CONTRIBUTION OF ON-FARM TREES TOWARDS CONSERVATION OF THE BIODIVERSITY OF AMANI NATURE RESERVE, TANZANIA

BY

BRUNO SAMWEL MALLYA

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ABSTRACT

On-farm tree planting has been practiced all over the world in order to supplement reserved forests in terms of wood products. On-farm tree planting was a strategy to reduce pressure in the Amani Nature Reserve (ANR), which is biologically important in the Eastern Arc Mountains and globally at large. The objectives of this study were to assess the contribution of on-farm trees in conservation of the biodiversity of ANR. Measurements were taken from total of 135 on-farm plots measuring 0.125 ha per plot for determination of on-farm tree composition, stocking, richness and diversity. The type of forest products collected from ANR were assessed in a 1 km transect from the boundary by identifying and counting the number of cut trees and poles. Questionnaire survey administered to 135 households was used to determine tree uses, preference and factors influencing on-farm tree planting. On-farm tree species richness was determined by the total number of tree species while tree diversity was determined using Shannon-Wiener index. A total of 99 tree species belonging to 39 families either planted or retained on-farm were identified. Of all trees measured, 40.5% were deliberately planted and 59.5% retained on the farms. The dominant species included *Maesopsis eminii*, *Grevillea robusta*, *Gliricidia sepium* and *Cedrella odorata*. The Shannon-Wiener index of diversity for on-farm trees was 4.15. This shows a high diversity of on-farm tree species comparable to undisturbed natural forests. On farm trees are used as fuelwood, building poles, tool handles, timber and animal fodder. About 69.5% of some tree based products were obtained from on-farm trees, while other products such as herbal medicines, alpenstock and weaving material were collected from ANR. Farm size and income were the major factors influencing tree planting on farm. It is concluded that on-farm trees have positive impact on ANR conservation as well as improving future household income.

DECLARATION

I, BRUNO SAMWEL MALLYA, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

___________________ ______________________

Bruno S. Mallya Date

(MSc. Candidate)

The above declaration is confirmed by

___________________ ______________________

Prof. P. K. T. Munishi Date

(Main Supervisor)

___________________ ______________________

Dr. G. E. Mbeyale Date

(Second Supervisor)

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LIST OF ABBREVIATIONS AND SYMBOLS

ABG	Amani Botanical Garden
ABE	Amani Butterfly Enterprise
ANR	Amani Nature Reserve
CBFM	Community Based Forest Management
CBD	Convention on Biological Diversity
DBH	Diameter at Breast Height
df	Degree of freedom
GN	Government Notice
H’	Shannon Wiener Index
HH	Households
FBD	Forest and Beekeeping Division
EUTCO	East Usambara Tea Company
EUCADEP	East Usambara Conservation and Agriculture Development Project
EUCAMP	East Usambara Conservation Area Management Programme
G (m^2/ha)	Basal Area (meter square per hectare)
JFM	Joint Forest Management
ID	Index of Dominance
IVI	Importance Value Index
MDGs	Millennium Development Goals
MNRT	Ministry of Natural Resources and Tourism
NGOs	Non-Governmental Organizations
NWFP	Non-Wood Forest Products
N/ha	Number of Stems per hectare
PRA	Participatory Rural Appraisal
PFM	Participatory Forest Management

SECAP	Soil Erosion Control and Agroforestry Project
Spp	Species
SPSS	Statistical Package for Social Science
SUA	Sokoine University of Agriculture
TAS	Tanzanian Shillings
V (m^3/ha)	Volume (meter cubic per hectare)
VFM	Village Forest Management Area
VNRC	Village Natural Resources Committee
WCED	World Commission on Environment and Development

CHAPTER ONE

1.0 INTRODUCTION

Tree planting and/or retention in rural or urban areas have been practiced all over the world, in orchard and fallows within shifting cultivation systems. Sometimes it is a result of deliberate management and/or planting in gardens and agroforestry system, as shade trees or permanent crops constituting a genuine and essential source of wood and non-wood forest products (NWFP) crucial for people's day to day needs (FAO, 2002; Leakey, 2010).

While forests are still being severely degraded, the number of trees on farms is increasing (FAO, 2002) and interestingly, there are many examples where the rise in on-farm tree numbers occurs in areas where population densities are high and farm size is very small. Leakey (2010) observed that as a result of deforestation for modern farming systems, local communities no longer have access to all traditionally important products formerly gathered from forests. Consequently, tree domestication is a means for farmers to rebuild the natural capital of species providing food, medicines and all their other products needed for everyday survival. It is common to find trees of certain species, such as *Erythrina abyssinica, Dracaena usambarensis, Ficus* species and others being retained, protected and managed on farms on many African farmlands (Iddi, 2002). Tree domestication therefore emerged as a farmer – driven, market led process. The other common practices are integration of trees in farming systems known as agroforestry aiming at providing environmental services and/or products that are either traded or used domestically to offer multiple livelihood benefits, especially for smallholder farmers in the tropics beset with poverty, malnutrition and hunger.

In rural areas, farming is the main source of livelihoods for the people of Tanzania. Farming systems tend to be household-based and thus their sustainability depends on the continuous existence of tree resources (Kessy, 1998; Leakey *et al.,* 2005; Bluffstone, *et al.,* 2008). Trees on farms interlink with agriculture, and livestock, and form an integral part of the farming system which not only complement but also supplements natural forests and forest plantations in terms of provision of a range of benefits, from ecosystem services (retain moisture, hydrologic water cycle, soil erosion control and carbon sequestration); to wood and NWFPs such as food, fuel, fodder, medicine, shelter, employment, recreation, and habitats for wildlife, landscape diversity (Nair, 1993; Leakey, 1999; Chamshama and Kiyiapi, 2005; Munishi *et al.,* 2008). Trees are also important for the protection of environment and conservation of biodiversity (Iddi, 1998; Lulandala, 1998).

Amani Nature Reserve (ANR) is recognized as one of the global important ecosystems for diversity of their plant and animal life. ANR plays an important role in conserving catchment forests, protecting and discharging water for the surrounding lowlands and urban community; providing wide range of forest products for local residents and moderating the climate of tea estates that surrounds the reserve (Madoffe, 2006). The local communities surrounding ANR access free of charge wood and NWFP like firewood, vegetables, mushroom, forest soil, traditional rituals and un-destructive picking of herbs for medicinal uses (ANR, 2007).

The increased rate of consumption of forest resources in the past three decades led to suggestion that industrial logging in reserve and general lands in 1986 should be banned (Hamilton and Mwasha, 1989). The tree planting campaign (in farms) was launched by the Forest and Bee-Keeping Division which is under the Ministry of Natural Resources and Tourism, and implemented by ANR as a new strategy for Participatory Forest Management (PFM) (MNRT, 2000, 2001; Kijazi, 2007).

In order to ensure smooth participation of surrounding local community in biodiversity conservation, the management of ANR provides the local community with various incentives such as tree seeds/seedlings, mud-brick making machines; bee hives equipment and fish fingerlets. Furthermore, capacity building programme was implemented to adjacent villagers, which included tree nursery establishment, soil and water conservation techniques and beekeeping. Apart from such materials, ANR management usually set aside 20% of its annual revenue accrued from tourism to motivate the surrounding communities through contributing to activities that reduce the dependence and threat to ANR forest resources, such as fires, tree cutting and encroachment for cultivation (Malundo, 2008). The incentives have influenced stakeholders to be active and willing to participate in managing forests sustainably thereby counterbalancing the opportunity costs incurred in the process. Trees on-farms in this perspective reflect farm–based practices rather than forest-based practise.

Trees on-farms which are either planted or retained have different composition, structure and richness compared to those obtained in reserved forest. Many studies have been conducted in various gazetted forest reserves to determine composition, structure and richness and ANR is among them, but less on -farms (Hamilton and Mwasha, 1989; Mbeyale, 1999; Frontier Tanzania, 2001; Isango, 2007; Killenga, 2007).

After many years of efforts to encourage tree planting on farm, it is time to evaluate their contribution towards reducing utilization pressure and hence the conservation of ANR.

1.2 Problem Statement and Justification

Despite an increase in the rate of tree planting on farms in order to reduce pressure on natural forests and to enhance biodiversity, little has been done to quantify and document how trees outside forests particularly on-farm trees can reduce and/or have various threats posed on the ANR by selective tree cutting and encroachment (Reyes, 2008; Methew, 2009). Some studies conducted around Amani Nature Reserve (ANR) indicate that trees on farms have impact to both people and the conservation of ANR (Kessy, 1998; Kijazi, 2007; Malundo, 2008). However, such studies did not quantify tree species composition, structure and extent of their contribution towards conservation of forest biodiversity (Isango, 2007). There is no current study that has assessed the contribution of on-farm trees towards conservation of protected forest and utilization of the trees at household level, a knowledge gap that will be bridged by this study.

This research is expected to avail useful information on the type, abundances, planting pattern, and the role of on-farm trees in reducing pressure on existing natural forests and therefore contribution to conservation of the biodiversity in ANR.

1.3 Objectives

1.3.1 Main Objective

The main objective of the study was to assess the contribution of on-farm trees to the conservation of biodiversity of Amani Nature Reserve.

1.3.2 Specific Objectives

The specific objectives of the research were to:

(i) Determine on-farm tree species composition and structure in villages neighbouring ANR.

(ii) Assess tree species uses and preferences of communities neighbouring ANR.

(iii) Determine the type of forest products needed and still extracted from ANR by neighbouring communities.

(iv) Assess the factors influencing on-farm tree planting/retention in villages surrounding ANR.

1.4 Research Questions

(i) What type, number and abundances of trees are on – farm?

(ii) What are the uses and preferences of on- farm tree resources?

(iii) What kind of forest products originate from ANR that are not available on farm?

(iv) What are factors influencing on-farm tree planting/retention?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Biodiversity Conservation in Amani Nature Reserve

Amani Nature Reserve is the largest block of forest in the East Usambara Mountains; it is a combination of six former forest reserves (Kwamkoro, Amani Sigi, Amani East, Amani West, Kwamsambia and Mnyuzi), 1 068 ha of forest donated by the East Usambara Tea Company and public land (MNRT, 2000). In terms of conservation, it is a habitat for a large number of endemic and threatened species. It is also a good example of a continuous forest block ranging from lowland to sub-montane forest (Kessy, 1998).

Relative to other reserves surveyed by Frontier-Tanzania, ANR has high average botanical and faunal species richness. In terms of fauna, the reserve is home to seven endangered and 26 vulnerable species according to IUCN categories (Frontier Tanzania, 2001). ANR has a high diversity of reptiles and amphibians. There are six animal species and one subspecies which have been recorded as endemic to the Usambara Mountains. The outstanding biodiversity of ANR has made Tanzania to be ranked high in terms of biodiversity conservation. It is one of the 34 biodiversity hot spot countries in the world (Burgess, 2010). One definition of a biodiversity hotspot is a region rich in endemic species, It is a geographic areas that contain high levels of species diversity but are threatened with extinction. Most of these hotspots are located in the tropics and most of them are forests. Hotspots unfortunately tend to occur in areas of significant human impact, leading to threats to many endemic species (Atta-krah *et al*., 2004).

Conservation of ANR forest was unique due to presence of communities, public and private organisation inside and around the reserve. These include villages, tea estates, and employee of medical research centre (NIMR), forest camps and villages. Presence of these communities poses threats to the reserve due to day to day forest resources utilization. Pole cutting and animal trapping are reported to be among the leading illegal activities within ANR (Mbeyale, 1999; Frontier Tanzania, 2001; Killenga, 2007). In order to overcome the problem related to future wood resource scarcity, the community was encouraged to plants and retain indigenous trees within the area under their jurisdiction for local utilization. This resulted into having people with tendency to retain trees on-their farms for various uses.

2.2 On-Farm Tree Planting and Management

Tree species composition is the assemblage of plant species that characterize the vegetation (Martin 1996 in Isango, 2007). It explains particular species present in a certain locality and its association and reflects a combination of physical environment and climatic history of events at the site. The common measure of composition is richness (the number of different species per unit area) and abundance (the number of individuals per species found in specified area). Therefore changes in species composition can provide a sensitive measure of ecologically relevant changes in the environment (Philippi *et al.,* 1998; Munishi, 2010). Species composition can vary greatly from place to place. For instance common species found in riverine vegetation which are mostly retained around wetlands and water bodies can hardly be found in terrestrial dry lands. These species include *Ficus spp, Newtonia buchananii, Khaya anthotheca, Trichilia dregeana, Rauvolfia caffra* and the moraceae family (figs) like *Ficus sur, F. natalensis* and *F. sycomorus* (Holmes, 1995a; Schulman *et al.,* 1998).

In farmlands, tree composition refers to the relative amount of a particular species as a percentage of the total number of species in a community (Munishi, 2001). Due to regular land management including tilling, planting various food and tree crops, weeding and shifting cultivation; there are a good number of various plants that are regenerating through natural means although some are planted based on tree planting awareness.

The implication of species composition to the livelihood is a possibility for sustainable supply of tree resources throughout the year (Atta-Krah *et al*., 2004). Species composition in farmlands vary from one agro- ecological zone to another depending on population pressure, availability of wood resources and/or alternative source of wood material and management awareness (Munishi *et al.*, 2006; Regmi and Garforth, 2010). Species composition on-farms particularly in highland villages like Amani where indigenous trees are growing together with planted exotic trees are expected to be more diverse than those found in intact non-disturbed natural forests due to regular land management (Mallya, 2003). The abundance, importance, or dominance of each species can be expressed numerically so that different communities can be compared on the basis of species similarities and differences (Munishi, *et al., 2008;* Munishi, 2009).

2.2.1 On-farm tree species richness and biological diversity

Species richness is the number of different species in a given area. It is a fundamental unit used to assess the homogeneity of an environment. Typically, species richness is used in conservation studies to determine the sensitivity of an ecosystem and its resident species. The actual number of species calculated alone is largely an arbitrary number (Burgess, 2010).

Species richness can be measured in terms of diversity, and can be considered either in terms of species richness or taxonomic uniqueness (Kindt *et al*., 2004). Biological diversity (biodiversity) is the term used to describe the variability/total variety among the living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part. It is conveniently classified and measured from three different angles: genetic diversity, species diversity and ecosystem diversity (Madoffe, 2006). The higher diversity of plants either on-farm or forest reserve, provides habitat for wild animals including small mammals, birds, reptiles and insects. These have both merits and demerits to crops and tree resources available (Munishi *et al*., 2006).

On-farm tree diversity is enhanced by mixture of various plant species, however, higher diversity will have beneficial effects on ecosystem functioning. Kindt *et al*. (2005) observed that one of the challenges of targeting enhancement of ecosystem functioning by increasing biodiversity is selecting the identities and traits of the component species. The challenge is also to match the variation in environmental conditions at a specific scale in the landscape with a mixture of species with the appropriate traits for the environmental conditions. However, different studies have shown that on average higher diversity will have beneficial effects (Swallow *et al*., 2006). Also on average, having more species in the landscape means that redundancy is higher: losing one species from a diverse landscape will have smaller consequences than losing one species from a species-poor landscape (Kindt *et al*., 2005; Swallow *et al*., 2006).

2.2.2 On-farm tree abundance

Tree abundance on farms is defined as the number of individuals per species found in specified farm. It is one of the measures of species composition in farms (Isango, 2007). As commonly found in East African farms, the abundance of tree species is very uneven. Some species, probably the fastest growing species are available locally, which are used for firewood and construction, currently constitute high percentage of the total tree population in the landscape. Farmers should have access to a great diversity of species that can in turn provide a high diversity, quality, and quantity of products for farmers (Boffa *et al*., 2005).

Tree abundance in Tanzanian forests are increasingly threatened by selective logging of valuable species, firewood collection, charcoal making, forest wild fires and forest conversion to agricultural land to meet the demand of growing population (Mbeyale, 1999; Mallya, 2003). In the Eastern Arc region, one of the major challenges is to meet the ever-growing demand for forest products while conserving biodiversity, providing critical ecosystem services, and maintaining rural livelihoods. This challenge is particularly acute in the biodiversity hotspot of East Usambara mountains, an area having high conservation value of both flora and fauna. The area is experiencing rapid human population growth, ecological degradation, and loss of traditional farming systems (Harvey *et al., 2005*).

It is estimated that the country looses 91 000 hectares to illegal felling each year (Mugasha *et al*., 2005). This affects greatly the abundance of tree both on-farms as well as those in protected areas. To overcome such losses, in early 2006, the Tanzanian Government reinforced the export ban on logs and sandalwood in an effort to reduce deforestation. However, it was observed that decline in forest cover may have been as much as 0.3% per year from 1955-1990 and as much as 3% from 1990-1993 (URT 2002). In addition, forestland under some kind of protection has also suffered from substantial encroachment, resulting in reduced qualities and quantities of the forest resources.

2.2.3 On-farm tree population structure

On–farm tree population structure has been described as the geographical trends in the distribution of different tree species and tree sizes in a given forest (Husch *et al*., cited in

Isango, 2007). Population structure has been also defined as the distribution of trees by diameter size classes (Adam and Ek cited in Isango, 2007). In most farms, trees are planted at different seasons and periods hence they grow at different rates. This captures the essential advantage of constant and sustainable harvesting and income earnings as well as other biological functions (Munishi *et al.*, 2004). It was observed by Lines *et al*., (2010) that both species composition and stand structure were likely to continue to undergo directional changes over decadal time scales, independent of any effects of climate change. Therefore, projections of future forest carbon dynamics will be erroneous unless they incorporate the effects of projected changes in species composition and population structure.

Isango (2007) revealed that although no information on tree structure and composition on-farm is available, it is important in management of multiple forest resource, wildlife, aesthetics, hydrologic recovery, range of forage conditions as bases for projecting changes in vegetation over time. On farm tree structure is important for regeneration, growth, mortality, understory development and spread of disturbances (Higgins, *et al.*, 1999).

Both species structure and composition are sensitive to environmental impacts (pressure) thus they can be used as indicators of forests destructions (Philippi, *et al.*, 1998).

2.2.4 On-Farm Tree Uses and Preference

It has been reported by Munishi *et al.* (2008) that poor countries of the world use most of their wood for fuel whereas wealthier countries use wood mainly for industrial purposes. In general, the wealthier a country is the more wood it consumes. Sutton (1999) observed that an average per capita use of wood in USA is 2.3 m^3 per person per year.

In the SADC Region, households consume about 97% of wood energy mostly for cooking, heating and cottage industries while industrial sector is the second to household sector (Monela and Kihiyo, 1999). Most of the industrial wood energy is consumed by small-scale industries which include food processing industries and service sectors such as brewing, fish smoking, salt production, baking, restaurants, schools, hospitals and food vending. Other uses include agro-processing industries such as tobacco curing, tea drying and beeswax processing. Wood energy is used in production of building materials such as burnt bricks, lime, smiths, foundries, pottery and ceramics (Monela and Kihiyo, 1999; Munishi *et al*., 2008).

The most important use of wood in Tanzania is for fuel; about 95% of the country's energy supply is met by fuelwood (Mugasha *et al.*, 2005). Wood is mostly obtained from either individual farms or village lands (formally known as open areas). Lulandala (1998) reported that it was a common practice among the local people to seek more preferred firewood and building poles from the nearby woodlands and forests, despite that many species were planted in their vicinity during the afforestation campaigns.

Although local people are using planted exotic trees such as *Grevillea robusta*, *Cedrella odorata*, *Senna species* and *Tectona grandis* for domestic purposes, it has been reported that farmers still prefer native trees since these are well adapted to Tanzanian conditions and produce high-quality wood (Kessy, 1989).

Tree based resources are mostly used in urban and peri-urban areas. Costs of acquiring such resources are quite low in rural areas but sales are high in urban area. Looking at the present economic forces, the majority of urban population in Tanzania will continue to depend on woodfuel for long time to come if alternative interventions will not outsourced

(Monela and Kihiyo, 1999; Munishi *et al.*, 2008). Data on wood consumption by species is not available at farm level, except in plantations where Pines, *Eucalyptus* and *Cypress* species are planted and therefore most consumed by individual and industrial sectors. The overall monthly solid woodfuel consumption in Tanzania have been studied and is summarized as Table 1 below explains.

Table 1(A): Overall monthly solid wood fuel consumption in Tanzania

Product	**Amount consumed**(m^3)	
	Formal	**Informal**
Saw logs from natural forests in tons (m^3)	40 000	Na
Poles (tons)	Na	Na
Saw logs from Plantation forests in tons (m^3)	453 000	Na
Round wood (m^3)	564 000	Na
Sawn wood (m^3)	24 000	Na
Domestic firewood household consumption (tons)	0.358	Na
Charcoal consumption (tons)	0.096	NA

Source: URT (1999)

Farmers have high preference for ‘premium’ native trees, i.e. those with high quality by-products and multiplicity of uses, both economic and ecological. On-farm trees provide quick access to household needs and are characterized by preferences such as for food (fruits, vegetable & oil), fodder, medicine, wood fuel, building poles, timber, home utensils, catalyst, shelter, employment, recreation, and habitats for wildlife, carbon sinks and reservoirs (Nair, 1993; Mbeyale, 1999; MNRT, 2001; ICRAF, 2009; Munishi *et al.*, 2009). The most preferred trees are planted in home gardens, along farm boundaries and river banks. When trees to be used for reforestation are based on farmers’ preferences, it is more likely that farmers’ desire to plant more trees is enhanced (Lawrence cited in Mangaoang and Pasa, 2003). In ANR forest was heavily exploited by wood industry like Sikh Sawmills (T) Ltd., a subsidiary of Tanzania wood industry corporation (TWICO) (Hamilton and Mwasha, 1989).

2.3 Natural Forests as an Alternative Source of Forest Products

Forest resources produce a variety of benefits which include direct use values, indirect use values, option values and existence or non-use values (Leakey, *et al*. (2005). It has been pointed out that a major cause of failure of sustainable forest management, or the cause of deforestation and transfer of forest to other land uses, is inadequate recognition and underestimation of the value of many goods and services provided by forests (Shylajan and Mythili, 2003).

On-farm trees provide inadequate material to sustain day to day wood resource demand of many communities. Due to ecological and silvicultural reasons, some of those products are still obtained from forest reserve. It was observed by Mbeyale (1999) and Munishi *et al*. (2009) that most extracted resources from the forest were wood for building, firewood, fodder, fruits, vegetables, wild honey and traditional medicines. Other goods and services provided by the forests included water, minerals, and hunting of wild animals. Kajembe (2008) reported that change in availability of nearby forest resources in different ways, depend on the particular resource, its importance for their livelihoods, access to cash and presence of local markets that trade in the resource or a close substitute. Over a long term, the response has been a change in volume, in the specific resources collected, and in where they are collected. The problem also is also reported for wild animals and indigenous black pepper, poles, weaving and rope material which are available quite far from the villages and are only collected by small number of households.

Munyazinza (1998) reported that miombo woodlands harbour a diversity of tree species producing valuable non-timber forest products. While most of these can be domesticated in man-made ecosystems, others may be specific to natural ecosystems. Depletion of natural forests and woodlands jeopardize the continued existence of many of these non-timber forest products. For instance, some mushrooms that obviously occur in natural woodlands or forests do not normally occur in converted lands. Leakey (2010) observed that as a result of deforestation for modern farming systems, local communities no longer had access to all the traditionally important products formerly gathered from forests.

2.4 Tree Cultivation Incentives in ANR

Incentives are specific inducements designed and implemented to influence or motivate people to act in a participatory way. In the context of conservation, economic incentives are concerned with making it more worthwhile in financial and livelihood terms for communities to maintain, rather than to degrade natural resources in the course of their economic activities. Generally, incentives not only provide direct products from the forest to the people but also other facilities like working gears to motivate local population to use their natural resources in a sustainable basis (Kajembe *et al.*, 2004). The aim of incentive is to promote alternatives to forest damaging activities in order to reduce pressure on the forest reserves.

Intensive tree planting in villages surrounding ANR started from 1998 when forest management signed an agreement with bordering villagers of JFM. It was expected that after 10 years, forest dependency will be reduced to a great extent (MNRT, 2000). Although such programs worked well in some areas, there was still a need for considerable efforts to determine suitable tree species that would fit into the local people’s needs and practices in the short, medium and long-term periods (Malundo, 2003).

Farmer's decisions about tree retention and/planting on-farm were influenced by a variety of factors, the most important include subsistence, market opportunities, constraints; and the relationship between tree crops and the household's availability of land, labour and capital. The second were social-economic factors such as income level and religious beliefs (Mbeyale, 1999; Kajembe *et al.*, 2003).

Atta-krah (2004) emphasized that it is equally important to understand the social, economic and political factors that support the decision making processes of farmers, communities and other stakeholders to adopt (or not), certain land-use systems or management practices. Most of these factors are related to short-term gains that often influence long-term conservation and use options of genetic resources, especially of trees. Climate change, inadequate water supply and rainfall variability as well as land degradation and desertification are among the most important obstacles to the achievement of tree planting (Munishi *et al*., 2004). Both land and tree tenure impacts negatively the motivation of tree planting (ICRAF, 2009).

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 Description of the Study Area

3.1.1 Location and access

The study was conducted in four villages surrounding ANR namely Shebomeza and Mlesa (Amani Division), Mashewa and Potwe Ndondondo (in Bembwera Division). The reserve is located about 70 km from Tanga City along the Indian Ocean. Specifically ANR lies between longitudes 38^o 33′ – 38^o 50′ East and latitudes 4^o 45′-5^o 15′ South (Fig.1). ANR was gazetted as a forest reserve on 9^{th} May 1997, through GN 152, following the upgrading of six forest reserves namely Kwamkoro Forest Reserve (2270.9 ha), Mnyuzi Scarp F. R. (672.9 ha); Kwamsambia F. R. (1822.8 ha); Amani Sigi F. R. (1153.5 ha); Amani East F. R. (122.2 ha) and Amani West Forest Reserve (158.5 ha). ANR also incorporated one privately owned forest in its management. This forest was formally under management of tea company (EUTCO).

3.1.2 Climate

ANR has a average annual rainfall ranging between 1 200 mm and 2 200 mm with two peaks; long rains (March - May) and the short rains (October – December) and precipitation is experienced however every month. The average annual temperature in Amani is 20.6^oC but in the lowlands, temperature rises up to 25.6^oC or more. The altitude ranges from 250 m in lowland villages bordering the forest to the highest peak of 1 506 meters above sea level.

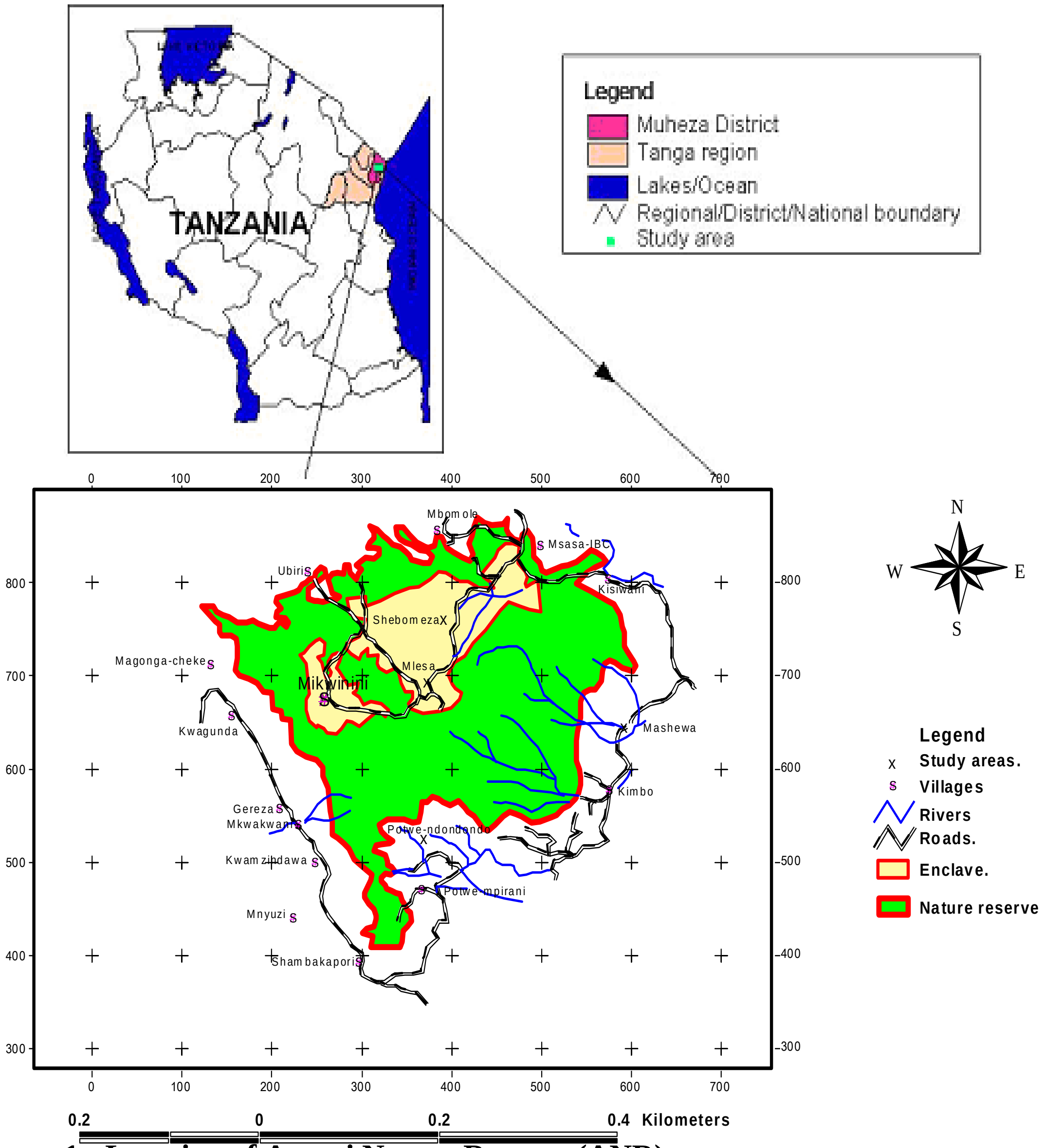

Figure 1: Location of Amani Nature Reserve (ANR).

3.1.3 Vegetation

The vegetation of ANR is dominated by sub montane rain forests. The main vegetation is composed of woody species with luxuriant growth of trees reaching up to a height of 65m with stratified canopy. Main tree species found in the area include submontane species like *Cephalosphaera usambarensis, Beilschemiedia kweo, Cola greenwayi, Allanblackia stuhlmannii, Newtonia buchanannii, Macaranga capensis, Sorindeia usambarensis and Trichilia emetica.* The outer edge of the forest is occupied by the species like *Maesopsis* *eminii, Spathodea campanulata*, *Albizia gummifera, Milicia excelsa* and *Anthocleista grandiflora* where most of these species are found in the forest neighboring farms.

3.1.4 Economic activities

The main economic activity of communities living adjacent to ANR is agriculture and livestock keeping. Most of them cultivate both food and cash crops. Food crops cultivated include; *Zea mays* (maize), *Musa* spp (banana), *Xanthosoma sagittifolium* (cocoyams), *Colocasia esculenta* (toad-yam) and *Oryza sativa* (rice). The main cash crops include *Saccharum officinarum* (sugarcane), *Cammellia sinensis* (tea) and spices which are assumed to threaten to the natural forest due to its characteristic growing under shade; these spices are planted in agroforestry plots. These include as *Elettaria cardamomum* (cardamom), *Cinnamomum zeylanicum* (cinnamon) and *Piper nigrum* (black pepper).

Livestock farming is the second largest economic activity to communities around ANR. Some farmers particularly in Amani villages practice indoor dairy farming, which provides more income.

Other sources of income to farmers is tree based products such as tree seedlings (*Grevillea* spp, *Tectona* spp, *Terminalia* spp,), poles (*Grevill*ea spp), logs (*Tectona grandis*), timber (*Terminalia* spp, *Grevillea* spp, *Cedrela* spp) and fruits (*Artocarpus heterophyllus*) and petty business.

3.1.5 Population and Ethnicity

According to 2012 census, the population of Amani Ward was reported to be 5 553, Kisiwani 7 123, Bwembwera was 5 557 and that of Potwe were 5 812 people with average house hold size of 4.2, 4.6, 4.0 and 4.1 repectivily (URT, 2012). The main ethnic groups are Sambaa and Bondei. The Shambaa reside mostly on the mountain slopes and constitute more than 54% of the population in the mountains, while the Bondei are concentrated in the lowlands. Other small ethnic groups found in the study area include Zigua, Pare, Bena, Hehe, Makonde, Chagga and Kinga. These are immigrants who came to seek jobs in tea and sisal estates. Other group constitute retired officers who worked with Forestry division, agricultural and medical research stations, who presumably increased pressure in adjacent forests (Kessy, 1989; Kajembe *at al.*, 2003).

3.2 Data Collection

Two data sets namely social economic and ecological were collected in this study. Primary data was collected from interviews and field measurements while secondary data/information was obtained from different sources, such as published and unpublished reports.

3.2.1 Social economic data

3.2.1.1 Research design and survey method

The design used was cross-sectional survey, whereby data were collected at a single point in time from a selected sample of respondents to represent the population. A sampling unit for a study was a household. The study adopted the sampling technique as postulated by Bailey (1994) who argued that a significant representation of a population is achieved when a random sample of 5% or more is taken for the study.

3.2.1.2 Sampling procedure

Four villages were purposively sampled based on accessibility, availability of people practicing on-farm trees farming and their closeness to ANR. Two villages from the highland (Mlesa and Shebomeza) and the other two from the lowland (Mashewa and Potwe Ndondondo) were selected. A total of 135 respondents were interviewed in these villages.

Table 2: Distribution of HH population in the study villages

S/N	Village	Total Population of HH	HH Sampled
1	Mlesa	254	38
2	Shebomeza	207	31
3	Mashewa	240	36
4	Potwe Ndondondo	167	25
	Total		**135**

3.2.1.3 Technique and instrument for data collection

Socio-economic data were collected using structured questionnaires (Appendix 1) and check list (Appendix 2), administered to the selected households. Focus group discussions and key informant interviews were employed to collect information on uses of on-farm trees, ranking of uses in order of prioritization, factors influenced tree planting/retention like farm size, education level, economic power and size of household. Also types of wood and non- wood products which are still being collected from the forest and adequacy of wood material on-farms.

Unstructured interviews were used to obtain information from the key informants who were Foresters, Village Agricultural Officers, village and Ward Executive officers and retired officer residing in the village. These were individuals who were willing to talk and had great depth of knowledge about issues in study area. They were used to guide open-ended discussions with the key informants (subject matter specialist); Foresters interviewed were ANR Management Team, Tanga Regional Forest Officer, Tanga Regional Catchment Manager, Muheza District Forest Management (e.g. DNRO, DFO, DCFM) and Longuza Plantation Manager (Appendices 5 and 6). According to Mettrick

(1993), the key informants are not only members of the clientele, but are most often informed outsiders.

3.2.2 Ecological data

Ecological data was collected in two phases; phase one incorporated on–farm tree inventory and second phase involved disturbance survey in the ANR buffer area delineated as utilization zone. On-farm tree inventory was done in the sample villages to assess tree species composition, structure and species richness. Disturbance survey was conducted in ANR to determine type of products collected by communities.

3.2.2.1 On-farm Inventory

In order to cover the whole village, a systematic sampling design was adopted. The villagers managing trees on their farms after being interviewed, had their farms assessed. Depending on the shape of farms one or more transects were located in each farm for the study since they reduce bias associated with sampling heterogeneous communities. Rectangular plots of 10 m wide and 125 m long were established in all selected HH, including one line along the field boundary. Every farm was considered as a plot; therefore 135 plots were established as described in Table 1. Within each sampled farm (plot), all trees were identified and assessed for composition, structure and richness.

Diameters at breast height (DBH) were measured and the perceived uses were recorded as demonstrated (Plate 1). Regenerants (seedlings, coppice shoots from roots/stumps) or newly introduced tree species over the past two years were recorded.

Plate 1: On-farm tree measurement and identification

3.2.2.2 Disturbance survey

In order to assess the local farmer's extraction of forest products in the Nature Reserve, data was collected to determine type of products collected and the level of impact caused. Four disturbance transects were established and assessed in the forest adjacent to respective study villages, in the area categorised as utilization zones set aside by ANR. The utilization zone was estimated to be at least one kilometre wide, located from the forest border heading inside the reserve, where human impact was experienced. The next zone is natural restoration followed core or biodiversity zone where the forest was intact with least human influence. In each village, one transect was laid starting randomly from village border via utilization zone. A series of plots of 50 meter by 10 meter were established along the line located systematically from randomly chosen starting point on the forest edge or path within the forest (Fig. 2). The starting point and direction of each transect was recorded using GPS and compass respectively to allow transects to be relocated in future. A strip of 1000 m long were made along the transect which covered the utilization zone. A total of 80 plots were established as 21 plots each in Potwe and Mashewa, 18 in Mlesa and 20 plots in Shebomeza. Number of plots varied due to rocky escarpment in core zone where no man interference. The level of disturbance was assessed as the number of standing, dead or cut trees and poles along the 50 m x10 m wide strip plot through the forest (Fig. 2). According to MNRT (2005) and Frontier Tanzania (2001), trees were defined as all standing woody plants with straight stem of at least 3 m high and with DBH over 15 cm. Poles/saplings were defined as all standing woody plants with straight trunk at least 2 m high and with DBH of between 5 and 15 cm.

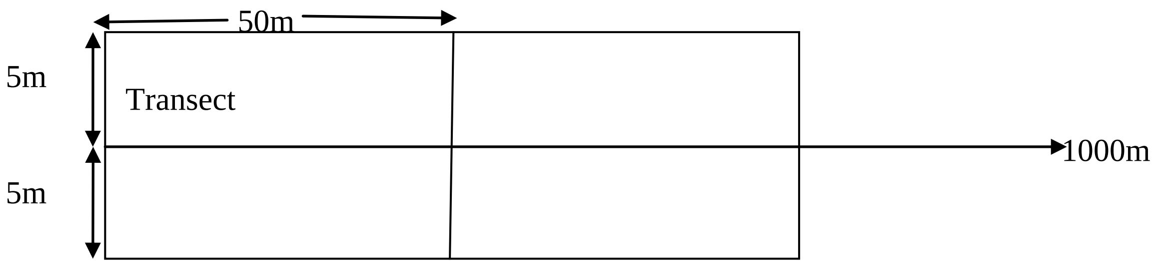

Figure 2: Schematic diagram of disturbance survey (Source: Madoffe and Munishi 2005).

The information recorded in each sampling plot included the number of live trees (or live poles/samplings), the number of naturally dead trees, the number of new cut trees and the number of old cut trees. Fallen trees, branches and woody plants with DBH smaller than 5 cm were not included since most of them were not collected for wood utilization.

3.3 Data Analysis

Both qualitative and quantitative data analysis was done.

3.3.1 Socio- economic data analysis

Both descriptive and inferential statistics were undertaken to analyze socio- economic data. The qualitative data from household questionnaire survey were collected, coded and the variables were selected for summarizing to present comparative result of on-farm trees. The results of the questionnaire survey were analyzed with the help of SPSS-12.0 Statistical Software and Ms-excel version 2007. The data from questionnaire were presented in the form of frequencies, tables, percentages, graphs (i.e. bar charts, pie charts and histograms).

In inferential statistics, multiple regression was used to unveil the relationship between the socio-economic parameters and on – farm tree densities according to Weber *et al.* (2001).

The multiple regression models employed was in the form of:

$$Y_i = \alpha+\beta_1X_1 + \beta_2X_2 +..\beta_iX_i +e \text{...}(1)$$

Where;

Y_i = Dependent variable (Number of tree species planted/retained)

$X_1 - X_i$ = Independent variables (Farm size, Education, Age, Gender/sex, HH size, Wealth/income status, duration of stay).

α = Intercept.

$\beta_1 - \beta_i$ = Independent variable coefficient.

e = Random error

I = 1, 2, ………., n^{th} where n is the total number of variables; in this case study, it is 8 variables.

The socio-economic factors (independent variables) considered to influence/motivate tree planting/retention in farms in the study area included; age of the farmer, gender/sex, education level, land size, marital status, income, household size, ethnicity of participants, and the duration of stay in the study village.

From the above, the independent variables included in the models were

X_1 = Age of the respondents in years:- The age was assumed to have a positive sign of the estimate β. It was assumed that the increase in years of respondent increases the participation in tree planting/retention. This could attributed to household needs and thus household head will participate in practising tree planting or/and retaining in farms so that they can secure more options of livelihoods diversification. However; it is assumed that as age increases rate of tree planting decreases due to nature of long investment of trees.

X_2 = Education level of the respondent:- Increase in education level was assumed to increase participation of a household in planting or retaining tree in farms because educated people have more access to technical information that enable them to participate to new innovations compared to illiterate ones. A dummy variable with values 1 were assigned for formal education or 0 if otherwise. Education was assumed to have positive sign to estimate β.

X_3 = Farm size:- It was assumed to have positive sign to estimate β. This was because when people have large farm land size, it means that they have enough land for tree planting or retaining some indigenous tree species for commercial purposes of (sawn timber/poles or animal fodder).

X_4 = Wealth/Income status:- The well off household tends to participate in tree planting and/or retaining indigenous trees in their farm compared to the poor. In study area, people having dairy cows, petty cash traders and those having big plots of commercial crops like *Syzigium aromaticum, Cinnamomum zeylanicum, Piper nigrum, Citrus sinensis, Cocos nucifera, Theobroma cacao* and *Tectona grandis* were considered to be rich. Wealth person always plant trees annually and tend it technically. They also have alternative wood sources like electric/gas cookers and construct energy saving stoves. They construct stone or mud-bricks houses to save the wood consumption. A dummy variable with value of 1 was assigned to a rich person who participated in tree planting and 0 if otherwise and was assumed to have a positive sign to estimate β.

X_5 = Household size (HH):- The family size influences greatly the plot size planted with trees due to availability of manpower and household needs. The larger the HH needs the more trees to be planted. Therefore it is assumed that a household that has a family size of more than 3 children have better chance of tree planting if other factors remain constant. A dummy variable with value of 1 for a big sized household and 0 if otherwise and was assumed to have a positive sign to estimate β.

X_6 = Gender/Sex:- Male and female have different roles in agroforestry system. The male always plant/retain trees that will produce timber, building poles or other construction purposes, and female plant trees that will produce firewood and support climbing crops. In Usambara traditions man own both land and tree. In this case it was assumed that trees planted/retained in farms remain the property of a man. A dummy variable with value of 1 was assigned to a man and 0 for woman and was assumed to have a positive sign to estimate β.

X_7 = Residence duration (years):- The period of stay in a particular village contributes significantly in retention or establishing tree plantation on farms. It is assumed that the more time a person stays adjacent to resource base has more influence to access and use resources than immigrant. This is because an individual who has stayed in a particular village for a long time is assumed to have owned enough land which mostly is occupied by tree resources and which is used to cultivate shed bearer crops which enables to meet their livelihoods than an immigrant to the area. The immigrants in the village who bought land from local people have different experience of planting trees and are assumed to plant trees. The long period of stay in the village, gives advantage of receiving various forestry extension services including seminars, study tours or participate on pilot farms to educate others. It is believed always that, farmer plant trees which they know. A dummy variable with value of 1 was assigned to a person who stays for long period and 0 if otherwise and is assumed that number of years individual stayed to have positive regression value (+β).

3.3.2 Ecological data analysis

The tree density/ stocking (stems per hectare) were derived from the total number of tree stems recorded in the sample plots.

On-farm tree density was estimated as: **N = n/A** ……………….…………….(2)

Where;

N = Number of trees on plot,
A = plot size,

Inventory data was analyzed by using Microsoft Excel software. Before analysis, the inventory data for trees having DBH >5 cm were categorized into eight diameter classes namely class I (5-15 cm), II (16 – 30 cm), III (31 45 cm), IV (46 – 60 cm), V (61 – 75 cm), VI (76 – 90 cm), VII (91 – 105 cm) and VIII (> 105 cm). DBH measurements were used to calculate basal areas (G-m^2/ha) which were used to assess dominance of tree species on the farms.

3.3.2.1 Species composition

Species composition was determined as the list of species that were encountered in the survey. The results were presented in tabular form and graphs.

3.3.2.2 Tree basal area (G)

Basal area of a tree was obtained through the following formula;

$g = \prod d^2/4$ where gi = cross sectional area of i^{th} tree in a plot,

d = diameter measured at breast height

Basal area per hectare was estimated as:

$G = \sum$**gi/a*n;**…………………………………………… ………………….(3)

Where;

a = plot size, n = number of plots sampled.

3.3.2.3 Tree species richness

Numbers of different species in a plot were measured to determine homogeneity and or sensitivity of an ecosystem and its resident species. Species richness was estimated in terms of diversity. Tree species diversity on-farm was estimated using Shannon-Wiener index of diversity as follows:

Shannon-Wiener Index of diversity (H')

The Shannon-Wiener Index of diversity was calculated using equation below (Kent and Coker, 1992);

$$H' = -\sum_{i=1}^{s} (P_i \ln \ P_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where, **H'** = Shannon index of diversity

P_i = is the proportional of individual of a species to total number of species in the sample

ln = natural logarithm

∑ = summation symbol

\- = negative sign multiplied by P_i to make it positive

3.3.2.4 Tree species distribution (Index of Dominance)

The index of dominance is a measure of the distribution of individuals among the species in a community. This index of dominance 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). The greater the value of dominance index, the lower is the species diversity in the community and vice versa. This index was calculated as described by Mirsa (1989) as follows:

$$ID = \sum (n_i / N)^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Where;

ID = the Index of Dominance

n_i = the number of individuals of species i^{th} in the sample

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

∑ = the summation symbol

3.3.2 5 Species Importance Value Indices (IVI)

The Important Value Index (IVI) shows the overall picture of ecological importance of a species with respect to the community structure. Important Value Index is a composite index based on the summation of the percentage value of the relative frequency, relative density and relative dominance (Ambasht, 1998). These constituent parameters were calculated according to Kent and Coker (1992) and Ambasht, (1998) as follows:

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of occurrence of a species}}{\text{Frequency of occurrence of all species}} \text{ X } 100 \ldots(6)$$

$$\text{Relative Density (RD)} = \frac{\text{Number of Individuals of a species}}{\text{Number of individuals of all species}} \text{ X } 100 \ldots \ \ldots (7)$$

$$\text{Relative Dominance (RD)} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \text{ X } 100 \ldots\ldots\ldots (8)$$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1. On-farm Tree Species Composition and Structure

Tree species composition of the four study villages varied substantially. There were more trees species in upland villages (Shebomeza and Mlesa) than in lowland villages (Mashewa and Potwe Ndondondo); few species were common in all villages (Table 4).

Table 3: General species composition in villages of ANR

Village	No of spp Planted	No spp Retained
Shebomeza	22	54
Mashewa	25	19
Potwe	23	20
Mlesa	21	41

Important species in highland villages included *Maesopsis eminii*, *Grevillea robusta*, *Syzigium aromaticum*, *Allanblackia stuhlmannii*, *Cephalosphaera usambarensis* and *Cinnamomum zeylanicum*. In lowland villages dominating species included *Gliricidia sepium* and *Cedrella odorata* which had high growth rates. Others were *Tectona grandis*, *Theobroma cacao*, *Mangifera indica* and *Artocarpus heterophyllus*

On-farm trees were composed of indigenous and exotic tree species. Some of exotic tree species were considered to be alien invasive from the Amani Botanical Garden. Frontier Tanzania (2001) reported that *M. eminii*, *C. odorata* and *Eucalyptus spp* were among alien invasive species. Similar results were obtained by Hamilton and Mwasha (1989) and Methew (2009). These species are commercially and domestically important for supplying fuelwood, timber, withies and medicine to the communities although they posed threat to ANR when their seeds disperse into the reserve and colonize the open gaps (Mbeyale, 1999).

The occurrences of some tree species were site specific. In highland villages, *Cinnamomum zeylanicum, S. aromaticum, M. eminii, A. stuhlmannii, C. usambarensis* and *Strombosia scheffleri* were commonly found. In the lowland villages, *T. grandis, Acacia nilotica, Gliricidia sepium, T. cacao, Citrus sinensis* and *Cocos nucifera* had high frequencies in the species list. It was observed that removal of indigenous tree species and introduction of exotic trees has caused some changes in productivity of shade loving spice and food crops.

The composition of on-farm trees was modified by local land use practices, which can change the structure and functioning of on-farm tree ecosystems and hence the type and quantity of services produced. Generally, it was observed that stable tree population structure in ANR was influenced by agroforestry plots which supplement the desired products as well as conservation of environment. Trees were commonly retained around water sources, streams and river banks with the aim of protecting land degradation as well as ensuring sustainable water flow for local and urban dwellers. Munishi *et al.* (2008) reported similar results from West Usambara.

Since the type and number of trees species in individual villages varied slightly from one village to another, results of each village are reported and discussed separately. This is done in order to observe the actual status of the individual village.

4.1.1 Tree species composition of Shebomeza Village

A total of 76 woody species were identified in Shebomeza Village out of which 22 species were deliberately planted and 54 were retained (Appendix 1). Some farms assessed were abandoned due to drop in production of some spices hence invaded by early colonising species such as *Maesopsis eminii. Maesopsis eminii* was widely represented with the highest density of 1 064 (stems/ha) and basal area of 16 m^2/ha). This is unique for normal farms but for Shebomeza it is common for some plots due to type of crops they practise. *Maesopsis eminii* was widely distributed in this area because Shebomeza village borders ANR in highland area where there was high disturbance of the natural forest. It was introduced in the ANR forest to nurse the remaining endangered and endemic indigenous trees (Hamilton and Mwasha, 1989). *Maesopsis eminii* reproduce prolifically in adjacent forest and is a good source of food for birds, primates and rodents which disperse its seeds to nearby farms. *Maesopsis eminii* and other indigenous trees species like *Cephalosphaera usambarensis*, *Odyendea zimmermannii*, *Allanblackia stuhlmannii* and *Isoberlinia scheffleri* were retained on-farm to provide shade to demanding crops like banana (*Musa spp*) and Cardamom (*Elettaria cardamomum*), which is valuable spice in the village (Reyes, 2008). *Maesopsis eminii* from conservation point of view was considered as alien invasive species; it was observed to colonise every open space created either naturally or deliberately (Methew, 2009).

Table 5 shows distribution of species like *Ocotea usambarensis, Cinchona hybrida*, *Zanthoxylum gilletii*, *Trema orientalis* and *Blighia unijugata which were* less represented in both density and basal area.

Table 4: Tree species composition, density and IVI of Shebomeza Village

Species richness	Family	Density (Tree/ha)	Basal Area (m^2/ha)	IVI (%)
Maesopsis eminii	Rhamnaceae	1064	15.79	15
Gliricidia sepium	Papilionoideae	1002	4.64	10
Syzigium aromaticum	Myrtaceae	720	2.00	7
Cephalosphaera usambarensis	Myristicaceae	336	6.84	4
Cinnamomum zeylanicum	Lauraceae	460	1.05	4
Odyendea zimmermannii	Meliaceaee	264	6.81	4
Grevillea robusta	Proteaceae	456	1.58	4
Persea americana	Lauraceae	320	2.06	3
Allanblackia stuhlmannii	Clusiaceae	192	4.97	3
Isoberlinia scheffleri	Caesalpiniaceae	144	5.15	3
Cynometra longipedicellata	Caesalpiniaceae	96	5.73	2
Artocarpus heterophyllus	Moraceae	232	2.20	2
Maranthes goetzeniana	Chrysobalanaceae	96	4.98	2
stereospermum kunthianum	Bignoniaceae	128	3.85	2
Anthocleista grandiflora	Loganiaceae	176	2.23	2
Others				32

Other important tree species and crops in this zone were *Gliricidia sepium*; *Syzigium aromaticum*. *G. sepium* was introduced in farms to support climbing crops like *Piper nigrum (*black paper), provide shade to *Elletaria cardamomum* and improve soil fertility (green manure) and provision of good fodder for animals. *Syzigium aromaticum* being a cash spice crop introduced from Zanzibar was planted in various farms. It was planted in open areas where food and spice crops proved failure due to soil degradation.

Cephalosphaera usambarensis was easily recognized in farms due to its straight bole and high canopy crown. It provides light to middle and lower canopy plants hence mild effect to other growing crops. The economic importance of *C. usambarensis* was veneer production.

4.1.2 Tree species composition of Mashewa Village

Mashewa being the lowland village had a total of 44 tree species of which 25 species were planted and 19 were retained. Results show that more than 80% of dominating tree species was planted in this zone (Table 6). This suggests more clearing of natural vegetation for establishment of fast growing fruits, spices and timber tree species. Initial spacing for tre planted were observed to very close especially for those supporting spice crops like *Gliricidia sepium*. *Gliricidia sepium* was widely represented all over the plots with the highest density (1 296 stems/ha) and basal area of 8 m^2/ha. Other species dominating were *Cedrela odorata* with density of 1 288 stems/ha and basal area of 9m^2/ha and *Tectona grandis* which has density of 1 100 stems/ha and basal area of 4m^2/ha.

Other species found abundantly in Mashewa Village included *Theobroma cacao* and *Grevillea robusta*; whereas *Azadirachta indica, Casuarina cunninghamiana, Markhamia lutea* and *Annona spp* were less represented in farm lands. The distribution of *Theobroma cacao* and *Grevillea robusta* in terms of sizes or diameter size classes varied from one farm to another. There were new planting of *T. cacao* in monoculture whereas *G. robusta* was planted to support *Piper nigrum*.

Table 5: Tree species composition, density and IVI at Mashewa Village

Species	Family	Density (N)	Basal Area(G) (m^2/ha)	IVI (%)
Gliricidia sepium	Papilionoideae	1 296	7.98	20.3
Cedrela odorata	Meliaceaee	1 288	8.77	17.1
Tectona grandis	Verbenaceae	1 100	4.22	12.0
Theobroma cacao	Sterculiaceae	1 064	2.34	11.1
Grevillea robusta	Proteaceae	968	6.25	10.9
Mangifera indica	Anacardiaceae	336	6.91	5.3
Citrus sinensis	Rosaceae	908	1.25	4.7
Ficus vallis-choudae	Moraceae	168	3.62	2.8
Milicia excelsa	Moraceae	120	2.39	1.9
Artocarpus heterophyllus	Moraceae	192	1.78	1.8
Cocos nucifera	Arecaceae	200	1.64	1.7
stercullia appendiculata	Euphorbiaceae	32	2.06	1.3
Antiaris toxicaria	Moraceae	120	0.63	0.8
Others	Varied			8.4

Results show that *Gliricidia sepium* was widely planted and spread in all farms in Mashewa Village. Being A multipurpose tree species, it was planted in farms basically to support popular spice crops known as *Piper nigrum* (black pepper), which provides substantial income to people of Mashewa Village. The species were easily planted through cuttings and were planted in narrow spacing of about 2 m by 2m in monoculture and 3m by 4m in agroforestry systems. In Mashewa Village, *Gliricidia sepium* was also very useful as fodder, food (flowers), bee forage and sometimes as fence of homesteads. Reyes (2008) reported that *Piper nigrum* can be planted parallel with *Gliricidia sepium* due to high growth rate of the later.

Cedrela odorata was the second widely planted in almost all farms. Villagers explained that *C. odorata* was introduced in order to replace valuable timber species which were almost extinct in the village; therefore it was purposefully planted for timber production due to its durability and termite free timber. *C. odorata* associate with *Gliricidia sepium* in supporting *P. nigrum,* but in pollard system, that means at least one log height of a tree is left to support *P. nigrum* while the rest of the tree is either cut or left to grow in low foliage density.

Tectona grandis (Teak) was found growing heavily on-farms that were in proximity to Longuza forest plantation indicating that there was dispersal of seeds from mature stand, although 67% of respondents explained that the regeneration of *Cedrela* is through seed dispersal, it was observed that *T. grandis* seedlings were raised in individual and group nurseries for both on-farm planting and sales to outside customers. *Theobroma cacao* was commonly planted in Mashewa Village more than in other villages. This crop does better in lowland village where soil is fertile with adequate rainfall. In the study area, *T. cacao* was reported in Mashewa and Potwe Villages, although could be found in some villages which experience floods along ANR foothill villages. Kessy (1998) observed similar results.

Apart from planted exotic tree species, there were very few indigenous trees in Mashewa Village. Most valuable timber trees like *Milicia excelsa*, *Khaya anthotheca* and *Albizia versicolor* have been exploited. Few trees were found coppicing from stumps.

4.1.3 Tree species composition of Potwe Village

A total of 43 woody species were identified in Potwe Village which comprised 23 planted species and 20 retained trees in farms. It was observed that *C. odorata, T. grandis, M. excelsa* and *G. sepium* were well distributed on-farms. The most dominant species was *C. odorata* with IVI of 16.4%; density of 1 164 stems/ha and basal area of 9.72 m^2/ha whereas *T. grandis* which compete closely had IVI of 15.7%; density of 1104stems/ha with basal area of 7.48m^2/ha (Table 7).

Unlike Mashewa Village, Potwe Ndondondo had good ratio of indigenous trees retained in farms particularly along riparian ones of rivers and sacred areas.

Table 6: Tree species composition, structure, density and IVI of Potwe Village

Species	Family	Density(N)	Basal Area(G) (m^2/ha)	%IVI
Cedrela odorata	Meliaceae	1164	9.72	16.4
Tectona grandis	Verbenaceae	1104	7.48	15.7
Milicia excelsa	Moraceae	384	22.42	11.2
Gliricidia sepium	Papilionoideae	1010	2.67	10.0
Mangifera indica	Anacardiaceae	612	9.01	9.3
Cocos nucifera	Arecaceae	536	8.75	8.3
Artocarpus heterophyllus	Moraceae	440	3.65	3.7
Acrocarpus fraxinifolius	Caesalpiniaceae	236	2.40	2.7
Terminalia spp	Combretaceae	204	1.46	2.1
Citrus sinensis	Rosaceae	164	0.38	1.5
Others				19.0

C. odorata and *T. grandis* were widely distrubuted in Potwe Ndondondo Village. *C. odorata* save the multipurpose function of supporting *P. nigrum* as well as timber production. It was observed that *C. odorata* was among the fast growing species with promising returns within short time of aboutr ten years.

Marginal farms bordering Longuza plantation especially those planted *Cocos nucifera* was invaded by *Tectona grandis* through seed dispersions. These trees were left to grow to replace dying *C. Nucifera*. In early 1990s, it was harvested which earned substantial income; this exacerbated the spread of tree species particularly in land which were prone to fire, pests and were unsuitable for food crops. Today people are self motivated to plant and harvest on-farm trees as Plate 2 showing.

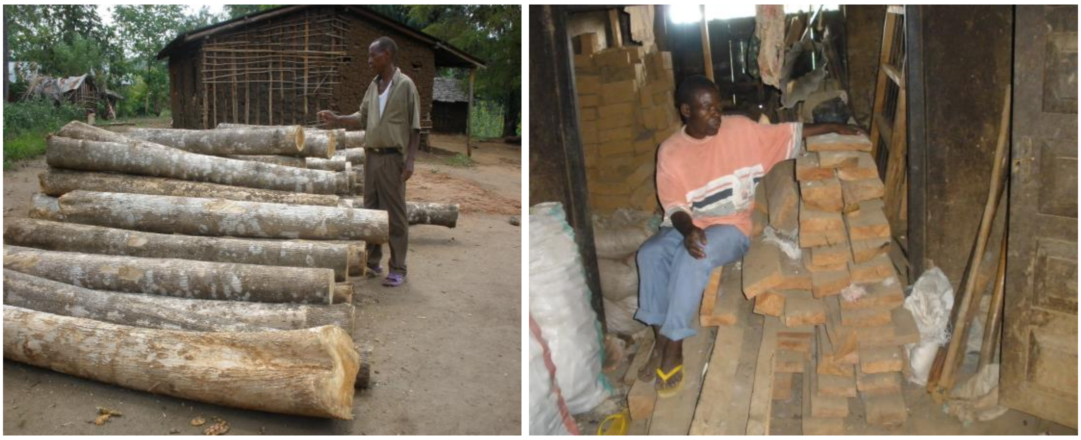

Plate 2:- Harvested on-farm wood stocks ready for selling

Milicia excelsa naturally grew on-farms and was retained mostly in schools and church farms although few coppices from big stems were observed in farms. This suggests past exploitation of the trees. Apart from valuable timber production, *Milicia excelsa* has been used to support climbing crops as well as providing shade to food and spice crops like *Musa spp* and *Theobroma cacao*. Other retained tree species like *Syzygium cuminii*, *Erythrina abyssinica, Allanblackia stuhlmannii and Scorodophloeus fischeri* were less dominant in the village due to over exploitation for various reasons including timber, medicine and building materials.

Fruit and nut trees like *Citrus sinensis, Mangifera indica, Artocarpus heterophyllus* and *Cocos nucifera* were dominant in Potwe Village. The fruits and nuts are good source of income to villages and they were found planted either mixed in farms or in isolation. Similar results were reported by Kessy (1998).

4.1.4 Tree species composition at Mlesa Village

In Mlesa Village, a total of 62 woody species were identified. Twenty one (21) species were deliberately planted and 41 retained on-farms. Structural distribution of the tree species varied significantly depending on farm management and planned uses. The dominant tree species in the village were *Grevillea robusta* and *Maesopsis eminii* represented with the highest density of 1020 stems/ha and 948stems/ha respectively. *G. robusta* had the highest Important Value Index followed by *Gliricidia sepium* (8%), *Cedrella odorata* (6.9%) and *Maesopsis eminii* (5.3%) (Table 8).

Table 7: Tree species composition, density and IVI of Mlesa Village

Species	Family	Density (N)	Basal Area(G) (m^2/ha)	%IVI
Grevillea robusta	Proteaceae	1 020	8.39	18.25
Maesopsis eminii	Rhamnaceae	948	16.18	11.68
Syzigium aromaticum	Myrtaceae	920	2.62	7.26
Allanblackia stuhlmannii	Clusiaceae	528	12.39	7.25
Milicia excelsa	Moraceae	506	4.47	4.99
Anthocleista grandiflora	Loganiaceae	448	2.76	4.89
Cinnamomum zeylanicum	Lauraceae	432	0.41	4.28
Maranthes goetzeniana	Chrysobalanaceae	176	8.16	3.72
Artocarpus heterophyllus	Moraceae	400	1.99	3.35
Cephalosphaera usambarensis	Myristicaceae	192	5.74	3.03
Persea americana	Lauraceae	244	2.47	2.92
Cynometra longipedicellata	Caesalpiniaceae	160	5.22	2.67
Mangifera indica	Anacardiaceae	43	2.12	2.16
Odyendea zimmermannii	Meliaceae	72	4.96	2.04
Myrianthus holstii	Moraceae	28	1.36	1.72
Spathodea campanulata	Bignoniaceae	24	0.74	1.37
Others				28.42

Mlesa Village being mountainous highland village had high ratio of retained trees compared to planted trees. It was observed that trees planted on farms were those promoted by various projects including EUCADEP and EUCAMP. Other tree species planted were obtained from Amani Botanical Garden nursery which was established since the colonial period.

The main species promoted on-farm were *Grevillea robusta* basically for timber production, *Syzigium aromaticum* and *Cinnamomum zeylanicum* for spice production and *Artocarpus heterophyllus* and *Persea americana* for fruits. *Grevillea robusta* was widely distributed in most farms. This is because apart from training induced by various projects, Mlesa Village is inhabited by Sambaa who migrated from west Usambara where *G.*

robusta had been planted widely. It was observed that *G. robusta* had been planted in different spacing depending on awareness, curiosity and land size owned by farmer.

Maesopsis eminii was the second woody species found everywhere in the village. Like other villages bordering ANR, this species as not intentionally planted but was naturally dispersed by birds and animals from ANR. The structures of M. eminii on-farms represent larger number of seedlings declining towards the mature trees particularly in farms where *Elettaria cardamomum* was cultivated. In agroforestry plots, the distribution of species and tree sizes in terms of diameter was encouraging. The species were found along the forest border as well as in area close to the village which was set aside as buffer utilization zone. The seeds of *M. eminii* are good source of food for birds especially hornbill as well as wild animals including squirrels and primates. Killenga (2007) and Hamilton & Mwasha (1998) reported similar results. The tree provides fuelwood for domestic use as well as commercial which were sold to EUTCO.

Medicinal trees like *Maerua variifolia, Funtumia africana* and *Rauvolfia caffra* had low representation on-farmlands. This is attributed to higher rates of consumption. Results shows that other timber and medicinal tree species like *Ocotea usambarensis* and *Tabernaemontana spp* were found debarked and poorly regenerating in farms. It was also observed that 78.1% of the respondents used herbal medicine which is believed to cure most of chronic diseases. Though 5% said they would first visit a doctor for diagnosis then use hedrbal medicine. Eighty six percent of respondents have planted / retained medicinal plants on-farms. This was also reported by Kessy (1998) and Kajembe (1988). Munishi *et al.,* (2006) reported that about 90% of the rural population in Tanzania and 60% of the Masai of Kenya for instance, meet their primary health care needs through traditional medicine. The use of medicinal plants is not well advitized at the village level although they are sold and advertised in urban areas (Kessy, 1998).

It was observed that some tree species planted in agroforestry systems and those receiving regular management like weeding, manure application and were well spaced or intercropped with other herbaceous crops grew well. However, those planted in abandoned farms, closely spaced in < 2 m, inter-planted with heavy feeders like *Saccharum officinarum* (sugarcane), *Tripsacum fasciculatum* (Guatemala grass) and those receiving poor management were stunted and prone to die (Plate 3).

A **B**

Plate 3: Poorly growing trees in unmanaged field (A) against healthy growing trees in well managed field (B).

4.2 Tree Species Uses and Preferences by Communities Neighbouring ANR

Preference and uses might be considered in terms of daily domestic or commercial basis. Preference and use of on-farm trees is determined by wood strength and calorific value. Generally native trees are still preferred since they are well adapted to ANR conditions and they have high-quality wood. The respondents perceived uses which were direct and others which were not directly distinguished. The direct uses include timber, fuelwood (fire wood and charcoal), food (fruits, seeds, nuts, oil, coconut wine and kernels), poles, withies, furniture, mortars, carvings, pestles and animal fodder. Other identified uses of on-farm trees were tool handles, alpenstocks, bow, pit latrine sleepers/rails, home utensils (spoons and platters) and wooden machines for extraction of sugarcane juice (Appendix 3). Kessy (1998) and Mbeyale (1999) reported that tree species preferred for construction material in the Usambara are those with high durability. Local people would need construction materials that will ensure durable houses which will take long time before replacement.

On-farm trees had more unrealized uses which were important for life and ecosystem stabilization (Kindt *et al*., 2004; Boffa *et al*., 2005). Respondents cited these uses as wind break, ethno-medicine, spice, water catchments and filtration. It was observed that some trees provided shade to other crops like *Cinnamomum zeylanicum, Elettaria cardamomum, Coffea arabica* and *Musa species*. Some tree species were used for hanging beehives and support climbing crops like *Piper nigrum* (black pepper), *Passiflora edulis (*passion fruits), *Telfairia pedata* (kweme), *Cucurbita* species (melon, pumpkin and cucumber), and *Vanilla planifolia* (Vanilla*)*. Since the preferred tree species and their uses were different for each village, the results and discussion are presented separately for each village.

4.2.1 Tree species uses and preferences by communities in Shebomeza Village

It was found that 30 tree species were preferred to be retained in the local community farms and 14 tree species were the major preferred planted species. As for retained tree species, *Maesopsis eminii* was the most preferred species (Table 9). As for planted tree species, *Cinnamomum zeylanicum was the most preferred whereas Leucaena spp* was the least (Table 10).

Table 8: Most used and preferred tree species retained in Shebomeza Village

Species richness	N	Percentage	Uses
Maesopsis eminii	31	85	F, T, Fd, W
Milicia excelsa	31	84	T, Fn, Pes, Bh,
Beilschmiedia kweo	31	81	T, Fn, Bh,
Bridelia micrantha	30	80	P, M,Th, Pes, PL, D
Allanblackia stuhlmannii	31	76	F, W, O, M, Fd
Alchornea hirtella	31	75	W, S, Bs
Syzygium guineense	30	72	Bh, D, Fn, T
Ocotea usambarensis	31	62	T, F, M
Drypetes usambarica	31	61	LB, Pl
Terminalia spp	30	60	T,F,p, Bh, Sh

Table 9: Most used and preferred tree species planted in Shebomeza Village

Spp Name	Frequency	Uses
Cinnamomum zeylanicum	81	Sp, Ig, P
Cedrela odorata	78	T, Fn
Gliricidia sepium	77	Fd, Scc,
Grevillea robusta	76	T, F,P, Fn, W, Bh
Syzigium aromaticum	70	F, P, W, Ig
Senna siamea	67	F, W, C, Sh
Artocarpus heterophyllus	62	Frt, T, Fn, Mt, Bh
Syzygium guineense	58	Bh, D, Fn, T
Macadamia tetraphylla	48	N, F
Acrocarpus fraxinifolius	46	F, T, Bh
Eucalyptus spp	45	F, P, T
Cupressus lusitanica	37	T, HBh, Sh
Croton macrostachyus	35	Sh, F, Fd, W
Leucaena spp	24	Fd, Scc,

Key: T=Timber; P=Poles; W=Withies; F=Fuelwood; F=Food, Frt=fruits, O=Oil, Sp=spice, N=Nut; Fn=furniture, Fd=Fodder, Bh=Bee hives, Me/M=Medicine; Mt=Mortar; Bh=Bee-hives; HBh=Hanging Bee hives, Sh=Shade to other crops, Scc=Support climbing crops; Other uses include Al=Alpenstock; Th=Toolhandle, Pes=Pestle, S=spoon; C=Charcoal Lb=Local brew machine; Pl=Pit latrine rails; D=Dye; Ig=Income generation; Bs=bow & snare.

Shebomeza Village was detached from Mlesa Village. It had varieties of trees mostly being indigenous trees. Patches of natural forest were still retained for supporting shade tolerating spice crop, *Piper nigrum*. In opening new farms some important tree species were left on-farm for future and sustainable uses. These species were perceived to have economic and social impacts although others were left due to forest extension exhorted and law enforcement exerted by ANR staff.

Maesopsis eminii for instance was not preferred for timber in the past but due to heavy exploitation in ANR forest, it was left to grow in mostly disturbed and open areas. Today timber obtained from mature trees is useful for domestic as well as commercial purposes compared to softwood obtained from plantations. The respondents argued that the species was preferred for its fast growing trait and minimum effects it had to growing crops.

Milicia excelsa and *Beilschmiedia kweo* being the second and third in terms of frequency, were mostly preferred for timber production. These species were among the most threatened speciesin ANR because of illegal harvesting. They were retained in farms because of their wood strength, durability and resistance against insects and other pathogens. The other preferred and retained species were *Bridelia micrantha* and *Alchornea hirtella* which were used for construction poles, withies and house utensils. *Allanblackia stuhlmannii* was retained due to its fruits production. The seeds produce unique oil for human and animal consumption. Today UNILIVER Company from UK is outsourcing seeds for processing oil for export, although locally it is not very useful due to availability of alternatives.

Tree species preferred for planting in Shebomeza Village had various uses; the foremost were income generation. *Cinnamomum zeylanicum, Syzigium aromaticum* and *Piper nigrum* were cultivated as spice. *Gliricidia sepium and Senna siamea* were preferred for multipurpose uses including support of climbing crops, animal fodder and rejuvenating soil fertility. For Timber production, *Cedrela odorata, Grevillea robusta* and *Syzygium guineense* were most preferred and planted. Trees planted for fruits while serving other functions such as timber, poles and fuelwood were *Artocarpus heterophyllus* and *Syzygium guineense*. *Funtumia latifolia* was less useful and rarely found on-farms. School children use the species latex for birdlime and adults use the tree for building poles.

4.2.2 Tree species Uses and preferences bycommunities in Mashewa Village

Mashewa Village had 18 indigenous trees species which were retained on-farm and 19 tree species planted on-farms. For retained tree species, *Milicia excelsa* was the most preferred species (84%), followed *Synsepalum msolo* (76), whereas *Acacia spp* was the least (25) (Table 11). As for planted tree species, *Gliricidia sepium* and *Tectona grandis* were the most preferred tree species (Table12).

Table 10: Most used and preferred tree species retained in Mashewa Village

S/N	Spp Name	Frequency	Uses
1	*Milicia excelsa*	84	T, Fn, M, Pes, Bh,
2	*Khaya anthotheca*	81	Fn, T, Bh, Fn, Scc
3	*Synsepalum msolo*	76	Th, A, S
4	*Albizia versicolor*	71	T, Fn, Mt, S, Scc
5	*Bridelia micrantha*	70	P, M,Th, Pes, PL, D
6	*Syzygium guineense*	69	Bh, D, Fn, T
7	*Milletia sacleuxii*	68	Pes, PL
8	*Syzygium cuminii*	68	T, Fn, M, Pes, Bh,
9	*Elaeis guineensis*	67	O, Me, Sh
10	*Cordia africana*	59	Fn, M, Bh, Hbh, Scc
11	*Combretum schumannii*	51	P, C, T
12	*Milletia dura*	48	Th, LB, PL
13	*Markhamia lutea*	45	P, A
14	*Markhamia hildebrandtii*	38	Th, A, BS
15	*Antiaris toxicaria*	33	Mt, Hbh, Sh
16	*Funtumia latifolia*	32	BS, D
17	*Acacia spp*	25	Hbh, F, C

Table 11: Most used and preferred tree species planted in Mashewa Village

S/N	Spp Name	Frequency	Uses
1	*Gliricidia sepium*	81	Sh, Fd, Scc
2	*Theobroma cacao*	80	F, W, O,Sp, Fd
3	*Tectona grandis*	78	T, F,P, Fn, Pes
4	*Cedrela odorata*	76	T, Fn, Scc, P, F
5	*Cocos nucifera*	76	F, SPc, N, Ig
6	*Citrus sinensis*	75	Frt, F, Th, Ig
7	*Artocarpus heterophyllus*	71	Frt, T, Fn, Bh
8	*Grevillea robusta*	69	T, F,P, Fn, W, Bh
9	*Terminalia sambesiaca*	68	F, T, Fd, W
10	*Mangifera indica*	68	Fr, HBh, Sh, Scc
11	*Senna siamea*	67	F, W, T, C, P, Sh
12	*Milicia excelsa*	57	T, Fn, M, Pes, Bh,
13	*Citrus limon*	52	Frt, F, Th, Ig
14	*Syzygium guineense*	50	Bh, D, Fn, T
15	*Acrocarpus fraxinifolius*	46	F, T, Bh
16	*Casuarina cunninghamiana*	46	P, Pl, F
17	*Citrus reticulata*	44	Frt, F, Th, Ig
18	*Croton macrostachyus*	35	Sh, Fd, F, S

Mashewa Village is one of the lowland villages which were affected by accessibility to the wood industry and market. The demand of wood products including fuelwood, timber, building poles and walking sticks were high. Other demanded products were wild and domesticated fruits, spice and beverages. In Mashewa village common species preferred and maintained on-farm were *Milicia excelsa, Khaya anthotheca, Albizia versicolor, Syzygium guineense* and *S. cuminii* which were useful in production of prime timber for indoor furniture, boxes, canoe, poles, posts and tool handle. *Synsepalum msolo* were specifically cited to produce walking sticks for old people commonly known as alpenstock which were highly demanded in DSM.

Tree species used for building poles included *Bridelia micrantha, Albizia versicolor* and *Combretum schumannii*. These species were preferred due to their resistance to rot and termites attack. It was found that *Elaeis guineensis* trees used for production of cooking oil were among preferred and retained in farms. The yellowish oil is medicinal due to its richness in vitamins and was highly recommended for eyesight remedy. Apart from cooking oil, the branches were used as sweeping brooms.

In order to supplement the domestic and commercial wood requirements, exotic trees were planted on-farms. The most preferred were *Gliricidia sepium* which was planted in close space of at least 2m x 2m in the open canopy. *G. sepium* is specifically used to support *Piper nigrum* which produces high income to Mashewa villagers. Apart from *P. nigrum*, *Theobroma cacao* was found on farms, cultivated in monoculture in narrow space. It is used as food (fruit and seeds), firewood, medicine, soil conservation, shade and fodder (fruit). The fruits eaten raw as a beverage but seeds are dried ready for market to produce drinking stimulant known as cocoa and cocoa butter. *T. cacao* seeds are also used to manufacture vinegar, jelly and alcohol at industrial level.

For timber production, farmers plant *Tectona grandis*, *Cedrela* odorata, *Grevillea robusta* and *Terminalia sambesiaca.* All timber producing species were introduced in the village naturally by various agents like wind or deliberately by elders who were employed in nearby forestry research stations and Longuza forest plantation. The demand of timber in study area is so high the situation which accelerates immature trees harvesting.

It was found that some species were preferred and planted to serve more than one purposes. For instance *Cocos nucifera, Artocarpus heterophyllus, Mangifera indica* and *Syzygium guineense* were planted basically for nut and fruit production. However, *Cocos nucifera* produces a nice and attracting timber, local brew, roofing material and sweeping brooms. *A. heterophyllus, M. indica* and *S. guineense* were basically planted for fruit production but mature stem were preferred for timber production.

Croton macrostachyus, Melia azedarach were not popularly planted in farms since they are not very useful and there are alternative tree species.

4.2.3 Tree species Uses and preferences by communities in Potwe Village

Potwe Ndondondo Village is a lowland village situated along the foothill of ANR, which was formed after deforestation and degradation of the natural forest. Being a fertile flood plain, twenty three (23) tree species were retained in the local community farms and 17 tree species were planted on-farms. As for retained tree species, *Milicia excelsa* was the most preferred species where as *Funtumia latifolia* was the least (Table 13). Among the planted tree species examined in the study farms, *Gliricidia sepium* and *Tectona grandis* were the most preferred species whereas *Croton macrostachyus* was the least preferred (Table 14).

Table 12: Most used and preferred tree species retained in Potwe Village

S/N	Spp Name	Frequency	Uses
1	*Milicia excelsa*	87	T, Fn, M, Pes, Bh,
2	*Bridelia micrantha*	80	D, P, M,Th, PL
3	*Albizia versicolor*	79	T, Fn, Mt, Ms, S
4	*Syzygium guineense*	72	Bh, D, Fn, T
5	*Trichilia dregeana*	69	Me, T, Fn, Pes,
6	*Syzygium cuminii*	68	T, Fn, M, Bh, Hbh
7	*Acacia spp (mgunga)*	67	Hbh, F, C
8	*Khaya anthotheca*	67	Fn, T, Bh, Sh
9	*Combretum schumannii*	66	C, T
10	*Synsepalum msolo*	61	Th, A, S
11	*Milletia dura*	58	Th, LB, PL
12	*Elaeis guineensis*	55	O, Me
13	*Zanthoxylum gilletii*	54	T, Fn, Me, Pes
14	*Albizia gummifera*	50	M, Hbh
15	*stercullia appendiculata*	47	Mt, Hbh, Sh
16	*Markhamia lutea*	41	P, A
17	*Celtis africana*	38	Th, S, Fd, Hbh
18	*Markhamia hildebrandtii*	35	Th, A, BS
19	*Newtonia buchananii*	35	T, HBh, Sh
20	*Melia azedarach*	26	W, P
21	*Milletia sacleuxii*	26	Pes, PL
22	*Cordia africana*	9	Fn, M, Bh, Hbh
23	*Funtumia latifolia*	6	BS, D

Table 13: Most used and preferred tree species planted in Potwe Village

S/N	Spp Name	Frequency	Uses
1	*Gliricidia sepium*	85	Scc, Fd,
2	*Tectona grandis*	83	T, F,P, Fn, Pes, Ig
3	*Cedrela odorata*	82	T, Fn, Scc, F
4	*Terminalia spp*	76	T,F,p, Bh, Sh
5	*Grevillea robusta*	74	T, F,P, Fn, W, Bh
6	*Citrus sinensis*	73	Frt, F, Th, Ig
7	*Artocarpus heterophyllus*	72	Frt, T, Fn, Mt, Bh
8	*Senna siamea*	72	F, W, C, Sh
9	*Cocos nucifera*	68	F, SPc, N, Ig
10	*Theobroma cacao*	68	F, W, O,Sp, Fd
11	*Citrus limon*	63	Frt, F, Bh
12	*Melia azedarach*	55	W, P, S
13	*Syzygium cuminii*	54	Frt, F, C, Bh,P, Fn, T
14	*Mangifera indica*	52	T, HBh, Sh
15	*Acrocarpus fraxinifolius*	46	F, T, Bh
16	*Citrus reticulata*	39	Frt, F, Bh
17	*Croton macrostachyus*	34	F, Sh, Fd,

Results revealed that trees were given priority by villagers of Potwe. The most preferred species were those retained for timber and building pole production. It was observed that *Milicia excelsa, Albizia versicolor, Syzygium guineense, Trichilia dregeana and Syzygium cuminii* ranked high in preference and uses. *M. excelsa* yields a high grade valuable timber which is heavy, durable and termite resistant. It is the species which was found both in lowland and mountainous villages described to have several uses including joinery, construction timber (furniture, boat), charcoal, tool handles, bee-hives, poles, and even firewood and charcoal depending on the part of the wood. It was observed that the main stem of *Milicia excelsa* produces timber, branches and off cuts were used to prepare tool handles, charcoal and firewood, but slabs obtained after sawing were useful in construction of livestock sheds, boat and local carpentry benches.

Other species preferred but mostly found in lowlands were *Albizia versicolor, Syzygium guineense and Trichilia dregeana.* These species were highly depleted and those found on-farms regenerated through coppicing except few. It was observed that apart from timber, these species were famous for manufacturing pestle, mortar, mask and home utensils including bowl, charcoal, firewood, spoon and coconut scooping device. *A. versicolor* was specifically used as fodder, shade in banana farms, rejuvenating the soil and also support *Piper nigrum*; whereas *Syzygium cuminii* produced edible fruits and medicine extracted from barks used as a remedy for diabetic patients.

The most preferred and planted tree species included *Gliricidia sepium, Tectona grandis* and *Cedrela Odorata. Gliricidia sepium* serves the same function as described in Shebomeza and Mashewa villages. *Tectona grandis* was preferred and mostly planted on-farms due to easiness of planting, silvicultural, management and its market availability. The species is sold as logs at the age of 12 to 16 years and especially for export. *T*ectona *grandis* is preferred for its valuable timber which produces various products including heavy and light furniture, boat, building poles, posts, home utensils including tool handles and spoons.

Tree species planted and used for poles and building in the village included *Cedrela odorata, Terminalia ivorensis* and *Grevillea robusta.* These species were preferred due to their resistance to rot and attack by termites. *Terminalia catapa* was also planted as ornamental and shade in homesteads. The kernels of *T. catapa* are eaten by children. *Croton macrostachyus* was the last in list of preference due to its limited uses and market value of wood products or fruits produced. *C. macrostachyus* was planted at homesteads as ornamental and for shade.

4.2.4 Tree species Uses and preferences of communities in Mlesa Village

A total of 35 woody species were preferred and retained in Mlesa Village and 14 species were planted on-farms for various uses. For retained tree species *Milicia excelsa* was the most preferred species followed by *Beilschmedia kweo. Stereospermum kunthianum* and *Polyscias fulva* were the least preferred (Table 15). For the case of tree species planted, the most preferred tree species were *Grevillea robusta* and *Syzigium aromaticum* whereas *Senna siamea* was the least preferred species (Table 16).

Table 14: Most used and preferred tree species retained in Mlesa Village

S/N	Spp Name	Frequency	Uses
1	*Milicia excelsa*	85	T, Fn, M, Pes, Bh, F
2	*Beilschmiedia kweo*	81	T, Fn, Mt, F, C, Bh,
3	*Allanblackia stuhlmannii*	72	F, W, O, Me, Fd
4	*Maesopsis eminii*	71	T, F, Fn, V, Sh
5	*Cephalosphaera usambarensis*	70	V, T, Hbh, F, C
6	*Englerodendron usambarense*	69	T, Pe, Mt, P
7	*Alchornea hirtella*	68	P, Bs
8	*Khaya anthotheca*	68	T, P, Fn, Mt, F, Me
9	*Newtonia buchananii*	68	T, HBh, Sh
10	*Cordia africana*	67	Fn, M, Bh, Hbh
11	*Sorindeia madagascariensis*	64	Th, frt, S, LB
12	*Ocotea usambarensis*	62	T, Me, F, Fn, SH
13	*Anisophyllea obtusifolia*	55	W,
14	*Bridelia micrantha*	51	P, M,Th, Pes, PL, D
15	*Cyathea manniana*	49	P, PL
16	*Syzygium guineense*	46	Bh, D, Fn, T
17	*Blighia unijugata*	45	P, W, A, Bs, LB
18	*Rauvolfia caffra*	45	Me, S, Bh, Sh
19	*Albizia gummifera*	38	M, Fd, Fn, P, Hbh
20	*Chrysophyllum spp*	38	S, F, PL
21	*Zanthoxylum deremense*	37	S, F, PL
22	*Strombosia scheffleri*	34	Bh, LB
23	*Cynometra longipedicellata*	32	F, LB, PL
24	*Parinani excelsa*	26	C, Pe, Mt, LB, F, P
25	*Albizia schimperiana*	25	T, F, C, Fn, Mt, S
26	*Isoberlinia scheffleri*	20	M, Th, F
27	*Myrianthus holstii*	20	Frt, Th, LB, P
28	*Maranthes goetzeniana*	19	F, Hbh, C
29	*Milletia sacleuxii*	12	Pes, PL
30	*Combretum schumannii*	10	C, T, F, P, Hbh
31	*Markhamia hildebrandtii*	9	Th, A, BS
32	*Markhamia lutea*	3	P, A, T, C
33	*Funtumia latifolia*	2	BS, D
34	*Polyscias fulva*	2	Mt, Pe, Bh,W, P
35	*Stereospermum kunthianum*	2	Th, A, S

Table 15: Most used and preferred tree species planted in Mlesa Village

S/N	**Spp Name**	**Frequency**	**Uses**
1	*Grevillea robusta*	85	T, F,P, Fn, W, Bh
2	*Syzigium aromaticum*	81	SPc, Me, P, F
3	*Cedrela odorata*	77	T, Fn
4	*Maesopsis eminii*	73	F, T, Fd, W
5	*Eucalyptus spp*	69	T, HBh, Sh, F,
6	*Cinnamomum zeylanicum*	67	SPc, Me, P, F
7	*Gliricidia sepium*	67	Scc, Fd,
8	*Persea americana*	64	Frt, Fd, Bh
9	*Allanblackia stuhlmannii*	50	F, W, O, Me, Fd
10	*Acrocarpus fraxinifolius*	44	F, T, Bh
11	*Cuprresus lusitanica*	44	T,F,P, Bh
12	*Artocarpus heterophyllus*	32	Frt, T, Fn, Mt, Bh
13	*Terminalia catapa*	25	T,F,p, Bh, Sh
14	*Senna siamea*	24	F, W, C, Sh

Mlesa Village is one of old mountainous village surrounded by forest. Historically, it was formed following the Tanga Regional Commissioner re-allocation of formally Karimjee forest which was heavily exploited and disturbed by heavy machines and pit sawyers immigrated from West Usambara. The remnant of sawmills and its structure were seen in the village and were considered as village property (Hamilton and Mwasha, 1989). The other part of Karimjee forest has been included in management of ANR in a dedicated covenant agreement (MNRT, 2000).

The main trees species retained when opening the new farms included *Milicia excelsa* and *Beilschmiedia kweo* which were the main timber species exploited. These species were mostly preferred in Mlesa Village due to their strength and durability as explained in other villages. During the study period, big diameter stumps of more than 60 cm were found remaining in many farms. *Milicia excelsa* has high utility, quality by-products and wood durability. *B. kweo* had several uses including timber (furniture, panelling and sleepers), building poles, veneer, mortars, pestles, charcoal, tool handles and firewood.

Allanblackia stuhlmannii was preferred due to its oil producing fruits. The fruits are also used as fodder (flowers and fruits) for fattening livestock. Other uses of *A. stuhlmannii* were production of light timber (for furniture, boxes, creates and bee hives), Medicine for chest pain and cough also oils treats rheumatism. *A. stuhlmannii* was retained in farms as part of agroforestry systems in the mountain villages.

Stereospermum kunthianum was least preferred species on-farms in Mlesa Village. Although tree species were retained on farms, farmers had limited uses due to various reasons. First of all the timber is of moderate durability compared to other species, good nail-holding capacity, slight tendency to warp, strong, works well with hand and machine tools and stains well. It is used for furniture, shelving, pattern making, tool and implement handles, poles, utensils, platters, gunstocks, mortars and pestle.

From medicinal point of view, the pods are chewed with salt to treat coughs and are used in treatment of ulcers, leprosy, skin eruptions and venereal diseases. Leaf infusion is used for washing wounds; macerated leaves are used to treat asthenia and exhaustion. Bark is used as a haemostasis and for treating wounds, and a stem-bark decoction is used to cure bronchitis, pneumonia and coughs. Venereal diseases, respiratory ailments and gastritis are treated using roots and leaves.

For the case of planted trees on-farms in Mlesa Village, the highest score of preference and uses was *Grevillea robusta* (85%). The study found that farmers preferred *G. robusta* for planting with other crops as it was a relatively fast growing species and did not compete too much with other crops for water and nutrients. *Grevillea robusta* was ranked as being the most compatible with other crops. It was ranked first in the speed of growth and in straightness (Reyes, 2008). It is observed that *G. robusta* was the best tree which can be used for fencing and timber from this tree was widely used for external window joinery as it is resistant to rotting. It was also popular for making furniture, window and door frame and shutters; beehives, drum, boxes, mortar, veneer, charcoal and firewood. The species is planted in agroforestry systems to provide shade to other crops as well as bee forage and mulching to prevent soil erosion Swallow, 2006).

Syzigium aromaticum was the second preferred and planted species. Initiation of *S. aromaticum* was from ABG which was established in the colonial error and well developed since 1954 (Reyes, 2008). It was informed that the species was planted as commercial crop which provide substantial income to villagers. Locally it was used as food (flowers for spice), medicine (liniment), firewood, poles and tool handle. Other preferred tree species were *Cedrela odorata* and *Maesopsis eminii* which was already discussed in other villages.

Senna siamea was planted as ornamental but it was the least in terms of preferred tree in Mlesa village. It was planted mostly in homesteads during the East Usambara Conservation and Agriculture Development Project (the IUCN project) which was sponsored by European Union. The tree was used by few people as bee forage, building poles and withies.

Generally it was observed by Boffa *et al.* (2005) and Munishi *et al.* (2008) that many farmers depended on on-farm trees for different domestic uses despite of few individuals who collected tree resources from the nearby forests leading to increased demand of forest products from both forest and village lands. Kessy (1998) reported that in Kilimanjaro, the preferred on-farm trees were used to generate cash income, shade, firewood, building materials, soil conservation and fruits. Munishi *et al.* (2008) reported that highly populated areas like Lushoto, Tanga and Tukuyu District in Mbeya, on-farm trees preferred were used as the main source of fuel, timber and many domestic needs.

Reyes (2008) reported that trees with food or particular household use value such as medicinal were also preserved and supplemented. Plate 4 shows climbing *Vanilla planifolia* and *Piper nigrum* supported by *Jatropha curcas* and *Milicia excelsa* species respectively in Shebomeza Village, Amani**.**

Plate 4: Climbing crops *Vanilla planifolia* (left) and *Piper nigrum* (right)

Ecologically trees on farm enhance forest connectivity by enabling movement of genetic material from nature reserve to other forest reserveS or movement of animal including birds from one ecological zone to another hence increasing interaction as well as providing niche (brooding and breeding centre) for other living organism, support other livelihoods like mushroom growth. Similar results were reported by other researchers (Mangaoang and Pasa, 2003; Methew, 2009).

It was realised that the threatened and endangered tree species were those species perceived to have many uses, which were also recorded on-farms but were among the reserved tree species and farmers nicknamed it '*Mpolisi'* meaning that whenever the species was illegally harvested , the policemen arrested the culprits. The main *Mpolisi* species was *Milicia excelsa*. The most important use of the wood in Tanzania is for fuelwood and about 95% of the country's energy supply is met by fuelwood (Mugasha *et al.*, 2005). The species is mostly obtained from either individual farms or village lands.

4.3 Forest Products Extracted from ANR by Neighbouring Communities

Most of the trees planted on-farms were those growing fast but also having known their silvicultural management. It was observed that tree-based products like tool handles, bow/snares, raphia, alpenstocks, pit latrine rails, sugarcane juice/local brew (boha) machines and withies for housing construction were inadequately available in farmlands; therefore they were widely collected from either ANR or Longuza plantation forest to supplement the needs (Fig. 3).

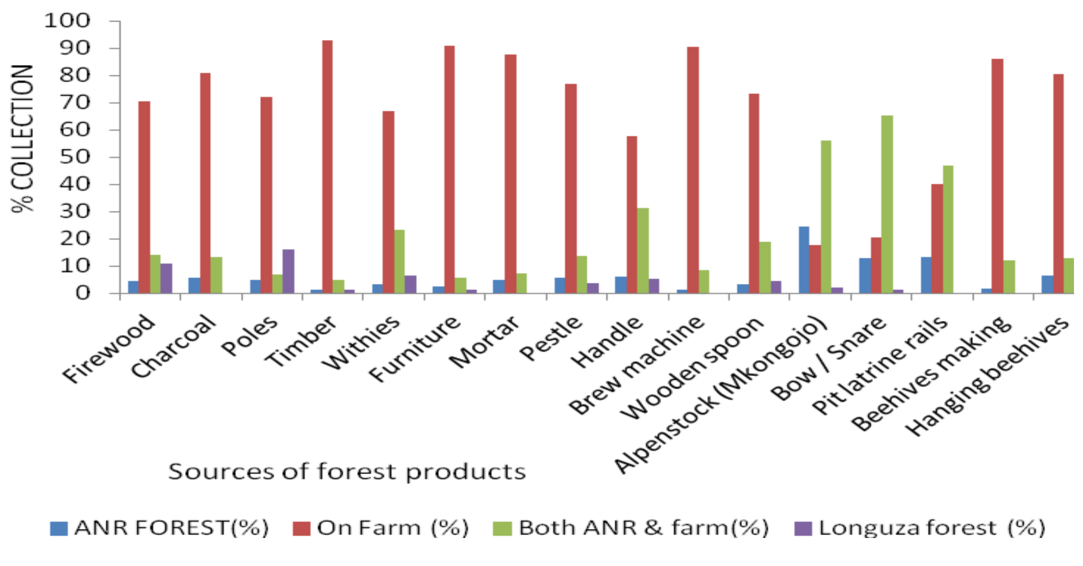

Figure 3: Tree products and their sources in communities adjacent to ANR.

It was observed that 70% of the household tree based products were obtained from on-farm sources. However, 52% of the respondents particularly those temporarily employed by various institutions like tea companies, sisal companies, tea research, Medical Research Institute and those having small farms obtained wood and non-wood products from the forest. This is clear indication how on-farm resources contributed towards conservation of ANR.

Villagers reported that some trees having valuable timbers were no longer obtained in adequate quantities from farmlands; most of them were available in adjacent forest reserves. These included *Milicia excelsa* (mvule), *Ocotea usambarensis* (mkulo), *Beilschmiedia kweo* (mfimbo) and *Khaya anthotheca* (mkangazi).

Apart from tree products, non-wood/timber forest products and services were inadequately available on-farms but were important and were still secured from adjacent natural forests. However, some of these products and services such as medicines, wild fruits, gums, fibres, resins, extractives, nuts, ropes, herbs, dyes, toiletries (msabuni) and animal products such as honey and the parent stock of butterfly for caging at home which were rarely found in disturbed areas were collected legally or illegally.

Illegal collection of forest products has been reported frequently by Forest Officers. The main parts collected were in form of barks, roots, twigs, leaves and sometimes whole plant. Sometimes flowers (African violets), Medicinal plants (*Cinchona hybrida*, *Zanha golungensis*), tree seeds (*Allanblackia stuhlmannii*) and aromatic plants including *Ocotea usambarensis* were taken. Other species illegally collected from the forest were those having stimulant properties like *Catha edulis (mirungi), Emilia species* and *Myristica fragrans* (kungumanga). Also species having properties of dye (*Euclea species*, *Harungana madagascariensis, and Bridelia micrantha*), beverages (*Rauvolfia caffra*), roots and tubers products have been reported to be a serious threat to ANR. Herbalists now travel far to find medicinal plants. Similar results were reported by Ross (2010).

4.4 Verification of Forest Product Extracted from ANR

Disturbance surveys were conducted in the all four study villages buffering ANR to verify the socio-economic information collected during the discussion. It was revealed that no current or past charcoal burning in the reservebut the existing forest trails indicate the sign of forest resource collection. It was repored that trails were used to collect fire wood, mushrooms, medicines, vegetables, ropes and sometimes for wildlife trapping. Robinson and Kajembe (2009) reported similar results.

The results revealed further that the number of dying and fallen trees/branches were high in areas which were remote, far from the forest border and hilly terrain in all sites visited. This implied less dependence of such wood material for domestic consumption. The number of recent cut stumps was small in Potwe, Mashewa and Shebomeza but Mlesa were still taking poles although frequency was not alarming. This explains how tea company workers depend on the forest for domestic uses. Old cut stumps were more than recent cut poles, withies and trees indicating that the dependency on natural forest by adjacent communities was decreasing (Table 17). Generally people go into the forest to supplement wood resources which were not available on-farms. Similar observations were reported by Heini (2005) and Mendoza (2005).

Ongoing illegal harvesting of forest products from the forest reserves indicates that people’s private farms do not completely fulfil their wood needs.

Table 16: ANR Forest Disturbance Survey

Village	No plot	Charcoal site	Number of **dying stump**			Number of **Recent Cut stump**			Number of **Old Cut stump**			No. **fallen** tree/ branche ≥ 5 cm
			Trees	Poles	Sapling	Trees	Poles	Sapling	Trees	Poles	Sapling	
Potwe	21	Nil	28	25	3	0	6	0	21	60	0	81
Mashewa	21	Nil	26	7	1	2	1	3	2	0	0	69
Mlesa	18	Nil	15	11	4	2	0	0	12	32	0	46
Shebomeza	20	Nil	21	5	9	0	0	0	1	0	0	75

4.5 Factors Influencing On-Farm Tree Planting/Retention in Villages Surrounding ANR

The study revealed socio-economic factors influencing on-farm trees planting or retaining. These included farm size, income, education level, sex of respondents, residence duration in the village, household size and age of respondent. Multiple regression model showed coefficient of determination (R^2 0.34, Std 2.45), which implies that independent variables explained about 34% variation of the dependent variables. Out of seven independent variables regressed against number on farm tree planted or retained; four had positive influence while the rest had negative influence. Variables which influenced tree planting/retention were farm size, income and education level while variables constraining tree planting/retention were sex or gender of respondent, age and household size though not significant (Table 18).

Table 17: Factors influencing on-farm tree planting /retention in study villages

Xi	Beta (β)	t	Sig.
Farm size owned by respondent	0.388	4.803	0.000*
Income level of respondent	0.303	3.857	0.000*
Education level of respondent	0.035	0.434	0.665
Residence duration of respondent in the village	0.012	0.151	0.881
Sex of respondent	-0.080	-1.078	0.283
Household size	-0.028	-0.379	0.705
Age of respondent	-0.003	-0.035	0.972
(Constant)		0.781	0.436

Where; Xi are independent variables (social economic factors), Beta (β) regression coefficient, t student t-test and * statistically significant at 0.05 level of significance, NS Statistically non significant at 0.05.

4.5.1 Farm size

Household farm size had positive regression coefficient of 0.388and significant level at p=0.000. This implies that farm size owned by respondent influenced the number of trees planted or retained. A plausible explanation was that farmers with large farms could plan different farming activities including cultivation of agricultural products and planting and or retaining trees. It was observed in study area that those having big land had different plots of different crops including spice, food crops, woodlots, reserved natural forest and grazing or fodder plots for smallholder dairy production. The most common fodder plants were *Pennisetum purpureum* (elephant grass), *Tripsacum laxum* (Guatemala grass) and *Setaria splendida* (Setaria). Ownership of on farm trees reduces temptations of encroaching the reserve for fuelwood and building materials, thus reduces pressure and disturbance in the reserve.

Land acquisition in the study area varied from one village to another. Generally, of the total households sampled, 60% cited inheritance as the mode of acquiring land, customarily involving partitioning of family property, while only 37% and 3% obtained ownership through purchase and village allocation respectively. Farm size owned differered from one household to another with an average of 5.1 hectares (a minimum of 0.4 ha and maximum of 20.0 hectares). It was found that 70% of small sized farms were intensively cultivated than large and very large farms. This was evidently seen in almost all small farms in all surveyed villages. Reyes (2008) reported that the majority of people living around ANR had medium to small size farm where food crops and few trees were planted mostly along the border. It was reported that big sized land practices agroforestry system where cash crops like *Piper nigrum*, *Cinnamomum zeylanicum* and *Elettaria cardamomum* were planted. These crops produces substantial amount of returns.

4.5.2 Income level of the respondent

Table 18 shows that there was positive correlation (Beta=0.303) between trees planted/retained and income level of the respondents. It was found that the income level of the respondents significantly influenced tree planting/retaining at P=0.000. This implies that people with high income in the village can buy pieces of land and opt to plant various trees and food crops. Either it was observed in all villages that big patches of retained natural forests and woodlots were owned by rich people. The income in study villages was basically obtained from sales of agricultural crops either herbaceous or woody crops. It was observed that some herbaceous crops were cultivated both for subsistence and cash income generation. Herbaceous and woody crops contributed an average of 79.3% of the family income, followed by livestock (dairy cattle particularly in the highland villages) and employment in tea/sisal estates and various institutions available. Cash crops were *Saccharum officinarum* (Sugarcane), *Elettaria cardamomum* (Cardamom), *Cinnamomum zeylanicum* (Cinnamon), *Piper nigrum* (black paper) and *Camellia sinensis* (tea). Other crops were *Syzigium aromaticum* (clove*), Citrus sinensis* (orange), *and Cocos nucifera* (coconut).

Apart from cash crops, other households depended on selling tree seedlings. The most important tree species which their seedlings had high market price include *T. grandis*, *C. odorata*, *G. robusta*, *S. aromaticum*, *C. zeylanicum*, *P. nigrum* and *C. sinensis.* It was reported that the price of seedlings ranged from TZS 100 to 500.

Selling raw woody materials such as logs, poles or firewood or processed products such as timber, fruits, flowers (cloves) and barks were important source of income. Firewood is sold to Tea Companies, bakeries, textile mills, and individuals in town at varying prices. The price of firewood ranged between T.shs. 2 000 and 3 500 per cubic meter. It was reported that market opportunities for fast growing herbaceous woody species played a significant role in encouraging tree planting. Kijazi (2007) reported the similar results. Heini (2005) reported that timber and poles provided substantial income to communities although some were extracted from the forest reserve. Mbeyale (1999) revealed that the main threat to ANR was illegal pole cutting of endemic or near endemic species. The availability of these materials on-farms will ensure sustainable conservation of biodiversity of ANR.

4.5.3 Education level of the respondents

Table 18 shows that education had a positive regression coefficient (Beta=0.035) but its influence on tree planting/retention was not statistically significant (p=0.665). Positive regression coefficient implies that an increase in education level tends to increase people's awareness on the importance of natural resources conservation for sustainable development. Increased level of education also increases the willingness of local communities to participate in tree planting campaign and/or conservation of retained trees on-farm. Involvement and willingness of local community to participate in tree planting/retention on-farms reduces the chances of resource depletion hence conservation and management of natural resources sustainably. Increase in level of education also increases options of respondents to meet their livelihoods (Nath and Inoue, 2012).

Fig. 5 displays education level of respondents in the surveyed villages. Majority of the respondents had primary school education (75.6%) and few had college level education (3%). Mbwambo (2000) reported that education had direct influence on people's participation in natural resources management and promoted sustainable utilization of the natural resources. Munishi *et al*. (2004) commented that an increase in education level increased the level of awareness and hence positive attitudes in natural resource management. This is due to the fact that educated people even with primary education can easily follow training administered by extension Officer, books and even media broadcasting. Kessy (1998) and Malundo (2008) reported similar results.

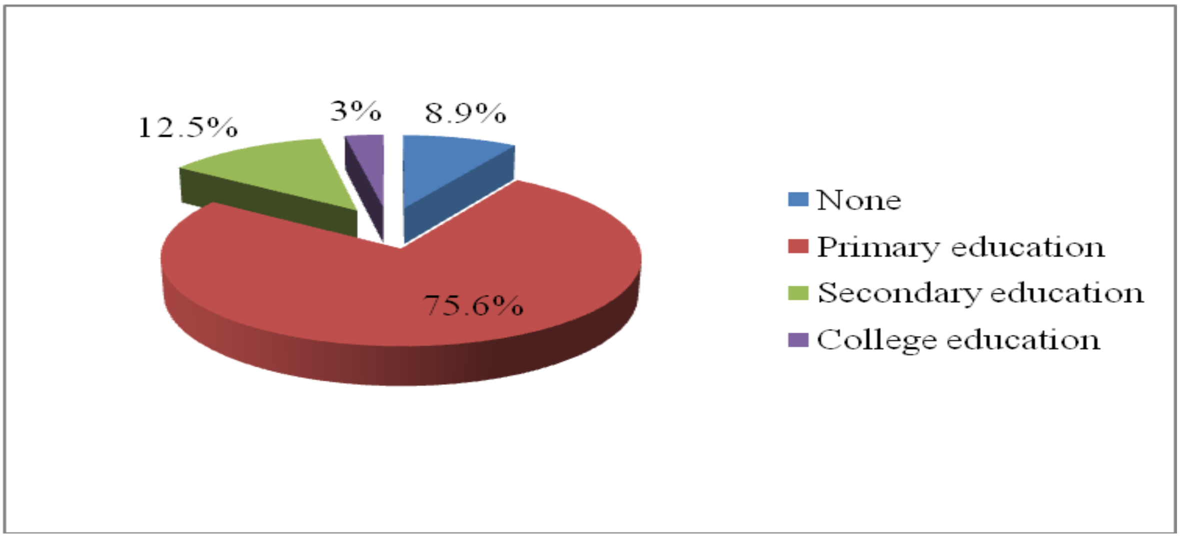

Figure 4: Education level of respondents in the study villages

4.5.4 Residence period of the respondents

Table 18 shows positive correlation (Beta = 0. 153) between number of years an individual has stayed in the study area and number of trees an individual had planted/retained in her/his farm. Residence duration however did not show statistical significance (p= 0.881) on number of trees planted or retained on-farms. The explanation of the positive correlation is that people who stayed in the study area for a long time, more than 15 years had acquired big sized land which contained indigenous trees. The forest was used to support spice and food crops (yams) cultivated under shade. Furthermore, staying in the village for a long time increased their chances of earning higher income from woody materials and invest on tree planting.

These findings are against those reported by Mbeyale (1999) who reported that the longer a person stays in a particular place the more he/she becomes involved in natural resources depletion through selling building material. It was observed that the majority of the respondents (45.3%) had stayed in the villages for more than 15 years. Whereas (25.4%) of the had respondents stayed in the study area between 0.25 and 5 years, 15.9 % between 6 and 10 years and 13.4 % between 11 and 15 years. This implies that in the study area the majority of the respondents had stayed in the study villages for relatively long time and therefore most of them had acquired enough land of which part of the land was used to plant or retain trees.

4.5.5 Gender or sex of the respondent

Table 18 shows that sex of the respondent in the study area had negative correlation (Beta=-0.080) with number of trees planted/retained on-farms. This implies that state of being male or female reduced the number trees planted/retained on-farms. Plausible explanation is that males were busy seeking family daily bread, thus put much efforts in management of natural resources. Females who are most victims of natural resources depletion are less involved in decision making forums and access to information. It was observed that the number of men participating in various occasions such as environmental seminars and meetings was higher as compared to women. Attendance to seminars and meetings increases the likelihood of men to become aware of various technologies including planting/reserving trees but do not adopt them.

It was observed that 84% of the respondents interviewed were males and 73 % of all households were male headed families. Males are normally heads of households and are the ones who make decisions at the house hold level. According to Sambaa traditions, males inherit the properties of their ancestors including farms, owns property rights of both land and trees planted and/or retained on-farms; whereas women were expected to be married and hence have no inheritance rights. The results conform to those reported by Malundo (2008), who reported that 60% of the households surveyed in East Usambara were male headed, and argued that male headed households were a typical characteristics of most traditional households. Kessy (1998) and Mbeyale (1998) had similar observations. The results were also similar to those of Mendoza (2005) who reported that problems of gender representation have arisen in the participatory planning of the Amani Nature Reserve management especially when women's needs were not properly addressed. Kessy (1998) reported that smallholders with insecure tenure were less likely to plant or protect natural regeneration of native trees on-farms.

4.5.6 Household size

Household size was among the factors constraining tree planting/retention on-farms. Table 18 shows that household size has negative regression value of -0.028 at (p=0.705). This indicates that increase of family size reduces number of tree planted/retained in the surveyed villages. It was observed that households with big families had more demand for resources for day to day uses, thus jumble for resources than household with few family members. Household with family size of more than 6 members and had small size land opt to cultivate food crops rather than planting or retaining trees. Increased number of households of this type always depend nearby forest for domestic wood resources, hence increases pressure in the reserve. The implication could be that increase in household size means high availability of labour and hence increased collection of the forest products for subsistence use, primary health care as well as for income generation.

Kessy (1998) and Mbeyale (1999) reported that high population was a factor which influenced deforestation. Mafupa (2006) found that the more the families grow up in size the more they became either farmers or livestock keepers and therefore more land is required to meet their demands.

4.5.7 Age of the respondents

Table 18 shows that the age of respondents were negatively correlated (Beta=0-.003) and weak statistically significant (p=0.972) with tree planting/retention on farms. The negative correlation indicates that as age of the household head increases the less number of trees planted/retained on farms. This shows weak involvement of old people in tree planting and or retention on farms. The plausible explanation can be that since tree planting is a long-term investment, as age increased, there was fear of not benefiting from the investment thus people opted for short term investments such as petty business, growing annual cash crops and casual labour.

In this study, it was found that 59% of the respondents were between 40-50 years which were active and strong; although some were above 75 years. It was also observed that in all four villages the young aged families aged 35 to 50 years established new tree farms mainly for commercial purposes whereas respondents of more than 60 years planted short rotation crops like spices and herbaceous crops among the existing trees (retained). National Strategy for Growth and Reduction of Poverty (NSGRP) reportsed the same (URT, 2005).

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Results from this study have revealed that on - farm trees have contributed towards conservation of biodiversity of ANR as well as restoring the lost productive capacity.

Ecological data taken from 135 on-farm plots measuring 0.125 ha indicated that there are total of 99 tree species belonging to 39 families either planted and /or retained. Of all trees measured, 40.5% were deliberately planted and 59.5% were retained on farms. The dominant tree species found included *Maesopsis eminii*, *Gliricidia sepium*, *Grevillea robusta*, *Syzigium aromaticum*, *Allanblackia stuhlmannii*, *Cephalosphaera usambarensis* and *Cinnamomum zeylanicum* in the mountain area; whereas important species found in lowland villages included *Gliricidia sepium*, *Cedrella odorata*, *Tectona grandis*, *Theobroma cacao*, *Mangifera indica* and *Artocarpus heterophyllus.*

The Wiener index of diversity for on-farm trees were 4.15. This shows a high diversity of on-farm tree species compared to undisturbed natural forests in the area.

Forest disturbance survey conducted in ANR revealed that adjacent communities still depend on the ANR for fuelwood collection, wild fruits, vegetables, tool handle and medicinal purposes. About 69.5% of some tree based products were obtained from on-farm trees, other products such as herbal medicines, alpenstocks and weaving material were still collected from ANR.

Apart from provision of supports and shade to commercial and food crops, on-farm trees were commonly retained around water sources, streams and river banks with the aim of protecting land degradation as well as ensuring sustainable water flow to down stream and urban dwellers. Due to products and services rendered by on-farm trees, it influences stable tree population structure of ANR, hence increasing conservation of biodiversity.

Multiple regression analysis revealed that farm size, education level and income had significant influence ($p < 0.05$) on tree planting and retention in villages surrounding ANR.

Finally the study revealed that wood and NWFP obtained on-farms do not suffice the communities, although farmers were deliberately planting or retaining tree species on their farms for multiple uses to optimize production of crops and livestock.

5.2 Recommendations

In order to manage on-farm tree planting and sustain the existing indigenous trees which some are endemic and threatened species, it is recommended that:

(i) More emphasis should be put in species that reduce threats to the Nature Reserve and other forest reserves. These will include multi-purpose trees which serve other functions like bee forage, medicinal plants, fruits and butterfly- keeping.

(ii) More investments on-farms is recommended to reduce illegality especially theft of wood and NWFP resources in ANR which has dropped significantly due to better awareness and motivation offered by ANR.

(iii) To ensure sustainable supply of the resources collected from ANR and to meet the diversified needs of people, a long-term integrated plan that focuses on sustainable management of land, water, and other resources with a coordinated approach are inevitable to reduce the unopened use of indigenous trees. However, a strong commitment and political will is needed to overcome these obstacles.

(iv) Updated and reviewed guidelines on silvicultural management of on-farm trees which include species selection, proper planting space, thinning and pruning.

(v) Financing projects like REDD+, CBo and NGOs is recommended in villages surrounding high biological importance globally like ANR in order to encourage management of on-farm trees.

(vi) Research on domesticating native tree species which are not in farms but frequently used by local people is recommended.

REFERENCES

Ambasht, R. S. (1998). *A text book of Plant Ecology 8th edition*. Department of Botany Banaras Hindu University Varanasi. Students' Friend and Co. Veranasi. SNAL QK901.45. 351pp.

Appiah, D. O. (2009). Personifying sustainable rural livelihoods in forest fringe communities in Ghana: A historic rhetoric?. *Journal of Food, Agriculture & Environment* 7: 873 - 877.

Arnold, M. and Dewees, P. (1998). Rethinking approaches to tree management by farmers. *Overseas Development Institute (Odi) natural resource perspectives journals* 26:1 – 14.

Atta-Krah, A. N., Kindt, R., Skilton, J. N. and Amaral, W. (2004). Managing biological and genetic diversity in tropical agroforestry. *Agroforestry Systems. Kluwer Academic Publishers. The Netherlands.* 61**:**183–194.

Bailey, D. K. (1994). *Methods of Social Research*. The free press Collier-MacMillan Publishers, London, UK. 478pp.

Blomley, T. and Iddi, S. (2009). Participatory Forest Management in Tanzania: 1993 – 2009. *Lessons learned and experiences to date*. 70pp [http://www.tzdpg .or.tz / Experience_and_lesson_learned] Site visited on 30/7/ 2011.

Bluffstone, R.; Boscolo, M. and Molina, R. (2008). Does better common property forest. management promote behavioral change? On-farm tree planting in the Bolivian

Andes1. *Environment and Development Economics.* Cambridge University. United Kingdom.13:137–170.

Boffa, J. M.; Turyomurugyendo, L.; Barnekow-Lillesø, J. P. and Kindt, R. (2005). Enhancing farm tree diversity as means of conserving landscape – based biodiversity. Insight from the Kigezi highland, Southern Uganda. Mountain Research and Development 25: 212–217.

Boyd, H. K. R.; Westfall, E. and Stasch, S. F. (1981). *Marketing Research, Text and Cases*, Illinois, Richard, D. Publisher, 813pp.

Burgess, N. D. (2010). The Year of Biodiversity – what does it mean? *The arc Journal* 25:1-4.

Buyinza, M**.** (2009). Land-use Intensity in the Tree Cropping Homesteads in Kamuli, Eastern Uganda. *Agricultural Journal* http://scialert.net/ asci/author.php?author =MukadasiBuyinza&last=. Site visited 20/07/2011.

Chamshama, S. A. O. and Kiyiapi, J. (2005). The AFORNET Research Agenda: - *Towards Sustainable Forest Management in Sub-Saharan Africa.* 27pp.

FAO. (2002). *Trees outside forests: towards better awareness.* FAO Conservation Guide 35. Rome.

FIDAfrique - IFADAfrica (2003). Promoting Rural Innovation through Participatory Tree Domestication Components – A. http://www.fidafrique.net/article2337.html. site visited 21/6/2011.

Frontier Tanzania (2001). *Amani Nature Reserve: A biodiversity survey.* East Usambara Conservation Area Management Programme. In Doody. K. Z., Howell, K. M. and Fanning, E. (editors). Technical Paper No. 52. Dar Es Salaam, Tanzania. 144pp.

Gujarat, D. N. (1995). *Basic Econometrics.* 3rd edition. McGraw-Hill Inc., New York, London. 838 pp.

Hamilton, A. C. and Mwasha, I. V. (1989). History of Resource Utilization and Management. After Independence. In: *Forest Conservation in the East Usambara Mountains Tanzania.* (Edited by Hamilton, A.C. and Bensted-Smith, R.), IUCN, Gland Switzerland and Cambridge, UK. pp. 45-56.

Harvey, C. A.; Alpizar, F.; Chacón, M. and Madrigal, R. (2005). *Assessing linkages between agriculture and biodiversity in Central America: historical overview and future perspectives. Mesoamerican & Caribbean region, Conservation Science Program. The Nature Conservancy, San José, Costa Rica.*

Heini, V. (2005). Politics of Participatory Forest Conservation: Cases from the East Usambara Mountains, Tanzania: *The Journal of Transdisciplinary Environmental Studies, 1602-2297* [http://www.journal-tes.dk/html] Site visited on 30/3/ 2011

Higgins, S. I.; Shackleton, C. M. and Robinson, E. R. (1999). Changes in woody community structure and composition under constrasting landuse systems in a semi-arid savanna, South Africa. *Centre for African Ecology, Department of Animal, Plant and Environmental Sciences, University of the Witwatersrand, South Africa.* Journal of Biogeography, 26: 619–627.

ICRAF, (2009). GRP2: Improving on-farm productivity of trees and agroforestry systems. Project Overview and Rationale. http//www.worldagroforestrycentre.org/downloads/publications/.../rp15672.pdf site visited 04/08/2010.

Iddi, S. (1998). Eastern Arc Mountains and their national and global importance. *Journal of East African Natural History* 87: 19-26.

Iddi, S. (2002). Community participation in forest management in the United Republic of Tanzania. In Iddi, S., Sarrazin, K. and Reeb, D (editor). *Second international workshop on participatory forestry in Africa*. 18-20th February 2002. Arusha, Tanzania. ftp://ftp.fao.org/docrep/fao/006/Y4807B/Y4807B04.pdf. pp. 59-67.

Isango, J. A. (2007). Stand Structure and Tree Species Composition of Tanzania Miombo Woodlands: A Case Study from Miombo Woodlands of Community Based Forest Management in Iringa District. *Proceedings of the First MITMIOMBO* Project Workshop held in Morogoro, Tanzania, 6th–12th February 2007.

Kajembe, G. C.; Shemweta, D. T. K.; Luoga, E. J. and Nduwamungu, J. (2004). Incentives for Sustainable Forest Management in Tanzania. In: *Institutions, Incentives and Conflicts in Forest Management. Proceedings of the IFRI East African Regional Conference.* (Edited by Shemwetta, D. T. K. *et al*.), 12 - 13 January 2004, Moshi, Tanzania. pp. 80-91.

Kajembe, G. C.; Luoga, E. J.; Kijazi, M. S. and Mwaipopo, C. S. (2003). 'The role of traditional institutions in the conservation of forest resources in East Usambara, Tanzania', *International Journal of Sustainable Development & World Ecology*, 10: (2) 101 - 107.

Kajembe, G. C. (1994). Indigenous Management Systems as a basis for Community Forestry in Tanzania. A Case of Dodoma Urban and Lushoto Districts. Tropical Resource Management Paper No. 6 Wageningen Agricultural University, The Netherlands 194pp.

Kent, M. and Coker, P. (1992). *Vegetation description and analysis. A practical approach.* Belhaven Press, 25 Floral Street, London. 363pp.

Kessy, J. F. (1998). Conservation and Utilization of Natural Resource in the Eastern Usambara Forest Reserve: Conventional view and local perspectives. Tropical Resource Management Paper no.18. Wageningen Agriculture University, Wageningen, The Netherlands. 168pp.

Kijazi, M. S. (2007). Impact of Joint Forest Management on resource base and livelihood on Community in Amani Nature Reserve, Muheza district, Tanzania. . Dissertation for the Award of MSc Degree of Sokoine University of Agriculture. Morogoro, Tanzania. 99pp.

Killenga, R. R. (2007).Effect of human disturbance on endemic and threatened plant species in Amani Nature Reserve, Muheza District, Tanzania. Dissertation for the Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 157 pp.

Kimberly, A. (2011). *The content analysis guide book.* [http;//en. wikipedia.org/wiki/content _ analysis].Content analysis – wikipedia, the free encyclopedia. Site visited on 03/5/2011.

Kindt, R.; Simons, A. J. and Van Damme, P. (2004). Do Farm Characteristics Explain Differences in Tree Species Diversity Among Western Kenyan Farms? *Kluwer Academic Publishers. Printed in the Netherlands. Agroforestry Systems* 63: 63–74.

Krebs, C. J. (1989). *Ecological methodology*. Harper Collins Publishers, New York, 554pp.

Leakey, R. R. B. and Simon, A. J. (1998). 'The domestication and commercialization of indigenous trees in agroforestry for the alleviation of poverty', *Agroforestry Systems* 38:165–176.

Leakey, R. R. B.; Tchoundjeu, Z.; Schreckenberg, K.; Shackleton, S. and Shackleton, C. (2005). Agroforestry Tree Products (AFTPs): Targeting Poverty Reduction and Enhanced Livelihoods. *International Journal of Agricultural Sustainability* **3**:1-23.

Leakey, R. R. B. (2010). Should we be growing more trees on farms to enhance the sustainability of agriculture and increase resilience to climate change? *Special report, agroforestry and Novel Crops Unit, School of Marine and Tropical Biology, James Cook University, Cairns, Australia.*

Lines, E. R.; Coomes, D. A.; and Purves, D. W. (2010). Influences of Forest Structure, Climate and Species Composition on Tree Mortality across the Eastern US. PLoS ONE 5(10): e13212. doi:10.1371/journal.pone.0013212.

Logomo, O. E. (2009). Community perception of on-farm trees and adjacent natural forest status under participatory management: Dodola District, Ethiopia.

Dissertation for Award of MSc Degree at Hawassa University, Wondo genet College of Forestry and Natural Resources, Wondo genet, Ethiopia. 109pp.

Lulandala, L. L. L. (1998). Meeting the needs of the people through species domestication. A basis for effective conservation of the Eastern arc Mountains forest biodiversity.*Journal of Eastern Africa Natural history.* 87: pp. 243-252.

Madoffe, S. S.; Hertel, G.; Rodgers, P.; O'connel, B. and Killenga, R. (2006). Monitoring the Health of selected Eastern Arc Forest in Tanzania. *Africa Journal of Ecology.* 44:171-177.

Makawia, N. (2003). Contribution of Agroforestry to human nutrition: A case study of Maji ya chai and Kisongo in Arusha Region. Tanzania. Dissertation for Award of MSc Degree at Sokoine University of Agriculture. Morogoro, Tanzania. 115pp.

Mallya, B. S. (2003). Effect of selective logging on structure and composition of montane rain forests of the ANR, East Usambara, Tanzania. A special report submitted on partial fulfilment of BSc. Degree at Sokoine University of Agriculture (SUA). Morogoro, Tanzania. 42pp.

Malundo, C. G. H. (2008): The impact of incentive on participatory forest management in East Usambara Mountains, Tanga, Tanzania. Dissertation for the Award of MSc Degree at Sokoine University of Agriculture. Morogoro, Tanzania. 156pp.

Mangaoang, E. O. and Pasa, A. E. (2003). Preferred Native Tree Species for Smallholder Forestry in Leyte. Annals of Tropical Research 25(1):25-30. Baybay, Leyte, Philippines.

Martin, G. J. (2004). *Ethnobotany: A method manual*. Botanic Garden, Kew. UK. Chapman and Hall Press. 268pp.

Mbeyale, G. E. (1999). Socio-economic assessment of the factors influencing building poles consumption, conservation and management of Amani Forest Nature Reserve.Dissertation submitted in partial fulfillment of the requirements for the Degree of Master of Sience (Forestry) of Sokoine University of Agriculture. Morogoro. 119pp.

Methew, M. M. (2009). Impact of forestland tenure changes on forest resources in part of Amani Nature Reserve, Tanzania. Dissertation submitted in partial fulfillment of the requirements for the Degree of Master of Sience (Forestry) of Sokoine University of Agriculture. Morogoro. 87pp.

Mettrick, H. (1993). *Development Oriented Research in Agriculture*. ICRAF Text Book. Wageningen, The Netherlands. 287pp.

Misra, C. K. (1989). *Manual of Plant Ecology*. Oxford and IBA Publishing Co., New Delhi. 491pp.

Ministry of Natural Resources and Tourism (MNRT) (2000). *Amani Nature Reserve General Management Plan 2000 -2003*. Forestry and Beekeeping Division and Department of International Co-operation, Finland 128pp.

Ministry of Natural Resources and Tourism (MNRT), (2001). National Forest Programme. Government printer. Dar-Es-Salaam, Tanzania. 134pp.

Ministry of Natural Resources and Tourism (MNRT), (2005). *Forest condition assessment of the Eastern Arc Mountains Forests of Tanzania.* Compiled by Madoffe, S.S. and P.K.T. Munishi for Conservation and Management of the Eastern Arc Mountain Forests, Forestry and Beekeeping Division, Dar es Salaam.

Ministry of Natural Resources and Tourism (MNRT), (2008). Participatory Forest Management: - Facts and Figures, Forestry and Beekeeping Division, Dar es Salaam, Tanzania. 13pp.

Monela, G. C. and Kihiyo, V. B. M. S. (1999). Wood energy in Sub-Saharan Africa. Pp.153-160. In Palo, M. and Uusivuri, J. (Eds). World forests, society and environment. Kluwer Academic Publishers, Dordrecht, The Netherlands. 404pp.

Mugasha A. G.; Chamshama S .A. O. and Gerald V. V. K. (2005). Indicators and Tools for Restoration and Sustainable Management of Forests in East Africa: - *I-TOO working paper No. 3 State of Forests and Forestry Research in Tanzania. 66pp.*

Munishi, P. K. T. (2001). The Eastern Arc Mountains Forests of Tanzania: Their role in Biodiversity, Water Resource Conservation, and Net contribution to Atmospheric Carbon. PhD Dissertation. pp. 28-29.

Munishi, P. K. T.; Philipina, F.; Temu, R. P. C. and Pima, N. (2008). Tree species composition and local use in agricultural landscapes of west Usambaras, Tanzania. African *Journal of Ecology.* 46 (Suppl. 1), 66–73.

Munishi, P. K. T.; O’Kting’ati, A.; Monela, G. C. and Kingazi, S. P. (2004). Small holder forestry for employment, income generation and rural development in Tanzania. *Journal of Tanzania Association of Foresters (TAF*) **(10):** 49-63.

Munishi, P. K. T.; Mbwambo, L.; Shirima, D. and Edward, E. (2009). Forest Based Enterprises and Extent of Trade in Non-Timber Forest Products (NTFPs) in Iringa and Mbozi, Southern Highlands of Tanzania. (Edited by Nshubemuki, L. *et al.*), 15^{th} - 16^{th} December 2008, Morogoro, Tanzania. pp. 36-44.

Munishi, P. K. T.; Philipina, F. and Temu, R. P. C. (2006). On – Farm Tree Resources for on farm tree retention and management in Bumbuli ward, Lushoto district North Western Tanzania. In: *Proceedings of the second National Agroforestry and Environmental Workshop.* (Edited by Chamshama, S.A.O. *et al*.), June 2006, Morogoro Tanzania. 188-198pp.

Munyanziza, E. (1998). Domestication of Mushrooms from the Miombo Woodlands: *Current status and crucial issues for Agroforestry*. FAO publications. Sokoine University of Agriculture. Morogoro, Tanzania pp. 206 – 211. http//www.greenstone.org/greenstone 3/nzdl;js site visited 20.7.2011.

Nair, P. K. R. (1993). *An Introduction to Agroforesty.* Kluwer Academic Publishers, Dordrecht, The Netherlands. 500pp.

Nath, T. K. and Inoue, M. (2010). Impacts of Participatory Forestry on Livelihoods of Ethnic People: Experience from Bangladesh, Society & Natural Resources, **23:11**, 1093-1107.

Norusis, M. J. (1990). *SPSS/PC + Advanced Statistics* ™ 4.0 for the IBM PC/XT/AT and PS/2.SPSS Inc. USA. http//www.srcosmos/generic_pinakas.aspx?pinakas. Site visited 24/5/2011.

Pampel, F. C. (2000). *Logistic regression: A primer. Quantitative Applications in the Social sciences.* Thousand Oaks, CA: Sage. 96 pp.

Pima, N. E. (2009). Plant species composition and restoration potential through soil seed bank in Zaraninge and Mbwebwe coastal forests, Bagamoyo District, Tanzania. Dissertation for the Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 61pp.

Philippi, T.; Dixon, P.M. and Taylor, B. M. (1998). *Detecting trends in species composition*. *Ecological Applications* 8:300-308. http//www.ug.edu/srel/Reprint/2265.htm site visited 2/7/2011.

Poate, C. D. and Daplyin, P. C. (1993). *Data for Agragarian Development*. Wye studies in Agricultural and Rural Development. Cambridge University Press, UK. 387pp.

Powers, D. A. and Xie, Y. (2000). *Statistical Methods for Categorical Analysis* Academic Press, London. 305pp.

Ramadhani, T.; Otsyina, R. and Franzel, S. (2002). Improving household incomes and reducing deforestation using rotational woodlots in Tabora District, Tanzania. *Agriculture, Ecosystems and Environment* 89:229–239pp.

Regmi, B. N. (2003). Contribution of agroforestry for rural livelihoods: *A case of Dhading District, Nepal. Paper presented at International Conference on Rural Livelihoods, Forests and Biodiversity*. Bonn, Germany 19-23 May 2003, 19pp.

Regmi, B. N. and Garforth, C. (2010). Trees outside forests and rural livelihoods: a study of Chitwan District, Nepal. *Journal of Agroforestry System* 79:393–407.

Reyes, T. (2008). *Agroforestry system for sustainable livelihoods and Improved land management in East Usambara Mountains*, Tanzania. Tropical Forestry Reports. Viikki Tropical Resources Institute (VITRI) 166pp.

Robinson, E. J. Z. and Kajembe G. C. (2009). Changing Access to Forest Resources in Tanzania. Environment for Development. Discussion Paper Series April 2009 EfD DP 09-10. 25pp.

Ross, S. (2010). Medicinal plants in Lushoto: protecting wild plants to protect health. *Journal of Eastern Arc* 25: 27-30.

Sangeda, A. Z.; Malende, Y. H. M. B.; Nzunda, E. F.; Malimbwi, R. E. and Scheer, L. (2001). *Determination of Suitable shape and Plot size for estimation of off-forest tree resources* in Machame, Moshi-Tanzania. *Acta Facultatis. Zvolen*. XL III. 287 – 294.

Schulman, L.; Junikka, L.; Mndolwa, A. and Rajabu, I. (1998). *Trees of Amani Nature Reserve, Tanzania.* Ministry of Natural Resource and Tourism, Dar es Salaam. 335pp.

Shylajan, C. S. and Mythili, G. (2003). Community Dependence on Protected Forest Areas: A Study on Valuation of Non-Wood Forest Products in a Region of India1. *Sri Lankan Journal of Agricultural Economics.* 5: 97 - 122.

Sutton, W. R. J. (1999). Does the world need planted forests? Paper presented at the "*Intersessional expert meeting on the role of planted forests*". Plantation Focus Limited, 24 Kerswell Terrace, Rotorua, New Zealand. Santiago, Chile. 6-9th April 1999. 14pp.

Swallow, B.; Boffa, J. M. and Scherr, S. J. (2006). The potential for agroforestry to contribute to the conservation and enhancement of landscape biodiversity. World Agroforestry Centre into future. http:/www.worldagroforestr.org/downloads/ publication/pdf,bc 0646.pdf. Site accessed on 25/3/2011.

URT. (1999). Speech of the Minister of Natural Resources and Tourism Hon. Zakia Hamdan Meghji (MP) to the Parliament Budget of 1999/2000. Government Printer, Dar es Salaam, Tanzania.

URT. (2002). Population and Housing Census. Tanga regional profile. http://www.tanzania.go,tz/region. Site visited 10/9/2011.

URT. (2003). *Resource Economic Analysis of Catchment Forest Reserves in Tanzania*. Ministry of Natural Resources and Tourism. Forestry and Beekeeping Division. Dar es Salaam, Tanzania. Government Printer. 222pp.

Weber, J. C.; Montes, C. S.; Vidaurre, H.; Dawson, I. K. and Simons, A. J. (2001). 'Participatory domestication of agroforestry trees: an example from the Peruvian Amazon', *Development in Practice*, 11(4):425 – 433.

World Agroforestry Centre (2007). Agroforestry science at the heart of the three environmental conventions. In: *Tackling global challenges through Agroforestry*, Annual Report 2006. Nairobi, Kenya.

APPENDICES

Appendix 1: Questionnaire for household survey

Date of interview………………..………………… Name of enumerator ………………….…………
Village ………………………..……..Ward……….………………. Division ……………….………
Household ID/No …………………………………………………………………………………….

GENERAL INFORMATION

1. Name of the household head/Respondent ……………………..………..…..………….……….
2. Gender: -Female …………………………….……..... Male ……………………………….……..
3. Age ………..………………….… 4. Ethnicity……………………………..……….…………………
5. Social position (i) Common person………..…. (ii) Ten cell leader..…………....., (iii) Village leader……………...…(iv) Religious leader…………..….. (v) Others (specify)…………………….…
6. Years of residence in the village……………………………………………………………………….
7. Total number HH member (i) Under 18 yrs……… (ii) Middle aged (18-55yrs) …… (iii) Adult (above 55yrs)……………………………………………………………………………….…………
8. Marital status. Single………… Married…………..…. Separated……………..….. Divorced……………………………………….……….… Widowed……….………………………….
9. Religious: Christian………../Muslim……………………...…….Others……………………………
10. What are major occupations of the household members?

Family member	Occupation	Period of work	Income level
Husband			
Wife			
Children(1)			
Children (2)			
Children (3)			
Others (1)			
Others (2)			
Others (3)			

NB: - Occupation can be farmer, tea plucker, driver, Livestock attendant, Shopkeeper, Business, Employee either government, NGOs, or private

11. Educational level of member of family

Family member	SEX	AGE(yrs)	Education Level
1			
2			
3			
4			
5			
N^{th}			

NOTE:- Include male and female children, adult, dependants and all relatives living in the house

SECTION B. Tree Species Composition, Structure, and Richness of Tree on Farms

12. Are all trees retained or planted in farms useful for your daily basis?
    (i) Yes
    (ii) No
    (iii) Not sure
13. How frequent do you plant tree?
    (i) Every season
    (ii) Every year
    (iii) Others (mention)

14. Which species are commonly found/retained/planted in farms and why

Species	Planted	Retained	Reason	Seed sources

SECTION C. TREE SPECIES PREFERENCE AND USES

15. Can you please tell for day to day wood consumptions where do you get the forest products?
    (i). Forest (ANR)
    (ii) Farm lands
    (iii). Others (specify)

16. Among the following product which is preferred species and area of collection

Product	Species name	Forest	Farmland	Forest &Farm
Fuelwood				
Charcoal				
Poles				
Timber				
Withies				
Furniture				
Mortars/pestle				
Hand tools				
Walking sticks				
Snares				
Beehives making				
Hang bee apiary				
Others (1)				
Others (2)				

17. In the following table, which species are more preferred for commercial purposes?

Products	Species name	Source area	Part used	Earnings (shs) /year
Fuelwood				
Charcoal				
Timber				
Poles				
Handle tools				
Kitchen tools				
Tree seedling				
Tree seeds				
Spices				
Jack fruits				
Mangoes				
Walking sticks				
Bamboo products				
Mushrooms				
Fodder				
Medicine (1)				

18. How preferred tree species are intercropped with food crops…..……
19. Which tree species are preferred and more specific to support climber crops (Black pepper, passion fruits)? ....
20. Which species are planted specifically for providing shade, bee and butterfly foods…….…………..…
    …………………………………………………………………………..……..…………..……………

21. Which source of energy do you use in your HH for cooking and heating? Firewood…………….… Charcoal………………..… crop residues………………………Others (specify)…………………...

Section D. Access and Extracted/Removed Forest Resources from ANR

22. Which among the following products do you access and utilize from the forest:

Type of products	Local Name	Uses	Before Tree planting	After tree on farm
Vegetables				
Firewood				
Wild fruits				
Wild nuts				
Wild animal				
Medicine				
Mushroom				
Ropes				
Poles				
Withies				
Timber				
Others				

23. How often do you acquire these products
    (i) Once a week, (ii)Twice, (iii). More (specify)
24. What is your opinion on easiness or any difficulties in obtaining these materials
    (i) Easy (ii) Moderate (iii) Difficult
25. Is there any effort of making alternatives of the products obtained to ensure sustainability?
    (i) Yes (ii) No
26. If yes mention them…………………………………………………………………………………...

NB: Alternative efforts can be tree planting for building poles, firewood production, brick making, fuel saving stoves construction and using, vegetable and fruit gardens and others

27. What type of forest products which were easily obtained before but now are hardly found in ANR?
28. What is your opinion on products that are hardly or not found from the ANR …………………..
    (May be can planted in farms, increase protection effort of the remaining)
29. Are on-farm wood materials sustains household requirements?
    (i) Yes (ii) No
30. If not where do you get wood supplements
    (i) Purchasing from others
    (ii) From ANR
    (iii) Others
31. What is your general observation on availability of forest products before and after tree planting campaign?
    (i) Plenty
    (ii) Moderate
    (iii) No idea

Appendix 2: Sample questionnaire with relevant questions

A: Sample questionnaire for villagers (Focussed Group Discussion)**.**

1. Perspective of tree planted /retained, intercropping with crops or in patches or woodlots in farm.
2. Situation in forest and society in terms of threats before and after tree planting in farms
3. Most tree preferred for domestic use /commercial and initiatives of tree planting/ conserving on-farms
4. Availability and use of forest tree resources in terms of wood and NWFR
5. Strength and weakness forest management agreements between government and villages
6. What about income gain to tree farmers comparing to non-tree farmers.
7. What other source of income to local communities
8. What is the main source of wood for building, cooking, body heating, furniture, supporting old people and others for most villagers
9. What type of forest products needed but are inadequately found in farmland?
10. What factors encouraging tree planting / retention and distribution in farm
11. Are the material from farm land surfaces the demand of people

B: TREE RESOURCE USERS
1. Types of wood-based industries
2. Source of material and its adequacy
3. Are there any restrictions in acquiring materials both in land and forest reserve.
4. Source of market and price fluctuation
5. Ownership of land and tree plantation
6. Preference of wood material for your industry and their source

C: ANR Conservator, District forest and natural resources office (DFO and DNRO)
1. Collaboration between District Catchment Forest Office (DCFO) and DFO/DNRO
2. Tree planting Programs in relation to PFM in villages bordering forest reserves
3. Tree planting campaign, records, species diversification over past 30 yrs record
4. Potentials of on-farm trees and its impact to sustainability of forests
5. Type of tree species domesticated many farmlands (Indigenous, Exotic)
6. The silvicultural management guidelines and the compatibility of tree in food crops
7. Record of tree planted and survival over past ten 10 yrs

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
N/Trees planted										
No survival										

Revenue accrued by the district council, village government and individual farmer from on farm

D: Regional Natural Resources Office-Secretariat
1. Link/coordination between regional and district forest offices
2. Institutional setup and future plan on management of trees on farms in the region
3. Capacity building on forest management at district level
4. Coordination with NGOs promoting tree planting at district &Region level
5. Regional support on tree planting for farmers, central and local government forests
6. Contributions of tree planted on farms towards conservation and parallel structures of local and central governments.

E: Regional and district catchment forest offices

1. Past and current management strategies and their differences
2. Existing forest management threats and potentials
3. Potentials of on-farm trees and its impact to sustainability of forests
4. Training need on silvicultural guidelines and tree selection for villagers.
5. Tree planting campaign, survivals and documentation over past 30 yrs
6. Cost and benefit sharing mechanism between government and communities
7. Sustainability of income generating sources and alternative use of forest resources
8. Improvement in reserved forest and society since tree planting on farms. Comments and future prospects

Appendix 3: List of tree species and their uses in villages surrounding ANR

Code	Vernacular name	Botanical name	Family	Uses
1	Mgunga	*Acacia nilotica*	Mimosaceae	Firewood, charcoal, poles, toolhandle, carvings, medicine (root), stimulant (bark), fodder, bee-forage, shelterbelt, soil improvement, dye, toothbrush
2	Mti kivuli	*Acrocarpus fraxinifolius*	Caesalpiniaceae	Firewood, timber(furniture, boat, boxes for tea and fruits), roof shingles, bee hives, bee forage
3	Mshai	*Albizia gummifera*	Sapotaceae	Firewood, Charcoal, timber (furniture, tea boxes), utensils (mortars, water troughs) poles, posts, beehives, medicine(pods, bark, roots), fodder (leaves), shade, ornamental, soil conservation, nitrogen fixation.
4	Mshai mamba	*Albizia schimperiana*	Sapotaceae	Firewood, Charcoal, timber, poles, posts, tool handle, bee forage, medicine(leaves), Medicine, shade, soil conservation, nitrogen fixation.
5	Mkingu	*Albizia versicolor*	Sapotaceae	Timber (furniture, boat), firewood, poles, charcoal, toolhandles, medicine (root, bark), bee-hives,shade
6	Msambu	*Allanblackia stuhlmannii*	Clusiaceae	Food (oil from seeds), fodder (fruits), Medicine (leaves for cough and chest pain, roots and leaves are taken to treat impotense, oil treats rheumatism), timber (furniture, boxes, creates, bee-hives, bee forage, fodder (flowers taken by goats 8 wild animal)
7	Mkorosho	*Anacardium accidentale*	Anacardiaceae	Food (fruits [juice, ligour,wine,jam], seed/nuts), medicine. Firewood, charcoal, posts, shade, ornamental
8	Msaa-mti (msala)	*Anisophyllea obtusifolia*	Anisophylleaceae	Firewood, poles
9	Mstafeli	*Annona muricata*	Annonaceae	Food(fruits), drink, medicine, ornamental, insects, fish poison
10	Mtopetope	*Annona squamosa*	Annonaceae	Food(fruits), drink, ornamental, insects,windbreak
11	Mpumu	*Anthocleista grandiflora*	Loganiaceae	Medicine(root, bark), bee foraging, bee-hives, veneer/plywood, pit-latrine sleepers
12	Mkuzu	*Antiaris toxicaria*	Moraceae	Veneer/plywood, fire wood, Tmber (canoe, boat), rubber(latex), poison (in fishing, arrow)balls and bird-lime, bee forage
13	Ubani	*Araucaria cunninghamii*	Araucariaceae	Ornamental, timber (furniture, boxes, rofing), firewood, wind break
14	Mfenesi	*Artocarpus heterophyllus*	Moraceae	Food (fruits, seed), firewood, charcoal, timber (furniture, carts, lorry bodies, doors, window), medicine, building pole, tool handles, mortars, tooth brush (young shoots) , gum, shade
15	Mwarobaini	*Azadirachta indica*	Meliaceaee	Insecticide (azadirachtin in leaves), oil (seed), soap(seed oil), bee forage, shade, windbreak, ornamental, soil conservation

Code	Vernacular name	Botanical name	Family	Uses
16	mfimbo	*Beilschmiedia kweo*	Lauraceae	Timber(furniture, panelling, sleepers), veneer, firewood, building poles, charcoal, tool handles, mortar
17	Mzinda nguuwe	*Blighia unijugata*	Sapindaceae	Wild boar/pig traps, poles, walking stick, bee forage, firewood, charcoal, toolhandle, pestle and mortars
18	Mwiza	*Bridelia micrantha*	Euphorbiaceae	Timber, food(fruits), firewoood, charcoal, dye, bee forage(source of nectar)
19	Mshawa	*Caesalpinia pulcherrima*	Caesalpiniaceae	Ornamental, live fence, medicine (leaves, flowers, roots), Bird forage, Bee forage, ink (charred wood)
20	mkaliandra	*Calliandra calothyrsus*	Mimosaceae	Fodder (leaves, shoots), firewood, Bee forage, mulch, green manure, soil conservation, nitrogen fixation, ornamental shade, Live fence, windbreak
21	Mkokoko	*Casearia engleri*	Ulmaceae	Firewood, shade, mulch, Soil conservation.
22	Mvinje	*Casuarina cunninghamiana*	Casuarinaceae	Timber (railway sleepers, outdoor furniture), poles, shingles, fuelwood, charcoal, yokes, posts.
23	Msedrela	*Cedrela odorata*	Meliaceaee	Timber (furniture, boat), firewood, poles, charcoal, toolhandles, medicine (root, bark), bee-hives,shade
24	Kimungwe /Mjambegha	*Celtis africana*	Ulmaceae	Firewood, toolhandle, bilding poles, shade, animal fodder
25	Mtambaa/ mtambala	*Cephalosphaera usambarensis*	Myristicaceae	Veneer/ Plywood, timber(boxes, furniture, Dye, bee hives, bee-forage
26	Kuti	*Chrysophyllum gorungosanum*	Sapotaceae	Firewood, timber(furniture, canoe), poles, tool handle
27	Mkwinini	*Cinchona hybrida*	Ruiaceae	Medicine (bark), firewood
28	Mdalasini	*Cinnamomum zeylanicum*	Lauraceae	Medicine forNticncer, anti-typhoid, antidyseptic (bark, leaves), bevarage (bark),
29	Mchungwa	*Citrus sinensis*	Rosaceae	Food (fruits), medicine
30	Mlimao	*Citrus limon*	Rosaceae	Food (fruits [juice, pickle, chutney,jam]), medicine (juice, roots. Leaves), Firewood (twigs, dead branches, perfume (oil), ornamental
31	Mchenza	*Citrus reticulata*	Rosaceae	Food (fruits), firewood, toolhandle.
32	Mnazi	*Cocos nucifera*	Arecaceae	Food/margarine (nuts), oils (in cosmetics), thatching roof(leaves), firewood (shells), timber, brooms(mid ribs of leave), ropes/carpet (fibrous layer of fruit), bee-hives (stem), utensils (shells), wine / arrack (cut inflorescences)
33	Msasani / mkwati	*Cola greenwayi*	Sterculiaceae	Timber, poles, pestle, firewood, food(fruits)
34	Mfufu/mzinga zinga	*Cordia africana*	Boraginaceae	Timber (furniture,drums, bee-hives, roof shingles, canoe, gongs), utensils (boxes, mortars), medicine (bark, roots) fodder, bee forage, shade, mulch
35	Mshunduzi	*Croton macrostachyus*	Euphorbiaceae	Firewood, timber, medicine, fodder, shade, bee forage, mulch, soil conservation

Code	Vernacular name	Botanical name	Family	Uses
36	Msaiprasi/mwangati	*Cupressus lusitanica*	Cupressaceae	Firewood, poles, timber (furniture, construction) post, ornamental, shade, windbreak, live fence, christmas tree
37	Mkwe	*Cynometra longipedicellata*	Caesalpiniaceae	Timber, building poles, firewood, charcoal, tool handle, sugercane juice squeezer
38	Mkaranga pori	*Desmodium species*	Papilionaceae	Food (seeds), medicine(liniment), ornamental
39	Mchikichi/ muwese	*Elaeis guineensis*	Arecaceae	Oil (fruit, seed), food (fruits), soap, baskets, medicine (root, leaves, stem, oil), broom, soil conservation, fibre (leaves)
40	Mzumba	*Englerodendron usambarense*	Caesalpiniaceae	Timber (furniture, construction), pestle, mortars, poles
41	Muungu magoma	*Erythrina abyssinica*	Anacardiaceae	Carvings, utensils(drum), mortar, carvings,mulch, bee hives, bee forage, medicine (bark, root), necklaces, curios(seed), ceremonies, sign stumps
42	Mkaratusi	*Eucalyptus species*	Myrtaceae	Firewood, charcoal, poles(powerline, fence), post, timber (construction, furniture, plywood and veneer), medicine (leaves), bee forage, windbreak, dermation of border
43	mdaa	*Euclea divinorum*	Ebenaceae	Medicine (root, bark, fruits), firewood, carvings, tool handle, timber(furniture)
44	Mkuyu	*Ficus sur*	Moraceae	Water conservation, Foods (figs), firewood, ball and bird-lime
45	Mkuyu	*Ficus vallis-choudae*	Moraceae	Food (figs, fruits, timber (cheap furniture, beer pots, boxes) mortar, beehives, cattlte trough, firewood, shade
46	Kilimboti	*Funtumia africana*	Apocynaceae	Balls and bird-lime, building poles, utensils (wooden cups, spoon)
47	Mbaridi	*Gliricidia sepium*	Papilionoideae	Shade, support climbing plants, Nitrogen fixation, soil conservation, mulch, firewood, live fence
48	Kihambie / mzonozono	*Greenwayodendron suaveolens*	Annonaceae	Building poles, toolhandles, firewood, utensils (spoon, comb) carvings
49	Mkabela / mchongoma	*Grevillea robusta*	Proteaceae	Timber (furniture,drums, bee-hives, canoe), utensils (boxes, mortars), veneer,charcoal, firewood, bee forage, shade, mulch , windbreak
50	Mromberombe	*Hallea rubrostipulata*	Rubiaceae	Indicator of ground water, protect water source, utensils(spoon)
51	Mkuntu	*Harungana madascariensis*	Clusiaceae	Dye, pestles, bee forage, firewood, poles, mulch, soil and water conservation
52	Mbarika	*Isoberlinia scheffleri*	Caesalpiniaceae	Timber, firewood, charcoal, Tool handle, sugercane juice squeezer
53	Mtondoro/mkangazi	*Khaya anthotheca*	Meliaceaee	Firewood, timber (furniture, panelling, boat building) post, flooring, medicine (bark), shade

Code	Vernacular name	Botanical name	Family	Uses
54	Mkaburi	*Jatropha curcas*	Euphorbiaceae	Support climbing crops, Medicine (purgative/laxative), windbreak, prevent soil erosion, illumination (Oil), making candles and soap, homecide, piscicide, and raticide. Also is living fence
54	Mpopoe/ Motomwaka	*Leucaena species*	Mimosaceae	Fodder (leaves, shoots), firewood,Bee forage, mulch, green manure, soil conservation, nitrogen fixation, ornamental shade, Live fence
55	makadamia	*Macadamia tetraphylla*	Proteaceae	Food (nuts), oils in cosmetics(nut), firewood, shade, charcoal (shells), timber, poles, bee-forage
56	Mkumba	*Macaranga capensis*	Euphorbiaceae	Firewood, shade, mulch, timber (boxes, crates), Soil conservation.
57	Mmea	*Maerua variifolia*	Capparidaceae	Food (tubers), Bee forage, ornamental
58	Mhesi	*Maesopsis eminii*	Rhamnaceae	Firewood, Timber (furniture, light construction), poles, veneer/plywood, shade (tea and cofee)
59	Mwembe	*Mangifera indica*	Anacardiaceae	Food (fruit, juice), firewood, fodder(leaves), bee forage, windbreak, shade, mulch, gum, dugout canoes,soil conservation
60	Ng'anga	*Maranthes goetzeniana*	Chrysobalanaceae	Timber(furniture, yokes, sleepers), firewood, building poles, food (fruits, kernal), charcoal, dye (bark), bee forage(source of nectar), shade, mulch
61	Mtalawanda	*Markhamia lutea*	Bignoniaceae	Firewood, charcoal, timber, furniture, boat, poles, posts, tool handle, bee forage, medicine(leaves), banana props
62	Mvule	*Milicia excelsa*	Moraceae	Timber (furniture, boat), firewood, poles, charcoal, toolhandles, bee-hives
63	Mlombelombe	*Morinda asteroscepa*	Rubiaceae	Carvings, utensils(drum), mortar, carvings,mulch, bee hives, bee forage, medicine (bark, root), necklaces, curios(seed), ceremonies, sign stumps
64	mkonde	*Myrianthus holstii*	Moraceae	Fruits, firewood, wooden cups, mulch, charcoal, windbreak, soil and water conservation
65	mnyasa	*Newtonia buchananii*	Mimosaceae	Timber(furniture, Canoe, sleepers), firewood, fodder(leaves, fruits/pod), charcoal, bee forage(source of nectar), shade, mulch
66	Mkulo	*Ocotea usambarensis*	Lauraceae	Timber, medicine(bark for malaria), poles, firewood
67	Banku	*Odyendea zimmermannii*	Meliaceaee	Timber (for light construction), plywood
68	Mbula/ muula	*Parinani excelsa*	Chrysobalanaceae	Food (fruits), firewood, charcoal, building pole, tool handles, mortars, tooth brush, carvings , bee forage, shade
69	Mparachichi	*Persea americana*	Lauraceae	Food (fruits), medicine (seed, leaves), timber, charcoal, oil (cosmets), shade.
70	Kogo/fumbati	*Polyscias fulva*	Araliaceae	Mortar and pestle, bee hives, utensils (Cup, bowl), timber (boxes, crates), mole trap

Code	Vernacular name	Botanical name	Family	Uses
71	Mpera	*Psidium guajava*	Myrtaceae	Food (fruits, jam, jelly, juice), medicine (bark, leaves, roots), firewood, shade, tool handles, posts, avenue, soil conservation
72	Mweeti	*Rauvolfia caffra*	Apocynaceae	Medicine (bark, roots), flavouring (bark for beer), firewood, bee forage, utensils (spoon, cup, bowl), shade for banana and cofee
73	Msase/ muhande	*Schefflerodendron usamberense*	Fabaceae	Firewood, charcoal, Timber (furniture, door), poles, shade, pestle, windbreak, bee forage
74	Mhande	*Scorodophloeus fischeri*	Caesalpiniaceae	Timber, poles, pestle, firewood
75	Mjohoro	*Senna siamea*	Caesalpiniaceae	Firewood, charcoal, Timber (furniture, door), poles, medicine (roots), fodder, shade, windbreak, bee forage
76	Mkongoo	*Shirakiopsis/ Sapium ellipticum*	Euphorbiaceae	Medicine, firewood, Soil and water conservationconservation
77	Mkwingwina	*Sorindeia madagascariensis*	Sapindaceae	Food (fruits), timber (furniture, door, spoon,), mortars, toolhandle, firewood, charcoal, poles, medicine (roots to cure tuberculosis and menstrual problems, bee forage
78	Kifabakazi	*Spathodea campanulata*	Bignoniaceae	Ornamental, windbreak, shade, medicine (bark), carving, Bee forage, firewood
79	Mgude/mfume	*Stercullia appendiculata*	Euphorbiaceae	Timber, plywood, food (seed), shade, ornamental, medicine (bark and leave of young plants to treat fever, and remedy of mental disorders), ropes and mats.
80	Mkande	*Stereospermum kunthianum*	Bignoniaceae	Firewood, poles, tool handle, carvings, medicine (bark,fruits), utensils (spoon), bee-forage,
81	Sangana / Msangana	*Strombosia scheffleri*	Olacaceae	Timber (furniture), firewood, charcoal
82	Mohoyo	*Synsepalum cerasiferum*	Sapotaceae	Timber, firewood, tool handle, food (fruits)
83	Msambia	*Synsepalum msolo*	Sapotaceae	Building poles, food (fruits), toolhandles, walking sticks, firewood, charcoal, utensils (spoon, comb), carvings, pestles, shade
84	Mkarafuu	*Syzigium aromaticum*	Myrtaceae	Food (seed for spices), medicine(liniment), firewood, poles, toolhandle
85	Mshiwi/ Zambarau	*Syzygium cuminii*	Myrtaceae	Firewood, charcoal, Timber (furniture, door, canoe), poles, posts, tool handles, carvings, medicine (bark, root, leaves), food (fruits), fodder, shade, windbreak, bee forage, tanin, dye
86	Mshihwi	*Syzygium guineense*	Myrtaceae	Firewood, charcoal, Timber (furniture, door, general construction), poles, posts, tool handles, carvings, medicine (bark, root, leaves), food (fruits), fodder, shade, windbreak, bee forage, tanin, dye
87	Mbwewe	*Tabernaemontana species*	Apocynaceae	Medicine (cancer), building poles, ornamental
88	Mtiki	*Tectona grandis*	Verbenaceae	Timber (heavy and light furniture, boat, building) poles, posts, firewood

Code	Vernacular name	Botanical name	Family	Uses
89	Mkungu	*Terminalia species*	Combretaceae	Ornamental, food(seed kernals), timber (boat), shade, tannin (fruit shell), Bird and Bee forage, wrapping material (leaves)
90	Mkakao	*Theobroma cacao*	Sterculiaceae	Food (fruits, seed[cocoa butter, stimulant],jelly, vinegar, alcohol), firewood, medicine, soil conservation, shade, fodder (fruit)
91	Mshinga/ Mshinda	*Trema orientalis*	Ulmaceae	Medicine(bark), Firewood, fodder(leaves, pods, seed), shade, bee forage, ornamental, mulch, nitrogen fixing, Dye (bark, leaves), oil(seed)
92	Mgoimazi	*Trichilia dregeana*	Meliaceaee	Firewood, poles, post, timber (furniture, boats), tool handle, medicine (leaves, bark root) ornamental, shade, Ornamental, soil conservation, oil, soap (seed)
93	Mgolemaji	*Trichilia emetica*	Meliaceaee	Firewood, poles, timber (furniture, boats), tool handle, medicine (leaves, bark root) ornamental, shade, soil conservation, oil, soap (seed), windbreak
94	Mzughu	*Trilepisium madascariense*	Moraceae	Food (fruits), Medicine (roots for remedy of impotence), timber (furniture, boxes), dye(red), building poles, tool handles, spoons, bedsteads, bow, gunstock, carvings, shade, ball and bird-lime
95	Mvilu	*Vangueria infausta*	Rubiaceae	Food (fruits, seedkernel), medicine (roots), handles, toys for children
96	Mnailo	*Xylopia aethiopica*	Annonaceae	Walking stick.firewood, poles, timber (furniture), tool handle, shade, Ornamental, soil conservation, windbreak
97	Mkwanga	*Zanha golungensis*	Sapindaceae	Medicine (bark for curing flu), firewood, bee forage,
98	Mfua kumbi	*Zanthoxylum deremense*	Rutaceae	Butterfly foraging (leaves), medicine (bark & roots), firewood, building pole, utensils (spoon, comb) carvings
99	Fulakumbi	*Zanthoxylum gilletii*	Rutaceae	Food (leaves, bark), medicine (bark & root) malaria, snake& scorpion bite, anaemia, oedema, body pain and sprains), firewood, pole, utensils(spoon, comb) carvings

Appendix 4: Most preferred trees for feeding butterflies

Tree species	Frequency	Percentage
Zanthoxylum giletii	25	20
Parinani excelsa	14	11
Cola usambarensis	15	12
Pauteria aldofi-fredericii	12	9
Bombax rhodognaphalon	3	2
Leptonichia usambarensis	12	9
Khaya anthotheca	18	14
Harungana madagascariensis	7	6
Zanthoxylum amaniensis	21	17
	127	**100**
Shrubs		
Vepris nobilis	25	24
Vepris amaniensis	14	13
Vepris gamiensis	10	9
Todalia asiatica	16	15
Deobolia asiatica	18	17
Zanthoxylum deremensis	23	22
	106	100

Appendix 5: Medicinal plants used mainly found in ANR.

Sambaa name	Botanical name	Frequency	Percent
Mzughwa	*Coleus kilimandschari syn Plectranthus barbatus Andrews*	27	14.0
Mkwanga	*Zanha golungensis*	25	13.0
Mwarobaini	*Azadirachta indica*	19	9.8
Mzumbasha	*Ocimum suave*	17	8.8
Mkwinini	*Cinchona hybrida*	13	6.7
Hozandoghoi	*Hyptis pectnata*	12	6.2
Mpumu	*Anthocleista grandiflora*	11	5.7
Mkongoo	*Sapium ellipticum*	9	4.7
Mdongonyezi	*Toddalia asiatica*	8	4.1
Mzughu	*Trilepisium madascariense*	8	4.1
Mhasha	*Vernonia iodocalyx*	8	4.1
Fivi	*Artemisia afra*	8	4.1
Muuka	*Microglossa densiflora*	7	3.6
mweeti	*Rauvolfia caffra*	6	3.1
Fulakumbi	*Zanthoxylum gilletii*	4	2.1
Mshinga	*Trema orientalis*	4	2.1
Mtango	*Spilanthes mauritiana*	4	2.1

Appendix 6: Medicinal plants species with % respondents uses

Sambaa name	Botanical name	Frequency	Percent
Mzughwa	*Coleus kilimandschari syn Plectranthus barbatus*	27	14.0
Mkwanga	*Zanha golungensis*	25	13.0
Mwarobaini	*Azadirachta indica*	19	9.8
Mzumbasha	*Ocimum suave*	17	8.8
Mkwinini	*Cinchona hybrida*	13	6.7
Hozandoghoi	*Hyptis pectnata*	12	6.2
Mpumu	*Anthocleista grandiflora*	11	5.7
Mkongoo	*Sapium ellipticum*	9	4.7
Mdongonyezi	*Toddalia asiatica*	8	4.1
Mzughu	*Trilepisium madascariense*	8	4.1
Mhasha	*Vernonia iodocalyx*	8	4.1
Fivi	*Artemisia afra*	8	4.1
Muuka	*Microglossa densiflora*	7	3.6
mweeti	*Rauvolfia caffra*	6	3.1
Fulakumbi	*Zanthoxylum gilletii*	4	2.1
Mshinga	*Trema orientalis*	4	2.1
Mtango	*Spilanthes mauritiana*	4	2.1
Mkulungo	*Terminalia zambesiaca*	3	1.6
Mgolemaji	*Trichilia emetica*	3	1.6
Mdaa	*Euclea divinorum*	2	1.0
Mgunga	*Acacia nilotica*	1	0.5
Mkaranga mti	*Desmodium species*	1	0.5
Mbwewe	*Tabernaemontana species*	1	0.5

Appendix 7: Tree planting record: Tanga Region from 2005 to 2009

Tree planting data was summarised in tabular form, comprising eight districts councils in the region. The tree planted include that was deliberately planted by government forest projects (Shume/magamba, Longuza, National Tree Seeds Agencies, TAFORI), Nature Reserves, NGOs like the green resource (Pangani), TFCG and various private companies like East Usambara Tea Company. It also include tree planted by various communities like churches, group of people and individual farmers.

YEAR 2005/2006

S/N	District	Target	Achiement	Survival	Achieved %
1	Kilindi	361 860	325 860	290 860	
2	Handeni	15 000	936 940	702 705	
3	Korogwe	1 500 000	565 115	500 200	
4	Lushoto	1 500 000	2 568 750	1 926 563	
5	Mkinga	1 500 000	205 756	154 000	
6	Muheza	1 000 000	2 063 073	1 753 610	
7	Pangani	100 000	65 000	56 550	
8	Tanga	1 000 000	684 000	526 680	
Total		6 976 860	7 414 494	4 003 558	

YEAR 2006/2007

S/N	District	Target	Achiement	Survival	Achieved %
1	Kilindi	1 500 000	2 356 000	2 006 000	
2	Handeni	1 500 000	988 500	741 375	
3	Korogwe	1 500 000	1 584 470	1 327 000	
4	Lushoto	1 500 000	2 405 700	1 804 276	
5	Mkinga	1 500 000	298 161	223 000	
6	Muheza	1 500 000	2 043 615	1 839 254	
7	Pangani	1 500 000	1 801 287	1 657 184	
8	Tanga	1 500 000	1 200 000	900 000	
Total		12 000 000	12 677 733	8 435835	

YEAR 2007/2008

S/N	District	Target	Achiement	Survival	Achieved %
1	Kilindi	1 500 000	2 150 000	2 115 000	141
2	Handeni	1 500 000	1 260 154	945 115	63
3	Korogwe	1 500 000	950 000	950 000	63
4	Lushoto	1 500 000	2 509 000	1 881 750	125
5	Mkinga	1 500 000	578 230	433 000	29
6	Muheza	1 500 000	2 520 000	2 318 400	155
7	Pangani	1 500 000	1 952 000	1 834 880	122
8	Tanga	1 500 000	1 115 000	838 250	56
Total		12 000 000	13 034 384	11 316 395	88

YEAR 2008/2009

S/N	District	Target	Achiement	Survival	Achieved %
1	Kilindi	1 500 000	2 278 200		
2	Handeni	1 500 000	750 500		
3	Korogwe	1 500 000	680 470		
4	Lushoto	1 500 000	2 500 000		
5	Mkinga	1 500 000	406 000		
6	Muheza	1 500 000	2 803 500		
7	Pangani	1 500 000	2 460 456		
8	Tanga	1 500 000	1350 000		
Total		12 000 000	13 229 126		

Appendix 8: Disturbance survey (Forest Plot) Collection Form

Date……………………………………….. Name of Recorder……………..……………………………………..………………
Village………………………. .Ward………………………
Division……………………….District………...………………………………….……..
Eastings……………………… Northings…………………. Vegetation type………..…..…………………..….…………………………………......

Plot no	No of Live			Number of Dying			No of Recent cut			No of Old cut			No Fallen trees and branches ≥5cm
	Trees	Poles	Sapling	Tree	Poles	Sapling	Trees	Poles	Sapling	Trees	Poles	Sapling	

Appendix 9: On - Farm Tree Survey (Village Forest Plot) Collection Form

Date………………………………… Name of
Recorder……………..…………………………………..………………………………………
Village……………………………… Ward………………………
Division…………………………..….District…..……...…………………….…...
Name of HH ………………………... Plot No ……………...……
Farm size ……………..…..……………………………….............................
Vegetation type….…………..……………………………………..
Main crops in farm……………………..…..…………………………...……...

Code	Local Name	Scientific Name	DBH	P. year	Local Uses	Comments

P. year = Planted year, Tree condition (check for any mgt like pruning, coppice, Pollard, crookedness, debarks for medicine or root digging).
Vegetation type look for Agroforestry, woodlot, border tree, fodder, fence or climber support