foerests under communal forestland tenur regime. This is also High dominance of closed woodlands was probably due to strong rules and regulations that governed state forests. Before change of tenure regime, removal of any forest produce was prohibited (Sjaastad *et al*., 2003; MNRT, 2003a; Vyamana, 2009). The high dominance of closed woodland in village forests was the reason that made them a target for gazettement into national forest reserve earlier in 1991/92 (Kajembe *et al*., 2003b).

Table 8: Forest cover area in 1993, 2000 and 2009

Forest name	Forest Cover class	Forest cover 1993		Forest cover 2000		Forest cover 2009	
		(Ha)	(%)	(Ha)	(%)	(Ha)	(%)
Bereku	Closed woodland	5076.7	83.1	4616.5	75.5	2967.9	48.6
	Open woodland	602.5	9.9	620.9	10.2	1889.6	30.9
	Bushed woodland	290.9	4.8	681.9	11.2	788.6	12.9
	Grassland	79.7	1.3	139.4	2.3	186.1	3.0
	Shrubs	61.2	1.0	52.3	0.9	278.9	4.6
	Total	6111.0	100.0	6111.0	100.0	6111.0	100.0
Haraa	Closed woodland	508.4	84.0	505.9	83.6	404.5	66.9
	Open woodland	82.9	13.7	94.0	15.5	175.0	28.9
	Bushed woodland	11.1	1.8	4.3	0.7	18.6	3.1
	Grassland	1.1	0.2	0.1	0.0	4.2	0.7
	Shrubs	1.5	0.3	0.6	0.1	2.7	0.4
	Total	605.0	100.0	605.0	100.0	605.0	100.0
Riroda	Closed woodland	1343.4	74.6	169.1	9.4	27.7	1.5
	Open woodland	283.6	15.8	984.4	54.7	307.5	17.1
	Bushed woodland	125.7	7.0	328.2	18.2	784.7	43.6
	Grassland	15.8	0.9	107.8	6.0	238.2	13.2
	Shrubs	31.5	1.7	210.6	11.7	441.9	24.6
	Total	1800.0	100.0	1800.0	100.0	1800.0	100.0
Bubu	Closed woodland	1564.8	68.0	580.2	25.2	17.9	0.8
	Open woodland	58.1	2.5	410.4	17.8	302.1	13.1
	Bushed woodland	382.3	16.6	675.6	29.4	760.3	33.1
	Grassland	98.1	4.3	267.7	11.6	528.6	23.0
	Shrubs	196.7	8.6	206.4	9.0	691.1	30.0
	Settlements	0.0	0.0	159.7	6.9	0.0	0.0
	Total	2300.0	100.0	2300.0	100.0	2300.0	100.0

Increased open woodlands and bushed woodland observed in later years could be due to timber extraction, charcoal making and grazing, indicating uncontrolled use of resources in communal forestland tenure. Forests under state forestland tenure regime being under secure tenure since gazettement of the forests, have shown to have more closed forests than forests under communal forestland tenure regime which were first under open access regime.

Other studies found out that vegetation cover in many forests were originally dominated by closed woodland but in later years the closed woodland cover declined (Abbot and Homewood, 1999; Luoga *et al.,* 2005; Backéus *et al*., 2006). Luoga *et al*. (2005) found that the decline in closed woodland cover was higher in the general lands which suggested that common property regime did not function in that area. Mechanism to control overuse of the resources was weak which proved the open access condition of the forests. In Malawi, Abbot and Homewood (1999), documented a decline in closed woodland cover caused by a doubled population of the fishing community near Lake Malawi National Park. Due to park's weak law enforcement, the local communities continued felling large size classes for commercial fish processing. In all the above studies, forestland tenure regime seems to be one of the factors affecting forest condition. Nevertheless, Aryal and Pokharel (2011) insisted that forest under secured tenure regimes performed better in maintaining forest cover than the ones with less secure tenure.

4.1.2 Change detection in state and communal tenure regimes

Figs. 9 – 12 present vegetation change in state and communal forestland tenure regimes. A general summary of 1993-2000 and 2000 - 2009 maps in the study area showed forest vegetation classes cover in state and village land forests have changed significantly in the last 16 years. There were remarkable changes under different vegetation classes from 1993 to 2000 and from 2000 to 2009 (Appendix 1). In state and communal tenure regimes a notable change was observed in closed woodland and open woodland (Table 9).

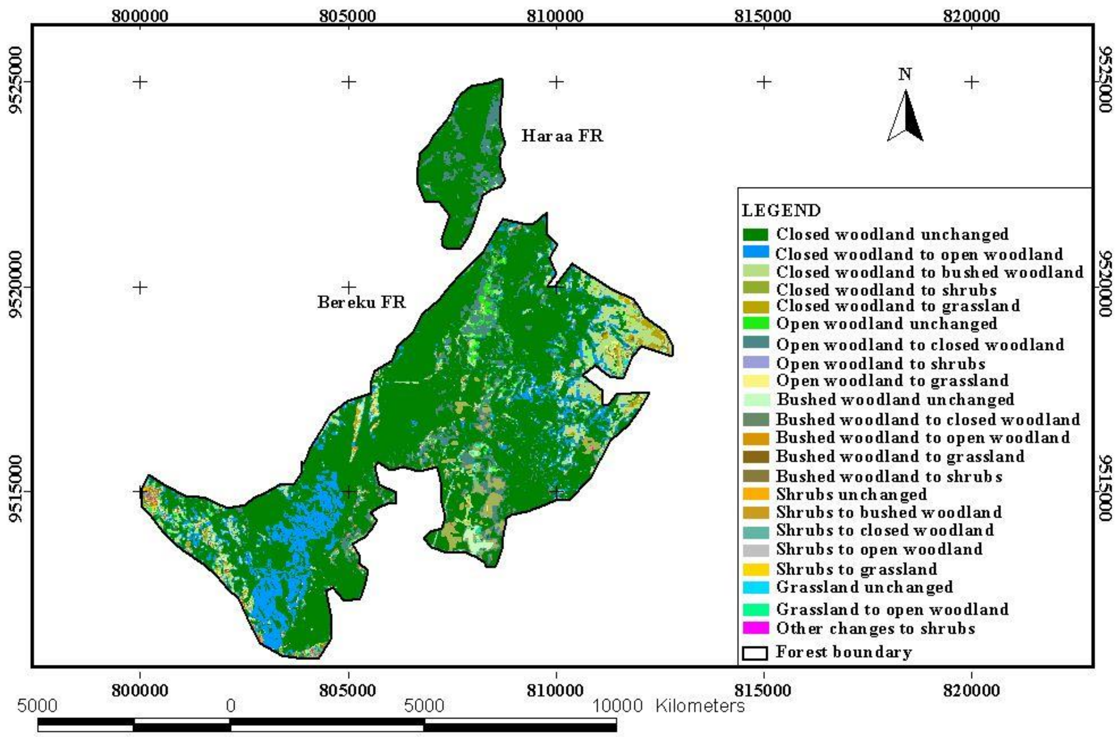

Figure 9: Forest cover changes in state forestland tenure between 1993 and 2000

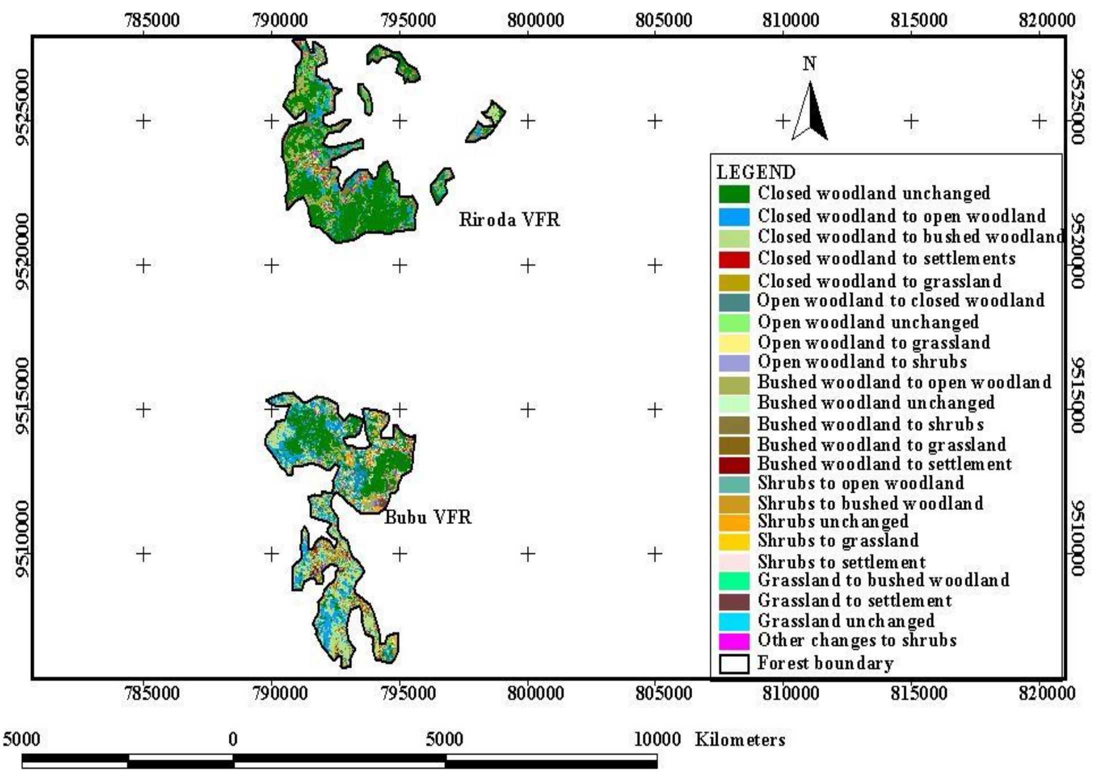

Figure 10: Forest cover changes in communal forestland tenure between 1993 and 2000

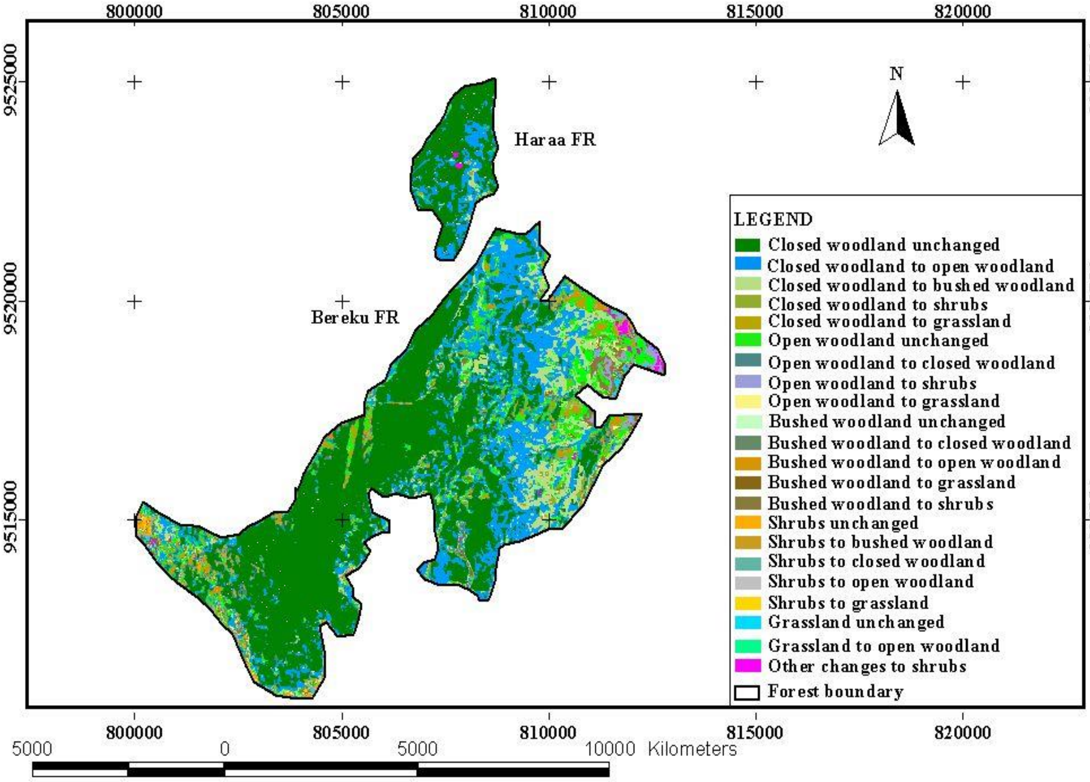

Figure 11: Forest cover changes in state forestland tenure regimes between 2000 and 2009

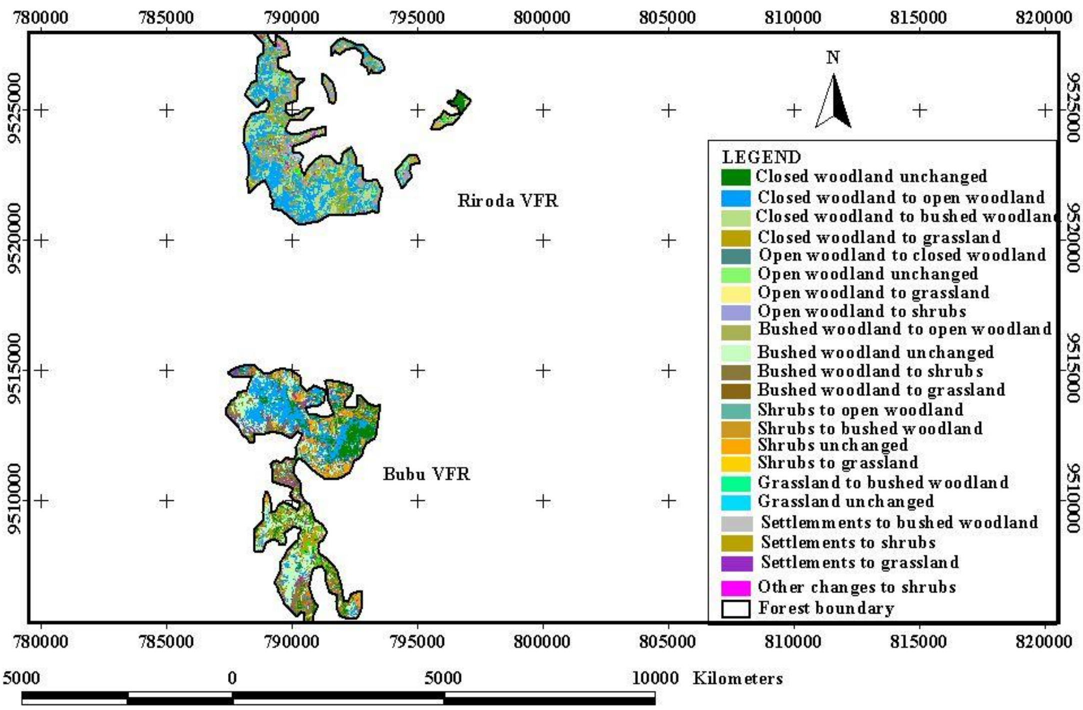

Figure 12: Forest cover changes in communal forestland tenure regimes between 2000 and 2009

Table 9: Cover change and rate of cover change between 1993 and 2000 and between 2000 and 2009 in state and communal forestland tenure regimes

Forest name	Forest cover class	Cover area change				Annual rate cover area change			
		1993 - 2000		2000 - 2009		1993 – 2000		2000 - 2009	
		(ha)	%	(ha)	%	(ha/yr)	(%/yr)	(ha/yr)	(%/yr)
Bereku	Closed woodland	-460.2	-7.5	-1648.6	-27.0	-65.7	-1.1	-183.2	-3.0
	Open woodland	18.5	0.3	1268.7	20.8	2.6	0	141.0	2.3
	Bushed woodland	390.9	6.4	106.7	1.7	55.8	0.9	11.9	0.2
	Grassland	59.7	1.0	46.7	0.8	8.5	0.1	5.2	0.1
	Shrubs	-8.9	-0.1	226.7	3.7	-1.3	0	25.2	0.4
Haraa	Closed woodland	-2.4	-0.4	-101.5	-16.8	-0.3	-0.1	-11.3	-1.9
	Open woodland	11.2	1.8	81.0	13.4	1.6	0.3	9.0	1.5
	Bushed woodland	-6.7	-1.1	14.3	2.4	-1.0	-0.2	1.6	0.3
	Grassland	-1.0	-0.2	4.1	0.7	-0.1	0	0.5	0.1
	Shrubs	-0.9	-0.2	2.1	0.4	-0.1	0	0.2	0
Riroda	Closed woodland	-1174.4	-65.2	-141.4	-7.9	-167.8	-9.3	-15.7	-0.9
	Open woodland	700.7	38.9	-676.9	-37.6	100.1	5.6	-75.2	-4.2
	Bushed woodland	202.6	11.3	456.5	25.4	28.9	1.6	50.7	2.8
	Grassland	92.0	5.1	130.5	7.2	13.1	0.7	14.5	0.8
	Shrubs	179.1	10.0	231.3	12.9	25.6	1.4	25.7	1.4
Bubu	Settlements	-984.6	-42.8	-562.3	-24.4	-140.7	-6.1	-62.5	-2.7
	Closed woodland	-352.3	-15.3	-108.3	-4.7	-50.3	-2.2	-12.0	-0.5
	Open woodland	293.3	12.8	84.7	3.7	41.9	1.8	9.4	0.4
	Bushed woodland	169.6	7.4	260.9	11.3	24.2	1.1	29.0	1.3
	Grassland	9.7	0.4	484.7	21.1	1.4	0.1	53.9	2.3
	Shrubs	159.7	6.9	-159.7	-6.9	22.8	1.0	17.7	0.8

In closed woodlands cover, the results indicated that between 1993 and 2000, forests under state forestland tenure regime of Bereku and Haraa, changed from closed woodland at a rate of -65.7 and -0.3 ha/year indicating a decrease of -1.1 and -0.1 % /year respectively. Within the same period, an increase in open woodland and bushed woodland cover was observed (Table 9). Similarly, between 1993 and 2000 communal forestland tenure of Riroda and Bubu experienced a decrease in closed woodland by -42.8 and -65.2% respectively. Open woodland cover in communal tenure regime changed at a rate of -9.3 and -6.1%/year, which is higher than the rate of change from closed woodland cover (to other vegetation covers) in state forestland tenure regime in the same period. The results further indicated that closed woodland in forests under communal tenure regime decreased rapidly than in state forestland tenure regime (cf. reduction of 65.7 ha/year and 0.3 ha/year in Bereku and Haraa FR respectively to reduction of 140.7 ha/year and 167.8ha/year in Riroda and in Bubu VFR respectively). Between 2000 and 2009 results showed that there were further decreases in closed woodland cover in state forestland tenure at a rate of -3.0 and -1.9 %/year which is much higher than the rate of change between 1993 and 2000. In the same period, the rate of change from closed woodland in communal forestland tenure regime was lower than the rate of change between 1993 and 2000 in Riroda and Bubu VFR respectively.

From the results it is clear that there was a remarkable change in closed woodland within the period of 16 years. This could be due to illegal activities in state tenure regime; whereas in communal tenure regime the forests suffered from charcoal burning and encroachment. Illegal tree felling in state forestland tenure is a serious problem as was observed during inventory.

From Figs 9 – 12, it was further observed that intense changes occurred on forest edge close to villages. During the FGD, some members of the village environmental committee asserted that most of the felled trees near the villages were used for brick burning and most of the illegal activities were done at night. These results comply with other studies done elsewhere (Varughese and Ostrom, 2001; Gautam *et al*., 2004; Jansen *et al*., 2008), where it was observed that there was a decrease in forests and woodland classes in favour of other land cover/use classes, for example open woodland, cultivation and settlements, woodland with scattered cultivation or bare land.

The annual rate of change for closed woodland cover in the communal forestland tenure regime was higher than the rate of change in state forestland tenure regime between 1993 and 2000; this could be due to the strict laws and regulations governing the state forestland tenure regime. In Riroda VFR the large change of closed woodland to open woodland and bushed woodland has a correspondence with the encroachment made by villagers when the forests were about to be gazetted (IRG, 2000; Wily, 2002). In general, these changes suggest that closed woodland in both tenure regimes are opened up to open woodland and open woodland to bushland and shrubs, which is a sign of degradation.

In this study, the change in forest cover displayed great variation in both spatial and temporal situations; this may be the effect of different strategies and efforts by the forest department and due to other socio-economic factors among them is forestland tenure reform. Results from this study conform well to other studies. Other studies in miombo woodland areas have also reported forest vegetation cover change for different regions over different time periods. Petit *et al*, (2001) reported an annual rate of change of -4.3% and -3.5% for closed forest and woodland respectively, in their study in Lusitu, Zambia from 1986 to 1997 where these cover classes were converted to other classes. Abbot and

Homewood, (1999) reported a decrease in closed woodland at a rate of 51.5 ha/year (-6.2%/year) whereas there was an increased sparse woodland at a rate of 60 ha/year (+7.2%/year) within a period of eight years from 1982 to 1990 in a study in Lake Malawi National Park, Malawi. Jansen *et al*. (2008) reported a -1.41% and -0.36% loss in closed forest and closed woodland cover per annum in Manica, Mozambique during a period of 14 years between 1990 and 2004. On the other hand, Aryal and Pokharel (2011) in Nepal observed that community forest regimes did very well in terms of both creating new forest and in improving the quality of existing forest due to secure tenure arrangements.

4.1.3 Accuracy assessment of classifications by error matrix

The results of accuracy assessment are summarized in the error matrix from which statistics and indices that indicate the accuracy of individual classes and of the whole map were derived (Table 10). The error matrix used 2009 image in classification accuracy assessment since ground truth data were collected in the same year.

The accuracy assessment yielded a high level of accuracy between the classified and observed data. The overall accuracy was 85.6% with a Kappa value of 0.79, which represents reasonable agreement (Congalton, 2001). These results were consistent with other accuracy assessments done in Babati forests.

Kashindye (2011) reported an overall classification accuracy of 80.3% with a Kappa value of 0.74 in Bereku FR and Duru-Haitemba VFR; only 5% lower than this study's results. Anderson *et al.*, (1976) and Thomlinson *et al.* (1999) recommended a minimum level of interpretation accuracy in the identification of land use and land cover categories to be at least 85 % which is almost the same with this study's result.

Table 10: Classification accuracy error matrix for the 2009 forest vegetation cover map

	Reference data											
	Class name	Unclassified	Water	Closed woodland	Open woodland	Bushed woodland	Shrubs	Grassland	Settlements	Total	User's accuracy %	Kappa for each class
Classified data	Unclassified	0	0	0	0	0	0	0	0	0		0
	Water	0	4	0	0	0	0	0	0	4	100.0	1.00
	Closed woodland	0	0	114	10	6	1	1	2	134	85.1	0.72
	Open woodland	0	0	2	12	1	0	0	0	15	80.0	0.78
	Bushed woodland	0	0	0	1	28	0	0	0	29	96.6	0.96
	Shrubs	0	0	1	0	0	22	2	1	26	84.6	0.83
	Grassland	0	0	0	0	0	7	26	0	33	78.8	0.76
	Settlements	0	0	0	0	0	0	1	8	9	88.9	0.88
	Total	0	4	117	23	35	30	30	11	250		
	Producer's accuracy		100.0	97.4	52.2	80.0	73.3	86.7	72.7		85.6	
	Overall kappa statistics											0.79

From the results, accuracy assessment for the detailed vegetation cover classes showed good producer's and user's accuracies (Table 10). The lowest accuracy was in open woodland which was 52.2% with 12 out of 23 points classified correctly. The low value could be due to mixed pixels classified as closed woodland. The user's accuracy for different forest vegetation classes was highest in bushed woodland cover with a value of 96.6% implying that there is 96.6% chance of finding bushed woodland correctly classified in the study area. The Kappa statistics for each class was high denoting good to perfect agreement but it was highest in water bodies (Lake Babati specifically) and bushed woodland with values of 1.0 and 0.9 respectively. Accuracy assessment provides a powerful mechanism for evaluation of the spatial data but it is important to consider both the producer’s and user’s accuracy, since the use of a single value could be misleading (Sullivan *et al*, 2009; Kashindye, 2011).

4.2 Influence of State and Communal Forestland Tenure Regimes on Stocking and Biodiversity Level

Results on influence of forestland tenure regime on stocking (number of stems ha^{-1}, basal area m^2ha^{-1}, and volume m^3ha^{-1}) and biodiversity indices in state and communal forestland tenure regimes are discussed and presented in the following subchapters.

4.2.1 Influence of forestland tenure regime on stocking

4.2.1.1 Stocking parameters in state and communal forestland tenure regimes

Table 11 describes stocking parameters for the four sites. Since Bereku and Haraa FRs comprise miombo as well as dry montane forests, separate results for these two forest types are included in the table, the focus however is on the total results regardless of vegetation types, given that they also showed small difference in the parameters.

(i) Number of stems per ha (N)

The results in Table 11 show that the mean number of stems ha^{-1} in forests under state forestland tenure of Bereku and Haraa FRs was higher than in forests under communal tenure regimes of Riroda and Bubu VFRs. The distribution of stems ha^{-1} in both - state and communal forestland tenure regime showed a reversed J- shaped trend (Figure 13 and 14). There were few individuals towards the larger diameter classes that is, trees with dbh more than 50 cm in forests under state and communal forestland tenure regimes. The size class distribution is suggestive of a healthy population, with populations being dominated by the juvenile class indicating good forest regeneration (Philip, 1994; Kajembe *et al*., 2009). The difference in density of the forests under state and communal forestland tenure regimes was well observed in the satellite images (Figs 7 and 8). There was no significant difference in mean number of stems ha^{-1} (N) among the four forests (Table 12).

Comparing with other studies, for example in Kitulangalo FR, Mugasha and Chamshama (2002) observed a higher number of stems in the general land forest, which is open access tenure regime (1495 stems ha^{-1}) than in SUA (private) and state forestland tenure (1084 and 1027 stems ha^{-1} respectively). The high number of stems in general land forest is the result of disturbances, which induced natural regeneration.

Malimbwi (2003) observed 2458±283 and 2017±258 stems ha^{-1} in Riroda and Bubu VFRs respectively which is far greater than what was observed in this study. This is probably because Malimbwi’s (2003) study included trees with dbh of 1cm and above. In another study, Kajembe *et al.* (2009) observed 620 and 477 stems ha^{-1} between state and communal forestland in Bereku FR and Duru-Haitemba VFR which practices JFM and CBFM, respectively. Figures obtained by Kajembe *et al.* (2009) were much lower than what was observed in this study, probably due to increased illegal harvesting at the time of the previous study. Mbwambo *et al*., 2012 reported 2028 stems ha^{-1} in Shagayu FR under state forestland tenure in montane forests in Tanga and 1155 ha^{-1} in Mgori VFR under communal tenure regime within Singida miombo woodlands. The number of stems ha^{-1} is quite high in state forestland tenure which could have been attributed by a number of reasons among them being socio economic conditions of the area, site specific conditions or forest conditions before the management and tenure changes.

Despite the fact that there was no significant difference in tree density among the four forests, it does not suggest that tenure regime has no influence on forest condition. Hayes (2006) cautioned that, although vegetation density enables an empirical assessment and provides a picture of forest condition; it is not a comprehensive measurement of forest condition hence other measurement like basal area, volume and satellite images should be considered when comparing forests in the same ecological zone.

Table 11: Forest stocking mean and standard error between plots within sites

Site	Vegetation type	No. of Plots	Parameter	Mean Confidence interval	Standard error %
Bereku	Miombo	48	N (ha^{-1})	1032±151	14.5
			G (m^2ha^{-1})	15.33±1.8	12.3
			V (m^3ha^{-1})	121.11±16.8	13.9
	Dry montane	7	N (ha^{-1})	994±422	42.5
			G (m^2ha^{-1})	12.91±5.3	41.5
			V (m^3ha^{-1})	98.92±42.9	43.5
	All	55	N (ha^{-1})	1027±146	14.2
			G (m^2ha^{-1})	15.0±1.8	12.2
			V (m^3ha^{-1})	118.3±16.3	13.8
Haraa	Miombo	20	N (ha^{-1})	1170±276	23.6
			G (m^2ha^{-1})	11.31±2.8	24.8
			V (m^3ha^{-1})	82.62±24.0	29.1
	Dry montane	13	N (ha^{-1})	1078±574	52.3
			G (m^2ha^{-1})	15.61±3.5	22.4
			V (m^3ha^{-1})	110.28±29.5	26.8
	All	33	N (ha^{-1})	1134±256	21.5
			G (m^2ha^{-1})	13.0±2.2	18.1
			V (m^3ha^{-1})	93.5±18.3	20.4
Riroda	Miombo	36	N (ha^{-1})	1015±216	21.3
			G (m^2ha^{-1})	11.35±2.1	18.8
			V (m^3ha^{-1})	89.93±23.4	26.1
Bubu	Miombo	30	N (ha^{-1})	848±127	15.2
			G (m^2ha^{-1})	10.45±1.7	16.5
			V (m^3ha^{-1})	78.04±15.1	19.4

N = Number of stems G = Basal area V = Volume

Table 12: Stand parameters p-value comparison between state and communal forestland tenure regime

Site	No. of plots	Parameter*	Bonferroni t-test (α = 0.05) **
Bereku	55	N (ha^{-1})	A
Haraa	33		A
Riroda	36		A
Bubu	30		A
Bereku	55	G (m^2ha^{-1})	A
Haraa	33		AB
Riroda	36		B
Bubu	30		B
Bereku	55	V (m^3ha^{-1})	A
Haraa	33		AB
Riroda	36		AB
Bubu	30		B

*N = number of stems, G = basal area, V = volume
**Means with the same letter are not significantly different

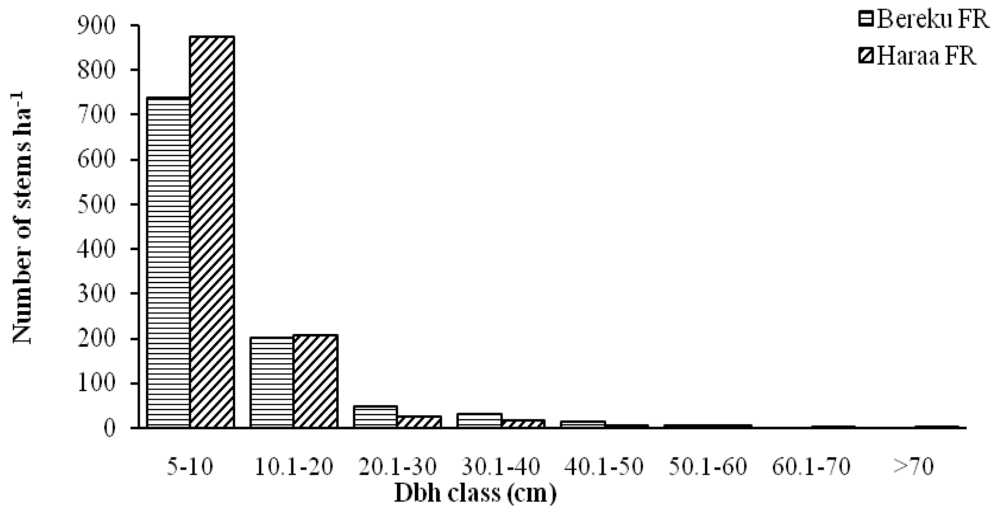

Figure 13: Stem distribution in state forestland tenure regime by diameter classes

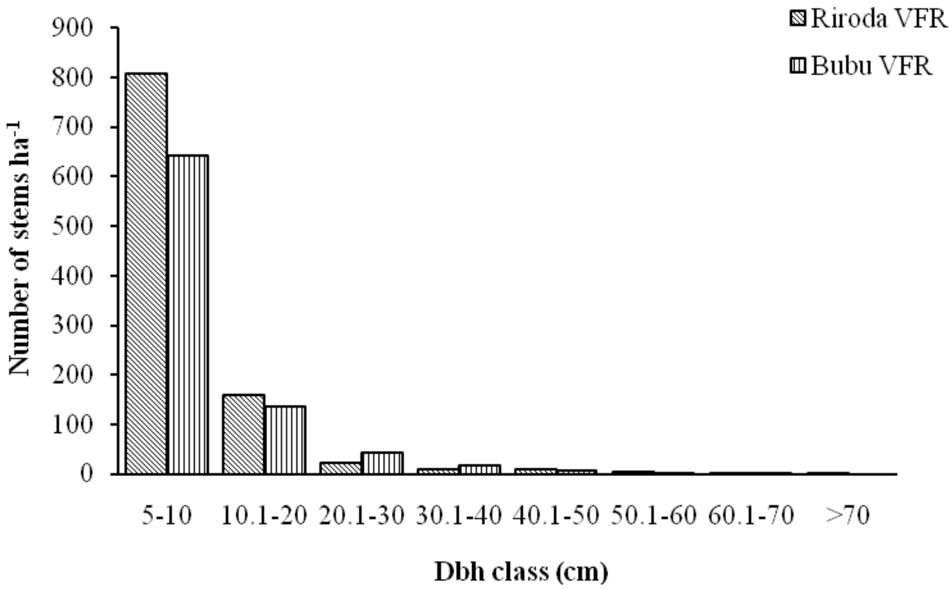

Figure 14: Stem distribution in communal forestland tenure regime by diameter classes

(ii) Basal area per hectare

The results in Table 11 show that the mean basal area m^2 ha^{-1} was higher in state forestland tenure than in village forest reserves, and there was a significant difference in basal area ha^{-1} between state and communal forestland tenure regimes of Bereku FR and Riroda VFR and between Bereku FR and Bubu (Table 12).

High basal area ha^{-1} in the state forestland tenure suggests that, state forestland tenure regime is dominated by a more mature forest than the village forest reserves due to long term protection nature of forests under state forestland tenure regime. The low basal area in forests under communal forestland tenure regime is an indication of over exploitation of these forests. In both tenure regimes, large number of individuals in small and medium diameter classes (5-10, 10.1-20 and 20.1-30) contributed to the basal area (Figure 15 and 16). The probable reason was that, there were few individual trees with larger diameter classes since most of larger diameter trees have been harvested for timber.

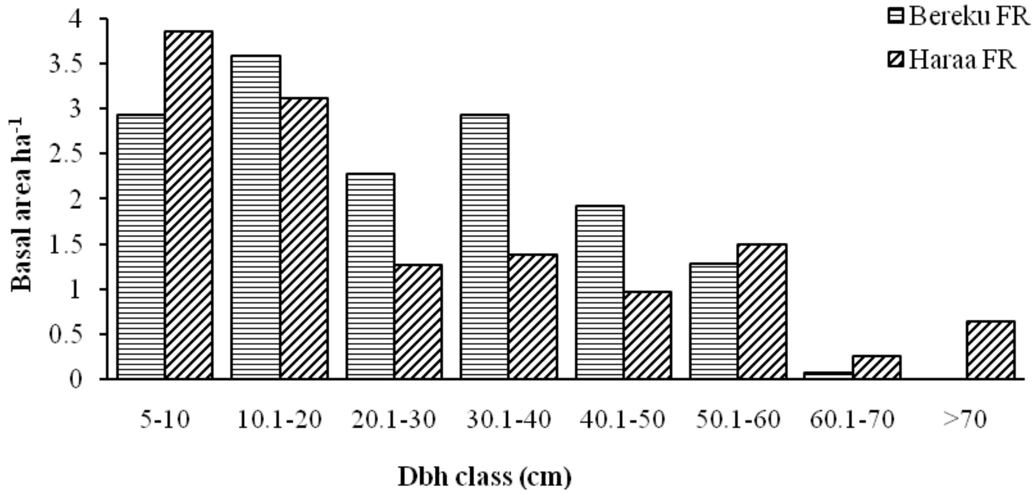

Figure 15: Basal area distribution by diameter class in state forestland tenure regime

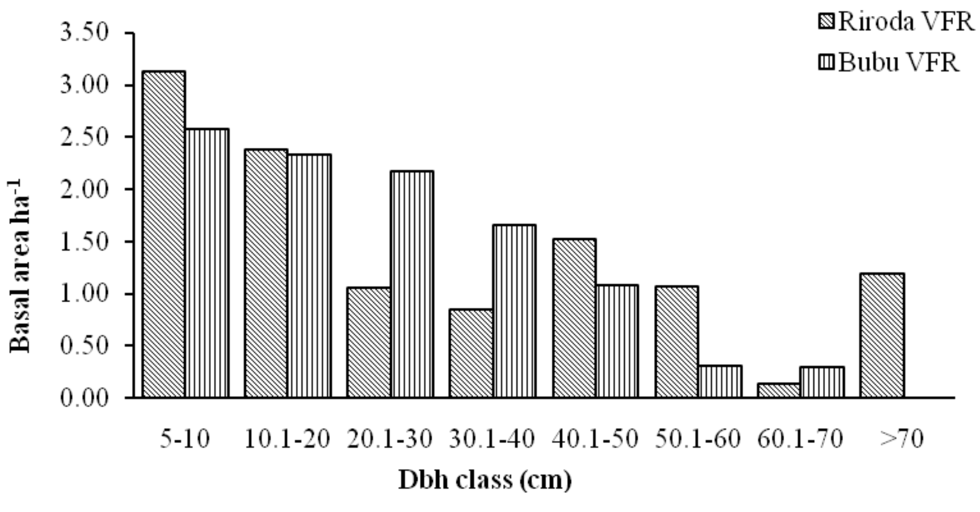

Figure 16: Basal area distribution by diameter class in communal forestland tenure regime

Results in this study are comparable to those reported in other studies. Malimbwi (2003) observed an average basal area of 10.99±0.99 and 11.13 + 0.70 m^2 ha^{-1} in Riroda and Bubu VFRs. The basal area is almost the same with the current study despite the fact that at that time the village forests appeared to be recovering with more trees of dbh <50 cm. In another study Mugasha and Chamshama (2002) observed the average basal areas

(m^2ha^{-1}) of 9.13 ± 0.78, 8.95 ± 0.73, and 7.78 ± 1.1 for the government (state) forest reserve, SUA forest reserve (private) and the general land (communal) forest in Kitulangalo, respectively. The government (state) forest reserve had a higher average basal area ha^{-1} than the other two forests due to previous protection strategies of the government forest.

In Iringa Tanzania, Isango (2007) observed a basal area in community managed forests in three sites to range from 15.0 – 15.6 m^2ha^{-1}. Banda *et al*. (2006) observed a high mean basal area ha^{-1} (24 m^2ha^{-1}) in the game controlled area with largest size class of trees among four levels of protection (Game Controlled Area, Katavi National Park, Forest Reserve and general land) in Katavi ecosystem in western Tanzania. Mbwambo *et al*. (2012) on the other hand observed a high basal area per ha for the montane forests (ranging from 17.4 to 37.6 m^2 ha^{-1}) than for miombo/lowland forests (ranging from 12.0 to 16.6 m^2 ha^{-1}). In southern Malawi, Lowore (1994) cited by Frost (1996) documented a low basal area of 7 m^2 ha^{-1} in dry miombo while in Zaire (DRC) the basal area was 22 m^2 ha^{-1} in wet miombo. The basal area per ha in miombo woodlands is believed to be in the region between 7 and 25 m^2ha^{-1} (Zahabu, 2001).

(iii)   Volume per hectare (V) m^3ha^{-1}

Table 11 shows that the mean volume (m^3 ha^{-1}) in forests under state tenure regime of Bereku and Haraa were higher than the means for forests under communal forestland reserves of Riroda and Bubu. The state forests showed a fairly higher volume than village forest reserves since larger diameter trees, which were found in state forests contributed to the larger proportion of volume (Mugasha and Chamsham, 2002). Figure 17 and 18 shows volume distribution in state and communal forestland tenure regimes in diameter classes.

The results showed a significant difference in mean volume m^3ha^{-1} between state and communal forestland tenure regimes in Bereku FR and Bubu VFR (Table 12).

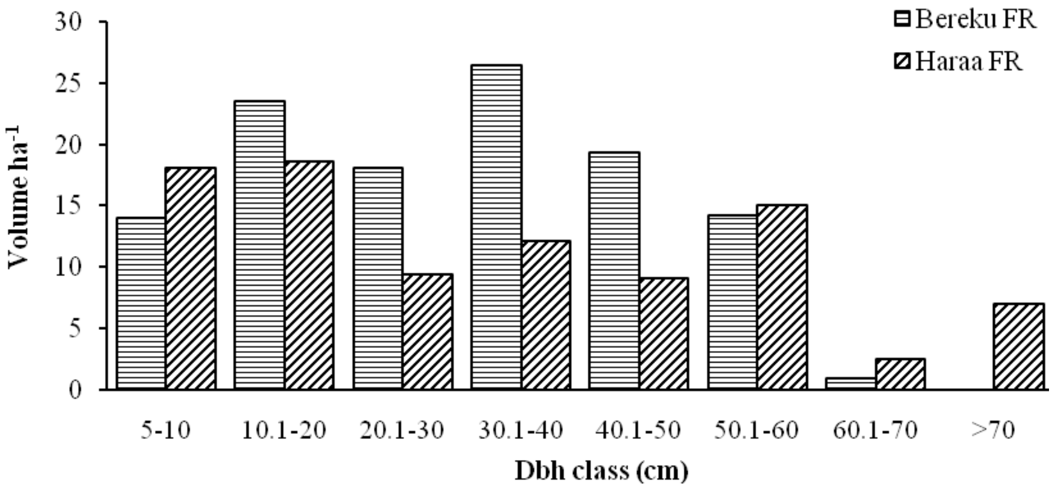

Figure 17: Volume distribution by diameter class in state forestland tenure regime

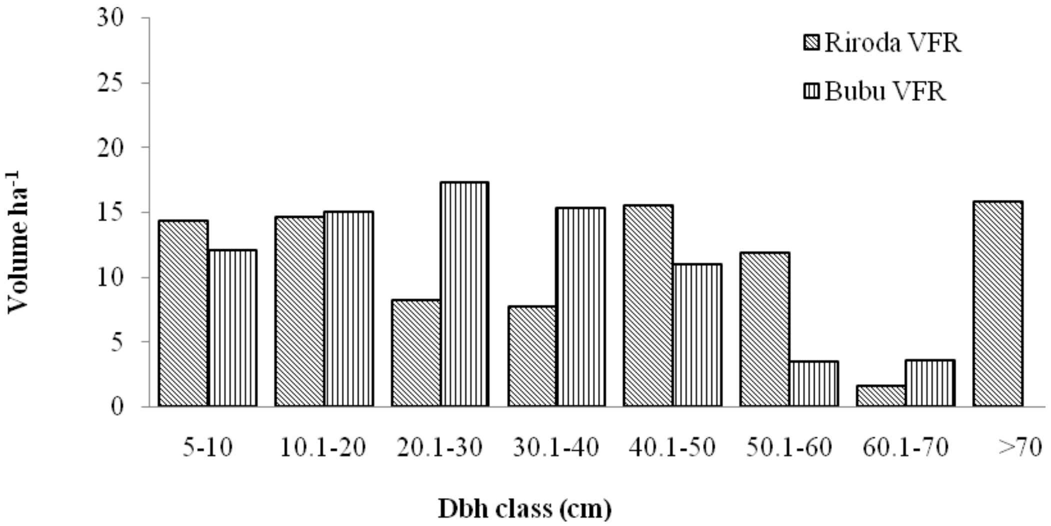

Figure 18: Volume distribution by diameter class communal forestland tenure regime

The results in this study are comparable to other studies reported in other forests with similar vegetation. Mugasha and Chamshama (2002) observed mean volumes (m^3ha^{-1}) of 76.02 ± 9.14, 76.03 ± 9.34 and 43.9 ± 7.75 for the government (state) forest reserve, SUA forest reserve and the general land forest, respectively. Isango (2007) reported a mean volume ranging from 63.6-65.7m^3ha^{-1} in Udekwa, Kitonga and Nyang'oro VFRs in Iringa region. In Shagayu FR and Mgori VFR, Mbwambo *et al*. (2012) observed a volume between 90 - 592 m^3ha^{-1}. In Malawi, Lowore (1994) cited by Frost (1996) observed a mean volume of about 14 m^3 ha^{-1} in dry miombo while Chidumayo and Frost, (1996) in Zambia observed a mean volume between 59 and 117 m^3ha^{-1}. Some values are lower than what was observed; the difference may be due to species composition, genetic and site difference. The mean volume observed in this study for Riroda and Bubu respectively have not changed much (79.86 ±9.91 and 82.00 ±6.80 m^3 h^{-1}) from what was observed by Malimbwi (2003) in the two village forest reserves in Babati.

4.2.1.2 Regeneration in state and communal forestland tenure regimes

Forests under state forestland tenure regime exhibited a high number of regenerants in the forests compared to the forests under communal forestland teure regime (Table 13). There was significant difference in number of regenerants ha^{-1} between Haraa FR and Riroda VFR and Haraa FR and Bubu VFR (Table 13). The plausible explanation for the high number of regenerants observed in the state forests may be due to recent disturbances on forest vegetation.

Table 13: Regenerants ha^{-1} p-value comparison between state and communal forestland tenure regimes

Site	No. of plots	Parameter* N_{reg} (ha^{-1})	Bonferroni t-test (α = 0.05) **
Bereku	55	18616	AB
Haraa	33	22824	A
Riroda	36	10063	B
Bubu	30	9368	B

* N_{reg} = number of regenerants,
**Means with the same letter are not significantly different

Mugasha and Chamshama (2002) argued that germination and recruitment of young forest is enhanced through increased gaps, light, high soil temperature and reduced nutrient competition. The disturbances in state forests have increased since the introduction of JFM (Persha and Blomley, 2009), hence more regenerants

Malimbwi (2003) observed a mean of 14 451 and 13 935 saplings ha^{-1} in Riroda and Bubu VFRs which is a bit higher than what was observed in this study. However, this was the period when the forests were closed to allow restoration of the forest. Currently, the number of saplings is low in village forestlands since grazing is allowed during the peak of the dry season. Comparing with other studies, Mbwambo *et al.* (2008) observed an average number of saplings (dbh < 5 cm) of 29 000 seedling ha^{-1} in Kitulangalo. The number is quite high, but it was reported from other forests that disturbances in miombo woodlands caused increased regeneration especially from coppices (Luoga *et al*., 2004; Campbell *et al*, 2007; Timberlake *et al*., 2010).

4.2.2 Influence of forestland tenure regimes on tree diversity

4.2.2.1 Tree species diversity in state and communal forestland tenure regimes

Tree species diversity was analysed from 154 sample plots out of which 20 plots were from dry montane parts of Bereku and Haraa FRs, the results are presented below.

(i) Species diversity in state and communal forestland tenure regimes

Table 14 shows the biodiversity indices of the four forests using Shannon-Weiner index of diversity *(H')*. *H'* values for forests under state forestland tenure regime of Bereku and Haraa FRs appeared to be higher compared to forests under communal forestland tenure in Bubu and Riroda VFRs. Bereku state forest reserve had the highest *H'* among the four forests which highlights the forest to be richer and more even than the others. However, there was no significant difference in *H'* values between state and communal forestland tenure regimes. The results in the communal forestland tenure regime is comparable to the study by Malimbwi (2003) who found *H'* to be 2.82 and 2.86 in Bubu and Riroda VFRs respectively. The values for Bubu and Riroda in this study have increased probably due to conservation strategy instituted in the village forest reserves.

Table 14: Biodiversity measures of the four forests

Diversity index	State forestland tenure		Communal forestland tenure		p value state vs communal
	Bereku FR	Haraa FR	Bubu VFR	RirodaVFR	
Shannon-Weiner index H'	3.17	3.02	2.93	2.99	0.37
Simpson's index of dominance D'	0.07	0.09	0.09	0.10	< 0.001*
Richness	71	66	55	60	0.02*
Spp regeneration	42 (59%)	30 (45%)	30 (54%)	32 (53%)	0.048*

* = significant at $p < 0.05$

Comparing with other studies, the values in this study shows that the species diversity in state and communal forestland tenure regimes are in average since the maximum diversity is 5. Zahabu (2001), observed *H*' values of 2.9 and 3.13 in public land (general land) and government (state) forest reserve for miombo woodland at Kitulangalo area respectively. A high *H'* value in state forest is the effect of forestland tenure regime; since the forest has been under state tenure regime with relatively strict management regime where harvesting was not allowed. One year later in the same forest, Mugasha and Chamshama (2002) found *H'* values to be 3.2, 3.1 and 3.3 for the government forest reserve, SUA training forest reserve and the general land respectively. Reasons provided for this increase of *H'* was that, disturbance in general land enabled miombo species to regenerate. In another study when comparing diversity among different forestland tenure regimes in Malawi, Mwase *et al.* (2007) found out that forest reserves had *H'* of 1.26 and 1.01 compared to customary tenure with *H'* of 0.55 and 0.77 which is more or less open access regime. Open access regime has an uncontrolled removal of different tree species.

(ii) Species dominance in state and communal forestland tenure regimes

The index of dominance *(D')* was low for all the four forests (Bereku, Haraa, Bubu and Riroda FRs) (Table 14), meaning that the forests exhibits a high diversity. Nevertheless, Bereku FR exhibited a lower dominance than the other three forests.

Mwase *et al*. (2007) argued that high *H'* corresponds to low *D'* which is indicative of high species diversity, although sometimes an opposite trend can be observed. In this study, Haraa FR had a high *H*' and high *D'* values, the plausible explanation is that the response of these indices change in the degree of dominance by the most abundant species which was *Brachystegia microphylla* in Haraa FR (Nagendra, 2002b). Dominance of some species or families is a defining characteristic and a unifying feature of a particular ecological region (Dorren *et al*., 2004). The observed *D'* values in this study falls within the ranges of other forests with similar vegetation.

Comparing with other studies, Malimbwi (2003) observed *D'* values for Riroda and Bubu VFR of 0.093 and 0.105 respectively, which have not changed much compared to this study. Zahabu (2001) observed *D'* values of 0.092 and 0.065 for the miombo woodlands in general land (open access tenure regime) and forest reserve (state tenure regime) respectively at Kitulangalo near Morogoro. Mafupa (2006) observed index of dominance (*D')* values of 0.088 and 0.135 for undisturbed and disturbed strata in Igombe River Forest Reserve in Nzega District, Tabora Region, respectively. The results indicated higher species richness in the undisturbed stratum. In a study done in southern Malawi, Mwase *et al*. (2006), found out *D*' value to be higher in customary forestland (communal tenure regime) (0.28 and 0.48) forest reserves (state tenure regime) (0.12 and 0.21) meaning high species diversity in state tenure regime which is the effect of forestland tenure regime.

(iii) Species regeneration status

Out of the 71 and 66 tree species in Bereku and Haraa FRs eight species in Bereku FR showed good regeneration whereby *Myrsine africana* which is a shrub contributing 21% of the regenerants followed by *Brachystegia microphylla* with 17% regenerants. In Haraa FR, ten species had good regeneration. High regeneration percent was recorded from *Brachystegia microphylla* (19%) and *Euclea divinorum* (17%). In communal forestland tenure regime, out of 55 and 60 tree species, seven and ten species had good regeneration in Bubu and Riroda VFR respectively, the most regenerating species were *Tarenna graveolens* (30%) and *Brachystegia microphylla* (15%) in Bubu VFR while in Riroda VFR *Brachystegia microphylla* (28%) and *Grewia platyclada* (9%) showed high regeneration. Bereku state forest reserve had the highest regeneration of 59%.

Regeneration in these forests was observed to be mainly through coppice re-growth and root suckers. This has been observed elsewhere (Luoga *et al*., 2004; Campbell *et al*, 2007). The two most regenerating species in this study were *Brachystegia*, and *Julbernardia* as expected in a miombo forest. A positive relationship was found between species dominance in terms of importance value index (IVI) and species extent of regeneration (Table 15).

Some of the species were not observed in the species regeneration list, this could be due to grazing pressure on palatable species along with limited adaptability to degradation by some of the species. This was also observed in the ngitilis (Monela *et al*., 2005) and in Zambia, where heavy browsing has been found to retard regeneration of some species

(Chidumayo *et al.,* 1996). Nevertheless, the regenerating species are all miombo species denoting that the species composition is not changing. Mugasha and Chamshama (2002) reported three species with high regeneration potential common in the forest reserve under central government, forest reserve under SUA and general land were *Julbernardia globiflora, Dichrostachys cinerea* and *Combretum molle.* Malimbwi (2003) found dominating species with abundant regeneration in Riroda and Bubu VFRs were *Brachystegia microphylla, Tarenna graveolens, B. Spiciformis, Combretum molle, Acalypha fruticosa*, *Tarenna graveolens* and *Myrsine africana*.

(iv) Species similarity in state and communal forestland tenure regimes

Comparison of species similarity (using Jaccard's similarity index) between forests under state and communal forestland tenure regimes showed highest similarity between Bereku FR and Riroda VFR (0.45) and between Bubu and Riroda VFRs (0.40). Similarity between Bereku FR and Bubu VFR was the same as between Bereku and Haraa FR (0.37). However, there was a low species similarity in state and communal forestland tenure regime of Haraa and Riroda (0.24). Chust *et al*. (2006) explains this low similarity within the same ecological zone as niches theory whereby adaptation of species to the environment such as climate and edaphic conditions affects the forests. The similarity in this study is comparable to other studies with similar vegetation for example Mafupa (2006) found the Jaccard Index (JI) of species similarity between undisturbed and disturbed strata to be 0.4.

Another study in miombo vegetation of Mozambique, Williams *et al.* (2008) observed that the Jaccard similarity index for species composition of abandoned farmlands (*machamba)* which are open access forests used for shifting cultivation, compared to protected woodlands ranged from 0.15 - 0.31 between recent and oldest abandonments and protected woodland plots. In this case, there is reduced species richness and species composition in open access forests an indication of unsustainable utilization of the forest resource (Williams *et al*., 2008). On the other hand, Mwase *et al*. (2007) found out high species similarity among the forest reserves but there was low similarity when forest reserves were compared with communal forests (70-31%). Mwase *et al.* (2007) results indicated high heterogeneity and evenness in forest reserves compared to leasehold and communal forests which clearly showed the effect of tenure on species similarity.

4.2.2.2 Forest Structure

Basal area in state forestland tenure regime was high in *Brachystegia microphylla*, *Julbernardia globiflora* and *Albizia gummifera* in Bereku and Haraa FRs. In communal forestland tenure regime, high basal area was recorded in *Brachystegia microphylla* and *Julbernardia globiflora* in Bubu and Riroda VFRs. In Haraa FR, the highest number of stems was recorded from *Brachystegia microphylla,* followed by *Combretum molle* (Table 15). In Bereku FR the highest number was recorded from *Brachystegia microphylla* and *Julbernardia globiflora* whereas in forests under communal forestland tenure regime of Bubu and Riroda, the highest number of stems was found in Brachystegia *microphylla* and *Combretum molle*. In all the four forests, *Brachystegia microphylla* had high number of stems ha^{-1}.

In Bereku and Haraa state forestland tenure regime *Brachystegia microphylla* appeared to be the most abundant species in terms of volume followed by *Julbernardia globiflora* in Bereku FR and *Combretum molle* in Haraa FR. In the communal forestland tenure regime in Bubu and Riroda the volume was mostly contributed by *Brachystegia microphylla* followed by *Julbernardia globiflora*. In another study in miombo woodlands of Angai VFR southern Tanzania, Kusaga (2010) reported high contribution of *Brachystegia* *speciformis, Julbernardia globiflora* and *Brachystegia boehmii* to stand parameters (30%, 16% and 9% respectively).

Table 15: Mean number of stems ha^{-1}(N) and basal area ha^{-1} (G) volume ha^{-1} (V) and importance value index (IVI) of dominating species in state and communal forestland tenure regimes

Forest	**Species name**	**N** (ha^{-1})	**G (**m^{2}ha^{-1})	**V** m^{3}ha^{-1})	**IVI**
Bereku	*Brachystegia microphylla*	197 ± 36	5.3 ± 1.0	45.9 ± 5.5	66.0
	Julbernardia globiflora	124 ± 35	3.1 ± 0.9	26.1 ± 4.3	42.3
	Combretum molle	65 ± 15	0.6 ± 0.1	4.6 ± 1.3	18.1
Haraa	*Brachystegia microphylla*	354 ± 59	4.5 ± 0.7	34.9 ± 6.3	76.2
	Combretum molle	70 ± 31	0.8 ± 0.3	9.2 ± 4.9	23.9
	Albizia gummifera	67± 28	1.3 ± 0.9	3.3 ± 1.9	12.1
Bubu	*Combretum molle*	98 ± 17	1.7 ± 0.2	7.4 ± 2.9	32.7
	Brachystegia microphylla	97 ± 10	2.5 ± 0.3	20.9 ± 4.0	45.8
	Julbernardia globiflora	76 ± 9	2.4 ± 0.2	21.4 ± 6.7	43.6
Riroda	*Brachystegia microphylla*	280 ± 56	5.1 ± 1.0	45.1 ± 2.5	86.9
	Combretum molle	76 ± 18	0.5 ± 0.1	3.1 ± 0.5	19.0
	Julbernardia globiflora	52 ± 14	1.8 ± 0.6	19.0 ± 9.6	28.1

4.2.2.3 Forest richness and species composition in state and communal forestland tenure regimes

A total of 43 plant families and 82 genera were recorded in the study area. Bereku FR had the highest number of species (Table 14). With respect to relative importance (IVI) of the woody species, the dominant species were *Brachystegia microphylla, Julbernardia globiflora* and *Combretum molle* in Bereku FR, while Haraa FR had *Brachystegia microphylla, Albizia gummifera, Combretum molle* (Table 15). For both forests under communal forestland tenure regime (Bubu and Riroda VFR) the dominant species were *Brachystegia microphylla, Combretum molle* and *Julbernardia globiflora* (Table 15). This dominance conforms well to the typical miombo woodland (Mugasha and Chamshama, 2002, Campbell *et al*, 2007; Lupala, 2009). In both forestland tenure regimes, five species contributed almost half of the total IVI (Figure 19 - 22).

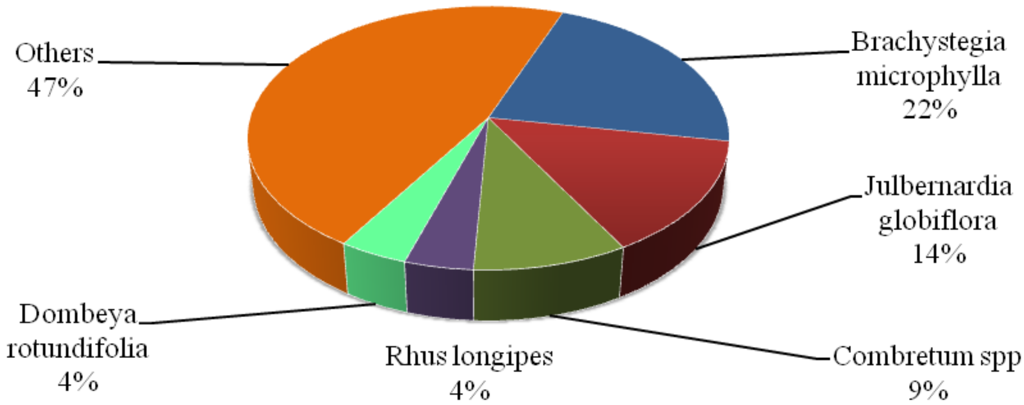

Figure 19: Proportion of important tree species in terms of IVI percent in Bereku FR

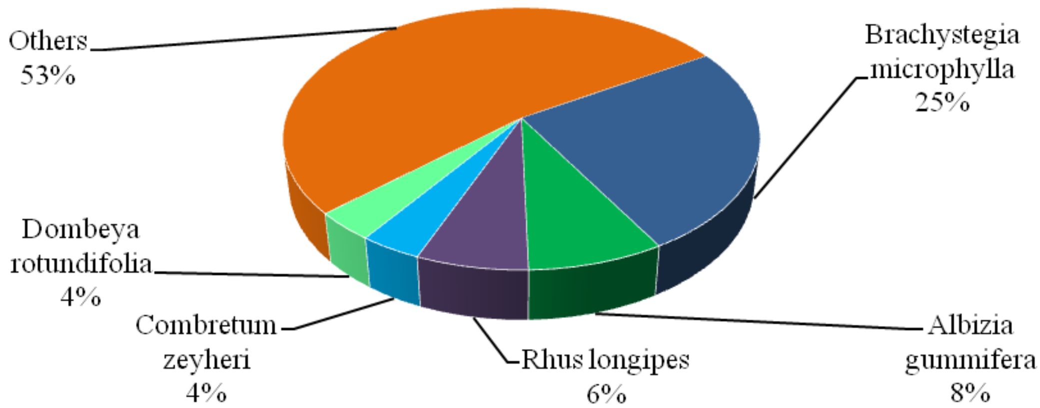

Figure 20: Proportion of important tree species in terms of IVI percent in Haraa FR

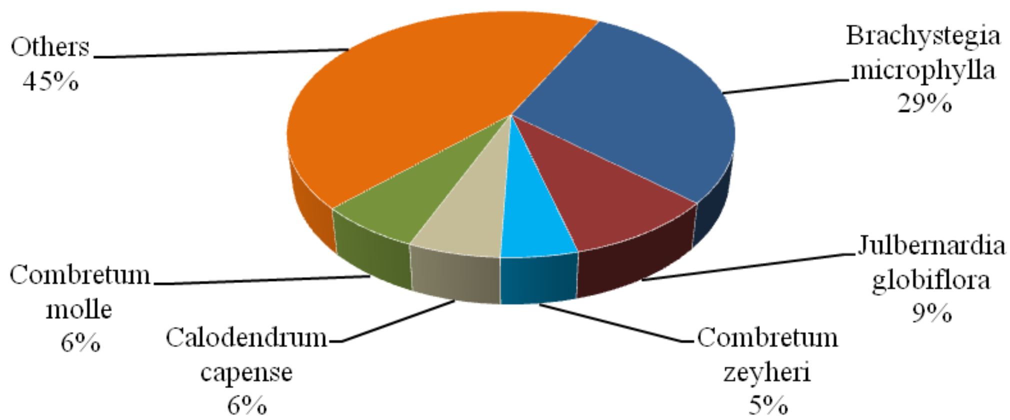

Figure 21: Proportion of important tree species in terms of IVI percent in Riroda VFR

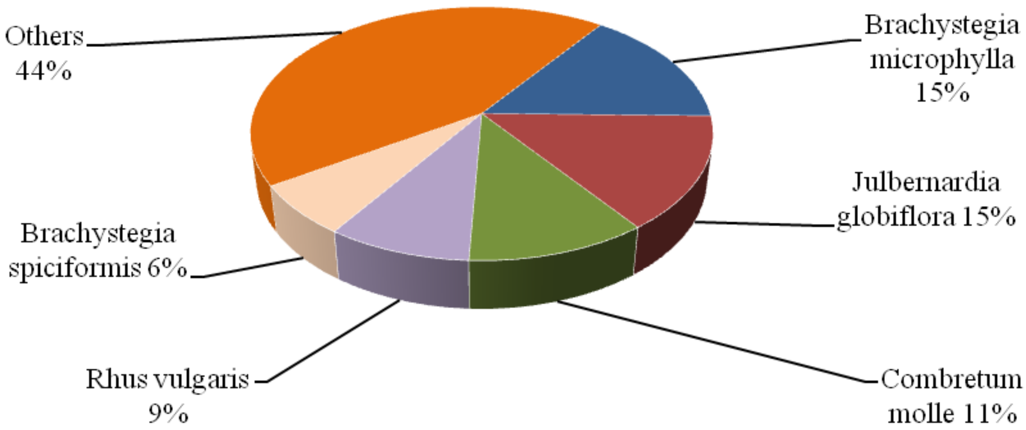

Figure 22: Proportion of important tree species in terms of IVI percent in Bubu VFR

The results are comparable to those of Malimbwi (2003) who observed a total of 97 tree species in Riroda and Bubu VFRs whereas the dominant tree species were *Brachystegia microphylla, B. spiciformis and Combretum molle.* Lupala (2009) observed a total of 87 tree species in 37 families (63 genera) in Bereku FR with highest IVI recorded for *Brachystegia microphylla, Brachystegia spiciformis* and *Julbernardia globiflora* (11.38, 9.03 and 6.42 respectively). In other studies in miombo woodlands, e.g. at Kitulangalo in Morogoro region, the forests were dominated by *Julbenardia globiflora, Brachystegia spp*. and *Pterocarpus rotundifolia* (Zahabu, 2001; Mbwambo *et al*, 2008).

Other studies reported the dominance of *Brachystegia microphylla,* followed by *Brachystegia spiciformis, Julbernadia globiflora* and sometimes *Combretum molle* (Malimbwi, 2003; Lupala, 2009; Giliba *et al.*, 2011). Although miombo forest composition has been defined by dominance of species like *Brachystegia, Julbenardia* and *Isoberlina*, there are some exceptions. Banda *et al*. (2006) found the dominance of

Markhamia, Grewia, Terminalia, Syzygium, Acacia and Combretum in Katavi ecosystem in Tanzania, this is due to the fact that species composition depends on environmental factors like soil conditions and other dynamic factors like fire and succession status (Backéus *et al*., 2006)

The dominant families with abundant species in state forestland tenure regime were *Caesalpiniaceae*, *Mimosaceae* and *Papilionaceae* in Bereku FR while in Haraa FR the dominant families were *Mimosaceae*, *Tiliaceae* and *Sapindaceae* (Figure 23 and 24). In communal forestland tenure regime the dominant families were *Caesalpiniaceae*, *Mimosaceae* and *Combretaceae* in Bubu VFR and *Mimosaceae*, *Rubiaceae* and *Caesalpiniaceae* in Riroda VFR (Figure 25 and 26). Comparing with other studies, Lupala (2009) found dominant families were *Caesalpiniaceae*, *Rubiaceae* and *Papilionaceae*. In Malawi, Mwase *et al.* (2007) found out that, forests under customary tenure was mostly dominated by *Euphorbiaceae*, *Caesalpiniaceae* and *Annonaceae* families, while forest reserves were dominated by *Euphorbiaceae*, *Caesalpiniaceae* and *Papilionaceae* families. This shows that there were differences in species abundance at different sites, although it lies within the dominant families of miombo woodland.

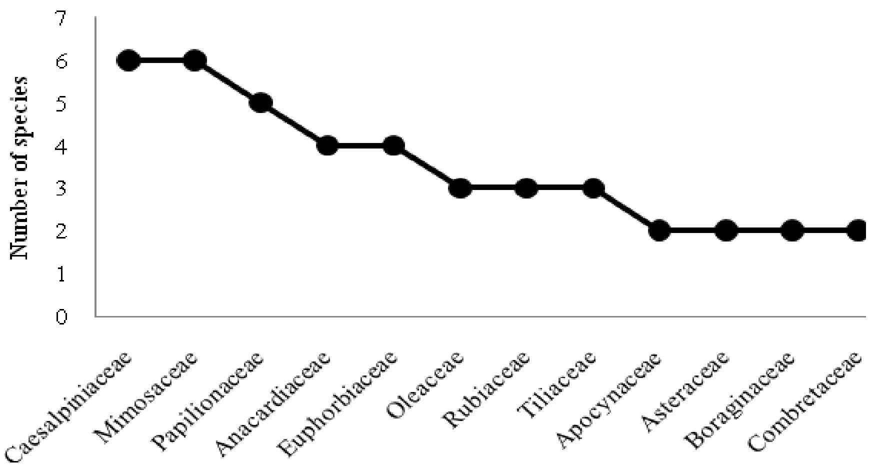

Figure 23: Families with abundant species in Bereku FR

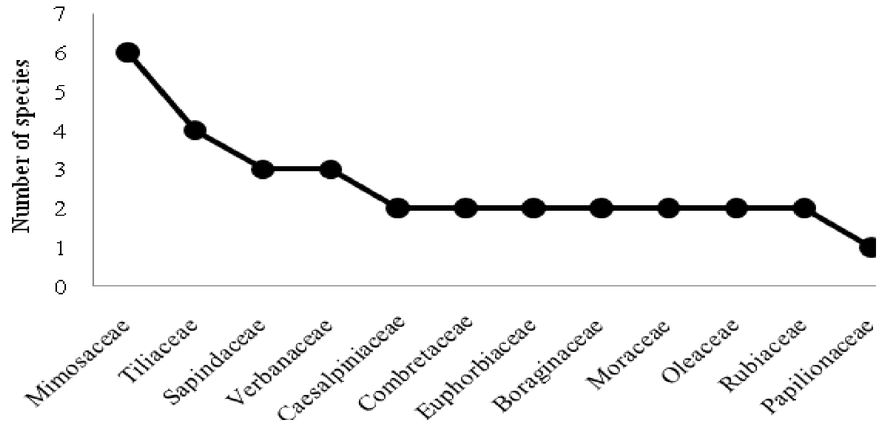

Figure 24: Families with abundant species in Haraa FR

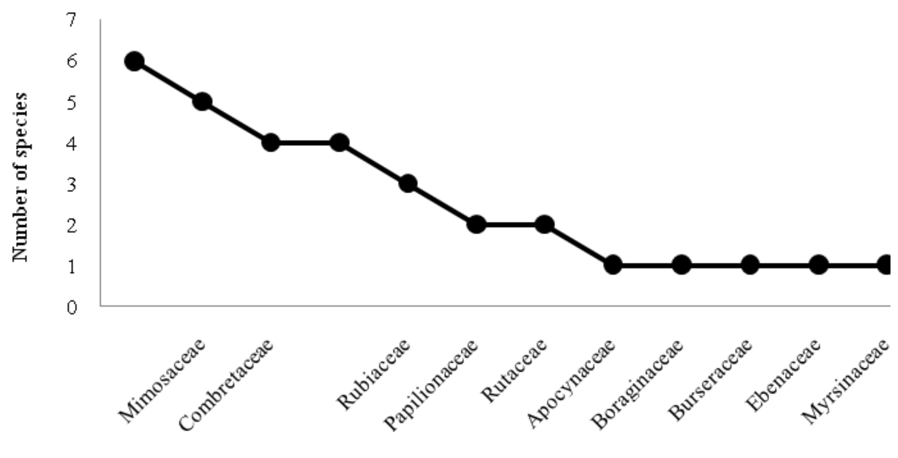

Figure 25: Families with abundant species in Bubu VFR

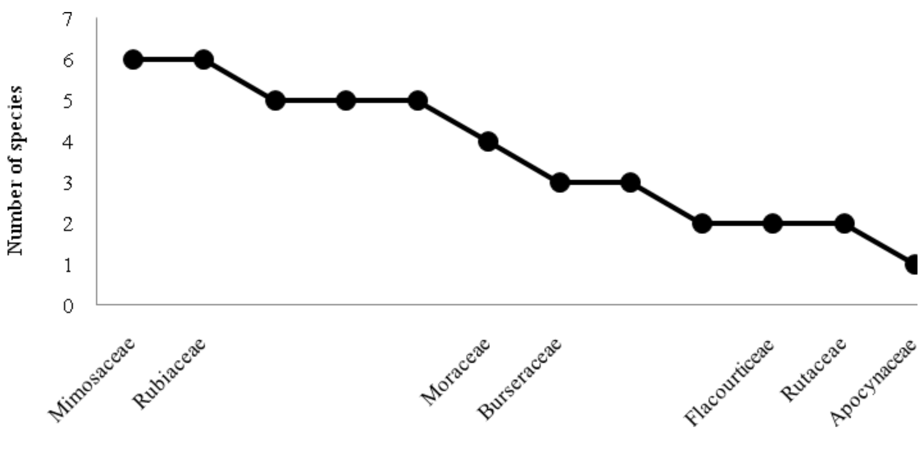

Figure 26: Families with Abundant Species in Riroda VFR

4.3 Disturbance Level and Main Causes of Forest Pressure in State and Communal Forestland Tenure Regimes

4.3.1 Disturbance level

(i) Level of removals

In this study it was observed that the mean number of stems ha^{-1} of removals from Riroda VFR was higher than the other three forests (Table 16).

Table 16: Number of stems, basal area and volume of removals in state and communal forestland tenure regime

Site	No. of plots	Parameter*	Mean, SE= $tS_{\bar{x}}$	Bonferroni t-test (α = 0.05)**
Bereku	55	N_{stump} (ha^{-1})	27 ± 9	B
Haraa	33		23 ± 14	B
Riroda	36		101 ± 28	A
Bubu	30		23 ± 13	B
Bereku	55	G_{stump} (m^2ha^{-1})	0.29 ± 0.18	A
Haraa	33		0.22 ± 0.19	A
Riroda	36		0.52 ± 0.24	A
Bubu	30		0.25 ± 0.32	A
Bereku	55	V_{stump} (m^3ha^{-1})	1.60 ± 1.60	A
Haraa	33		1.15 ± 1.13	A
Riroda	36		2.21 ± 1.87	A
Bubu	30		1.35 ± 2.09	A

N_{stump} = number of removed stems, G_{stump} = removed basal area, V_{stump} = removed volume,
**Means with the same letter are not significantly different

The state forests were affected by illegal logging of large diameter trees as witnessed during the inventory. The result on mean basal area and mean volume ha^{-1} removals between the state and communal forestland tenure regimes did not show statistical significant difference whereas there was statistical significant difference in mean number of stems ha^{-1} removals between state forestland tenure regime and Riroda VFR under communal forestland tenure regime. Although mean removals in state forestland tenure regime were low, the long run removal of large diameter trees will lead to substantial damage of the forest. Disturbance is a constraining factor to forest condition but is a sign that the forest is being utilized that is, the community can obtain their livelihoods from the forest. Disturbace in both tenure regimes causes opening up of closed woodlands as observed from the satellite images.

Removal results in this study are comparable to other studies with similar vegetation. For example Luoga *et al.* (2002) observed a mean of 55.00 ± 8.96 stems ha^{-1} in Kitulangalo Forest reserve whereas the general land in Kitulangalo had a mean removal of 182.00 ± 24.19 stems ha^{-1}. The general land forest experienced high removal since it was an open access regime. On the other hand, Mbwambo *et al.*, (2012) observed that the lowest number of stems (42 ± 39 stems ha^{-1}), basal area (0.6 ± 0.3 m^2ha^{-1}) and volume (2.8 ± 1.7 m^3ha^{-1}) harvested were recorded in Mgori VFR compared to Shagayu FR (state) with 52 ± 42 stems ha^{-1} harvested. The low harvestable rate in Mgori VFR is attributed by improvement in conservation strategies. In the VFRs, most removals were from basal diameter ranging between 1 and 10 cm (Table 17). The reason for high removal of small diameter trees is probably due to their uses in domestic requirements.

Table 17: Percentage removals and removal/standing ratio in state and communal forestland tenure regime

Forest name	Percentage removal distributed over Basal diameter classes based on number of trees						Removal/standing Ratio based on number of trees
	1-10	10.1-20	20.1-30	30.1-40	40.1-50	> 50	
Bereku	35	49	4	3	2	7	0.03
Haraa	63	20	4	0	2	11	0.02
Riroda	86	12	1	1	0	0	0.10
Bubu	76	10	5	9	0	0	0.03

Removal /standing ratio (R/S)

The removal/standing stock ratio (R/S) based on N ha^{-1} was highest in Riroda VFR (Table 17). Bereku and Haraa being state forest reserves, issues permits for collection of dry firewood as part of JFM agreements, but during the study many trails were observed which signifies disturbance in the forests. At the same time, some fresh stumps and lumbering structures were observed in the state forests (Plates 1 and 2); in addition, intensive grazing has rendered the forest floor open in various places of the forests. Persha and Blomley (2009) also observed an increase in tree removals from state forests which practice JFM in montane forests of West Usambara Mountains, Tanzania.

1(a)

1(b)

1(c)

Plate 1: Forest disturbance (a) fresh stump, (b) fresh log and (c) lumbering structure in Bereku FR (Photo by: C. Mongo, 2009)

2(a)

2(b)

2(c)

Plate 2: Forest disturbance (a) fresh stump, (b) fresh pieces of lumber and (c) lumbering structure in Haraa FR (Photo by: C. Mongo, 2009)

Riroda VFR has been divided into production and protective parts of which 359.9 ha have been set aside for protective purposes and the rest is for production purposes. There are substantial disturbances in terms of cutting for fuelwood, building poles and grazing in the production forest part, cattle tracks were seen in the forest and according to the committee members grazing has been encouraged as a measure to reduce fire incidences since it reduces fuel load.

The aims of setting aside VFRs were partly management option after state failure to protect forests on general lands and partly to help communities turn their eyes from the forest reserves, though the initial condition of the forests handed to local communities was significantly poor (Nagendra, 2002a; Wily, 2002; Blomley and Ramadhani, 2006). Several studies have shown that village forest conditions have greatly improved after the implementation of community forestry programme (Wily, 2002; FAO, 2008). Communities applied a natural regeneration method by restricting access to forests, which helps to increase both canopy cover and density (Nagendra, 2002a; FAO, 2008). This could partly be an effect of natural variability in environment, but is more likely due to the variation in degree of protection accorded the community forests which have improved over time as a result of protection. Adjacent communities obtain their fuelwood, timber and grazing requirements from the nearby national forest reserves. It is possible that the community forest is regenerating after protection at the expense of the national forest reserves.

The high number of saplings in the state forests indicated increased recent disturbance as was observed during the field visits in September - November 2009. Much higher incidences of felled timber trees and poles were observed in forests under state forestland tenure regime as compared to forests under communal forestland tenure regime and there were very few patches which have been affected by fire. This has been noted elsewhere in forests under state forestland tenure with high incidences of grazing and removal of trees and shrubs (Nagendra, 2002a). The forests under state forestland tenure in Babati are bordered by villages that have just set aside areas for village forests, which make the state forests to be an alternative to the communities for all wood and non wood forest products, since the areas set aside consists of very much degraded hills adjacent to the forest reserves.

4.3.2 Causes of forest pressures

From the PALI it was found that, forest pressures in the study area comprised proximate causes (expansion of farms, pasture, wood harvesting and extension of infrastructure); however the underlying causes (demographic, economic, policy and institutional factors, technological, and socio-political or cultural factors) were not mentioned to contribute directly to forest degradation. Among the proximate causes which were identified in PALI and PRA were logging, commercial fuelwood collection, charcoal making, grazing, annexing land for agriculture, and wild honey gathering. From the mean scores it was revealed that logging accounted for major forest destruction/degradation in both-state and communal forestland tenure regimes followed by grazing (Table 18). Banana and Gombya-Ssembajjwe, (2004), found out in Uganda that proximate causes contributing to forest loss were clearing for agriculture, pitsawing, logging, charcoal, and firewood production.

Table 18: Matrix index for causes of forest pressure in state and communal forestland tenure regimes

Forest name	Logging	Commercial fuelwood	Charcoal making	Grazing	Annexing land for agriculture	Wild honey gathering
Bereku	4.1	2.8	2.6	3.2	1.3	1.6
Haraa	4.4	2.6	2.9	3.7	1.2	1.9
Riroda	4.1	2.2	3.7	3.6	1.4	1.6
Bubu	3.2	1.4	1.8	3.2	1.8	1.1
Mean index	4.0	2.3	2.8	3.5	1.4	1.5

Commercial fuelwood collection was also observed to be an upcoming pressure in forests under state forestland tenure regime, this was witnessed by the number of cart trails in the forests and some vehicles were found loading firewood (Plate 3). Annexing land for agriculture was not perceived as a big pressure at that particular time since all the forest boundaries were marked (Plate 4); similarly wild honey gathering posed very little pressure to the forests due to the introduction of modern beekeeping in the villages as an alternative income generating activity. However, given current trends, these pressures are likely to increase forest degradation.

Plate 3: Commercial firewood loading in Bereku state forest reserve and boundary mark Riroda Village Forest Resereve (Msitu wa Hifadhi Riroda - MHR) (Photo by: C. Mongo, 2009)

4.4 Influence of State and Communal Tenure Regimes on Rural Livelihoods

Results and discussion on the influence of forestland tenure regimes on livelihood of the adjacent forest communities are presented under access to livelihood capitals, and forest dependence. There are numerous indicators in each livelihood capital, depending upon the objectives of the study the indicators have been narrowed to suit forest dependency. In each capital "key indicators", which were factors that could best describe each of the five capital assets, were discussed. The results from the five capital assets through on-farm and other non farm activities should help policy makers and other institutional experts to realize general trend of social development and establish appropriate policies. The results and discussions are presented in the following subsections.

4.4.1 Influence of state and communal tenure regimes on access to livelihood capital assets

Summaries of the responses to the key indicators in the access to the five capital assets and vulnerability context are given under respective subheadings. Although natural capital was the basis for livelihoods dependent on forest, other forms of capital have been discussed since it was found that all the five capitals are interlinked and there was some overlap between them.

4.4.1.1 Influence of state and communal tenure regimes on the availability of firewood and building materials

Indicators used to measure the influence of forestland tenure regime on physical capital included availability of firewood as an affordable household energy and presence of wood for housing material. The major source of household energy was firewood in both forestland tenure regimes in the study area. Respondents near state forestland tenure perceived that there was good (enough) availability of firewood while those near communal forestland tenure perceived that availability of firewood was in average (Table 19). There was no statistical significant difference in availability of household energy among villages near state and communal forestland tenure regimes (Table 19).

Firewood has been reported to constitute the main household energy (90%) in many rural areas of the world (Zewdie, 2002; Kaale, 2005; Kamanga, 2005; Mugarura, 2007; Haarstad *et al*., 2009). Kamanga (2009) termed the reliance on firewood as indicative of both necessity and/or lack of better options in the rural areas.

Table 19: Selected indicators for physical capital assets in villages near Bereku and Haraa FRs, and Riroda and Bubu VFRs

Perception on	Rating	Forest of the respondent				X^2	p-value
		Bereku	Haraa	Riroda	Bubu		
Availability of firewood	Poor	15 (33.3)	14 (29.2)	14 (25.9)	13 (28.9)		
	Average	14 (31.1)	20 (41.7)	25 (46.3)	20 (44.4)	1.57	0.45
	Good	16 (35.6)	14 (29.2)	15 (27.8)	12 (26.7)		
Presence of wood for housing material	Poor	2 (4.4)	0	17 (31.5)	11 (24.4)		
	Average	7 (15.6)	7 (14.6)	11 (20.4)	11 (24.4)	30.37	< 0.001
	Good	36 (80.0)	41 (85.4)	26 (48.1)	23 (51.1)		

Figures in parentheses are percentages and those out of parentheses are frequencies

In both forestland tenure regimes, dry wood and twigs used as firewood for household consumption could be collected from the forests without permit, but firewood for bricks burning and firewood sold to other communities needed a permit and was charged between Tsh 3 000 and 10 000 per cart depending on the size (1 USD = Tsh 1568/=). Most of the commercial firewood was obtained from the forests under state tenure regime, which is one of the upcoming pressures since sometimes collectors cut green wood. The study revealed that there was little control in commercial firewood collection in forests under state forestland tenure regime.

Among the most important physical asset was housing which is not only a shelter but also a permanent dwelling for the rural communities. Results showed that all respondents were living in their own houses except for two percent who lived in rented houses. It was further noted that most houses were built from burnt bricks and iron sheets, the highest number of such houses were found in villages near state forests of Bereku 62.2% and Haraa 68.8% compared to 22.2% in Bubu and 29.6% in Riroda probably due to the reliable good roads passing near the villages within state forests. The difference in housing condition was relatively attributed by use of timber from private farms in villages near state forestland tenure and location of the villages, that is- those near the main road had better houses. Apart from using other materials, wood was used in all the constructions involving, windows, doors, and roofing. Presence of wood for housing material was higher in forests under state forestland tenure, although villagers supplemented construction timber from their farms. During FGD it was revealed that in both forestland tenure regimes, the community relied very much on forest products for house building, which has been observed elsewhere (Zewdie, 2002; Kamanga, 2005).

4.4.1.2 Influence of state and communal tenure regimes on access to training and community empowerment

Indicators used in human capital were: different trainings offered to the villagers and community empowerment. Results showed that villages under state and communal forestland tenure regimes received trainings on forestry conservation, energy saving stoves, agriculture and gender. The study revealed that 24.4 and 54.2% of respondents within state forestland tenure regime of Bereku and Haraa were moderately involved in trainings while those from Bubu and Riroda VFR were 48.9 and 31.5% in average (Figure 27). The Chi-square statistics showed no statistical significant difference on influence of forestland tenure regime on trainings received between villages near state and communal tenure. Villages in both forestland tenure regimes received the same type of trainings from the district forest office, NGOs (LAMP, SIDA and NORAD) and field offices at different occasions, these trainings strengthened the adjacent communities' knowledge and skills. Other indicators like family composition in age and number were also considered.

Furthermore, the results revealed that perceptions on women empowerment in capacity building was average in villages near state and communal forestland tenure of Bereku, Haraa, Riroda and Bubu FRs with values of 31.1, 43.8, 24.1and 42.2 % respectively.

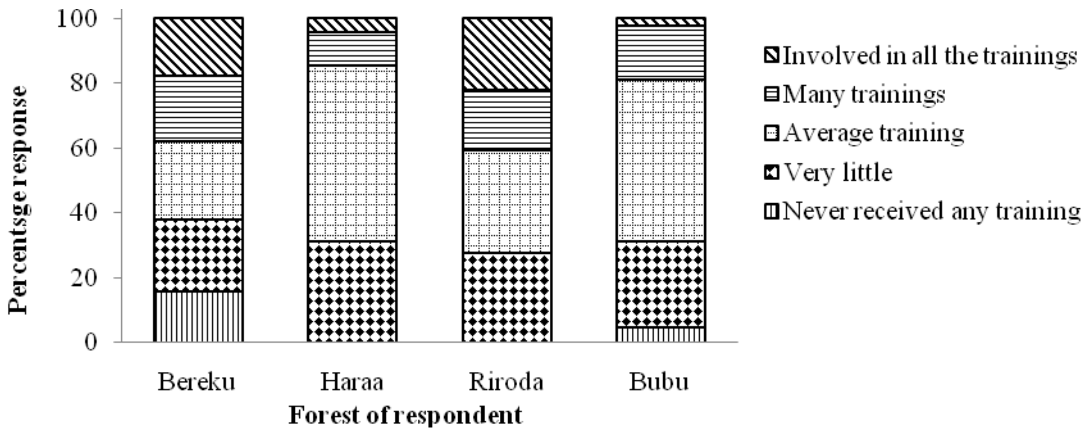

Figure 27: Respondents perception on trainings received

There was no statistical significant difference between the two tenure regimes ($\chi^2 = 1.560; p = 0.458$) since it was revealed that inclusion of women in all levels of leadership was an obligation and the composition of all the VNRC's in the study area was 50% females. Comparing with other areas for example in Maharashtra State in India, the representation in community's forest-management committee included one male and one female member from selected sub-villages which feature equitable participation (Ghate, 2003). Kayambazinthu (2000) argued that for a successful community based natural resource management (CBNRM) which will benefit the poorest members, empowerment of the members is required, while Pokharel *et al*. (2007) emphasised that providing training to female local facilitators had a significant impact in increasing women's awareness, social role and increase confidence. Traditionally, there is differentiation in type of products collected by men and women although sometimes there is change in gender roles (e.g. selling charcoal was men's job); so far no conflict has emerged over the products in the study area. Participation of women in forestry activities in the study area has increased awareness and confidence and increased their participation in meetings.

4.4.1.3 Influence of state and communal tenure regimes on VNRC performance and collective management

Social capital was measured in terms of performance of the VNRC as local institution, and work relations in collective management. Results showed that rating of the VNRC was higher in villages adjacent to state forestland (Table 20). VNRC performance had no statistical significant difference between state and communal forestland tenure regimes.

Table 20: Selected indicators for social capital assets in villages near Bereku and Haraa FRs, and Riroda and Bubu VFRs

Perception on:	Rating	Forest of the respondent				X^2	p-value
		Bereku	Haraa	Riroda	Bubu		
VNRC performance	Poor	0	2 (4.2)	19 (35.2)	3 (6.7)		
	Average	13 (28.9)	15 (31.2)	12 (22.2)	12 (26.6)		
	Good	32 (71.1)	31 (64.6)	23 (42.6)	30 (66.7)	2.58	0.27
Work relations in collective management	Poor	9 (20)	14 (29.2)	6 (11.1)	9 (20)		
	Average	16(35.6)	20 (41.7)	11 (20.4)	8 (17.8)		
	Good	20 (44.4)	14 (29.2)	37 (68.5)	28 (62.2)	2.26	0.51

Figures in parentheses are percentages and those out of parentheses are frequencies

Similarly, work relations in collective management are very important at community level. This enables a friendly atmosphere where the community can have confidence to invest in collective activities (Pretty, 2003). Rating of good collective management was higher in villages near forests under communal forestland tenure regime (Figure 28); but there was no significant difference in perception on collective management (Table 20).

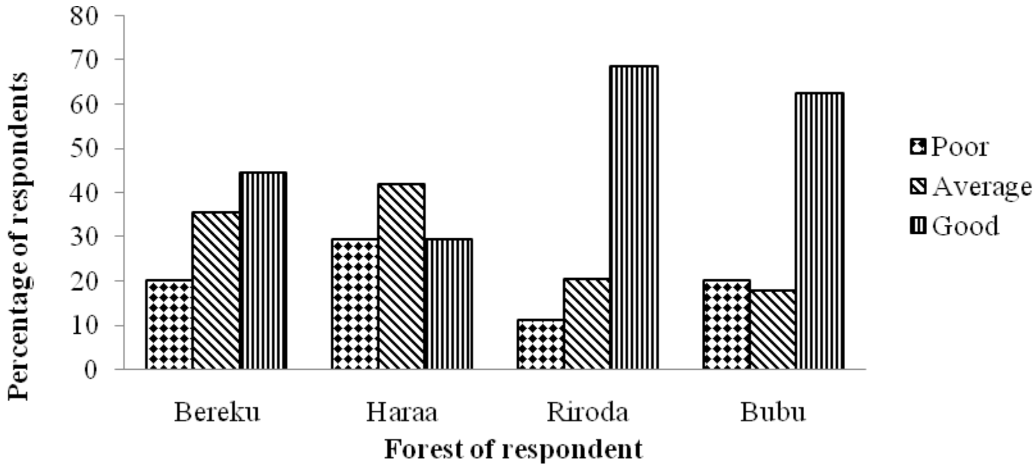

Figure 28: Respondents perception on working relations in collective management

Results can be compared to others studies (Soini, 2005; Vyamana 2009; Kitula, 2011) where it has been argued that performance of VNRC ensures sustainable forest management and control of illegal activities in the forest. Since social capital improves the social structures of the community and JFM seeks collaboration with the communities, then trust should be build between the partners for a successful collective resource management programs (Pretty, 2003; Shahbaz, 2009).

4.4.1.4 Influence of state and communal tenure regimes on access to forests and forest condition

Key indicators used in natural capital were access to forests and forest condition. Results in Table 21 shows peoples' perceptions on access to forests and forest condition. Results show that it was easier to access the forests, even in forests under state forestland tenure; there was no statistical significant difference in access to the forests between the two tenure regimes (Table 21). Results further showed that 62.2 and 47.9% of respondents near state forestland tenure of Bereku and Haraa FRs had the opinion that the forests were in good condition while from communal forestland tenure regime, 44.4 and 50% said that the forests were in good condition. There was no statistical significant difference in respondent's perception on forest condition (Table 21).

Table 21: Perceptions on access to forests and forest condition in Bereku and Haraa FRs, and Riroda and Bubu VFRs

Perception on	Rating	Forest of the respondent				X^2	
		Bereku	Haraa	Riroda	Bubu		
Difference between past and present access to the forest	No difference	16 (35.5)	18 (37.5)	19 (35.2)	9 (20.0)		
	Easy to access now	24 (53.3)	19 (39.6)	27 (50.0)	25 (55.6)		
	Difficult to access now	5 (11.1)	11 (22.9)	8 (14.8)	11 (24.4)	7.34	0.29
Forest condition	Poor	8 (17.8)	11 (22.9)	6 (11.1)	10 (22.2)		
	Satisfactory	9 (20.0)	14 (29.2)	21 (38.9)	15 (33.3)		
	Good	28 (62.2)	23 (47.9)	27 (50.0)	20 (44.4)	3.10	0.22

Figures in parentheses are percentages and those out of parentheses are frequencies

Results from satellite image analysis and inventory showed forests under state forestland tenure regime were in good condition in terms of cover and stocking compared to forests under communal tenure regime. Respondents near Haraa state forestland tenure asserted that some few areas in the forest have deteriorated due to illegal logging.

Forest condition is of vital importance since it determines the availability of forest goods and services. It is one of the natural assets, which is an important livelihood source for many rural people (Adhikari *et al*., 2004, FAO, 2006a; Mamo *et al*., 2007; Larson *et al*., 2008; Babulo *et al*., 2009). Communities adjacent to the forests obtain non-timber forest products such as grass, fuel wood, medicinal plants, and fodder that play important role in the livelihood and well-being of the rural community. In forests near state forestland tenure regime, the products are restricted to those which will not undermine the catchment value of the forest.

Another important natural capital is land. Land holding for agricultural activities is assumed to increase incomes of rural communities. Most of the respondents (46.9%) had crop acreages of greater than three acres followed by others (40.1%) who had between one and three acres, these are regarded as large and medium size area for cultivation. Findings of this study revealed that all respondents (100%) indicated that they owned land in their respective villages.

In all four areas approximately 10 % of respondents own less than 1 acre of cropland. Otherwise, the structure of cropland properties is very similar in Bereku and Riroda. On the other hand, Haraa has 56.2 % of properties between 1 and 3 acres, while in Bubu over 60 % of respondent own properties of more than 3 acres (Figure 29). These differences are probably due to commercial agriculture and free range grazing practiced in the area. There was no statistical significant difference in access to cropland between villages near state and village forests ($\chi^2 = 5.578, p = 0.061$). Boundary marking in VFRs has reduced encroachment and conversion of forestland to cropland.

In many parts of the world, land has been termed among the productive natural assets and in other areas is a sign of wealth and those who possess land have better livelihood opportunity (Meinzen-Dick and Adato, 2001; Chileshe, 2005).

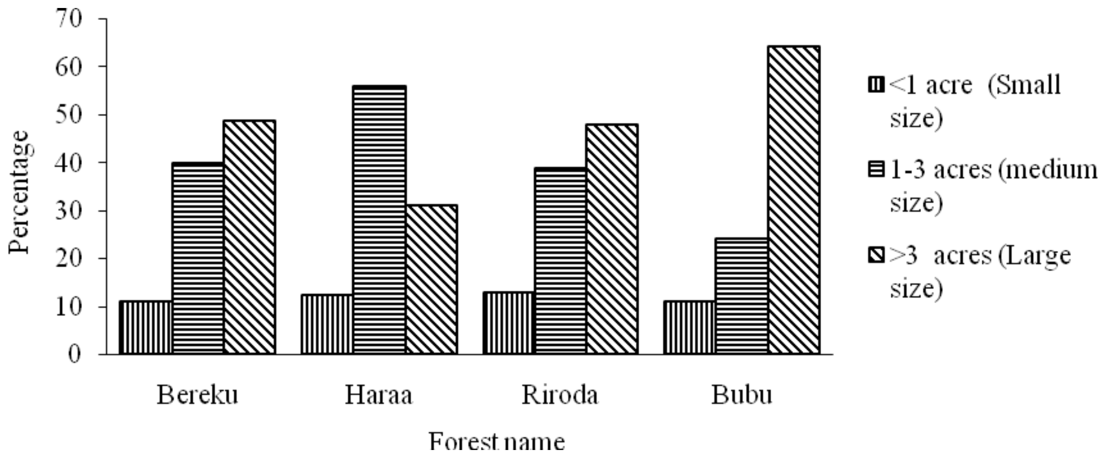

Figure 29: Size of land owned by respondents near forests under state and communal forestland tenure

Some studies have documented competition for forestland in offering fertile soils for agriculture which is a threat to ecological functions of the woodlands (Chileshe, 2005; Yanda, 2010), currently there is no such competition in the study area although deforestation outside the forest reserves is severe on areas where there was no efforts for conservation.

4.4.1.5 Influence of tenure regimes on household income and revenues from state and communal forestland tenure reserves

Table 22 summarizes respondents' perception on household income from forests and revenues from forests reserves dependent on tenure regime as part of financial capital. The results revealed that revenues from sales of forest products was ranked poor by 55.6 and 39.6% in villages near Bereku and Haraa FRs while 40.7 and 42.2% of respondents in villages near communal forestland tenure (Riroda and Bubu) ranked income from the forest to be good. There was a statistical significant difference in respondents' perception on income from forest products in state and communal tenure regimes ($X^2 = 17.50,\ p < 0.001$). The plausible reason for that was probably due to seasonal activities like brick making and fish smoking which fetched high financial income in Riroda and Bubu villages near Lake Babati and River Bubu respectively. Firewood for these activities was obtained from the forest. During the FGD, participants acknowledged using some forest products to supplement household income or food in times of adverse condition.

Table 22: Perception on household income and revenues from forests in villages near Bereku and Haraa FRs, and Riroda and Bubu VFRs

Perception on	Rating	Forest of the respondent				X^2	p-value
		Bereku	Haraa	Riroda	Bubu		
Household income from forest products	Poor	25 (55.6)	19 (39.6)	15 (27.8)	11 (24.4)		
	Average	14 (31.1)	21 (43.8)	17 (31.5)	15 (33.3)		
	Good	6 (13.3)	8 (16.7)	22 (40.7)	19 (42.2)	17.50	<0.001
Income from forest entrance (village)	Poor	27 (60.0)	32 (66.7)	38 (70.4)	35 (73.3)		
	Average	17 (37.8)	13 (27.1)	13 (24.1)	12 (26.7)		
	Good	1 (2.2)	3 (6.2)	3 (5.6)	0 (0.0)	1.19	0.551

Figures in parentheses are percentages and those out of parentheses are frequencies

Burning of bricks and fish smoking are some of the indirect forest incomes which are important in some of the villages. In brick burning, usually green wood was used but it was illegal to cut down green wood particularly from forests under state forestland tenure. Apart from agriculture and livestock keeping, income from forest products was found to be important to the livelihoods of the rural community. Acharya *et al.* (2008) documented that rural community in Nepal benefited more in terms of income and employment from leasehold forest and community/communal tenure regimes than from private and state tenure regimes. However, Sunderlin *et al*. (2008) observed that, regardless of many households using forest products in many countries, forest is not a primary source of livelihood, but is complementary to other activities. Above all, in many areas it was found that cash income from forests is very low and insignificant (Shahbaz and Suleri, 2009;

Gautam, 2009). Another reason for forests to be a minor source of livelihood is that the timing of availability and use of forest products can be critical, even for those households that do not use forest resources frequently or in large amounts (Shackleton, 2006).

Influence of forestland tenure regime on entrance fees was perceived as poor in state as well as in communal forestland tenure regimes. Respondents ranked the income poor by 60 and 66.7% in Bereku and Haraa FRs while it was 73.3 and 70.4% in Bubu and Riroda VFRs. There was no statistical significant difference in respondents' perception on income from forest entrance fees in state and communal tenure regimes ($\chi^2 = 1.192,\ p = 0.551$). Discussion with village leaders disclosed that the amount charged per visitor is low (Tsh 10000/= in both forestland tenure regimes) and mostly it was used to cover the VNRCs expenses. The villages received very few visitors and researchers. Ecotourism was not well promoted in the study area although it has been found to benefit other communities (Ramser, 2007; Salum, 2009).

(i) Summary of influence of state and communal forestland tenure regimes access to livelihood capitals

Figure 18 shows influence of state and communal forestland tenure regimes on access to livelihood capitals based on the indicators. It was observed that access to physical capital (affordable household energy, shelter) was highest in villagers near state forests of Bereku and Haraa FRs (Haraa and Managhat villages respectively) with index of 0.66 and 0.65 respectively. Access to natural capital asset (forest, land) was highest in villages near communal forestland tenure regime of Riroda and Bubu (0.75 and 0.73 respectively).

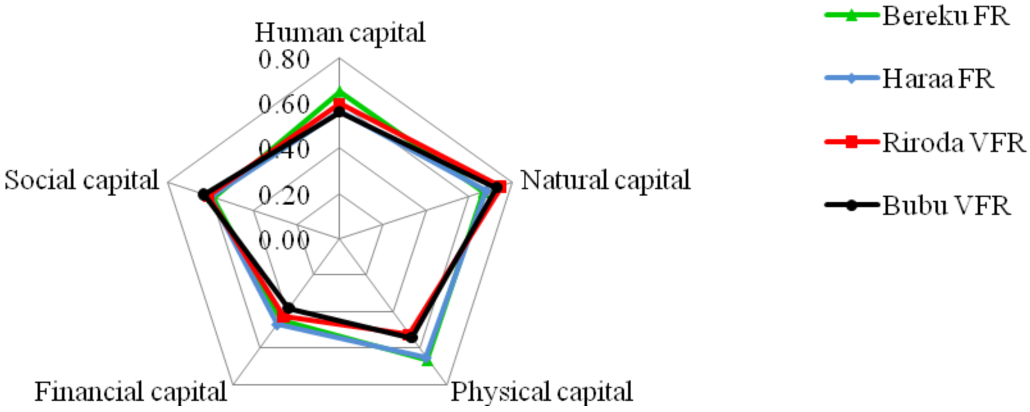

Figure 30: Summary of livelihood capital assets in villages near Bereku and Haraa FRs, and Riroda and Bubu VFRs

In the FGD, it was revealed that access to natural capital assets were highest in Riroda village (Figure 30) due to the fact that part of the forest reserve had been converted into utilization zone. The low access to natural capital assets in state forestland tenure regime was attributed by the fact that access to forest products was limited to collection of very few products. These restrictions in state forestland tenure regime are based on the catchment value of the forests, some of the activities for example grazing and logging were regarded as disadvantageous to the ecology of the forest. This has been experienced in other places as well where there is limited access to forests under state forestland tenure (Banana and Gombya-Ssembajjwe, 2004; Acharya *et al*., 2008; FAO, 2011).

Pokharel *et al.* (2007) mentioned the most critical challenges facing community forestry in state and communal forestland tenure in terms of livelihoods, is the unbalanced distribution of benefits and reduced access to forest products of the local forest dependent communities in Nepal. Improved financial asset in villages near Bereku and Haraa FRs are probably contributed by incomes diversification in the villages. There was enough evidence that forestland tenure regime was responsible for the significant difference in access to natural asset but other factors significantly contributed to the differences in the other assets, for example proximity to the main road , agroforestry practice and income diversification contributed as well.

4.4.2 Influence of state and communal forestland tenure regime on coping to vulnerability

Vulnerability to external shocks and trends is a livelihood issue. The influence of forestland tenure regime on adaptation to vulnerability was analysed by selecting occurrence of forest fire and boundary conflicts as sources of vulnerability to forest related livelihoods. Results on forests fire is summarised in Table 23.

Table 23: Perception on forest fire occurrence in Bereku and Haraa FRs, and Riroda and Bubu VFRs

Perception on	Rating	Forest of the respondent				X^2	p-value
		Bereku	Haraa	Riroda	Bubu		
Forest fire	Frequent	0	0	0	3 (6.7)		
occurrence	Average	45 (100)	48 (100)	0	0		
	Reduced	0	0	54 (100)	42 (93.3)	1.92	<0.001

Figures in parentheses are percentages and those out of parentheses are frequencies

Results showed that 100% of the respondents in state forestland tenure regime of Bereku and Haraa said that occurrence of fire in the forest were in average. In communal forestland tenure regime occurrence of fire was perceived to be low (reduced) by 100 and 93.3% of respondents in Riroda and Bubu respectively. There was significant difference in the responses in fire occurrence between state and communal forestland tenure regimes. Grazing in communal forestland tenure regime was used as a means of reducing fuel load in the forests which is contrary to state forestland tenure regime where grazing is prohibited. During the FGD, it was revealed that fire occurred in particular areas of the forest. The fire was believed to be caused by nearby villagers for the purpose of improvement of grazing areas especially during the dry season. Although these particular areas were termed as fire prone areas, the burnt areas were between 0.5 and 2 ha which can be regarded as not significant since significant fire should reach a final size of ≥ 200 ha (Williamson *et al*., 2007).

Livestock keeping supplements farming in the study area. In the villages near Bereku and Haraa FRs near state forestland tenure, reported to practice cut and carry of fodder, although during inventory, grazing in the forest was observed to be severe in areas near the villages. Riroda and Bubu villages practice free range grazing in the farms and in the forest. According to key informants, the VNRC in VFRs permitted grazing during the dry season to reduce fuel load eventually lower fire risks, which is a plausible explanation on reduced fire incidence in communal forestland tenure regime. This has been observed elsewhere where grazing was said to remove biomass hence reducing fire intensity if it occurred (Topp-Jørgensen *et al*., 2005; Sharam *et al*., 2006).

4.4.3 Dependent livelihood capital in villages near state and communal forestland tenure regimes

During PALI, respondents were asked to rank which of the five livelihood capitals they are highly dependent on for their livelihoods. Results showed that respondents from villages near state and communal forestland tenure regimes ranked natural capital as the capital they depend mostly, with the highest score of four in villages near Bereku, Haraa, Riroda and Bubu forest reserves respectively (Table 24).

Table 24: Livelihood capital ranking by scores in study villages

Livelihood Capitals	Forest name							
	Bereku		Haraa		Riroda		Bubu	
	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank
Natural	4	1	4	1	4	1	4	1
Financial	3	2	3	2	3	2	2	3
Physical	2	3	2	3	2	3	3	2
Human	1	4	0	5	0	5	1	4
Social	0	5	1	4	1	4	0	5

The results conform to other studies where it was noted that the rural communities highly depended on natural capital (Vedeld *et al*., 2004; Kamanga *et al*., 2009). These scholars argued that natural capital assets are used to build more income hence needs more attention. Among the incomes from natural capital assets, forest income from sales of forest produce and other environmental incomes has been observed to be important for rural households (Kamanga, 2005; Mamo *et al*., 2007; Babulo *et al*., 2009; Lepetu, 2009; Barrow *et al*., 2008).

4.4.3.1 Forest dependence based on relative forest income (RFI)

Results showed that forest income contributed an average of 8.4, 8.2, 12.1 and 10.3 percent of total income in villages near Bereku, and Haraa FRs, and Riroda and Bubu VFRs respectively. In the study area, it was revealed that besides farming and livestock keeping, forest goods and services were important constituents in villagers' livelihoods although the contribution was not much (Figure 31). There was a weak statistical significant difference in relative forest income (RFI) (R^2=0.04; p=0.04; N=192) between state and communal forestland tenure regimes. Discussion with the key informants revealed that utilization of forest resources which involved non timber forest products and small diameter trees was permitted in forests under communal forestland tenure.

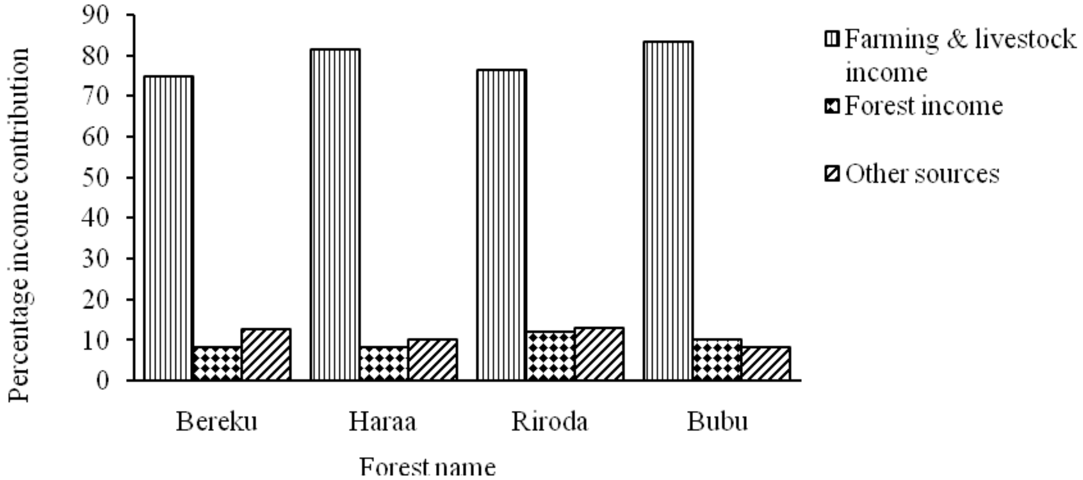

Figure 31: Percentage household income contribution from different sources in villages near Bereku and Haraa FRs, and Riroda and Bubu VFRs

The low RFI occurrences in the households were characterized by low absolute forest income since some of the households were not engaged in forest activities due to different reasons. The resource that provided the highest share of relative forest income as revealed in the PALI was firewood. Most households in the villages use firewood for cooking and heating, regardless of total absolute income levels. The contribution of forest income to total household income in this study was found to be lower compared to other studies done elsewhere. The plausible reason is probably due to limited range of forest products available from these forests and the types of livelihood strategies in the households attributed to this lower contribution. Babulo *et al.* (2009) found out in Tigray, Northern Ethiopia that forest environmental income was the second contributor of household income after agriculture which accounted for 27 and 43% of total household income respectively. Furthermore, Mamo *et al.* (2007) in a study carried out in Dendu, Ethiopia, found that forest environmental income contributed 39% of the total household income.

In a meta-study of forest incomes in 28 countries, Vedeld *et al*. (2004) reports a mean contribution of forest environmental income to be 22%, while income from agriculture (including livestock) was 37% and off-farm activities contributed 38% of the total household income. In another study in Chiradzulu Malawi, Kamanga *et al*. (2009) found that off-farm income contributed 47% and agriculture 28% which was higher than forest income which constituted around 15% of total household income. From these studies it is obvious that forest environmental income represent a significant income source to household income of the communities adjacent to the forests.

Some researchers argued that forest income-earning activities mostly generate very low absolute returns, and poor households with limited access to credits and limited options highly depend on such activities (Vedeld *et al*., 2004; Mamo *et al*., 2007; Kamanga *et al*., 2009). However, Vedeld *et al*. (2007) insisted that even if contributions from forest environmental income are relatively “small” they may be of greatest importance to households living close to the survival line. In this case, such data are important in development programs and strategies, and in policymaking with a focus on rural livelihoods and poverty. In rural communities, forest income is of particular significance with regards to gap filling used as an additional income source during both expected and unexpected deficit in other livelihood sources.

4.4.3.2 Socio-economic and institutional factors enabling orconstraining household dependence on forest income

Enabling and constraining socio-economic factors influencing dependence on forest income were separated into state and communal forestland tenure regimes. Table 25 and 26 present results on household socio-economic factors enabling/constraining forest income dependence from villages within forests under state and communal forestland tenure regimes. Results showed that there was a positive correlation between household relative forest income and number of livestock owned, age of household head, total household income and household having savings in villages near forests under state forestland tenure. On the other hand, negative correlation was observed between household relative forest income, and household size, household cropland size (ha), sex of household head and forestland tenure type (Table 25).

Table 25: Socio-economic and institutional predictors of household dependence on forest in the vicinity of Bereku and Haraa FRs, Babati District.

Socio-economic and institutional factors, X_i	Coefficients (a)			
	Beta weight (β)	S. E	t	Significant (p value)
Age	0.025	0.091	0.497	0.621ns
Level of education	0.024	0.002	0.491	0.624ns
Number of livestock owned	0.724	0.001	11.742	0.000**
Total household income	0.177	0.012	2.366	0.020*
Household having savings	0.108	0.011	2.026	0.046*
Household size	-0.015	0.001	-0.284	0.777ns
Household cropland size	-0.450	0.002	-5.770	0.000**
Sex of household head	-0.012	0.011	-0.247	0.806ns
Tenure of the forest	-0.117	0.007	-2.427	0.017*
Constant		0.037	1.090	0.279

N=93; R^2=0. 82; R^2 adjusted=0. 80; F=42.9; p<0.001.

a. Dependent Variable: Relative forest income (Y_i). SE =Standard error of the estimate. *Statistically significant at 0.05 level, ** Statistically significant at 0.001 level of significance, ns = not statistically significant at 0.05 level of significance.

In villages near forests under communal forestland tenure regime, results showed that there was a positive correlation between household forest income and family size, number of livestock owned, sex of household head and forestland tenure type. Furthermore, negative correlation was observed between household relative forest income and age of household head, education level, land size (ha), total household income and forestland tenure type (Table 26).

Table 26: Socio-economic and institutional predictors of household dependence on forest income in the vicinity of Riroda and Bubu VFRs. Babati District.

Socio-economic and institutional factors X_i	Coefficients (a) Beta weight (β)	S. E	t	Significant (p value)
Age	-0.138	0.010	-2.080	0.040*
Level of education	-0.082	0.002	-1.217	0.227ns
Number of livestock owned	0.566	0.001	9.980	0.000**
Total household income	-0.254	0.001	-3.648	0.000**
Household having savings	0.011	0.010	0.196	0.845ns
Household size	0.188	0.002	3.265	0.002*
Household cropland size	-0.337	0.002	-4.749	0.000**
Sex of household head	0.028	0.011	0.509	0.612ns
Tenure of the forest	-0.063	0.009	-1.130	0.262ns
Constant		0.038	4.530	0.001

N=99; R^2=0. 756; R^2 adj=0. 732; F=30.6; p<0.001.

a. Dependent Variable: Relative forest income (Y_i). SE =Standard error of the estimate. *Statistically significant at 0.05 level, ** Statistically significant at 0.001level of significance, ns = not statistically significant at 0.05 level of significance.

(i) Relative forest income and age of household head

Results on relationship between age of household head and relative forest income in villages near forests under state forestland tenure regime of Bereku and Haraa showed no statistical significant relationship (p = 0.621) while in communal forestland tenure regime there was statistical significant difference at p=0.040. There was no enough evidence to say that household under older heads derived less forest income than younger ones, but it was found that in these communities the younger households were engaged in more paying off-farm activities rather than forest activities with marginal profits, hence there was a trend towards older households using more forest environmental resources.

The results are similar to those of Mitinje *et al.* (2007) where they had a small proportion (6.7%) of respondents within the age group of 18-25 whereby it was found that the youths around Uluguru Mountains in Tanzania, were out of their respective villages looking for more paying jobs elsewhere. On the other hand, Mamo *et al.* (2007) was of the opinion that the age of the head of household may be positively related to forest resource utilization until a peak of physical strength is reached and that older people may possess superior knowledge about various forest resources, and may utilize more medicine plants and wild foods.

(ii) Relative forest income and level of education

Education level which was presented as number of years spent in school did not show any statistical significant relationship between education of household head and relative forest income in state and communal forestland tenure regime of Bereku and Haraa FR (p=0.624) and Riroda and Bubu VFR (p=0.227). It was assumed that the more education of the head of household, it was more likely to access other income opportunities like formal employment. Whereas the lower the number of years in school, the less the opportunities to access other sources of off-farm income. There was no much difference in education level within the households, whereby just 4.2% in the community had secondary school education (Table 27). As explained earlier, those with more education seek opportunities elsewhere. This was observed in other parts of the world, where it was found that households with low education tend to depend more on forest income than those with higher education levels (Adhikari *et al*., 2004; Vedeld *et al*. 2004; Babulo *et al*., 2009; Kamanga *et al*., 2009).

Table 27: Household education level in villages near Bereku and Haraa FRs, and Bubu and Riroda VFRs

Attribute	Rating	Number of respondents				
		Bereku	Haraa	Riroda	Bubu	Total
Level of education	No formal education	6 (13.3)	11 (20.4)	11 (20.4)	17 (37.8)	42 (21.9)
	Primary education	36 (80.0)	40 (72.7)	40 (72.7)	27 (60.0)	140 (72.9)
	Secondary education	3 (6.7)	3 (5.6)	3 (5.6)	1 (2.2)	10 (4.2)

Figures in parentheses are percentages and those out of parentheses are frequencies

A large proportion of communities (72.9%) in villages near state and communal forestland tenure regimes had primary education of which 1.6% had attended college. These findings conforms with REPOA (2010) where it was found that 69.5% of the household heads in rural areas had primary school education in a study done in seven regions of Mainland Tanzania. From the findings of this study, it appeared that after completing primary education most rural children usually remained in the villages and continue with farming activities, while those who finished secondary school education had likely migrated to urban areas for job seeking which is said to be part of livelihood diversification (Ellis, 1999).

(iii) Relative forest income and number of livestock owned by a household

Results showed that that there was statistically significant relationship between number of livestock owned by a household and relative forest income in state as well as communal forestland tenure regimes in Bereku and Haraa FR ($p<0.001$) and Bubu and Riroda VFR ($p<0.001$) respectively. The beta weight for number of livestock is much higher in villages near state FRs but has the same sign with villages near VFRs. This is a highly significant predictor in both cases. It was assumed that households with more livestock have greater need for animal fodder hence more forest utilization especially for grazing area. Communities in the study area kept local breeds of cattle for both food provision (milk and meat) and a secure saving for emergencies. Grazing was done in the forest and in the farms. During the FGD it was reported that grazing was one of the pressures in forests. In rural Africa, livestock acquisition remains a key form of wealth accumulation (Soini, 2005; Lepetu, 2009). Soini (2005) found out in rural Kenya that number of animals measured influence of a person however; Narain *et al.* (2005) reported that in India, the educated grazers kept lower numbers of livestock.

(iv) Relative forest income and total household income

Total household income and relative forest income showed statistical significant relationship in state as well as communal forestland tenure regimes in Bereku and Haraa FR ($p<0.001$) and Bubu and Riroda VFR ($p<0.001$) respectively. It was believed that households with lower income would have high dependence on forest, the main reason being that forest activities have minimum entry capital and are less skilled (Angelsen and Wunder, 2003; Vedeld *et al*., 2004; World Resource, 2005). Within villages near forests under communal forestland tenure regime, there was evidence that those with low income, depended very much on forests as gap fillers and safety net to their livelihoods. With low income, these households cannot engage in more paying activities. Their counterparts from villages near state forestland tenure had other alternatives like labour selling in different activities. This has been associated with location of the village rather than the tenure of the adjacent forest. Comparing with other studies, Mamo *et al*. (2007) found out in Ethiopia that relative forest environmental income was inversely and significantly correlated with household income ($p=0.01$) which meant that households with more income (wealthy) extracted greater values but relied less on forest resources.

(v) Relative forest income and household having savings

Household having savings in banks or credit societies and relative forest income showed a statistical significant relationship in state forestland tenure regimes of Bereku and Haraa FR ($p<0.04$) but there was no statistical significant relationship in communal forestland tenure regimes in Riroda and Bubu VFR ($p=0.84$). It was assumed that households with more savings depended less on forest environmental income, since accumulation of wealth to the extent of having savings enabled them to have other avenues for livelihood diversification and in case of emergency one can access the savings. During the FGD it was revealed that in both tenure regimes few people saved money in banks or other institutions meant for that purpose, 69.8% of the respondents said that they don't have savings in the banks (Table 28). However, savings in terms of livestock, crops and land were the main type of savings practiced in the study area. The few respondents with savings had less than Tshs 50 000 which is the down payment for opening an account with Savings and Credit Cooperatives (SACCOs).

Table 28: Household savings status in villages near Bereku and Haraa FRs, and Riroda and Bubu VFRs

Savings	Rating range (Tsh)	Number of the respondents				
		Bereku	Haraa	Riroda	Bubu	Total
Bank saving and SACCOs	< 50,000	8 (17.8)	5 (10.4)	5 (9.3)	2 (4.4)	20 (10.4)
	50,000-100,000	7 (15.6)	2 (4.2)	2 (3.7)	3 (6.7)	14 (7.3)
	200,000-500,000	2 (4.4)	9 (18.8)	3 (5.6)	3 (6.7)	17 (8.9)
	>500,000	3 (6.7)	1 (2.1)	3 (5.6)	0 (0)	7 (3.6)
	None	25 (55.6)	31 (64.6)	41 (75.9)	37 (82.2)	134 (69.8)

Figures in parentheses are percentages and those out of parentheses are frequencies
1USD=Tsh 1568/=

The findings are similar to those of Ali *et al*. (2007) who found out that about 70% of respondents in North West Frontier Province (NWFP) of Pakistan did not have savings in banks and depended on forest resources. Tumusiime (2006) reported low membership turn-up in saving and credit associations in communities near mount Ruwenzori national park, Uganda. Given that savings and credit depend on the availability of income sources, the rural community with low income could not benefit from these institutions. Lepetu (2009) disclosed that households with larger wealth assets and savings were less dependent on forest resources.

(vi) Relative forest income and cropland size held by the household

Size of cropland owned by the household was statistically significant predictor of relative forest income in state as well as in communal forestland tenure regimes. The negative sign of β suggests that relative forest income is higher among households with smaller land holdings. This is most likely because households with large cropland size get more incomes, relatively speaking, from their farms.

Villagers near forests under state forestland tenure regime practiced agroforestry whereby trees (mainly *Grevillea robusta* and *Senna* spp.) were mixed with banana in their respective pieces of land. In villages within communal forestland tenure regime it was found that farmers retained some few trees in their farms or around the farms. These findings are similar with those of Kitula (2011) who reported farmers with larger farm sizes in Uluguru nature reserve retained trees in their farms that catered for construction material and firewood which eventually helped to improve the forest condition.

(vii) Relative forest income and household size

Results showed that that there was no statistically significant relationship between household size and relative forest income in state forestland tenure regimes of Bereku and Haraa FR (p=0.777) whereas there was a statistical significant relationship in communal forestland tenure regimes of Bubu and Riroda VFR (p=0.002). In villages near state forestland tenure regime there was not enough evidence to suggest that households with more members have relatively higher forest income than those with few members.

Usually, household size was expected to influence the demand for forest resources. In communal tenure regime, the positive relationship between number of household members and relative forest income indicated that an increase of household size increased the demand for forest resources especially firewood consumption. In both forestland tenure regimes, households with more family members used more bundles of firewood, being the main source of energy and most of them built more houses in their compounds hence utilising more forest resources. The positive relationship was also observed in Malawi, Uganda and Botswana (Kamanga, 2005; Buyinza, 2008; Lepetu *et al*., 2009). On the contrary, households near state forestland tenure regime utilized more products from their agroforestry plots.

(viii) Relative forest income and sex of household head

There was no statistical significant relationship between relative forest income and sex of household head in either state or communal forestland tenure regimes $p = 0.806$ and $p=0.612$ respectively. In this study it was perceived that female headed household had less manpower hence low forest utilization and eventually low forest income. However, the results showed that there was no much evidence to suggest that female-headed households had low relative forest income.

In other studies, it was explained that male-headed households derived more forest income than female-headed households due to labour availability (Vedeld *et al.*, 2004). Nevertheless, it was found that male household heads were involved in forest related activities if it had high returns (Babulo I., 2009). On the other hand, Babulo *et al*. (2009)

adds that in Tigray Ethiopia female-headed households were the least-educated, usually held small areas of land for cultivation and were the least fortunate in terms of access to credit hence were bound to utilize more forest resources.

(ix) Relative forest income and forestland tenure type

Forestland tenure type was statistically significant predictor of relative forest income in state forestland tenure regime ($p=0.017$) while it was not statistically significant in communal forestland tenure regime ($p=0.262$). The associated negative β coefficients in both forestland tenure regimes indicate a probability that strict tenure (forest under state tenure) constrains access to forest income. During the FGD, it was revealed that the community near forests under communal forestland tenure regime had a sense of ownership and valued their forest which is contrary to their counterparts from state forestland tenure regime. This suggests that tenure security is important for extraction of forest resources. Although they have user rights, respondents from villages near forests under state forestland tenure regime complained that they receive minimum in terms of livelihood supplement apart from firewood for domestic use.

According to forest policy, it was expected that local communities in Tanzania should benefit directly and indirectly from adjacent forests through involvement (URT, 1998), which is contrary to what villagers near state forestland tenure regime experience. This has encouraged illegal extraction of commercial forest products in forests under state forestland tenure regime. Persha and Blomley (2009) also observed this in forests under state forestland tenure in West Usambara.

The results conform to that of Acharya *et al*. (2008), who disclosed that communities in Nepal benefited more from community forestry than from state owned forests. However, Ali *et al.* (2007) did not find any significant difference between communities who practiced JFM and those who did not in state forestland tenure in Pakistan. According to Acharya *et al*. (2008) secure tenure is important for the conservation of forest resources and for encouraging the rural community to invest their labour in conservation and improve their livelihoods.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Forestland tenure is one of the most important factors influencing management and utilization of forest resources hence affecting directly forest condition and livelihood provision. With the evolving forestland tenure reforms, much is needed to be learned about the influence of forestland tenure to enhance sustainable forest management. The overall objective of this study was to analyse the influence of forestland tenure regimes on forest resource condition and livelihoods in selected forests in Babati District. Two tenure regimes namely state and communal tenure were studied. The conclusions are based on results with respect to hypotheses that forests resource condition is not influenced by forestland tenure regimes and forest based livelihood is not influenced by forestland tenure regimes; while the alternative hypotheses were forest resource condition is influenced by forestland tenure regimes and the alternative is forest based livelihood are influenced by forestland tenure respectively. Forest condition is covered in forest vegetation cover change, stocking, biodiversity and forest disturbance.

5.1.1 Influence of state and communal tenure regimes on forest vegetation cover change

This study found that there was an influence of forestland tenure regimes on vegetation cover change when the two tenure regimes were compared. Overall results showed that forests under state forestland tenure regime had a higher proportion of closed woodland cover than communal forestland tenure regime. The annual rate of change for closed woodland in the communal forestland tenure regime was higher than the rate of change in state tenure regime. This was probably contributed by forestland tenure regime where state forestland tenure regime previously restricted utilization of the forest. There is therefore enough evidence that forests under state forestland tenure regime were better in terms of forest cover than forests under communal forestland tenure regime.

5.1.2 Influence of state and communal forestland tenure regimes on stocking and biodiversity level

The stocking level in terms of mean numbers of stems ha^{-1}, mean basal area m^2ha^{-1} and mean volume (m^3ha^{-1}) were higher in state forestland tenure regime in Bereku FR and Haraa FR compared to communal forestland tenure regime in Riroda and Bubu VFRs. This was probably an influence of forestland tenure regime, whereby large diameter trees contributed to higher basal area and standing volume in forests under state forestland tenure regime denoting long-term conservation. High number of regenerants observed in forests under state forestland tenure regime was a result of wide gaps caused by illegal harvesting of large trees. Although grazing in forests under communal forestland tenure regime in Bubu and Riroda VFRs had reduced fuel load hence has also reduced number of regenerants.

Tree biodiversity values were higher in forests under state forestland tenure regime in Bereku and Haraa FRs compared to Riroda and Bubu VFRs. The low *H'* in forests under communal forestland tenure regime is a function of insecure forestland tenure when the forests were proposed to be under state tenure regime, this was during a transition period from general land to village land.

5.1.3 Influence of forestland tenure regime on disturbance level and main causes of forest pressure in state and communal forestland tenure regimes

Mean number of stems ha^{-1} removals from Riroda communal forestland tenure regime was higher compared to the other three forests. In the village forest reserves, most removals were from basal diameter ranging between 1 and 10 cm since they are highly used domestically. Riroda VFR had higher removals because the villagers had decided to utilize the forests for their livelihoods. Most removals of trees with large diameters were found in state forestland tenure regime compared to communal forestland tenure regime. In the two forestland tenure regimes, the major forest disturbance was caused by logging followed by grazing. Riroda VFR, which is under communal forestland tenure regime, suffered the most.

5.1.4 Influence of state and communal tenure regimes on rural livelihoods

Access to physical capital was highest in villages near state forests of Bereku and Haraa (Haraa and Managhat villages respectively) compared to villages near communal forestland tenure regime whereas access to natural capital was highest in villages near communal forestland tenure regime of Riroda and Bubu.

Villages near state forestland tenure regime (Bereku and Haraa FRs) had well developed physical capital asset, improved financial and human capital assets probably due to their location and not due to tenure regime. Access to natural capital assets was highest in Riroda village since they decided to turn part of the forest reserve into utilization zone. The low access to natural capital assets in state forestland tenure regime was attributed by the fact that access to forest products was limited to collection of dry firewood which could not suffice other livelihood needs. This limitation in state forestland tenure regime is due to catchment value of the forests, some of the activities including grazing and logging were regarded as destructive to the ecology of the forest.

Generally, efforts for conservation of forest reserves and their effect on communities' livelihood vary in different forestland tenure regimes. Overall, results of this study show that among other factors, forestland tenure regime was seen to directly influence forest condition and access to forest products. Bereku and Haraa FRs under state forestland tenure regime were better in improving forest condition than Bubu and Riroda VFRs under communal forestland tenure regime which succeeded in improving livelihoods of the adjacent communities. Therefore there is sufficient evidence to reject the null hypotheses and support the alternative hypotheses that both forest resource condition and forest based livelihoods are influenced by forestland tenure regimes.

5.2 Recommendations

5.2.1 The need for forestland tenure reforms

Forestland tenure reform is an important step towards sustainable forest management; the study suggest the need for forestland tenure diversification under different models, since each forestland tenure regime functions better in a certain condition. The study also recommends that forest reserves, particularly forest under communal forestland tenure regime, should be part and parcel of the wider land use plan of their respective districts to prevent further loss of forest areas.

5.2.2 The need for community training on forest condition assessment

Since almost every conservation or development policy strongly emphasise involvement of local community who provide the needed manpower for forest resource assessment; it is recommended from this study that a group of local community members should be given simple and appropriate training (in each village with forest resources) to collect accurate data on stocking, diversity and forest disturbance to enhance monitoring of forest condition.

5.2.3 The need for harvesting plans and concerted efforts on forest patrols

To reduce illegal harvesting by some of the community members, harvesting plans should be prepared in communal forestland tenure regime and mechanisms for equitable distribution of benefits among all stakeholders should be established. Forest staff and village governments with the help of the VNRCs should make concerted efforts to stop the prevailing forest disturbances in state forestland tenure regime by increasing the number of patrols.

5.2.4 Creation of buffer zone forests

The study advocates interventions to communities with limited user rights by creating buffer zone forests by either helping the communities conserve degraded forest patches within their authority or demarcating a utilization zone in the forest. This will help communities with limited user rights in state forestland tenure regime to have incentives to protect the resources. Above all, the user rights should be accompanied by strong obligations in forest conservation and clear benefits from forests under state forestland tenure should be affirmed. This can be supplemented by tree planting activities in the villages to reduce pressure on the forests and to help improve livelihoods by selling products from planted trees.

5.3 The Need for Further Research

Sustainable forest management has been linked to participatory governance with a common decision-making and shared rights among the stakeholders. Since state and communal forestland tenure regimes operate under different user rights, further research is needed on power relations and social inequity/equity in association with governance of the forests. In this way, knowledge gap surrounding power relations and inequity/equity and their interaction with other variables to shape up successful forest governance will be met. The research may help policy-makers to lessen the destructive effects of power relations and inequality, and find ways to build equity and sustainability in forest governance in general.

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APPENDICES

Appendix 1: Change detection matrix

FOREST NAME	FOREST COVER	Forest Cover between 1993-2000 in Ha						Forest Cover between 2000-2009 in Ha				
		CW	OW	BW	GL	SH	ST	CW	OW	BW	GL	SH
Bereku	CW	(3982.7)	251.1	412.5	50.8	7.4	0.0	(2785.8)	1262.7	310.6	3.0	23.0
	OW	481.2	(322.8)	99.7	22.3	12.4	0.0	144.6	(424.9)	149.1	3.6	17.2
	BW	97.6	42.5	(61.9)	17.7	8.4	0.0	36.0	194.3	(249.7)	81.1	97.8
	GL	46.4	2.7	53.2	(36.5)	7.4	0.0	1.1	5.0	12.7	(90.9)	21.3
	SH	8.6	1.8	54.6	12.1	(16.7)	0.0	0.4	2.8	66.6	7.6	(119.4)
	Total	4616.5	620.9	681.9	139.4	52.3	0.0	2967.9	1889.6	788.6	186.1	278.7
Haraa	CW	(371.1)	11.5	1.3	0.0	0.2	0.0	(401.1)	161.3	12.0	1.3	1.6
	OW	134.1	(81.9)	1.8	0.0	0.1	0.0	3.2	(10.0)	3.7	0.8	0.5
	BW	0.7	0.6	(1.0)	0.0	0.1	0.0	0.3	3.4	(1.8)	0.2	0.4
	GL	0.0	0.0	0.0	(0.1)	0.0	0.0	0.0	0.1	0.1	(0.1)	0.0
	SH	0.0	0.0	0.2	0.0	(0.2)	0.0	0.0	0.1	1.0	1.9	(0.2)
	Total	505.9	94.0	4.3	0.1	0.6	0.0	404.5	175.0	18.6	4.3	2.7
Bubu	CW	(534.5)	354.4	497.8	66.7	73.9	37.1	(17.2)	221.5	285.2	9.6	48.5
	OW	11.2	(5.7)	18.7	11.3	8.5	4.2	0.3	(36.2)	236.6	16.5	117.3
	BW	30.7	36.0	(119.0)	91.2	65.7	36.3	0.4	42.7	(183.0)	157.2	295.2
	GL	0.0	0.4	5.3	(33.8)	10.7	47.8	0.0	0.6	11.0	(183.8)	67.4
	SH	3.8	13.9	34.9	64.7	(47.6)	34.3	0.0	1.0	44.1	58.4	(103.4)
	ST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	103.0	59.3
	Total	580.2	410.4	675.6	267.7	206.4	159.7	17.9	302.1	760.3	528.6	691.1
Riroda	CW	(154.4)	798.5	237.9	34.8	101.5	0.0	(26.0)	86.3	55.3	0.7	4.6
	OW	13.1	(172.7)	66.3	28.3	61.6	0.0	1.3	(202.1)	542.6	20.7	141.2
	BW	1.4	11.2	(20.1)	31.2	36.6	0.0	0.2	14.8	(138.5)	41.1	138.0
	GL	0.1	0.2	0.6	(3.8)	2.8	0.0	0.0	1.2	9.2	(89.8)	36.7
	SH	0.2	1.8	3.4	9.7	(8.0)	0.0	0.1	3.2	39.1	86.0	(121.4)
	Total	169.1	984.4	328.2	107.8	210.5	0.0	27.7	307.5	784.7	238.2	441.9

Note: CW = closed woodland; OW = Open woodland; BW = Bushed woodland; GL =Grassland; SH = shrubs; ST = settlements

Numbers in bracket indicate cover areas that remained unchanged within the period

Appendix 2: Tree species checklist for Bereku, Haraa, Bubu and Riroda Forest Reserves

spp code	Botanical name	Local name	Genus	Family
1	*Acacia albida*	Tlehharimo	Acacia	Mimosaceae
2	*Acacia hockii*	Fitsimo1	Acacia	Mimosaceae
3	*Acacia nilotica*	Baryomodi	Acacia	Mimosaceae
4	*Acacia polyacantha*	Fitsimo2	Acacia	Mimosaceae
5	*Acacia tortilis*	Tsansafi	Acacia	Mimosaceae
6	*Acalypha fruticosa*	Galii	Acalypha	Euphorbiaceae
7	*Achyranthes aspera*	Kutsu	Achyranthes	Amaranthaceae
8	*Albizia antunesiana*	Moi	Albizia	Mimosaceae
9	*Albizia gummifera*	Tsori	Albizia	Mimosaceae
10	*Albizia harveyi*	Tlehharimo	Albizia	Mimosaceae
11	*Albizia petersiana*	Simihhi	Albizia	Mimosaceae
12	*Allophylus africanus*	Datlei	Allophylus	Sapindaceae
13	*Aspilia mossambicensis*	Khathathaumo	Aspilia	Aspilia
14	*Azanza garckeana*	Tlaghay	Azanza	Malvaceae
15	*Balanites aegyptiaca*	Hawi	Balanites	Balaniteceae
16	*Boscia mossambicensis*	Sangetmo	Boscia	Capparanceae
17	*Brachystegia boehmii*	Nafumo1	Brachystegia	Caesalpiniaceae
18	*Brachystegia microphylla*	Hhewasi1	Brachystegia	Caesalpiniaceae
19	*Brachystegia spiciformis*	Nafumo2	Brachystegia	Caesalpiniaceae
20	*Bridelia micrantha*	Isalmo	Bridelia	Euphorbiaceae
21	*Bridelia sp*	Tsarmo	Bridelia	Euphorbiaceae
22	*Calodendrum capense*	Tliatlii	Calodendrum	Rutaceae
23	*Canthium lactescens*	Tlerghw	Canthium	Rubiaceae
24	*Carissa edulis*	Titiwi	Carissa	Apocynaceae
25	*Cassia singuena*	Dalaagi	Cassia	Caesalpiniaceae
26	*Catha edulis*	Walfi	Catha	Celasraceae
27	*Catunaregan spinosa*	Getalongo	Catunaregan	Rubiaceae
28	*Clausena anisata*	Mealytlakwi	Clausena	Rutaceae
29	*Clerodendrum myricoides*	Tlaghmo	Clerodendrum	Verbanaceae
30	*Clerodendrum rotundifolium*	Fori	Clerodendrum	Verbanaceae
31	*Combretum molle*	Gendai/gendaumo1	Combretum	Combretaceae
32	*Combretum zeyheri*	Gendai/gendaumo2	Combretum	Combretaceae
33	*Commiphora africana*	Niimo	Commiphora	Burseraceae
34	*Commiphora mollis*	Itlahumo	Commiphora	Burseraceae
35	*Commiphora zimmermannii*	Hlahumo	Commiphora	Burseraceae
36	*Cordia africana*	Sei	Cordia	Boraginaceae
37	*Cordia ovalis*	Bagharimo	Cordia	Boraginaceae
38	*Croton machrostachys*	Meali	Croton	Euphorbiaceae
39	*Croton megalocarpus*	Meeli	Croton	Euphorbiaceae
40	*Croton menyarthii*	Girgimo/afahhawi	Croton	Euphorbiaceae
41	*Cussonia arborea*	Hhatsini	Cussonia	Araliaceae
42	*Dalbergia arbutifolia*	Warambu	Dahlbergia	Papilionaceae
43	*Dalbergia nitidula*	Gaudi	Dahlbergia	Papilionaceae
44	*Dicrostachys cinerea*	Girwangw	Dicrostachys	Mimosaceae
45	*Dodonea viscose*	Berimi	Dodonea	Sapindaceae
46	*Dombeya rotundifolia*	Gwataati	Dombeya	Sterculiaceae
47	*Dombeya sp*	Wahari	Dombeya	Sterculiaceae
48	*Dovyalis sp*	Mummui	Dovyalis	Flacourticeae
49	*Dracaena manii*	Sansuli	Dracaena	Dracaenaceae
50	*Entada abyssinica*	Aaredesu	Entada	Mimosaceae
51	*Erythrina abyssinica*	Angal	Erythrina	Papilionaceae
52	*Senna obtusifolia*	Etitimo	Senna	Caesalpiniaceae
53	*Euclea divinorium*	Sinyanyi	Euclea	Ebanaceae
54	*Fadogia sp*	Bo-aani	Fadogia	Rubiaceae
55	*Faurea saligna*	Dukti	Faurea	Proteaceae
56	*Ficus sp*	Tiita	Ficus	Moraceae
57	*Ficus sp*	Ila-aantsumo	Ficus	Moraceae
58	*Ficus stuhlmannii*	Pombosimo	Ficus	Moraceae
59	*Ficus sycomorus*	Aantsi	Ficus	Moraceae
60	*Flacortia indica*	Tsapenai	Flacortia	Flacourticeae
61	*Galiniera coffeoides*	Daa'atmo	Galiniera	Rubiaceae

62	*Glycine javanica*	Sa-aam	Glycine	Papilionaceae
63	*Grewia bicolor*	Lomo	Grewia	Tiliaceae
64	*Grewia platyclada*	Firaakwi	Grewia	Tiliaceae
65	*Grewia similis*	Saski	Grewia	Tiliaceae
66	*Grewia tenax*	Tumatimo	Grewia	Tiliaceae
67	*Harrisonica abyssinica*	Kantsi	Harrisonica	Simaroubaceae
68	*Hibiscus fuscus*	Intsangw	Hibiscus	Malvaceae
69	*Hoslundia opposita*	Mathar	Hoslundia	Lamiaceae
70	*Hymenodictyon floribundum*	Laliyd	Hymenodictyon	Rubiaceae
71	Inthakamo	Inthakamo		
72	*Ocimum gratissimum*	Itsinana	Ocimum	Lamiaceae
73	*Julbernardia globiflora*	Hhewasi2/irihu	Julbernardia	Caesalpiniaceae
74	*Kigelia africana*	Dati	Kigelia	Bignoniaceae
75	*Lannea schimperi*	Tsarmai	Lannea	Anacardiaceae
76	*Lannea stuhlmanii*	Thigi	Lannea	Anacardiaceae
77	*Leonitis mollisima*	Tsusutsunghi	Leonitis	Lamiaceae
78	*Maytenus sp*	Akoa'awak	Maytenus	Celastraceae
79	*Myrsine africana*	Mahheli	Myrsine	Myrsinaceae
80	*Ocimum suave*	Soriyangi	Ocimum	Lamiaceae
81	*Olea africana*	Sahhati	Olea	Oleaceae
82	*Olea capensis*	Tsalmo	Olea	Oleaceae
83	*Ormocarpum trichocarpum*	Natsiay	Ormocarpum	Papilionaceae
84	*Osyris compressa*	Kipaartu	Osyris	Santalaceae
85	*Oxyanthus speciosus*	Owi	Oxyanthus	Rubiaceae
86	*Ozoroa reticulata*	Burthi	Ozoroa	Anacardiaceae
87	*Parinaria curatellifolia*	Amafaa	Parinaria	Rosaceae
88	*Phyllanthus engleri*	Indakhakha	Phyllanthus	Euphorbiaceae
89	*Piliostigma thonningii*	Galapi	Piliostigma	Papilionaceae
90	*Pleurostylia africana*	Daateni	Pleurostylia	Celasraceae
91	*Podocarpus latifolius*	Dukmo	Podocarpus	Podocarparacea
92	*Protea sp*	Bahhay	Protea	Proteaceae
93	*Prunus africana*	Gwaamu/gwaami	Prunus	Rosaceae
94	*Pseudolachnostylis mapruneifolia*	Ghaghari	Pseudolachnostylis	Euphorbiaceae
95	*Psorospermum febrifugum*	Daa'lusmo	Psorospermum	Guttiferae
96	*Rauvolfia caffra*	Haraie	Rauvolfia	Apocynaceae
97	*Rhus longipes*	Aambalangw/ambalaki	Rhus	Anacardiaceae
98	*Rhus natalensis*	Datei/datlii	Rhus	Anacardiaceae
99	*Rhus vulgaris*	Datlaii	Rhus	Anacardiaceae
100	*Schrebera elata*	Pararaumo	Schrebera	Oleaceae
101	*Schrebera trichoclada*	Tsarimo	Schrebera	Oleaceae
102	*Scolopia sp*	Mumui	Scolopia	Flacourticeae
103	*Erythrina caffra*	Qanguzi	Erythrina	Papilionaceae
104	*Steganotaenia araliacea*	Tsei	Steganotaenia	Steganotaenia
105	*Strychnos innocua*	Furuduw/furudawu	Strychnos	Loganiaceae
106	*Strychnos spinosa*	Khokhoi	Strychnos	Loganiaceae
107	*Syzigium cordatum*	Awartu	Syzigium	Myrtaceae
108	*Tamarindus indica*	Mithingi	Tamarindus	Caesalpiniaceae
109	*Tarenna graveolens*	Ma-aari	Tarenna	Rubiaceae
110	*Teclea simplicifolia*	Warfi	Teclea	Rutaceae
111	*Terminalia mollis*	Sohhi	Terminalia	Combretaceae
112	*Thylachium africanum*	Thakwethakwei		Capparaceae
113	*Trema orientalis*	Maauk	Trema	Ulmaceae
114	*Triumpheta sp*	Botlaghani	Triumpheta	Tiliaceae
115	*Turraea robusta*	Tumatumo	Turraea	Meliaceae
116	*Vangueria infausta*	Baranghu	Vangueria	Rubiaceae
117	*Vernonia excertifolia*	Aankwi	Vernonia	Asteraceae
118	*Vernonia sp*	Pungani	Vernonia	Asteraceae
119	*Vernonia sp*	Baraii	Vernonia	Asteraceae
120	*Vitex doniana*	Oor'oroumu	Vitex	Verbanaceae
121	*Vitex mombassae*	Tlambau	Vitex	Verbanaceae
122	*Ximenia caffra*	Maayangu	Ximenia	Olacaceae
123	*Zanha africana*	Mnughumo	Zanha	Sapindaceae
124	*Zanthoxylum chalybeum*	Morungi	Zanthoxylum	Rutaceae

* Local names are in Iraqw, Gorowa, Fyomi, Barbaig and Nyaturu languages spoken in Babati District.

Appendix 3: Distribution of N, G and V by species in state and communal forestland tenure regime

3a. Bereku and Haraa FRs for trees of > 5cm dbh in order of increasing number of stems per ha

Bereku FR								Haraa FR							
Spp code	**N**	**B**	**V**	**H'**	**(n/N)^2**	**IVI**	**IVI %**	**Spp code**	**N**	**B**	**V**	**H'**	**(n/N)^2**	**IVI**	**IVI %**
18	197	5.37	45.95	0.315	0.035905	66.04	22.01	18	354	4.49	34.92	0.354	0.073424	72.11	25.4
73	124	3.14	26.17	0.253	0.014193	42.27	14.09	97	103	0.55	2.65	0.194	0.005614	18.04	6.6
31	66	0.68	4.63	0.175	0.004060	18.13	6.04	45	68	0.30	1.39	0.158	0.002965	9.82	3.3
46	61	0.45	2.67	0.167	0.003497	12.68	4.23	9	67	1.26	9.24	0.188	0.005021	25.15	8.0
97	54	0.29	1.59	0.153	0.002660	12.77	4.26	87	58	0.37	1.62	0.146	0.002331	9.79	3.3
99	47	0.18	0.92	0.141	0.002093	8.64	2.88	31	70	0.83	3.31	0.134	0.001800	12.84	4.1
32	40	0.23	1.32	0.126	0.001496	9.18	3.06	48	39	0.17	0.70	0.108	0.000968	5.11	1.8
43	36	0.19	1.18	0.117	0.001209	7.93	2.64	46	34	0.28	1.77	0.100	0.000781	10.55	3.6
87	35	0.38	2.31	0.114	0.001125	7.78	2.59	78	29	0.24	1.15	0.136	0.001891	8.98	2.4
12	35	0.11	0.54	0.114	0.001120	6.00	2.00	20	25	0.22	1.35	0.085	0.000493	7.40	2.4
20	33	0.24	1.47	0.110	0.001023	8.25	2.75	56	24	0.28	1.47	0.086	0.000514	5.12	1.7
55	29	0.16	0.88	0.099	0.000761	7.62	2.54	32	22	0.52	4.20	0.076	0.000367	10.81	3.6
85	23	0.41	3.44	0.084	0.000487	8.38	2.79	11	19	0.10	0.41	0.065	0.000242	3.03	1.1
53	20	0.11	0.60	0.075	0.000360	4.85	1.62	53	19	0.09	0.39	0.088	0.000558	5.13	1.5
81	19	0.10	0.53	0.074	0.000339	5.04	1.68	95	19	0.14	0.80	0.076	0.000365	5.76	1.8
116	15	0.10	0.53	0.060	0.000201	3.64	1.21	93	19	0.54	4.39	0.064	0.000231	9.90	3.3
117	14	0.08	0.43	0.058	0.000179	3.14	1.05	37	16	0.07	0.31	0.060	0.000197	3.37	1.1
19	13	0.27	2.11	0.056	0.000165	4.34	1.45	60	14	0.10	0.61	0.052	0.000136	6.15	2.1
74	13	0.16	1.24	0.055	0.000160	4.56	1.52	33	14	0.16	1.05	0.050	0.000124	4.48	1.5
100	13	0.19	1.38	0.054	0.000148	5.01	1.67	59	14	0.77	7.77	0.050	0.000124	9.83	3.3
17	10	0.20	1.49	0.045	0.000092	3.27	1.09	42	13	0.04	0.22	0.046	0.000102	2.75	0.9
8	10	0.12	0.87	0.044	0.000089	4.25	1.42	12	13	0.07	0.38	0.060	0.000200	2.65	0.8
112	9	0.09	0.57	0.042	0.000080	1.84	0.61	36	11	0.47	3.23	0.043	0.000084	6.63	2.2
115	8	0.07	0.45	0.039	0.000065	1.91	0.64	65	11	0.06	0.31	0.066	0.000250	3.48	0.9
96	8	0.14	1.01	0.038	0.000060	3.61	1.20	99	10	0.05	0.28	0.066	0.000254	2.69	0.6
56	8	0.06	0.42	0.037	0.000056	1.75	0.58	80	9	0.08	0.38	0.039	0.000065	2.09	0.7
93	8	0.17	1.45	0.036	0.000055	3.13	1.04	74	9	0.07	0.39	0.035	0.000049	1.92	0.7
80	8	0.03	0.11	0.036	0.000053	1.24	0.41	63	8	0.07	0.38	0.032	0.000039	2.60	0.9
89	8	0.06	0.32	0.036	0.000053	1.72	0.57	98	8	0.03	0.12	0.039	0.000064	1.70	0.5
75	7	0.10	0.69	0.035	0.000052	4.26	1.42	28	5	0.04	0.20	0.022	0.000015	2.12	0.7

Bereku FR								Haraa FR							
Spp code	**N**	**B**	**V**	**H'**	**(n/N)^2**	**IVI**	**IVI %**	**Spp code**	**N**	**B**	**V**	**H'**	**(n/N)^2**	**IVI**	**IVI %**
44	7	0.06	0.35	0.034	0.000045	2.00	0.67	4	4	0.03	0.17	0.018	0.000010	1.24	0.4
65	5	0.02	0.10	0.027	0.000025	1.27	0.42	16	4	0.02	0.10	0.018	0.000010	1.20	0.4
45	5	0.01	0.06	0.024	0.000020	1.17	0.39	54	4	0.02	0.11	0.018	0.000010	1.17	0.4
48	5	0.02	0.09	0.024	0.000020	0.88	0.29	116	4	0.02	0.08	0.032	0.000040	1.48	0.4
94	5	0.17	1.60	0.024	0.000019	2.82	0.94	118	4	0.01	0.05	0.022	0.000016	1.19	0.4
59	4	0.44	4.45	0.021	0.000015	4.60	1.53	122	4	0.01	0.05	0.029	0.000031	1.34	0.4
14	3	0.03	0.20	0.016	0.000008	1.12	0.37	68	3	0.05	0.26	0.014	0.000005	1.31	0.4
37	3	0.01	0.08	0.016	0.000008	1.00	0.33	100	2	0.02	0.12	0.010	0.000002	1.03	0.4
33	3	0.02	0.09	0.015	0.000006	0.68	0.23	120	2	0.04	0.30	0.014	0.000006	1.27	0.4
50	3	0.02	0.11	0.015	0.000006	0.99	0.33	41	1	0.08	0.74	0.008	0.000001	1.45	0.5
6	2	0.01	0.02	0.014	0.000005	0.58	0.19	108	1	0.06	0.41	0.009	0.000002	1.32	0.4
21	2	0.00	0.02	0.014	0.000005	0.57	0.19	75	1	0.01	0.08	0.010	0.000003	0.96	0.3
24	2	0.01	0.02	0.014	0.000005	0.59	0.20	76	1	0.01	0.08	0.010	0.000003	0.96	0.3
25	2	0.01	0.04	0.014	0.000005	0.59	0.20	84	1	0.01	0.05	0.010	0.000003	0.92	0.3
40	2	0.01	0.03	0.014	0.000005	0.58	0.19	91	1	0.03	0.18	0.010	0.000003	1.09	0.3
51	2	0.01	0.04	0.014	0.000005	0.60	0.20	104	1	0.01	0.08	0.010	0.000002	0.95	0.3
69	2	0.01	0.02	0.014	0.000005	0.58	0.19	121	1	0.01	0.10	0.015	0.000006	1.05	0.3
95	2	0.01	0.02	0.014	0.000005	0.58	0.19	1	1	0.14	1.46	0.005	0.000000	1.82	0.6
118	2	0.01	0.03	0.014	0.000005	0.59	0.20	38	1	0.06	0.40	0.010	0.000002	1.28	0.4
9	2	0.15	1.25	0.013	0.000004	1.53	0.51	107	1	0.07	0.61	0.018	0.000010	2.30	0.7
92	2	0.02	0.09	0.011	0.000003	0.59	0.20	49	1	0.12	1.17	0.008	0.000001	1.75	0.6
29	1	0.01	0.06	0.002	0.000000	0.40	0.13	113	1	0.02	0.16	0.005	0.000001	0.96	0.6
36	1	0.01	0.11	0.002	0.000000	0.43	0.14	**Total**				3.020	0.099437	300	100.0
39	1	0.05	0.39	0.005	0.000001	0.72	0.24								
2	1	0.02	0.10	0.004	0.000000	0.48	0.16								
27	1	0.01	0.03	0.004	0.000000	0.41	0.14								
106	1	0.01	0.05	0.004	0.000000	0.44	0.15								
Total				3.172	0.072060	300									

3b. Distribution of N, G and V by species in Bubu and Riroda VFRs for trees of > 5cm dbh in order of increasing number of stems per ha

Bubu VFR								Riroda VFR							
Spp code	N	B	V	H'	(n/N)^2	IVI	IVI %	Spp code	N	B	V	H'	(n/N)^2	IVI	IVI %
99	132	0.48	2.22	0.274	0.019227	24.45	8.15	18	280	5.11	45.19	0.355	0.076153	86.96	28.99
31	98	1.08	7.43	0.235	0.010776	31.62	10.54	31	76	0.55	3.10	0.193	0.005548	19.04	6.35
18	97	2.52	20.93	0.326	0.042993	55.21	18.40	22	73	0.37	1.86	0.190	0.005235	17.21	5.74
73	76	2.42	21.43	0.203	0.006483	42.71	14.24	12	60	0.22	1.01	0.167	0.003457	12.29	4.10
19	52	0.78	5.59	0.158	0.002962	18.96	6.32	73	52	1.84	19.03	0.153	0.002675	28.13	9.38
23	34	0.11	0.49	0.119	0.001280	5.74	1.91	32	52	0.38	2.15	0.153	0.002665	14.33	4.78
25	27	0.07	0.33	0.100	0.000782	6.78	2.26	98	32	0.15	0.72	0.109	0.000985	7.12	2.37
55	25	0.15	0.85	0.095	0.000687	6.23	2.08	99	28	0.09	0.38	0.100	0.000778	5.80	1.93
75	25	0.31	2.02	0.095	0.000681	12.69	4.23	75	27	0.32	1.97	0.097	0.000715	10.40	3.47
17	24	0.69	5.55	0.094	0.000655	15.13	5.04	74	25	0.07	0.27	0.091	0.000596	3.91	1.30
27	22	0.11	0.55	0.086	0.000523	5.48	1.83	19	24	0.23	1.53	0.090	0.000582	5.82	1.94
64	21	0.08	0.36	0.085	0.000500	3.55	1.18	25	22	0.08	0.37	0.083	0.000475	6.04	2.01
90	19	0.11	0.59	0.079	0.000405	5.79	1.93	117	22	0.09	0.42	0.083	0.000475	4.77	1.59
87	17	0.12	0.66	0.072	0.000320	4.07	1.36	27	17	0.08	0.44	0.068	0.000274	4.18	1.39
86	14	0.08	0.43	0.062	0.000211	5.52	1.84	33	15	0.27	2.01	0.064	0.000231	7.00	2.33
116	13	0.05	0.32	0.059	0.000194	3.56	1.19	23	15	0.05	0.25	0.062	0.000220	4.19	1.40
22	13	0.07	0.33	0.058	0.000180	3.61	1.20	43	15	0.05	0.24	0.062	0.000220	3.30	1.10
65	13	0.03	0.10	0.058	0.000180	2.13	0.71	53	15	0.05	0.22	0.062	0.000220	3.70	1.23
107	11	0.11	0.80	0.052	0.000136	3.29	1.10	24	15	0.06	0.28	0.061	0.000206	3.73	1.24
12	11	0.07	0.40	0.050	0.000125	2.91	0.97	34	12	0.07	0.38	0.052	0.000137	3.14	1.05
32	11	0.08	0.45	0.050	0.000125	3.53	1.18	116	12	0.03	0.13	0.051	0.000128	2.29	0.76
97	11	0.06	0.31	0.050	0.000125	2.76	0.92	44	11	0.03	0.12	0.048	0.000109	2.64	0.88
117	10	0.03	0.15	0.046	0.000101	2.42	0.81	64	11	0.04	0.17	0.048	0.000109	3.63	1.21
121	8	0.03	0.13	0.042	0.000080	1.72	0.57	70	10	0.15	0.98	0.046	0.000098	3.19	1.06
1	8	0.10	0.65	0.040	0.000069	2.86	0.95	115	9	0.04	0.18	0.041	0.000076	2.55	0.85
94	7	0.09	0.53	0.038	0.000061	2.69	0.90	4	7	0.04	0.17	0.035	0.000049	1.46	0.49
33	5	0.06	0.34	0.029	0.000031	2.20	0.73	60	7	0.02	0.07	0.035	0.000049	2.19	0.73
52	5	0.04	0.22	0.029	0.000031	1.49	0.50	83	7	0.04	0.17	0.035	0.000049	1.46	0.49

Bubu VFR								Riroda VFR							
Spp code	**N**	**B**	**V**	**H'**	**(n/N)^2**	**IVI**	**IVI %**	**Spp code**	**N**	**B**	**V**	**H'**	**(n/N)^2**	**IVI**	**IVI %**
124	5	0.05	0.33	0.026	0.000025	1.55	0.52	86	7	0.03	0.15	0.035	0.000049	1.42	0.47
37	4	0.01	0.03	0.024	0.000020	1.07	0.36	58	5	0.10	0.63	0.027	0.000027	1.84	0.61
71	4	0.02	0.07	0.024	0.000020	1.15	0.38	50	4	0.02	0.09	0.024	0.000019	1.49	0.50
83	4	0.02	0.07	0.024	0.000020	1.15	0.38	94	4	0.05	0.37	0.022	0.000015	1.73	0.58
103	4	0.02	0.10	0.024	0.000020	1.20	0.40	15	4	0.01	0.04	0.020	0.000012	0.88	0.29
109	4	0.01	0.05	0.024	0.000020	1.11	0.37	28	4	0.02	0.08	0.020	0.000012	0.95	0.32
115	4	0.01	0.04	0.024	0.000020	1.09	0.36	40	4	0.01	0.03	0.020	0.000012	0.87	0.29
46	4	0.14	1.09	0.021	0.000014	3.87	1.29	42	4	0.01	0.04	0.020	0.000012	0.89	0.30
111	2	0.02	0.11	0.014	0.000005	1.50	0.50	47	4	0.02	0.08	0.020	0.000012	0.95	0.32
3	2	0.05	0.37	0.010	0.000003	1.74	0.58	88	4	0.01	0.06	0.020	0.000012	0.92	0.31
10	1	0.12	1.11	0.010	0.000002	2.41	0.80	97	4	0.03	0.15	0.020	0.000012	1.04	0.35
11	1	0.01	0.06	0.008	0.000001	0.75	0.25	109	4	0.01	0.04	0.020	0.000012	0.89	0.30
13	1	0.02	0.12	0.004	0.000000	0.75	0.25	46	3	0.05	0.31	0.017	0.000009	1.63	0.54
41	1	0.01	0.09	0.004	0.000000	0.72	0.24	8	2	0.12	1.04	0.012	0.000004	3.53	1.18
93	1	0.03	0.20	0.004	0.000000	0.84	0.28	29	2	0.03	0.21	0.011	0.000003	1.36	0.45
Total				2.931	0.090096	300	100	17	2	0.14	1.24	0.010	0.000002	2.71	0.90
								57	1	0.10	0.94	0.006	0.000001	0.73	0.24
								2	1	0.01	0.08	0.006	0.000001	0.66	0.22
								35	1	0.01	0.07	0.006	0.000001	0.64	0.21
								56	1	0.02	0.15	0.008	0.000001	1.91	0.64
								122	1	0.01	0.04	0.006	0.000001	0.60	0.20
								123	1	0.02	0.15	0.006	0.000001	0.73	0.24
								59	1	0.00	0.03	0.003	0.000000	0.53	0.18
								102	1	0.01	0.11	0.003	0.000000	0.62	0.21
								Total				2.993	0.102745	300	100

Appendix 4: Pairwise ranking of dominant pressure in the forests

Pressure	Logging	Commercial Firewood	Charcoal making	Grazing	Thatching grass	Beekeeping	Score	Rank
Logging								
Commercial Firewood								
Charcoal making								
Grazing								
Thatching grass								
Beekeeping								

Identified activity	**1 (does not increase open space)**	**2 (very small increase of open space)**	**3(average increase)**	**4 (more than average increase)**	**5 (intense increase of open space)**
Logging					
Commercial fuelwood					
Charcoal making					
Grazing					
Annexing land for agriculture					
Wild honey gathering					

Appendix 5: Checklist questionnaires for key informants

A: District natural resources officers/ DCFM

1. Prevailing tenure types/regimes and their management strategies?
2. What is the current cost/benefit sharing mechanism with the community around the forest reserves?
3. What are the costs incurred in establishing village land forests?
4. Stages reached so far in gazzetting the village forests.
5. What are the harvesting procedures?
6. How much do you charge per license ?
7. What is the price of timber? (Tsh/m^3)
8. How much do you charge per head load of fodder?
9. How much do you charge for poles?
10. How much do you charge for license for grazing?
11. How much do you charge for a head load of firewood?
12. How much do you charge for eco-tourism/day?
13. What is the system used for license granting?
14. Who is given priority?
15. system of Revenues distribution
16. Management problems
17. Future prospects

B: Village government and environmental committee

1. Who initiated community conservation activities
2. What is the status of village environmental committee in forest management
3. How do you participate in the activities
4. How do the villagers participate in the activities
5. What costs is incurred in this joint venture
6. What are the benefits accrued
7. How do you implement forest protection rules and village forest bylaws

C: Non governmental organization (NGO’s)

1. Main objective of the project
2. Activities done and their contribution to the management of forest reserves
3. What are the uses of the planted trees if there is any tree planting activities
4. How does the community benefit from this NGO activity
5. What are the costs incurred in the activities.
6. What are the problems experienced and how are they solved.

Appendix 6: Likert scale for the five livelihoods assets

Human capital	**1 (lowest)**	**2**	**3**	**4**	**5 (highest)**
Access to school	No school in the village	School outside village 1hr walk	School outside less than 1hr walk	School in village but poor facilities	Good quality school in the village
Primary					
secondary					
Access to health facilities	No health facilities in the village	Health service neighbouring village	Health service less 1hr walk	Health service in the village but poor facilities	Good quality health facilities in the village
Involvement in trainings	Never involved	A little involvement	Average involvement	more involvement	Involved in all the trainings
Capacity building for women	No capacity building at all	Some capacity building	Average capacity building	Capacity building for majority	Equal chances for all women
Natural capital	**1**	**2**	**3**	**4**	**5**
Village forest reserve	No village forest	Area identified dialogue in progress	Area identified no conservation measures	VFR present but not conserved	VFR present and conserved
Difference between past and present forest access	Not accessible	restricted access	Average	Much easier accessibility	Free access
Forest condition	In very bad state	Bad state	Not bad not good	Good state	Excellent condition
Presence of wildlife in the forest	No animals present	Very few animals	average	Many animals	A lot of animals
Level of erosion	Highly eroded	Eroded	Average	Few eroded parts	No erosion at all
Biodiversity	Many spp reduced	Some spp not available	Average	Very few spp reduced	All the spp present
Protection of water sources	No protection	Few areas protected	Average	Much protection	All sources protected
Physical capital	**1**	**2**	**3**	**4**	**5**
Quality of housing	Very poor housing/deteriorating	All thatched with withies	Some houses thatched	Mud houses with iron sheets	Burnt bricks and iron sheets roofs
Water supply	No permanent water supply in the village	1hr walk to water supply	Centred piped water supply for all	Piped water available to some	All with tap water
Electricity	No electricity or generators	Very few with generators or solar	Some few electricity, generators/solar	Some connected to national grid electricity	All connected to national grid electricity
Cooking	Completely not	Very little	Average	Available	Readily

energy (firewood)	available		availability		available
Communication	No communication facilities	Very difficult	Average	improved	Excellent facilities
Financial capital	**1**	**2**	**3**	**4**	**5**
Income from agriculture/live stock	No income at all	Very little	Average	Satisfactory	A lot of income
Income from forest products	No income at all	Very little	Average	Satisfactory	A lot of income
Income from petty business	No income at all	Very little	Average	Satisfactory	A lot of income
Savings	No savings at all	Very little	Average	Satisfactory	A lot of savings
Employment	No employment at all	Very little	Average	Satisfactory	Plenty employment
Social capital	**1**	**2**	**3**	**4**	**5**
Relationship with VNRC	No relationship at all	Very little relationship	Average	Satisfactory relationship	A lot of cooperation
Involvement in Forest Management	Excluded	Little participation	Average	Satisfactory participation	A lot of participation
Awareness of JMAs	Not known at all	I am not sure	Very little known	known but boundaries not known	clearly known
Traditional governance	Completely removed	Very little practiced	Average	Sometimes used	Always used
Corruption in public services	A lot of corruption	There is some corruption	Average	Very little corruption	No corruption at all
Influence on Vulnerability	**1(lowest score)**	**2**	**3**	**4**	**5(highest score)**
Number of conflicts in the village during the past 5 years	Substantially increased	Somewhat increased	Remained stable	Somewhat decreased	Substantially decreased
Prices of agricultural inputs over past 5 years	Substantially increased	Somewhat increased	Remained stable	Somewhat decreased	Substantially decreased
floods	Always	Often	Sometimes	Rarely	Never
bush fires	Always	Often	Sometimes	Rarely	Never

Appendix 7: Livelihoods' household questionnaire survey in Babati

1. Basic location information **Date______________**

No	Item	Name
1.0	Name of interviewer	
2.0	Questionnaire number	
3.0	Hamlet	
4.0	Village name	
5.0	Ward	
6.0	Division	
7.0	District	
8.0	Region	

2. Basic household information

1.0 Name of household head……………………………………..

2.0 Gender of respondent

(i) Male……………………

(ii) Female……………………..

3.0 Age of head of household (years)………………………….

4.0 Marital status

(i) Single………………

(ii) Married……………..

(iii) Widowed……………

(iv) Divorced……………

5.0 Education attained

(i) None…………………

(ii) Primary school…………

(iii) Secondary school…………

(iv) College/university…………

(v) Others (specify)……………

6.0 Household size

Age category	Male	female
< 20 years		
20-40 years		
41-60 years		
> 60 years		

7.0 Residence period of respondent in the area (years)……………………..

3.Livelihood data

1.0 Main household income generating activities

No	Type of economic activity	Estimated annual income
1.0	Agriculture	
2.0	Livestock keeping	
3.0	Beekeeping	
4.0	Lumbering	
5.0	Brick making	
6.0	Petty business	
7.0	Herbalist	
8.0	Poles	
9.0	Collection of other forest products	
10.0	Others (specify)	

2.0 Household assets

Item	Number	Estimated cost
Number of buildings/structures locally:		
Number of buildings/structures elsewhere:		
Size of household's cropland last 12 months:		
Tenure on household's cropland:		
Financial assets/savings:		
Machinery		

Tenure: 1=own land, 2=rented land, 3=borrowed land, 4=communal land

3.0 Type of crops cultivated

No	Type of crop	Amount harvested (90kg=1bag)	Amount sold	Income generated (Tshs/yr)
1.0	Maize			
2.0	Sunflower			
3.0	Beans			

4.0 Does the harvest satisfy your annual household food requirements?

(i) Yes……………………..

(ii) No…………………………

5.0 Reasons for inadequate agricultural crop production if any

(i) Draught………………….

(ii) Poor seed quality……………….

(iii) Infertile soil/no fertilization…………….

(iv) Inadequate land…………………………

(v) Use of poor agricultural tool/technology………….

6.0 (a) If no in Qn 3, what do you do to fill the deficit?

(i) Purchase food……………………

(ii) Engage in forest activities…………..

(iii) Collect food from the forest………….

7.0 (b)Is there any hunger period? Yes/No…………..

(c) which is the hunger period (months)………….

8.0 (a) Do you collect and use products and services from the forest?

(i) Yes……

(ii) No…….

(b) If No why……………………………………………………

…………………………………………………………………….

(c) If Yes, for how long have you been using the forest products?

(i) Less than one year…………………..

(ii) 1-7 years……………………………..

(iii) more that 7 years…………………….

(d) What is the objective of using the forest?

(i) Increase household income……..

(ii) Supplementing food…………….

(iii) Others (specify)…………………

(e) What is the difference between past and present uses of the forest?

(i) No difference………………..

(ii) Easy to get products………….

(iii) Products have diminished……….

(f) How is accessibility to the forest?

(i) Not easily accessible

(ii) Easily accessible,

(g) Major events in the forests you can recall

No	Event	Year

(e) What do you take from the forest?

(i) Timber forest products (mention)……………………………..

(ii) Non timber forest products (mention)…………………………

(f) Income from forests and woodlands last 12 months

Type collected	**Total collected or produced**	**Amount sold**	**Total net income from sales**
Charcoal			
Firewood			
Fodder			
Poles			
Others			

9.0 (a) Do you keep livestock

(i) Yes…..

(ii) No…..

(b) Livestock information

Type of livestock	**Bought last 12 months**				**Sold last 12 months**			**Given last 12 months**
	Quantity	**Price**	**costs**	**Bought from**	**quantity**	**price**	**income**	**Sold to**
Cattle								
Mature								
Young								
Donkeys								
Goats								
Sheep								
Others								

Young animals = two years old or less
"Bought from" and "sold to" (type of market): 1=within village, 2=local primary market, 4=secondary market, 5=travelling trader, 6=others
When different animals of the same type are exchanged in different markets, indicate market with number of animals in brackets, e.g. 1(4), 2(73), 3(14)
Note: give price range (min-max). Note: gifts include animals slaughtered for communal ceremonies.

(c) Where do you graze your livestock?

(i) In the farms

(ii) In the forest

(iii) Cut and carry

(d) Milk production for the last 12 months

Type of livestock			
Season	**Period**	**No. of animals**	**Price (mean) TSh/litre**
Season 1			
Season 2			

Note: must first ask about different milking seasons; peak periods, slow periods, etc

10.0 **Other income sources last 12 months**

THANK YOU VERY MUCH FOR YOUR COOPERATION

Appendix 8: Matrix scores for livelihood capital assets in Haraa, Managhat, Bubu and Riroda villages

Name of village	Livelihood Capitals	Natural	Financial	Physical	Human	Social	Scores	Rank
Haraa (Bereku FR)	Natural	XX	N	N	N	N	4	1
	Financial	XX	XX	F	F	F	3	2
	Physical	XX	XX	XX	P	P	2	3
	Human	XX	XX	XX	XX	H	1	4
	Social	XX	XX	XX	XX	XX	0	5
Managhat (Haraa FR)	Livelihood Capitals	Natural	Financial	Physical	Human	Social	Scores	Rank
	Natural	XX	N	N	N	N	4	1
	Financial	XX	XX	F	F	F	3	2
	Physical	XX	XX	XX	P	P	2	3
	Human	XX	XX	XX	XX	H	1	4
	Social	XX	XX	XX	XX	XX	0	5
Bubu	Livelihood Capitals	Natural	Physical	Financial	Human	Social	Scores	Rank
	Natural	XX	N	N	N	N	4	1
	Physical	XX	XX	P	P	P	3	2
	Financial	XX	XX	XX	F	F	2	3
	Human	XX	XX	XX	XX	H	1	4
	Social	XX	XX	XX	XX	XX	0	5
Riroda	Livelihood Capitals	Natural	Financial	Physical	Social	Human	Scores	Rank
	Natural	XX	N	N	N	N	4	1
	Financial	XX	XX	F	F	F	3	2
	Physical	XX	XX	XX	P	P	2	3
	Social	XX	XX	XX	XX	S	1	4
	Human	XX	XX	XX	XX	XX	0	5