# FOREST COVER AND USE CHANGES UNDER DIFFERENT TENURE REGIMES: A CASE OF "NGITILI" IN MEATU DISTRICT, TANZANIA



BY

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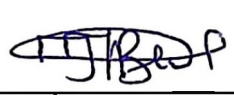
## ABSTRACT

Despite the fact that forestland tenure changes occurred in "Ngitili" management systems in Meatu district Tanzania, no study had been conducted to assess the impacts of these changes on forest cover, stocking, tree species diversity and use. This study was an attempt to address this knowledge gap. Spatial, biophysical, and socio-economic data were collected. The Spatial data were obtained through satellite imageries and ground verification using a hand held GPS. Biophysical data were collected through woodland inventory whereas socio-economic data were collected through PRA and a checklist. Spatial and biophysical data were analyzed by using ERDAS IMAGINE Software and MS-Excel computer programs respectively. Socio-economic data were analyzed with the help of the participants as well as through content and structural-functional techniques. Results show that open land, grassland, bushland and open forest decreased in favour of semi closed forest after tenure changes in both HASHI and outside HASHI Ngitili". The number of stems, volume and basal area per hectare outside HASHI "Ngitili" were 3197 stems/ha, 36.04$m^3$/ha and 6.92$m^2$/ha respectively. "Ngitili" under HASHI were found to have number of stems, volume and basal area per hectare of 1233 stems/ha, 20.24 $m^3$/ha and 6.8 $m^2$/ha respectively. No significant difference was observed in basal area and volume per hectare between HASHI and outside HASHI "Ngitili". Furthermore, fodder which was a dominant product in "Ngitili" for feeding young, seek and oxen animals before tenure change, changed dramatically to production of wide range of products and services including timber, thatching materials, hiring grazing rights, gums, firewood and medicinal herbs after tenure changes in both HASHI and outside HASHI "Ngitili". The study concludes by supporting the alternative hypothesis that, forest land tenure changes have significant impacts on forest cover and use. Furthermore species diversity was similar in HASHI and outside HASHI areas. The study recommends that, a follow up

study is needed to assess the impact of devolution on forest cover change in the future. Furthermore, economic analysis of the products emanating from "Ngitili" need to be done.

## DECLARATION

I, John Petro Bernardol, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and it has neither been nor concurrently being submitted for a higher a degree award in any other university.



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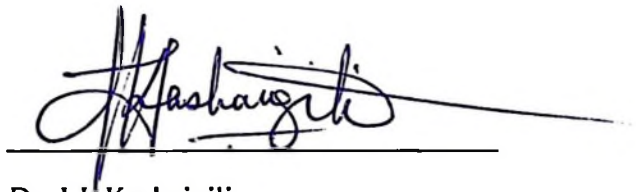

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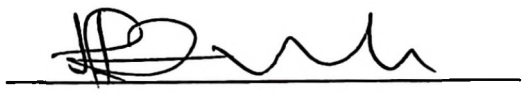

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## DEDICATION

This work is dedicated to all people who appreciate the little knowledge added to Science.

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## LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| C' | Index of dominance |
| cm | centimeter |
| Dbh | Diameter at breast height |
| DFO | District Forest Officer |
| DRC | Democratic Republic of Congo |
| FAO | Food and Agriculture Organization of the United Nations |
| FBD | Forestry and Beekeeping Division |
| G | Basal Area per Hectare |
| GIS | Geographical Information System |
| GPS | Global Positioning System |
| H' | Shannon Wiener Index of Diversity |
| HADO | Hifadhi Ardhi Dodoma |
| HASHI | Hifadhi Ardhi Shinyanga |
| ICRAF | International Centre for Research in Agroforestry |
| IUCN | International Union for Conservation of Nature (World Conservation Union) |
| km | kilometer |
| $km^2$ | square kilometer |
| m | meter |
| MNRT | Ministry of Natural Resources and Tourism |
| NAFRAC | Natural Forest Resources Management and Agroforestry Centre |
| NORAD | Norwegian Agency for Development Cooperation |
| NWFP | Non-Wood Forest Products |
| PRA | Participatory Rural Appraisal |

| | |
|---|---|
| SPM | Stems Per Hectare |
| SSA | Sub-Saharan Africa |
| TAS | Tanzania Shilling |
| TM | Thematic Mapper |
| $ETM^+$ | Enhanced Thematic Mapper Plus |
| URT | United Republic of Tanzania |
| $ | United States Dollar |
| V | Volume per hectare |

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background

It is estimated that 27% of 3.5 billion hectares of the earth's surface is covered by forests (FAO, 1999; Palo and Uusivuori, 1999). In Tropical Africa, forest covers 520 million hectares (FAO, 1999). In Tanzania, the total area covered by forests and woodlands is estimated to be about 34 million hectares about 38% of total land in the country (Malimbwi, 2002). Out of these, 33.5 million hectares classified as forest land, almost two third consists of woodlands on general lands. The area under private and community forestry is estimated to be 70 000 to 150 000 hectares including woodlots. About 600 000 hectares of the forests are owned and managed by Local Government.

The major challenge to the Tanzania's forest particularly in semi-arid and arid areas where water quality and quantity depends to a large extent on the forest cover is deforestation (MNRT, 2001). Deforestation can be defined as: "change of land use with depletion of tree crown cover to less than 10 percent (FAO, 1993). The most plausible average figure of deforestation in Tanzania is about 91 000 hectares per year. Before independence the forest cover was more than 50%. It gradually decreased to 45% in the late 1970s, to about 41% in the mid 1990s and to about 36% in the late 1990s (Luoga *et al.*, 2000). The underlying causes include shifting cultivation, overgrazing and rapid population growth. The natural vegetation of Meatu District historically consisted of Miombo and Acacia woodlands (Malcolm, 1953). However, extensive deforestation through shifting cultivation, tsetse flies and quellea quellea control campaigns in early 1920s and most recently extensive grazing, led to soil fertility decline, low crop yields, shortage of dry season fodder, scarcity of fuel wood, construction poles and severe wind and soil erosion

(MNTE, 1995). Early attempts of reforestation launched by Tanzania Government, the World Bank, and other agencies largely failed to stem the loss of woodlands and their impacts on communities in Shinyanga region. Top-down, bureaucratic management of projects meant that villagers had little involvement or stake in these efforts. In order to cope with shortages of fodder during dry season, the Sukuma developed indigenous fodder conservation system known as "Ngitili", which involves deferred and controlled grazing of natural rangelands (Mlenge, 2004).

The "Ngitili" (enclosure) system refers to a system of 'bush fallow' management in which areas of grazing land which have been 'closed' to livestock by either the village council or a private landowner are used to supply fodder in the dry season (Kilahama, 1994). This is an example of an indigenous silvopastoral technology for forest cover rehabilitation. Also it is a fodder bank system that the Sukuma use to conserve pasture for their livestock during dry season. It involves regeneration and conservation of indigenous trees on cropping and grazing lands (Kilahama, 1994). Two types of "Ngitili" are recognized, those which are owned by the community and those which are owned by individuals. The study conducted by Otysina (1994) in Shinyanga region indicated that 67% of the farmers own "Ngitili". He further reported that the system is widespread and common in all the districts in the region.

During the 1970s, the Socialist Government under the Late President Julius K. Nyerere adopted laws that increased communal ownership of rural land and encouraged people to live in discrete villages where services could be better provided; a programme known as "villagisation" (Mlenge, 2004). Individual Ngitili or enclosures, which many villagers had carefully sustained for food, fodder, fuel wood, and medicines, were no longer encouraged. Indeed, many "Ngitili" were destroyed during the period as the villagisation

programme undermined traditional institutions and practices (Monela *et al.*, 2004). This resulted into severe land degradation in Shinyanga region.

In 1986, because of the severe land degradation problems in Shinyanga region, the Government of Tanzania shifted tactics dramatically and launched people centered, community-based Shinyanga Soil Conservation Programme, popularly known as HASHI (Hifadhi Ardhi Shinyanga) (Otysina, 1994). The old traditional "Ngitili" practices were reintroduced to reverse the severe land degradation and deforestation by HASHI. From 1991, HASHI started receiving financial support from the Government of the Royal Kingdom of Norway through the Norwegian Agency for Development Cooperation (NORAD). At the same time, funding was also extended to Agroforestry research in collaboration with the World Agroforestry Centre (ICRAF) (Machanya *et al.*, 2003). HASHI worked in tandem and served as an extension arm of the HASHI/ICRAF research project by disseminating tested technologies such as management of woodlots and improved fallows (Machanya *et al.*, 2003).

**1.2 Problem statement**

Land tenure is the institutional (political, economic, social, and legal) structure that determines how individuals and groups secure access to land and associated land resources, including trees, minerals, pasture, and water, and who can hold and use these resources for how long and under what conditions. Land tenure may also have both spatial and temporal dimensions and are typically defined through statutory or customary laws (Abdallah, 2006). According to URT (1998), forestland has been categorized into state, common, private and open access tenure regimes. These property regimes were categorized for the purpose of enhancing better management and hence sustainability of forest resources. "Ngitili" which is regarded as traditional dry season fodder reserves

(Otsyina and Asenga, 1994) among the Sukuma of Tanzania, fall under private, communal and state tenure regimes.

Before 1970, ownership and access rights of "Ngitili" were governed under customary law. When the villagisation programme was introduced in 1970s, village governments took the lead in the "Ngitili" management. Most of the private/household "Ngitili" collapsed because of the Ujamaa notion "Ardhi ni mali ya umma" - that is land is a common property (Mlenge, 2002). Land reallocation led to loss of private "Ngitili". Private "Ngitili" was banned by the government in favour of communal "Ngitili" and gradually the traditional institutional arrangement for Ngitili management was abandoned (Marcolm, 1953). By 1976 individual Ngitili were to a large extent eroded in some villages in Meatu District (Monela *et al.*, 2004). This institutional failure resulted into increased pressure on land resources, exacerbated by settlements, villagisation programme, *tsetse* fly and *quellea quellea* eradication, rural poverty status, extensive agricultural practices coupled with uncontrolled grazing and fires, firewood, charcoal, timber production and natural catastrophes (Mlenge, 2002). These and other factors led to serious environmental degradation by the early 1980s forcing many people to leave the region in search of better grazing land for their livestock.

To counter the situation, the Government of Tanzania through Mwadui workshop held in 1984 came up with a resolution on environmental conservation; that the Ministry of Natural Resources and Tourism (MNRT) through Forestry and Beekeeping Division (FBD) introduced a conservation project in order to tackle the problem of severe land degradation (Machanya *et al.*, 2003). The Soil Conservation project (Hifadhi Ardhi Shinyanga- HASHI) project was launched in 1986 to restore forest cover in the land area which had been so degraded including the area under communal and private "Ngitili" in

Shinyanga Region. Among the areas which changed from communal to state under HASHI were "Ngitili" of Bulyanaga and Mwambegwa. Areas which changed from private to state under HASHI tenure regime were Mwamishali and Peri Urban 1 "Ngitili". Also, some areas changed from communal to Private tenure regime outside HASHI, including Mussa Sambe "Ngitili".

Despite all these changes in forestland tenure underlying "Ngitili" management system, no study had been conducted to assess forest cover and use change brought about by these tenurial changes in Meatu district thus this study intended to assess the forest cover and use changes under different tenure regimes underlying the "Ngitili" system in the study area.

**1.3 Justification of the study**

A crucial link between forests and sustainable development has been recognized in the Millennium Development Goals (FAO, 2001). The area of forest cover is one of the indicators for the 7$^{th}$ Goal "to ensure environmental sustainability" (FAO, 2001). On the other hand, examining stocking parameters in "Ngitili" (Number of stems per hectare, Basal area per hectare and Volume per hectare) definitely addresses the sustainable development concept that is 'Conservation with development'. The study contributes in filling the existing knowledge gap on the changes in forest cover brought by the forestland tenure changes in "Ngitili" under different tenure regimes. The study intended to generate baseline data on "Ngitili" characteristics and yield in terms of woodland stocking parameters (number of stems, volume and basal area per hectare). The data would be important and useful to various institutions, including: the Ministry of Natural Resources and Tourism, Academic Institutions and Local Governments. Other beneficiaries would be the international and national Organizations interested in forest conservation. Moreover the findings would be very useful to Natural Forest Resources Management and Agroforestry

Centre (NAFRAC) in understanding the impacts of the HASHI project in restoring the forest cover in Meatu District.

### 1.4 Objectives

#### 1.4.1 Overall objective

The overall objective of the study was to assess the forest cover and use changes under different tenure regimes in selected "Ngitili" of Meatu District.

#### 1.4.2 Specific objectives

The specific objectives of the study were:

(i) To assess forest cover changes in "Ngitili" under different tenure regimes

(ii) To examine stocking and tree species diversity in "Ngitili" under different tenure regimes; and

(iii) To assess forest use changes in "Ngitili" under different tenure regimes

### 1.5 Hypotheses

(i) $H_0$: Forest land tenure changes have no significant impacts on forest cover and use.

$H_1$: Forest land tenure changes have significant impacts on forest cover and use.

(ii) $H_0$: Forestland tenure type has no impact on forest stock and species diversity

$H_1$: Forestland tenure type has impact on forest stock and species diversity

(iii) $H_0$: There is no significant difference in stocking parameters between HASHI and outside HASHI "Ngitili"

$H_1$: There is significant difference in stocking parameters between HASHI and outside HASHI "Ngitili"

### 1.6 Conceptual framework

Conceptual framework provides guidance towards realistic collection of data and information (Mbwambo, 2007). Without theoretical framework to bind facts together, knowledge is fragmented into discrete segments (Mbwambo, 2007). Research performed without a conceptual framework is usually sterile for the reasons that the researcher does not know quite well what data to collect and he/she cannot put them to use (Kajembe, 1994).

Fig.1presents the conceptual framework underlying the study. It shows that, before 1986 Ngitili was under private and Communal tenure regimes. However change in tenure regimes took place in 1986 whereby some of the "Ngitili" which were under private and communal tenure regimes changed into state tenure regime under HASHI Project under the Ministry of Natural Resources and Tourism. In the light of this study, this involved the "Ngitili" of Bulyanaga and Mwambegwa which changed from communal to state tenure regimes (C-S). On the other hand, the "Ngitili" of Mwamishali and Peri urban 1 changed from private to state (P-S). Similarly some other "Ngitili" outside HASHI changed from communal to private tenure regimes as a consequence of out migration of some clan members. Those who remained behind reclaimed the degraded "Ngitili" and hence became private property.

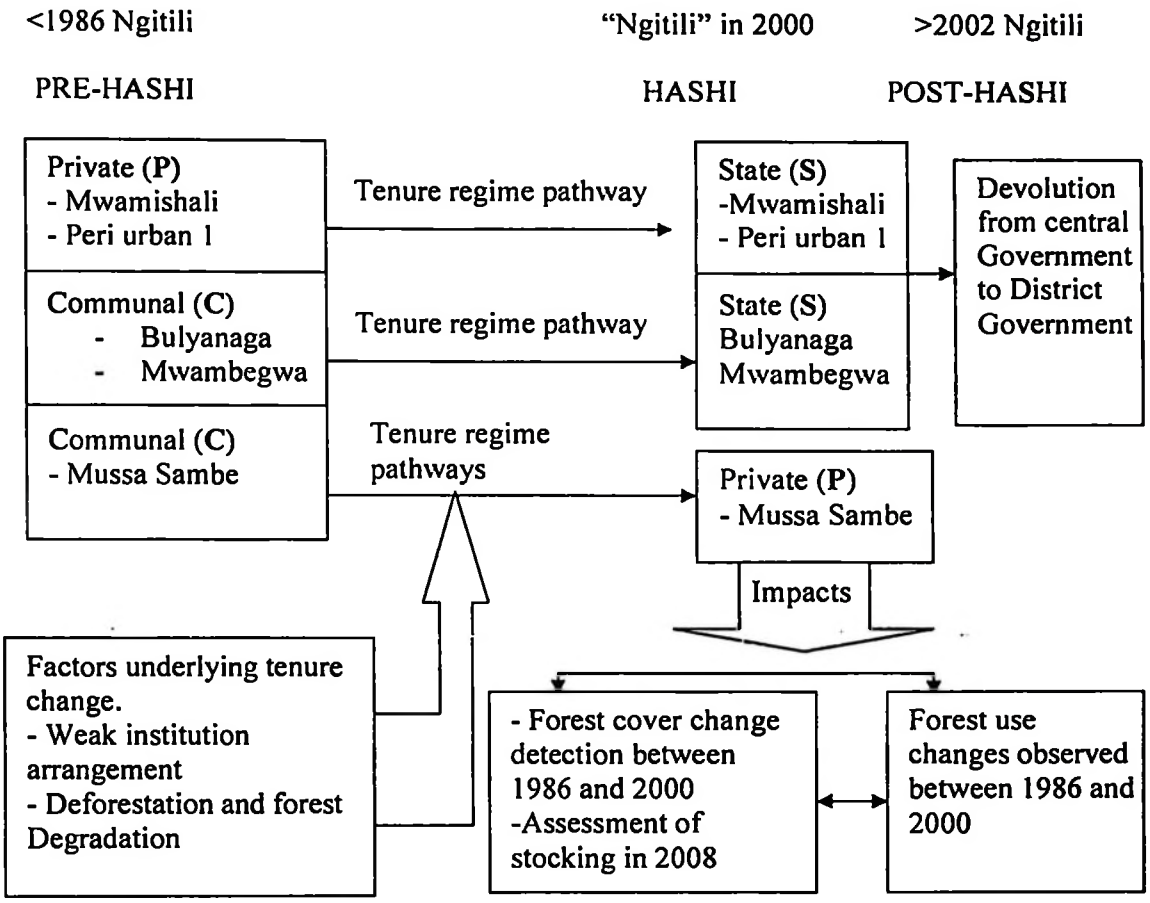


**Figure 1: Conceptual framework underlying the study**

**Keys:**

Mwambegwa, Bulyanaga, Peri urban 1 and Mwamishali are the "Ngitili" under HASHI while Mussa Sambe is the "Ngitili" outside HASHI. The "Ngitili" Under HASHI are named with reference to the names of the villages they belong. Furthermore, the "Ngitili" outside HASHI is named with reference to the name of the owner.

P-S = Tenure changes from private (customary) to state (Under HASHI), involved Ngitili of Mwamishali and Peri urban 1

C- S = Tenure change from communal (customary) to state (Under HASHI), involved Ngitili of Bulyanaga and Mwambegwa

C-P = Tenure change from communal (customary) to private (non HASHI), involved Ngitili of Mussa Sambe

### 1.7 Limitations of the study

Several limitations were encountered during the study. These include among others the following:

**(i) Inability to assess regenerants**

Most of the regenerating species were not assessed in this study because it was the time when livestock were allowed to graze in the Ngitili and hence were completely grazed. However, those assessed were sufficient to supplement the study.

**(ii) Inability to collect recent Landsat imageries of 2008**

Recent Landsat imageries of 2008 were not available, instead Landsat imageries of 2000 were used in the study because they were within the framework of tenure change and the temporal resolution of 14 years was sufficient to assess the impacts.

**(iii) Memory problems**

There was a memory problem during household/ village surveys whereby some respondents were not able to recall historical issues with regard to forest uses changes in the Ngitili under different tenure regimes. However, this was minimized by triangulation of information obtained through PRA and focused group discussions.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 The Concept of Ngitili

The Sukuma are agropastoralists keeping cattle and at the same time growing both food and cash crops. "Ngitili" is the local Sukuma word describing pasture management where by areas of grazing land are closed either by the village council or by a private land owner during the wet season to be used for grazing during the dry seasons (Otysina and Ng'atigwa, 2003). The practice is known throughout Shinyanga region, Tanzania, and is culturally well established (Barrow, 1991). Similarly the term "Ngitili" is being regarded, as traditional dry season fodder reserve (Otsyina and Asenga, 1994), which is farmer led initiative that evolved out of the traditional strategies in grazing. "Ngitili" encompasses retaining of an area of standing hay until the rain season ends; the area remains closed to livestock at the onset of rain season and opened up at the peak of the dry season to allow the livestock get dry season fodder (Maro, 1995; Mugasha *et al.*, 1996). "Ngitili" is divided into sections; each section is completely grazed before the next is opened. Grazing under "Ngitili" normally starts from July/August of the year after crop residues and forage in fallow areas have been depleted; and animals are removed from "Ngitili" after all the fodder is exhausted or when fodder becomes available outside the "Ngitili" (Kilahama, 1994; Otsyina and Asenga, 1994). There are two types of "Ngitili" namely family or private and communal differing in size, location and management. Depending on availability of land, the size of private Ngitili varies from 0.2 to 70.0 ha with an average of 20.0 ha. Communal Ngitili, on the other hand, is established with mutual consent of village members and, consists of large areas ranging between 10.0 and 100.0ha with an average of 50.0 ha. (Otsyina, 1994; Maro, 1995). Private "Ngitili" is established on a private land, communal "Ngitili" can be established on communal land suitable for dry season grazing.

Private Ngitili can increase a farmer's land value. Private "Ngitili" are increasing in number, which may reflect a shift from common property to private ownership. Communal "Ngitili" are found in riverbeds and hill areas (Kilahama, 1994; Otysina *et al.*, 1993). They provide badly needed dry-season forage, reduce soil erosion and conserve catchment areas. They also help lessen the need for agro-pastoralists to move long distances to seek for fodder during the dry season; this reduces livestock theft and disease contamination.

**2.2 Institutional arrangement underlying Ngitili management system**

In almost all the villages in Shinyanga region, there is mixture of formal and informal institutions in managing "Ngitili". Mlenge (2002) documented the central role played by informal Sukuma institutions popularly known as the "Dagashida" (Community Assembly), in regulating access and control of natural resources in the area. The "Dagashida" is led by a wise old man chosen among the Village community elders. The "Dagashida" despite its prominence is not widely spread in all the villages in Shinyanga region. Most of the villages had the Council of Elders, village Government Committees and Traditional Guards which are directly responsible for "Ngitili" management.

The Elders' Council mediates between informal and formal institutions; they act as advisors to Ten Cell and Hamlets leaders. Traditional guards (sungusungu) on the other hand, are voluntary local guards who deal with serious cattle raiding problems that the community face (Mlenge, 2002). Currently, the traditional guards keep peace by enforcing village customary laws and discipline. As far as "Ngitili" management is concerned, the traditional guards are also responsible for ensuring that encroachment by 'outsiders' is contained. The costs for trespassing in a "Ngitili" are usually based on traditional systems of sanctions. It is thus the responsibility of the traditional guards to monitor and oversee

that the rules for use of the "Ngitili" are upheld by local communities in all the villages (IUCN, 2002).

## 2.3 Land tenure and forestland tenure regimes

### 2.3.1 The concept of land tenure

The term tenure is derived from a Latin word for "holding" or "possessing". Hence tenure generally refers to the bundle of rights such as ownership, tenancy, usufruct, access, acquisition, labour and benefits on land, forest, water or other resources held by a individual, group and the state (Adams *et al.*, 2003). Land tenure is the system of rights and institutions that govern access to and use of land (Adams *et al.*, 2003). It can be further defined as the terms and conditions under which land is held, used and transacted and is one of the principal factors determining the way in which resources are managed and used and the manner in which benefits are distributed. Moreover, land tenure is best conceived as the 'bundle of rights' associated with land and values related to land. Rights in land resources are enforceable claims related to the ability to hold, occupy, or use land, the expropriation of benefits derived from land use, and the right to exclude others from sharing the land or its benefits (Kajembe, 1994).

Since colonial time, land tenure of Tanzania is statutory granted and customary land ownership to natives (indigenous Africans). Statutory rights over land are granted by the state to companies, persons and associations. Customary land is deemed rights to natives and therefore is based on the customs of a tribe. One important feature of the customary right is that it has no time limit. The obligations and rights to own land depends on the customs of the tribe, which are inherited from the ancestors. The majority of Tanzanians own land under this land tenure system (Abdallah, 2006).The ownership of land and natural resources, access and the right to use the area are of fundamental importance, not

only for a balanced and equitable development, but also to the level of care accorded to the environment (Abdallah, 2006). It is only when people can satisfy their needs, have control of the resource base as well as have secure land tenure that long-term objectives of environment protection can be satisfied. According to Tanzania Land Act Number 4 of 1999, "general land" is defined to mean all public land, which is not reserved or village land (URT, 1999). The Act provides for sustainable management of forest resources under the respective categories and discourages misuse including shifting cultivation in favour of effective occupancy. However, in practice this is in most parts easily said than done.

The Village land act No. 5 of 1999 (URT, 1999) administers village land and vests authority in the village assembly with the assistance from the village council as trustee to the villagers. It empowers the village assembly to divide the village land into the following: occupied, used, available for occupation, community used and or public used, known as communal village land. It also identifies land being occupied or used by an individual, family, or group of persons ,under customary law. Finally, village councils identify land, which may be made available for communal or individual occupation and use, through allocation by the village council. Also the Act provide mandate to the village assembly to further plan land uses to be designated as communal village land. Under these circumstances, the villagers are not very eager to develop the land they reside for fear that they may loose it to the government in the future.

### 2.3.2 Forestland tenure

Forest tenure determines who can use what forest resources, for how long and under what conditions (FAO, 2001). Forestland tenurial systems have, and till now been a replica of colonial legacy in Tanzania. They also reflect the features, issues, and ambiguities that characterize land tenure in general. Tenure if clearly defined enables local communities to

protect the forests and woodlands from encroachment so as to increase their benefits (FAO, 2001).

Under current forest policy (URT, 1998) all forestland is divided into the following categories: Private forestland is the assignment of rights to an individual, a group of people, or a corporate body. Other people can be excluded from using these resources without the consent of those who hold the rights. Common forestland tenure is where rights of the commons may exist within a community where each member has a right to independently use the holdings of the common. Whereas state forest is property rights that are assigned to the mandate of the state, whether central or local level government. Finally open access in which specific rights are not assigned to anyone and no-one can be excluded (i.e. property to nobody).

#### 2.3.2.1 Forests under common property regime

Scholars in the neo-Hardinian tendency have carried out many important empirical studies of common property systems across the planet and have made a number of important distinctions in the study of common property. Common property regimes arise in situations where appropriators acting independently in relationship to a common-pool resource generating scarce resource units would obtain a lower total net benefit than what is achieved if they coordinate their strategies in some way, maintaining the resource system as common property instead of dividing it up into bits of private property. Common property regimes typically protect the core resource and allocate the fringe benefits through complex community norms of consensus decision-making facing the difficult task to devise rules that limit the amount, timing, and technology used to withdraw various resource units from the resource system. Setting the limits too high

would lead to overuse and eventually to the destruction of the core resource, while setting the limits too low would unnecessarily reduce the benefits obtained by the users.

Widespread people's participation in forest management, owning the forests as common property, is the current thinking towards forest management. Common property refers to a particular property rights arrangement in which a group of resource users share rights and duties toward a resource. This term therefore refer to social institutions, and not to any inherent natural or physical quality of the resource (McKean, 1996).

In this arrangement, a particular group of individuals share rights to a resource, for example a forest. User rights are common to a specified group of individuals, not to all. Thus, common property is not access open to all but access limited to a specified group of users who hold their rights in common. When a group of individuals and property rights they share are well defined, common property should be classified as a form of shared private property. The property rights in a common-property regime can be very clearly specified, they are by definition exclusive to the co-owners (members of the user group), and they are secure if they receive appropriate legal support from the government.

It can be noted that while the Tanzanian Government and international agencies have overestimated their own capabilities for forest management, they have underestimated the value of local governance over those resources (Kajembe, 1994). Local communities who depend on forests for many commodities and services not just timber, are more sensitive to their protective functions and the wide variety of goods available from them in sustainable harvest. But when the governments overrule traditional use rights to forests, local communities and individual households are unable, and less willing to prevent destructive encroachment or overexploitation. In effect, these *de jure* state forests are turned into *de*

*facto* open access. Environmental degradation can occur where there is a growing disharmony between the community and its natural environment, and the implied solution is to restore harmony to environment-society relations (Leach *et al.*, 1997). Restoring or awarding such rights to local groups would induce them to attend to the possibilities of sustainable long term production from the forests. Ostrom (1990) and Ascher (1995) emphasized the need, and provide approaches for analysing human institutions at the local level in order to understand and possibly reduce the negative environmental and societal costs of deforestation. They contend that sustainability of forests depends on local rules, use patterns, and incentives created by international, regional, national and local institutions. Indeed, if ecological conditions are the same, major structural and biological differences between local patches of forests may be almost completely the consequence of human rules and use patterns.

***Advantages of forests being under common property regime***

According to the new forest policy (URT, 1998), to abolish open access in general lands, covering more than 19 million hectares in Tanzania, clear ownership for all forests and trees on those lands need to be defined. The allocation of forests and their management responsibility to villages, private individuals or to government will be promoted. Central, local and village governments may demarcate and establish new forest reserves.

Ascher (1995) argues that, communities are best suited to manage and regulate resource use because of four main reasons, including:

(i) Empowering a community to manage and regulate the use of a resource will reduce the pressure on the resource because by the mere fact that it is owned by a certain community it will not be an open access. Potentially, there are many users of a

resource and if one group retain exclusive use of a resource, there is high possibility that more sustainable practices are likely to be implemented.

(ii) A community living near a resource and depending on it for livelihood, and knows that it will enjoy the benefits of the resource for a long time, is more likely to refrain from misusing it. People rooted in one locality which they call home, will use a resource more careful because if they deplete it they have nowhere else to go. They are different from a commercial corporation which is always on the move and depletion of a resource in one place means moving to another place and continue with the same trend.

(iii) The limited resources of governments in terms of manpower and finance to manage natural resources means that this task is better placed in the hands of local people who will do it for their own benefit with no burden of payment on the part of the government.

(iv) Traditional users of a biotic resource like forest are more likely to have developed techniques which will enable them to use the resource sustainably. Other groups or companies with less knowledge of the resource are more likely to exploit the resource to extinction with the aim of short term gains.

**2.3.2.2 Tenure in Ngitili management system**

Contemporary "Ngitili" woodlots in Meatu fall broadly into two tenure categories, either under private (individual) or communal tenure regime. Individual ownership pattern has proven to have very positive implications in the management, improvement and

development of the "Ngitili" as farmers have been more willing to undertake development work on their own land (Msangi, 1995). Under traditional system, the ownership and management of land tenure rights over "Ngitili" and land in general in Shinyanga region governed by customary laws (Mlenge, 2002). After independence, the *Villages and Ujamaa Villages Act* (1975) was introduced, which relocated farmers from traditional villages to newly created settlements. Household assets including houses, farms and "Ngitili" were often abandoned (Otsyina *et al.*, 1993).

In 1998, Tanzania approved its revised forest policy, which places strong emphasis on participatory management and decentralization (URT, 1998). Local communities are encouraged to participate in the management of forests through collaborative and community-based forest management. Communities tend to select and set aside degraded and village forested areas to be conserved and managed as village forests (Kilahama, 1994).Village boundaries have been surveyed to help villages obtain village title deeds and individuals obtain title deeds within village land. This helps secure village and farm lands, and is an incentive for future improvement. The National Land Policy of 1997 (URT, 1997), the *Land Act* number 4 of 1999 (URT, 1999) and the *Village Act* number 5 of 1999 (URT, 1999) have actively supported the formal establishment of "Ngitili".

**2.4 Factors underlying changes in forestland tenure**

Forestland tenure changes are driven mainly by deforestation and forest degradation which are also driven by market and policy failures, rapid and uncontrolled population growth and rural poverty (Kaoneka, 2000). Many of these underlying causes are related but as they are often embedded in divergent social and economic contexts, their relative importance varies substantially among regions.

### 2.4.1 Market and policy failures

Market and public policies are important determinants of how forests are used and managed. Market failures refer to the inability of market prices under certain conditions, such as the presence of open access exploitation, externalities, incomplete information and imperfect competition, to reflect accurately the value of marketed and non-marketed or non-tradable environmental services (Wardle and Kaoneka, 1999). Such failures also mean that markets are unable to ensure equitable resource and income distribution to promote maximization of collective welfare of the society (Wardle and Kaoneka, 1999). Policy failures are consequent upon the following (Wardle and Kaoneka, 1999; Kaoneka, 2000): Inability of governments to institute strict centralized management due to inadequate financial and managerial capacity, the consequence has been inefficient management of forest resources. Also inability of governments to adequately define property rights thereby rendering forests an "open access" resource regimes with consequent risk of over-exploitation and general resource degradation and lack of investment incentives on forest activities, implementation of old forest policies which fail to adequately address emerging opportunities and constraints imposed by national aspirations, international agreements and conventions. Peasant farmers who, hitherto, depended on subsidized farm inputs have been compelled to encroach forests in order to expand farmlands to meet the rising demand of food as a consequence of family expansion and population growth. This leads to an upsurge in deforestation and degradation (Kaoneka, 2000). On the other hand, higher crop prices may result in increased land clearance as new land is opened up for cultivation (Misana *et al.*, 1996).

Other past and present policies which have contributed to tropical forests degradation include: Colonial land alienation policies which led to much of the land especially the more fertile being reserved for European settlers and peasants being concentrated in marginal

lands leading to severe deforestation and forest degradation (Misana *et al.*, 1996). The colonial agrarian systems reinforcement by post-independence agricultural policies and land reclamation policies e.g. in Shinyanga region where miombo woodlands invaded by tsetse flies were reclaimed by clearing woody biomass were another cause for forest degradation. Thus the problem of land degradation which is characteristic of livestock concentration zones is simply exported to other areas. Resettlement policies e.g. the Tanzania villagisation policy of 1967 which involved establishment of nucleated villages, some in virgin lands necessitated extensive clearance of woodlands for farmland and settlement expansion. Woodlands became no man's land, open for exploitation by everybody. Energy policies focus on the commercial energy sector (electricity) rather than wood fuel used by over 80% of the population in the sub-humid zone further encourage deforestation. Such inadequacies of the energy policies in addressing wood fuel problems have led to the depletion of forests particularly around major towns/cities. Population policies emphasizing on family planning rather than rural-urban migration have lead to increased wood fuel demand, usually in form of charcoal and increased deforestation in the vicinity of the urban areas.

### 2.4.2 Population pressure

According to Barraclough and Ghimire (1996), many analysts using national level data, frequently blame deforestation in tropical countries on a country's population growth. Detailed local-level case studies in Tanzania, however, reveal that the relationships between population dynamics and environmental degradation are much too complex to support reductionism generalizations about cause and effect (Barraclough and Ghimire, 1996). The authors in a study in Tanzania found out that, in a highland Lushoto District, large population increases have led to more vegetation cover while in a sparsely populated Rufiji District, there has been rapid deforestation. In another degraded area, Kondoa

District, the authors found for a conservation project (HADO) that, colonial rulers rehabilitated deforested land by excluding local pastoralists and farmers which resulted in social and ecological problems elsewhere. On the other hand, the reports by Yirdaw (1996) among others have shown that, there is a significant correlation between population pressure and deforestation, especially when there is a prevailing poverty, an ambiguous land tenure system, lack of agricultural intensification, market failures, and political instability.

In the past, population density in the sub-humid areas of Sub Saharan Africa (SSA) was low and the agricultural systems followed by indigenous farmers did not degrade soil and water resources due to the long fallow periods (10 to 20 years) and respect developed by shifting cultivators for the forested areas (i.e. sources of food and medicine) surrounding them. With the coming of outside civilizations, however, indigenous shifting cultivators have been given access to modern life-saving drugs and medicines that have helped prolong their lives. This has resulted in population increases that placed more pressure on the food production systems and less reliance on natural products (medicines) and thus less care of the forests. Rapid population growth often intensifies pressure to convert forest areas to other uses, as well as exploit forests for short-term benefits (e.g. food and fuelwood supply) (Nduwamungu, 2001).

### 2.4.3 Poverty

Poverty is one of the main underlying factors contributing to deforestation and soil fertility depletion (Quinones *et al.*, 1997). Poverty-led environmental degradation is responsible for much of the degradation of marginal lands, deforestation, overgrazing of fragile rangelands, cultivation of steep slopes, and consequent soil erosion, flooding, and loss of vegetative cover observed in many parts of the developing world, especially in the sub-

humid zone of SSA (Quinones *et al.*, 1997). The majority of rural poor rely heavily on forests and woodlands for their subsistence. While many traditional rural communities have developed comparatively sustainable forms of resource use, many others are compelled, by circumstances often beyond their control, to exploit forests unsustainably for short-term gains. Since most of the poor people in Africa are rural dwellers, and agriculture is their mainstay, therefore, it follows that agricultural development must be the central strategy for economic growth and poverty alleviation (Birdsall, 1995). It is important to stress, however, that hunger, poverty, and environmental degradation in Africa are intimately correlated thus implying that any action to reduce poverty and hunger will assist in minimizing environmental degradation as well (Quinones *et al.*, 1997).

**2.5 Forest cover changes in Tanzania**

Malimbwi (2002) estimated the total area covered by forests and woodland to be about 34 million ha, making up about 38% of total land area in the country. Almost two-thirds of the forest and woodland areas are found on general lands and are under open access regime. Tanzania's forests have been faced with the problem of deforestation and forest degradation caused by increased pressure on land resources, exacerbated by settlements, extensive agricultural practices coupled with uncontrolled grazing and fires, firewood, charcoal, timber production and natural catastrophes. Between 1990 and 2000, the United Republic of Tanzania lost an average of 412 300 hectares of forest per year (FAO, 2001). Also, between 2000 and 2005, the rate of forest loss increased by 11.0% per annum (FAO, 2001). In total, between 1990 and 2005, United Republic of Tanzania lost 14.9% of its forest cover or around 6 184 000 hectares (FAO, 2001). On the other hand some of the regions in Tanzania are still having extensive forest cover, most of which being woodlands and montane forests, though there are scattered patches of lowland forests. Much of these forests have high biodiversity and endemism especially in the southern highland regions.

In Shinyanga region, natural and planted forests cover an area of about 704 200 ha (Mlenge, 2002). Historically, the natural forest cover in Shinyanga consisted of the deciduous miombo woodlands towards the west and Acacia savannah towards the east (Marlcon, 1953). These woodlands were infested with tsetse flies and this prompted the colonial administration to promote widespread bush clearing to eradicate them (Malcolm, 1953). The elimination of tsetse flies saw an end to trypanosomiasis, a livestock disease that was a real threat to farmers. Consequently, livestock population shot up and these put a lot of pressure on the once tree-covered land (Mlenge, 2002). The introduction of 'Ujamaa' or villagisation on the other hand by the Tanzanian Government in 1974 as a new form of centralized authority, destroyed the traditional community-level regulations that once limited the over-use of rangelands. These and other factors led to serious environmental degradation by the early 1980s forcing many people to leave the region in search of better grazing land for their livestock and for Agriculture.

**2.6 Detection of forest cover changes through remote sensing and GIS**

Remote sensing data can be fully utilized if scene from one date or from one portion of spectrum are linked with those acquired at different dates or different part of the spectrum (Mbilinyi, 2000). It is further argued that a geographical information system is a proper tool for manipulating such data (Kashaigili, 2006). The combination of remote sensed data and Geographical Information system (GIS) is possible due to the fact that these two are complimentary to each another. Remote sensing may be used as a tool to collect datasets for use in GIS, while GIS datasets can be used as ancillary information to improve products obtained from remote sensing. The goal of detecting change is to discern those areas on digital images that depict changing features of interest (e.g. forest clearing or changed land cover/use) between the dates on which two or more images were captured (Kashaigili, 2006). In conducting change detection in an area, various change detection

algorithm techniques for change detection analysis in remote sensing are used. The most popular and widely used are revisited hereunder:

### 2.6.1 Cross-correlation Analysis

Cross-correlation Analysis is a change detection method developed by Earthsat, Inc. and measures the differences between an existing land cover image and a recent single date multispectral image (Koeln and Bissonnette, 2000). The benefits of this technique are that, it eliminates the problems associated with radiometric and phonological differences that are so readily experienced when performing change detection. According to Civco (2002) cross-correlation works by using the class boundaries from the base land cover image to derive an expected class average spectral response.

### 2.6.2 Monotemporal change delineation

In monotemporal change delineation, the pattern recognition routine itself functions as the change detection algorithm, encompassing all classification and enhancement methods developed for single-scene analysis. However, the technique relies heavily on the strong assumptions about the initial state of the land cover. Generally speaking, these assumptions are based either on available historical records such as aerial photography and existing cartographic data, or on surrounding land parcels that are presumed to represent the state of the land cover before the disturbance. Vogelmann and Rock (1988) successfully used sophisticated hybrid clustering routines on six band TM data sets to map forest damage in Vermount and New Hampshire. Lee (1988) utilized Laplacian convolution filter on TM band 3, 5 and 7 on principal components 1 and 2, and was able to produce an edge detection feature that gave a clear one-pixel line surrounding the clear cut areas.

### 2.6.3 Change detection using write function memory insertion

Two or three individual bands of remotely sensed image or scanned aerial photographs acquired at different dates can be overlaid in the digital image processing system to form a colour composite image (Mbilinyi, 2000). Changes are visually identified using additive colour theory. It is assumed that change in the use of particular parcel of land will accordingly lead to change in the spectral response of that parcel. However precaution should be taken during the interpretation process because change in brightness values can be influenced by factors other than changes in land use such as intensity and angle of illumination and processing.

### 2.6.4 Image algebra change detection

Change detection between two temporal images may be determined by rationing or differencing bands previously rectified to common base map and resample to a simple pixel size (Kashaigili, 2006). This technique is also known as band differencing and rationing (Kashaigili, 2006). Mbilinyi (2000) argued that image differencing involves subtracting imagery of one date from that of another and in that ratio of pixel value represents the ratio of pixel values from two temporal images. Both image differencing and band rationing suffer from the critical problem of choosing a threshold boundary between change and non-change pixel.

## 2.7 Trees and shrubs species diversity in Ngitili management system

Species diversity refers to the number of different species in particular area and their relative frequencies (Wilson, 2006; Harrison *et al.*, 2007). Species richness on the other hand is defined as the actual number of different species in a community rather than the number of individuals contained therein (Harrison *et al.*, 2007). The knowledge of species diversity is particular useful in understanding the importance of the contribution of the

particular tree species diversity to the forest cover and uses. A study conducted by Monela *et al.*, (2004), showed that 152 different trees, shrubs and climbers species were found in the surveyed "Ngitili" forest management systems in Shinyanga region, Tanzania. Also the study found that, there are variations in species composition between the districts, but two major vegetation types were distinguished. Bush land (*Acacia, Dalbergia*, and *Combretum* bushland) in Shinyanga Urban, Meatu, Bariadi and Maswa districts (eastern side of the region); and regrowth miombo woodland in Kahama, Shinyanga Rural and Bukombe districts (western side of the région). Generally speaking the regowth miombo vegetation had higher stocking, basal area, volume production, and tree species diversity compared to the bushland. The distribution of number of stems per hectare follows the usual expected reversed J-shaped trend with noticeable high number of trees of below 10 cm Dbh.

**2.8 Forest uses**

The first forest historical activities were hunting and gathering. Animal husbandry and forest grazing came later. Shifting cultivation was a wide spread form of agriculture, especially in Sweden and Finland (FAO, 2001). Wood was first used for domestic purposes and for construction, and in the 18th century, wood became a commercial product. Over cutting, grazing and agricultural cultivation caused deforestation and forest degradation. These problems accelerated the creation of forest policy in many countries. The principles of sustained yield wood production were first applied in Scandinavia in the 18th century. In the 19th century, forests became a source of raw material for the forest industry. Recently, increasing urbanization has created the need for renewed contact with nature and led to the development of modern multiple-use forestry management (FAO, 2001).

Forests in Sub-Saharan Africa (SSA) and other tropical areas provide many wood and non-wood forest products (NWFP) and other services of direct benefit to mankind (Kaoneka, 1999). The wood products include: fuelwood, charcoal, round wood, sawn wood, wood based panels and pulp and paper. The NWFP consist of game meat, medicinal plants, fodder, latex, beverages, dyes, fibers, gums, resins, oils, beeswax and honey, tannins and toxins. Other benefits which are accrued from the forest include: watershed functions, maintenance of soil fertility, and conservation of biodiversity, sustaining cultural values, carbon dioxide sequestration, climatic amelioration and eco-tourism (Kaoneka, 1999). In Shinyanga region, Tanzania households use wood for cooking every day. For villages located near forest reserves especially in Western Shinyanga, such as in Kahama and Bukombe districts, collecting enough firewood is not so difficult. However, in the eastern districts, Bariadi, Meatu and Maswa, forest reserves are almost nonexistent. Before the active restoration of trees in village and households enclosures 'Ngitili', finding enough wood fuel was a time- consuming task for the women (Mlenge, 2002).

Ngitili are providing poles, medicine, firewood, grass for thatch and fodder. A study on the indigenous medicinal plants by HASHI in 1999 showed that over 300 tree species were being used for treating some 100 different human ailments (HASHI, 1999). The ten most important of those species came from forest reserves, either government forests or local Ngitili enclosures. Some of the products are sold earning income to households. Seedlings production and beekeeping also earn income to the communities.

# CHAPTER THREE

## 3.0 STUDY AREA AND METHODS

### 3.1 Study area

#### 3.1.1 Location

The study was conducted in Meatu District, Shinyanga Region, Tanzania (Fig.2). It covers a total of 8871 $Km^2$ (URT, 1996). It is located within a semi-arid zone between 3° and 4° south and 34°8' and 34° 49' east. The district is bordered by Bariadi district in the North, Maswa and Kishapu districts in the west, Tabora region in the south, Arusha region in the east and Singida region in the south.

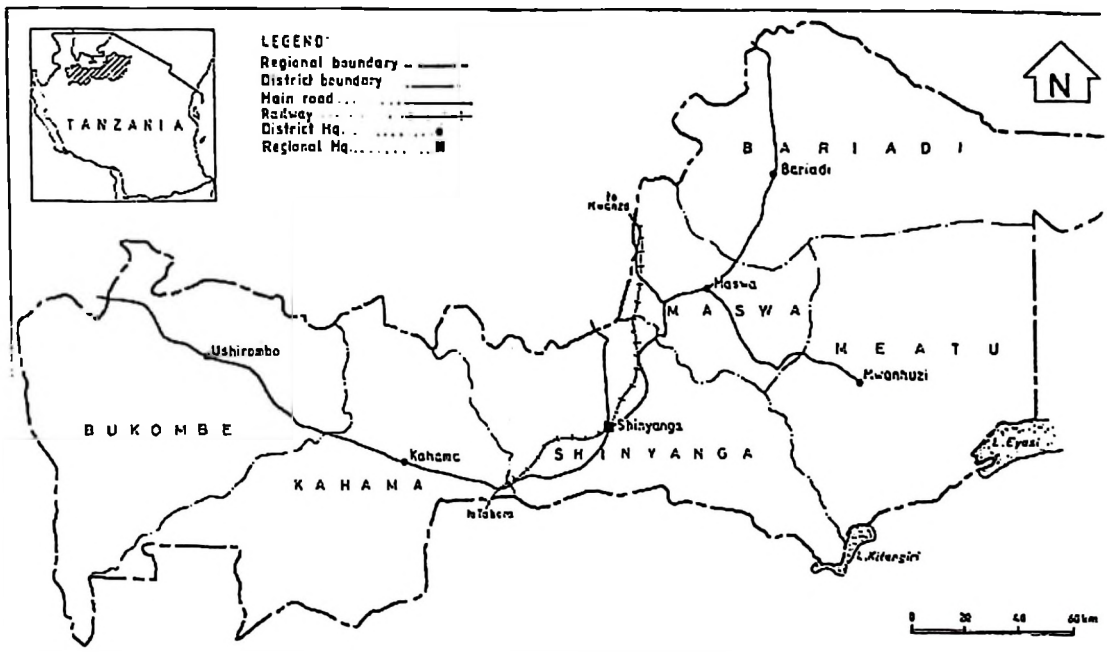


**Figure 2: Map of Shinyanga region showing location of Meatu district**

### 3.1.2 Physical features

Meatu district landscape is mostly flat, with a vast horizon interrupted by isolated low stony hills. These stony hills are often surrounded by small farms, with fields of maize, millet, sorghum and cotton visible from the road side. Altitude varies between 1000 and 1500m above sea level with detached hills and grassy "mbuga" (URT, 1996).

#### 3.1.2.1 Climate

The district has high evapotranspiration rates with erratic rainfalls (URT, 1996). The district receives uni-modal rainfall of 600 to 800 mm per annum. The rain season is mainly in mid November through mid May. The monthly evapotranspiration rate exceeds the monthly rainfall almost every month (MNTE, 1995). Minimum and maximum temperatures are 26.8 and 33.6°C respectively.

#### 3.1.2.2 Vegetation cover

The natural vegetation of Meatu district was originally woodlands on unreserved land (Mlenge, 2002). However, due to a massive deforestation which took place in 1920s, many areas turned into treeless except for a few acacia and baobab trees. The vegetation gradually reverted to an open bush savanna characterized by short grasses with scattered shrubs (4-6m high) and trees that are dominated by *Acacia* species mainly *Acacia tortilis, polycantha, nilotica, drepanolobium and Senegal* (Otysina, 1994).

#### 3.1.2.3 Soils and Geology

The soils are mainly red to yellowish freely drained, often referred to as *latisols* (Kamwenda, 1999). The major soil types found in the district include: *ferric luvisols*, *Acrisols* and chromic *cambisols* (Otysina, 1994). In low lying areas often referred as

"mbugas", black to greyish clays or *vertisols* are found. These are often fringed by mottled soils (Otysina and Asenga, 1993).

### 3.1.3 Land use and ownership

According to Msangi (1995), land was traditionally allocated by the village or clan headman and its acquisition, was through inheritance in Sukumaland. Ownership of land was based on the principles of usufruct. Land use patterns in the district are strongly influenced by Sukuma culture and traditions. Women control low-income crops while men control livestock and cash crops such as cotton, despite the shared labor between couples (Machanya *et al.*, 2003). Traditional land use patterns are however increasingly challenged by pressure on land because of human and livestock population increases leading to increased land fragmentation. Decreasing soil fertility is making farming unproductive but the farmers are not used to application of manure (Machanya *et al.*, 2003).

### 3.1.4 Population and socio-economic activities

Economic activities in Meatu district include: cultivation of food and cash crops, cattle rearing and mining (Maro, 1995). The population of Meatu district is dominated by the Sukuma, who are traditionally agropastoralists (Kamwenda, 1999). Over 80% of the population in Meatu district own livestock for household sustenance and income generation. The district has 248 214 people in which 119 241 are males and 128 973 are females (URT, 2002b). The population density of Meatu district is 18 persons per $km^2$.

## 3.2 Methods

### 3.2.1 Data collection

In this study, three data sets were collected including spatial, biophysical and socio-economic data. Spatial data were acquired from satellite imageries, aerial photograph and topographic sheets. Biophysical data were collected through forest inventory in the "Ngitili" which has undergone forestland tenure changes. Finally, socio-economic data were collected through key informants discussion with the help of a checklist, key and Participatory Rural Appraisal. The primary data were supplemented by secondary data which were collected from previous study reports, published and unpublished documents as well as other relevant literature and through internet search.

#### 3.2.1.1 Spatial data

One period was considered in studying forest cover changes in the "Ngitili". The period was between 1986 and 2000. For this period two data sets were derived from Low Resolution Landsat Thematic Mapper (TM) imagery for 1986 and High Resolution Thematic Mapper (TM) imagery for 2000 for five "Ngitili" under the study. Landsat image of 1986 was collected to determine the forest cover of the "Ngitili" before forestland tenure change likewise Landsat image of 2000 was selected to determine the forest cover after forestland tenure change. Using the Global positioning system (GPS) receiver, points were taken in the "Ngitili" to assist in correctly locating the "Ngitili" in the imageries and for ground truthing. Moreover topographical sheets of 1972 were collected to supplement the determination of forest cover of the "Ngitili" before tenure change. (Table 1).

**Table 1: Spatial data collected for forest cover changes detection**

| S/No. | Data type | Path/row | Acquisition date | Remarks |
|---|---|---|---|---|
| 1. | Landsat TM | 169/63 | 1986 | Before tenure change |
| 2. | Landsat ETM$^{+}$ | 169/63 | 2000 | After tenure change |
| 3 | Topographic sheets | - | 1972 | Before tenure change |

### 3.2.1.2 Biophysical data

#### 3.2.1.2.1 Sampling design, intensity and plots layout

Synnott (1979) recommended that a sampling intensity of 0.5% to 0.7% for natural tropical forest inventory is sufficient. For this study, a sampling intensity of 0.5% was adopted. Prior to the actual inventory, reconnaissance survey was carried out in order for the researcher to get acquainted with the "Ngitili" to be studied. Plots were laid systematically in the "Ngitili" selected for the study. These were Mwamishali, Mwambegwa, Mussa Sambe, Bulyanaga and Peri urban 1. Transect was established parallel to the longest side of the stratum and the interval between transects was 200m while the interval between plots was 100m. Forest inventory was very important in order to estimates the available stock, tree and shrubs species diversity and their distribution.

#### 3.2.1.2.2 Plot shape and size

Circular concentric plots were established in the study "Ngitili" in which measurement and identification of tree species were done by the researcher with the help of two field assistants:

*Within 2m radius*: Identification and recording tree/shrubs, grasses were done as well as counting of regenerants less than or equal to 1cm Dbh;

*Within 5 m radius*: All trees with Dbh $\geq$1cm were identified, measured and recorded.

*Within 10 m radius*: All trees with Dbh ≥10 cm were identified, measured and recorded

*Within 15 m radius*: All trees with Dbh ≥20 cm were identified, measured and recorded in the field inventory form. (*Appendix 1*) (Njana, 2008)

### 3.2.1.3 Socio-economic data

#### 3.2.1.3.1 Participatory Rural .Appraisal

Participatory Rural Appraisal was used as the research tool for collecting socio-economic data on forest use changes under different tenure regimes. The different tenurial regimes were from private tenure regime to state tenure regime under HASHI which involved "Ngitili" of Mwamishali and Peri urban 1. Also from communal tenure regime to state tenure regime involved "Ngitili" of Bulyanaga and Mwambegwa. In addition to that the change was also from communal tenure regime to private tenure regime involved "Ngitili" of Mussa Sambe (Outside HASHI).

In order to form a PRA team in each "Ngitili", individuals were selected on the basis of long term residence, experience and knowledge. The PRA techniques used in this study included participatory resource mapping, local histories and time lines. Participatory mapping consisted of marking, drawing and colouring on the ground by rural people with minimum interference and instruction by outsiders (Kessy, 1998). Villagers were able to map the boundaries of their "Ngitili" and show different resources they got from "Ngitili" before and after tenure changes.

#### 3.2.1.3.2 Key informants interviews

While the group meetings can provide details on the broad context for local circumstances and practices, there are frequently particular individuals who for whatever reason have acquired significant knowledge about specific issues (Katani, 1999). These individuals

come from a society including farmers, bureaucrats, elders, priests, and local historians. What sets them apart as key informants is that they are recognized by others in their community as being particularly knowledgeable about the issues under discussion. Key informants are not only members of the clientele, but are most often informed outsiders (Mettrick, 1993). For the purposes of the study, District Forest and Land Survey officers, elders, and traditional leaders were interviewed either individually or in groups with the help of a checklist (*Appendix 2*).

### 3.3 Data analysis

#### 3.3.1 Spatial data

The analysis followed two steps: First, satellite imagery interpretation which involved image processing and image classification and second, change detection analysis was done involving assessment of the rate of change.

##### 3.3.1.1 Satellite images interpretation

To understand the forest cover and use changes with time as well as the relationship between changes of forestland tenure regimes using remote sensing data, upon image selection and acquisition the following processes were done:

###### 3.3.1.1.1 Image processing

This involved image pre-processing, image rectification/geo-referencing and image enhancement. The images were geo-referenced to be as close as to the real world coordinate system. Enhancement usually reinforces the visual interpretation of the images. False colors composites were created by combining images (bands) captured at different wavelengths to enable better visualization of vegetation, soil, water bodies and settlement in the landscape (Kashaigili, 2006).

#### 3.3.1.1.2 Image classification

Both Visual and Digital image classification approaches were used. The contrast stretch, spatial filtering, and colour composite image enhancement techniques were used for visual image interpretation. Through visual interpretation, features showing changes in vegetation were extracted. Supervised image classification using maximum likelihood classifier was performed using ERDAS IMAGINE software. Training fields were identified by inspecting enhanced colour composite bands 4, 5 and 3.

### 3.3.1.2 Change detection analysis

Change detection analysis involves the ability to quantify temporal effects using multi temporal data sets (Singh, 1999). Many change detection methods have been developed and used for various applications. However, they can be broadly be divided into: post – classification and spectral change detection approaches (Singh 1999). This study used post classification. In post-classification change detection approach, two images from different dates are classified and labeled and the area of change extracted through the direct comparison of the classification results (Mbilinyi, 2000; Kashaigili *et al.*, 2006). The imageries of 1986 and 2000 were analyzed and the detection of forest cover was carried out.

### 3.3.1.3 Assessment of the rate of cover change

The estimation for the rate of change for the different covers was computed based on the formulae (Kashaigili, 2006):

$$\%\ Cover\ change\ = \frac{Cover\ area_t - Cover\ area_{t+1}}{Cover\ area_t} x\ 100\% \qquad [3.1]$$

$$Annual\ rate\ of\ area\ change = \frac{Cover\ area_t - Cover\ area_{t+1}}{t_{years}} \quad [3.2]$$

$$\%\ Annual\ rate\ of\ area\ change = \frac{Cover\ area_t - Cover\ area_{t+1}}{Cover\ area_t x t_{years}}\ x\ 100\% \quad [3.3]$$

Where:

$Cover\ area_t$ = area of cover at the first date,

$Cover\ area_{t+1}$ = area of cover at the second date, and

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

### 3.3.2 Woodland inventory

The Microsoft computer spreadsheet was used for data analysis. The parameters computed were diversity indices, index of dominance, basal area per hectare (G) ($m^2$/ha), density (SPH) (stems/ha) and standing volume for each Ngitili. Before conducting the computation for various stand parameters, a checklist of tree and shrub species was prepared (Appendix 1).

#### 3.3.2.1 Development of height/diameter equation

Using the sample trees whose heights were measured for both HASHI and non HASHI "Ngitili", height diameter equation was developed. The equation developed was Ht = Exp (0.719654 + 0.569437* In (Dbh)). The equation was used to estimate the heights of other trees that were measured only for Dbh.

#### 3.3.2.2 Forest stands density, basal area and Volume

The total tree volume was calculated by using the following formula (Malimbwi *et al.*, 1994):

$$V_i = 0.0000481 d_i^{2.032} h_i^{0.66} \quad [3.4]$$

Where: $V_i$ = Volume of the $i^{th}$ tree ($m^3$),

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

$h_i$= Total height of the $i^{th}$ tree (m)

### 3.3.2.3 Shannon-Wiener index of diversity

Shannon index of diversity also called Shannon-Wiener index of diversity was used to measure species richness (abundance) and evenness. This species diversity index increases with the number of species in the community, Shannon index of diversity of biological communities in practice does not exceed 5.0 (Krebs, 1989). The index was calculated as follows (Kent and Coker, 1992):

$$H' = \sum_{i=1}^{s} (p_i \log_a p_i) \quad [3.5]$$

Where; H' is the Shannon index of diversity;

S is the number of species;

$p_i$ is the proportion of individuals i in the sample;

$Log_a$ is the logarithm to base a

Diversity indices were calculated for each studied "Ngitili". The calculations were done to allow comparison of trees species abundance in different forestland tenurial regimes for the studied "Ngitili".

### 3.3.2.5 Index of dominance

The index of dominance is a measure of the distribution of individuals among the species in a community. It equals the probability of picking two organisms at random of different species (Krebs, 1989). The greater the value of dominance index, the lower is the species diversity in the community and vice versa (Misra, 1989). Therefore the index of dominance was calculated for each Ngitili type using the following formula.

$$C = \sum (n_i/N)^2 \qquad [3.6]$$

Where; C is the index of dominance

$n_i$ is the number of individuals of species i in the sample

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

### 3.3.2.6 Comparison of stocking parameters

Comparison of stocking parameters was carried out through student t test. In student t-test, a paired t-test of unequal variances was carried out to test whether there is or no significant difference in stocking parameters (number of stems, volume and basal area per hectare) between HASHI and outside HASHI "Ngitili". The stocking parameters in the outside HASHI "Ngitili" of Mussa Sambe was compared with stocking parameters in the HASHI "Ngitili" of Mwambegwa, Mwamishali, Bulyanaga and Peri urban 1 through student t-test of unequal variances. Finally calculated t values with respective probabilities were compared with the tabulated p value ($p<0.05$) to see whether there is or no significant difference in the stocking parameters between HASHI and outside HASHI "Ngitili".

### 3.3.3 Socio-economic data

All data and information that was collected using Participatory Rural Appraisal techniques was analyzed by the help of the participants during the field survey and the results were

communicated back to them for confirmation and verification. Content and structural-functional analysis approaches were used to analyze socio-economic data According to Mayetta (2004) content analysis is a set of techniques for analyzing the symbolic content of any communication. The basic idea was to reduce the total content of communication to some set of categories that represented some characteristics of research interest. Through this approach, the information gathered using verbal discussion with key informants was recorded and broken down into small meaningful units of information. Kajembe (1994) recommends structural-functional techniques in explaining the way social facts relate to each other in a social system and the way they relate to the natural environment. Content analysis on the other hand helps the researcher to distinguish between obvious and concealed functions. Obvious functions are those consequences that are intended and are recognized by actors in the system (Katani, 1999), whereas the concealed functions are those consequences that are neither intended nor recognized (Kajembe, 1994).

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSION

### 4.1 Forest cover changes under different tenure regimes

Forest cover change detected from Landsat imageries of 1986 and 2000 showed the status of "Ngitili" of Bulyanaga and Mwambegwa which changed from communal to state tenure regimes under HASHI project. It also showed the status of "Ngitili" of Mwamishali and Peri urban 1 which changed from private to state tenure regimes under HASHI project. Furthermore assessment showed the status of "Ngitili" of Mussa Sambe which changed from communal tenure to private tenure regimes outside HASHI area.

#### 4.1.1 Forest cover changes in "Ngitili" under HASHI

HASHI was the project launched by the Central Government to reverse severe and alarming land degradation that faced Shinyanga and which made the Late President J.K Nyerere to nickname the region as the desert of Tanzania. Four "Ngitili" management systems were analyzed to determine the change of forest cover in Ngitili under HASHI. Two "Ngitili" (Mwamishali and Peri urban 1 "Ngitili") were selected to determine changes in forest cover in "Ngitili" which changed from private to state under HASHI and the other two (Bulyanaga and Mwambegwa "Ngitili") were selected to determine forest cover changes in "Ngitili" which changed from communal to state under HASHI. The changes in forest cover in "Ngitili" under HASHI are discussed in the subsequent sections;

##### 4.1.1.1 Impacts of forestland tenure changes from private to state under HASHI on forest cover

Forest cover classification clearly discriminated five classes for the year 1986 and 2000 in "Ngitili" of Mwamishali and Peri urban 1. For the year 1986 the identified forest cover

were: open land, grassland, bushland, open forest and semi closed forest. The same classes were used for 2000. Table 2, Fig. 3 and Fig. 4 shows the proportion of these forest cover classes.

**Table 2: Cover area and the percentage change between 1986 and 2000 for Mwamishali "Ngitili"**

| Forest cover classes | Private tenure in 1986 | | State tenure in 2000 | | Change area 1986 - 2000 (ha) | % change | Annual rate of area change (ha/yr) | % Annual rate of change |
|---|---|---|---|---|---|---|---|---|
| | Area (ha) | % coverage | Area (ha) | % coverage | | | | |
| Open land | 18.45 | 17.74 | 1.65 | 1.59 | -16.80 | -91.06 | -1.20 | -6.50 |
| Grass land | 33.27 | 31.99 | 2.99 | 2.88 | -30.28 | -91.01 | -2.16 | -6.50 |
| Bush land | 6.85 | 6.59 | 11.39 | 10.96 | 4.54 | 66.28 | 0.32 | 4.73 |
| Open forest | 45.43 | 43.68 | 22.33 | 21.47 | -23.10 | -50.85 | -1.65 | -3.63 |
| Semi closed forest | 0.00 | 0.00 | 65.63 | 63.11 | 65.63 | infinity* | 4.69 | infinity* |
| **Total** | **104.00** | **100.00** | **104.00** | **100.00** | | | - | - |

* division by zero

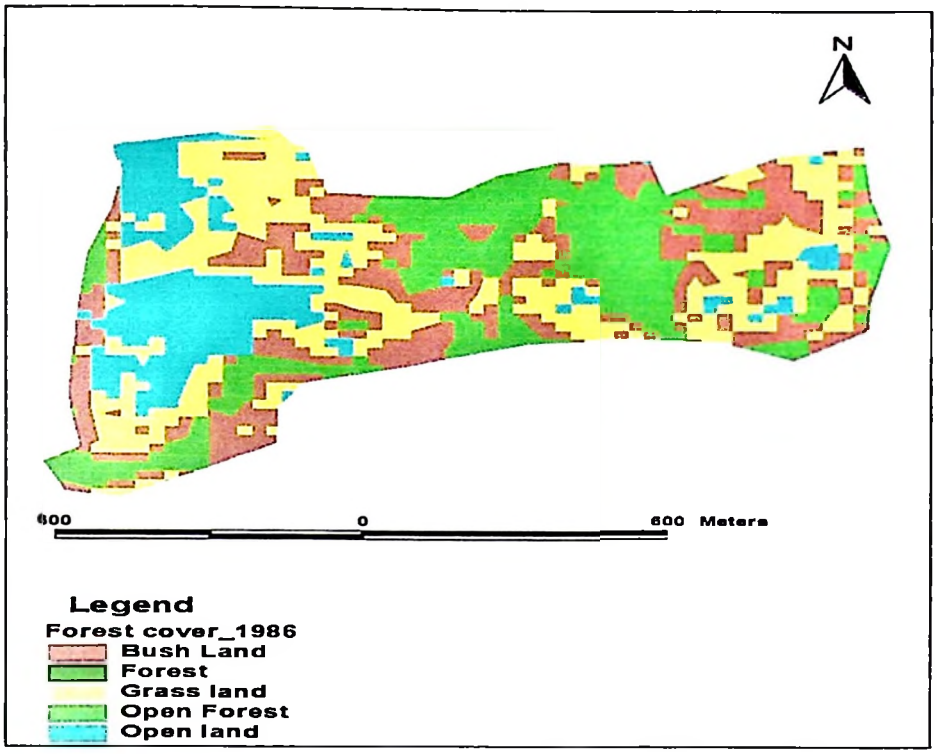


**Figure 3: Forest cover map of Mwamishali "Ngitili" in 1986**

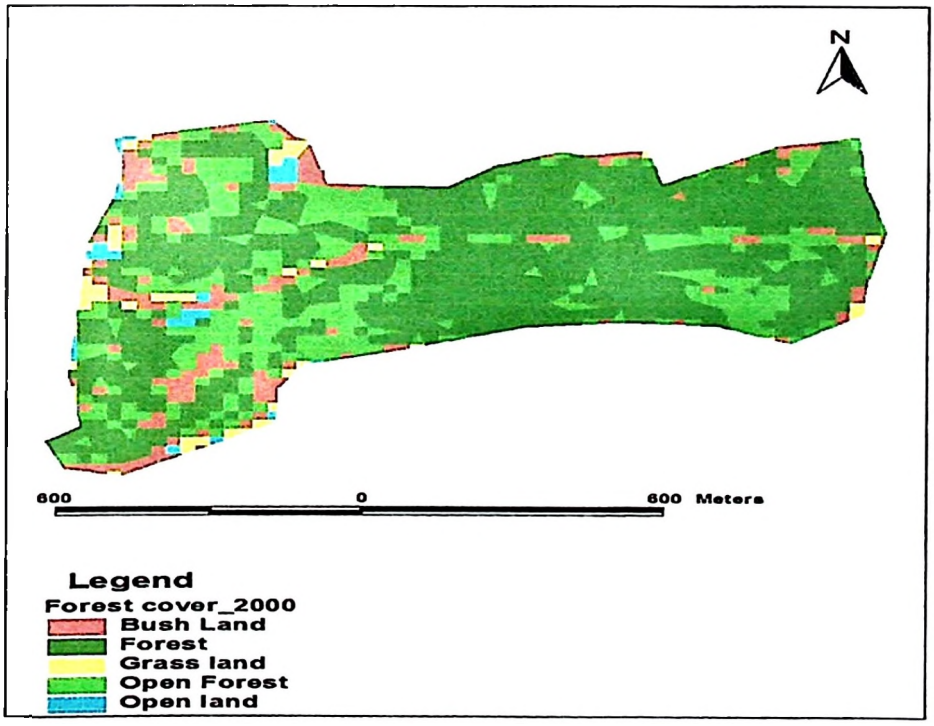


**Figure 4: Forest cover map of Mwamishali "Ngitili" in 2000**

The results shows that, during private tenure regime in 1986, the open forest dominated the area by covering 45.43 ha (43.68%) followed by grassland 33.27 ha (31.99%), open land 18.45 (17.74) % and bushland 6.85 (6.59%) while semi closed forest was completely lacking in the case of Mwamishali "Ngitili" (Table 2 and Fig. 3).

In 2000 when Mwamishali "Ngitili" was under state tenure regime a reverse trend was observed in which spatial expansion in semi closed forest area was observed. The trend of this forest cover was from none existence 0.00 ha (0%) in 1986 to 65.63 ha (63.11%) in 2000 under state tenure regime. Assuming a constant increase in semi closed forest cover the annual rate of change was estimated at 4.69ha per year (Table 3). This indicates that semi closed forest improved significantly in the state tenure regime under HASHI. On the other hand, the increase in the semi closed forest cover suggests that there was no disturbance in the "Ngitili" after the tenure change.

Table 3 and 4 also shows that rapid decrease of open land was from 18.45 ha (17.74%) under private tenure regime to 1.65 ha (1.59%) which is almost 11 times less of what was observed in 1986 under state tenure regime. Grassland decreased from 33.27 ha (31.99%) under private tenure regime in 1986 to 2.99 ha (21.47%) under state tenure regime in 2000. Also open forest decreased from 45.43 ha (43.68%) under private tenure regime in 1986 to 22.33 ha (21.47%) under state tenure regime in 2000. While bush land increased from 6.85 ha (6.59%) under private tenure regime in 1986 to 11.39 ha (10.96%) under state tenure regime in 2000 with the overall percentage increase of 66.36%. The decrease of open land, grassland and open forest as revealed by percentages changes of -91.04%, -90.99 and -50.86 respectively from 1986 to 2000 suggest the increase of semi closed forest cover in the "Ngitili" area. Furthermore, there was a constant decrease of open land, grassland and open forest at -1.2, -2.16 and -1.65 ha annually respectively. This also

corroborates with the inventory data results which showed an increase on woodland parameters as the results of tenure change (Table 11). Fig. 4 shows the forest cover map classes in 2000 of Mwamishali "Ngitili". It is evident from the map that, in 2000 the "Ngitili" area had more vegetation cover than what was observed in 1986 under private tenure regime, which suggests that tenure changes have been effective in restoring forest cover in "Ngitili" management systems.

In addition, Table 4. Fig. 5 and 6 show the results of forest cover changes for Peri Urban 1 "Ngitili" which changed from private tenure in 1986 to state tenure regimes under HASHI in 2000. Open land changed from 13.72 ha (21.89%) under private tenure regime in 1986 to 0.31 ha (0.49%) under state tenure regime in 2000. Grassland forest cover changed from 11.05 ha (17.69%) under private tenure regime in 1986 to 0.56 ha (0.95%) under state tenure regime in 2000. Bushland forest cover changed from 12.83 ha (20.47%) under private tenure regime in 1986 to 3.09 ha (4.93%) under state tenure regime in 2000. Also open forest changed from 25.07 ha (40.00%) under private tenure regime in 1986 into 8.89 ha (14.19%) under state tenure regime in 2000. Fig. 5 shows forest cover map as at 1986 in the Peri urban 1 "Ngitili".

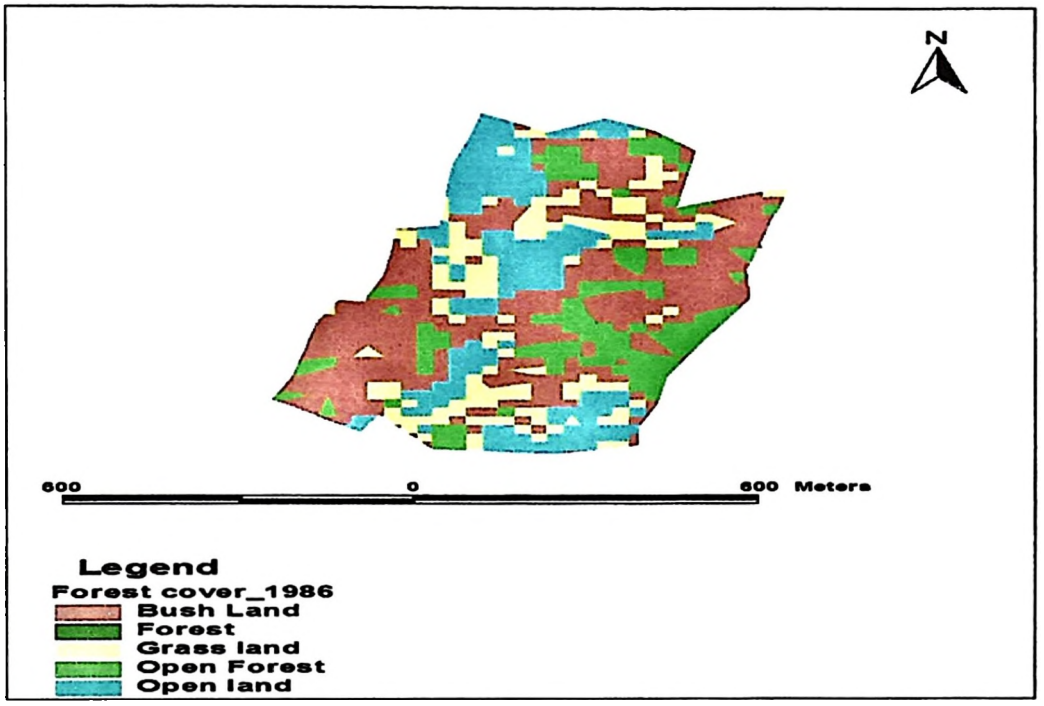


**Figure 5: Forest cover map of Peri urban 1 "Ngitili" in 1986**

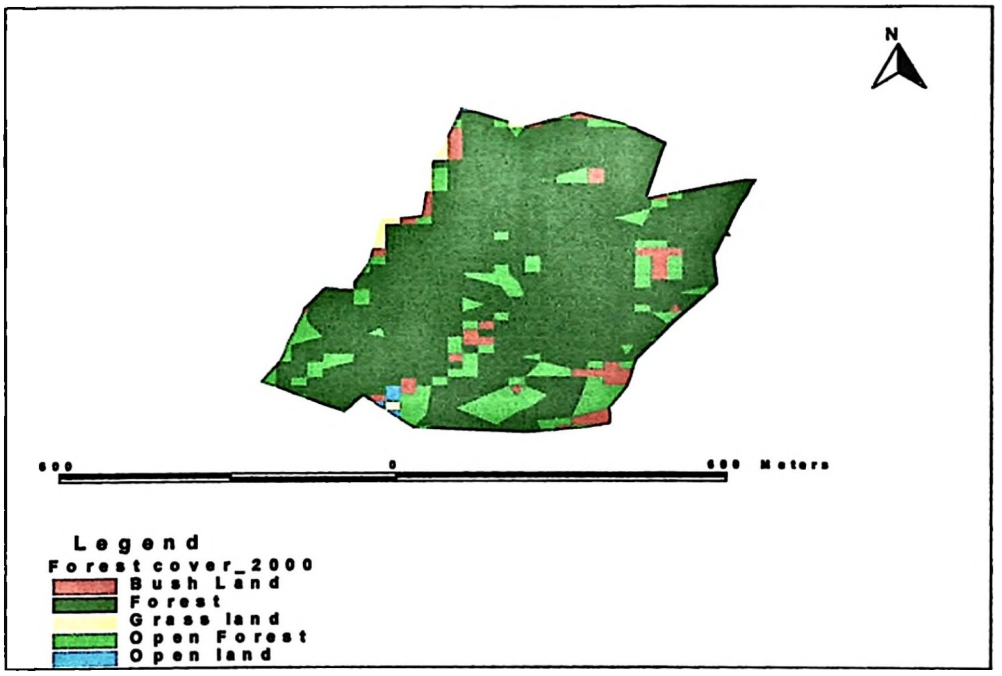


**Figure 6: Forest cover map of Peri urban 1 "Ngitili" in 2000**

**Table 3: Cover area and the percentage change between 1986 and 2000 for Peri urban 1 "Ngitili"**

| Forest cover classes | Private tenure regime in 1986 | | State tenure regime in 2000 | | Change area 1986-2000 (ha) | % change | Annual rate of area change (ha/yr) | % annual rate of change |
|---|---|---|---|---|---|---|---|---|
| | Area (ha) | % coverage | Area (ha) | % coverage | | | | |
| Open land | 13.72 | 21.89 | 0.31 | 0.49 | -13.41 | -97.74 | -0.96 | -6.72 |
| Grass land | 11.05 | 17.69 | 0.56 | 0.90 | -10.49 | -94.93 | -0.75 | -6.78 |
| Bush land | 12.83 | 20.47 | 3.09 | 4.93 | -9.74 | -75.92 | -0.70 | -5.42 |
| Open forest | 25.07 | 40.00 | 8.89 | 14.19 | -16.18 | -64.54 | -1.16 | -4.61 |
| Semi closed forest | 0.00 | 0.00 | 49.82 | 79.49 | 49.82 | infinity* | 3.56 | infinity * |
| **Total** | **62.67** | **100.00** | **62.67** | **100.00** | | - | | - |

* division by zero

Table 3 further indicated that there were decrease of open land, grassland, bushland and open forest at the percentage change of -97.74%, -94.93%, -75.92%, and -64.54% respectively. In addition to that open land, grassland, bushland and open forest cover decreased at 0.96, 0.75, 0.70 and 1.16 ha per year respectively. As the consequence of the decrease in these forests cover classes, semi closed forest cover increased considerably from almost no existence under private tenure regime in 1986 to almost the whole area being converted into semi closed forest under the state tenure regime in 2000 (Table 3 and Fig. 6). Semi closed forest was constantly increasing at rate of 3.56ha annually from 1986 to 2000. This indicates that the HASHI project had a positive impact in restoring forest cover in Peri urban 1 "Ngitili" in Meatu district.

#### 4.1.1.2 Impacts of forestland tenure changes from communal to state tenure regime under HASHI on forest cover

In this category two "Ngitili" (Bulyanaga and Mwambegwa "Ngitili") were analyzed to determine forest cover changes. Table 4 presents results of areas, percentage area of the Bulyanaga "Ngitili" between 1986 when it was under the communal tenure regime and 2000 when it was under state tenure regime. The results with regard to forest cover changes on Table 4 indicate that, in 1986 when Bulyanaga "Ngitili" was under the communal tenure regime, the open land dominated the area by covering 16.33 ha (32.36%) of the total "Ngitili" area followed by grassland 12.21 ha (24.19%), open forest 11.45 ha (22.69%) and bushland 10.48 ha (20.76%). While semi closed forest was completely missing. These forest cover classes are further shown by the forest cover map for 1986 (Fig. 7).

**Table 4: Cover area and the percentage change between 1986 and 2000 for Bulyanaga "Ngitili"**

| Forest cover classes | Communal tenure regime in 1986 | | State tenure regime in 2000 | | Change area 1986-2000 (ha) | % Cover change | Annual rate of change (ha/yr) | % annual rate of change |
|---|---|---|---|---|---|---|---|---|
| | Area (ha) | % Coverage | Area (ha) | % Coverage | | | | |
| Open land | 16.33 | 32.36 | 1.03 | 2.04 | -15.3 | -93.69 | -1.09 | -6.69 |
| Grass land | 12.21 | 24.19 | 2.46 | 4.87 | -9.75 | -79.85 | -0.70 | -5.69 |
| Bush land | 10.48 | 20.76 | 6.83 | 13.53 | -3.65 | -34.83 | -0.26 | -2.49 |
| Open forest | 11.45 | 22.69 | 13.08 | 25.92 | 1.63 | 14.24 | 0.12 | 1.02 |
| Semi closed forest | 0.00 | 0.00 | 27.07 | 53.64 | 27.07 | infinity* | 1.93 | infinity* |
| **Total** | **50.47** | **100.00** | **50.47** | **100.00** | | | - | - |

* division by zero

Table 4 shows that, in 2000 when Bulyanaga "Ngitili" was under the state tenure regime, the semi closed forest occupied more than half of the area by covering 27.07 ha (53.64%) of the total area. Semi closed forest was steadily increasing at an annually rate of 1.93ha. This is further supported by ground truthing results through inventory which indicated higher volume per hectare in 2008 under the state tenure regime (HASHI). The substantial increases in semi closed forest cover class definitely answer the question why other cover classes decreased. Table 4 also indicates the decrease of open land, grassland and bushland as indicated by the percentage change of -93.69%, -79.85% and -34.83% of the total area respectively. On the other hand, open land , grassland and bushland forest cover classes were annually decreasing at -1.09, -0.70 and 0.26 ha respectively from 1986 to 2000. However semi closed forest and open forest cover increased annually at 1.93 and 0.12 respectively from 1986 to 2000. The changes in forest cover are also shown in Fig. 7 and 8 in 1986 and 2000 respectively.

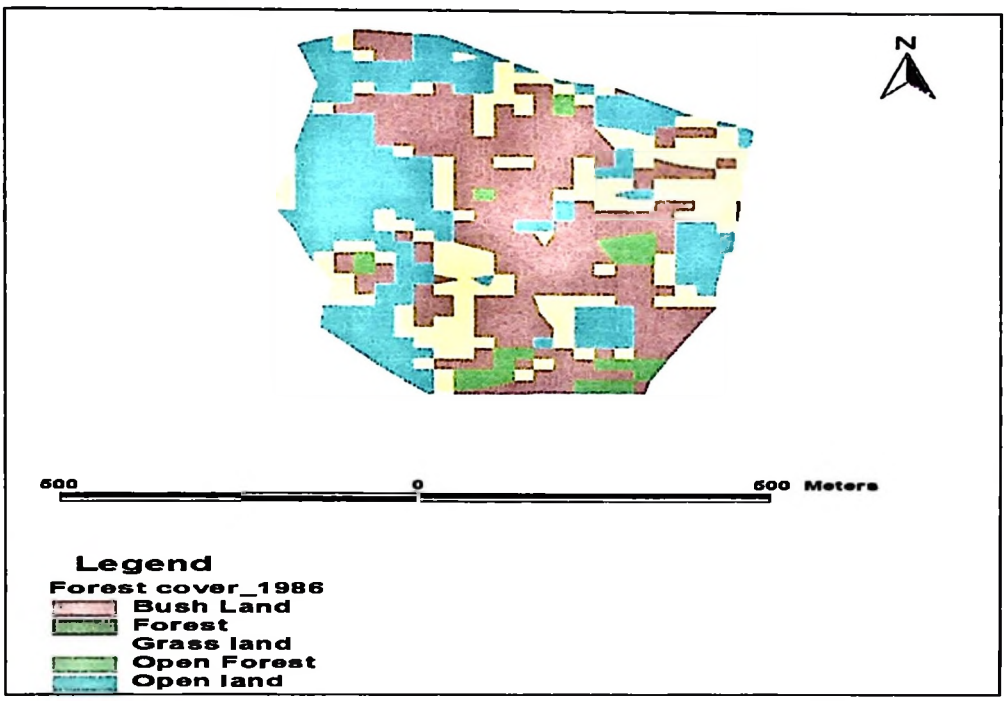


**Figure 7: Forest cover map of Bulyanaga "Ngitili" in 1986**

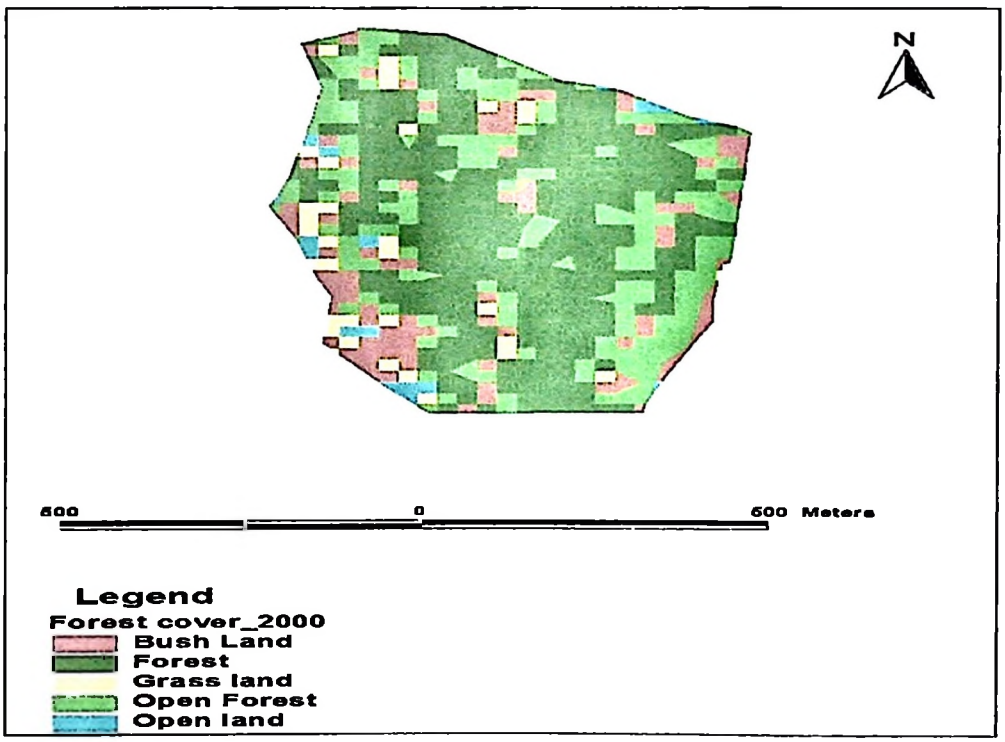


**Figure 8: Forest cover map of Bulyanaga "Ngitili" in 2000**

Furthermore, Table 5 Fig. 9 and Fig. 10 present, the results of forest cover changes and forest cover maps for Mwambegwa "Ngitili" between 1986 when was under communal and 2000 when was under state tenure regimes (HASHI).

**Table 5: Cover area and the percentage change between 1986 and 2000 for Mwambegwa "Ngitili"**

| Forest cover classes | Communal tenure regime in 1986 | | State tenure regime in 2000 | | Change area 1986-2000 (ha) | % change | Annual rate of change (ha/yr) | % annual rate of change |
|---|---|---|---|---|---|---|---|---|
| | Area (ha) | % coverage | Area (ha) | % coverage | | | | |
| Open land | 6.22 | 19.44 | 0.40 | 1.25 | -5.82 | -93.57 | -0.42 | -6.68 |
| Grass land | 6.59 | 20.59 | 0.29 | 0.91 | -6.3 | -95.59 | -0.45 | -6.83 |
| Bush land | 9.19 | 28.72 | 1.87 | 5.84 | -7.32 | -79.65 | -0.52 | -5.69 |
| Open forest | 10.00 | 31.25 | 2.19 | 6.84 | -7.81 | -78.10 | -0.56 | -5.58 |
| Semi closed forest | 0.00 | 0.00 | 27.25 | 85.16 | 27.25 | infinity* | 1.95 | infinity* |
| **Total** | **32.00** | **100.00** | **32.00** | **100.00** | | - | | - |

* division by zero

The results in Table 5 show that in 1986 when the Mwambegwa "Ngitili" was under communal tenure regime the open forest dominated the area by occupying 10.00 ha (31.25%) followed by bushland land 9.19 ha (28.72%), grassland 6.59 ha (20.59%) and open land 6.22 ha (19.44%), while semi closed forest was missing. These findings are supported by the forest cover map of the "Ngitili" as at 1986 (Fig. 9). These imply that, "Ngitili" management systems were poorly managed and hence forests in the systems were degraded before tenure changes.

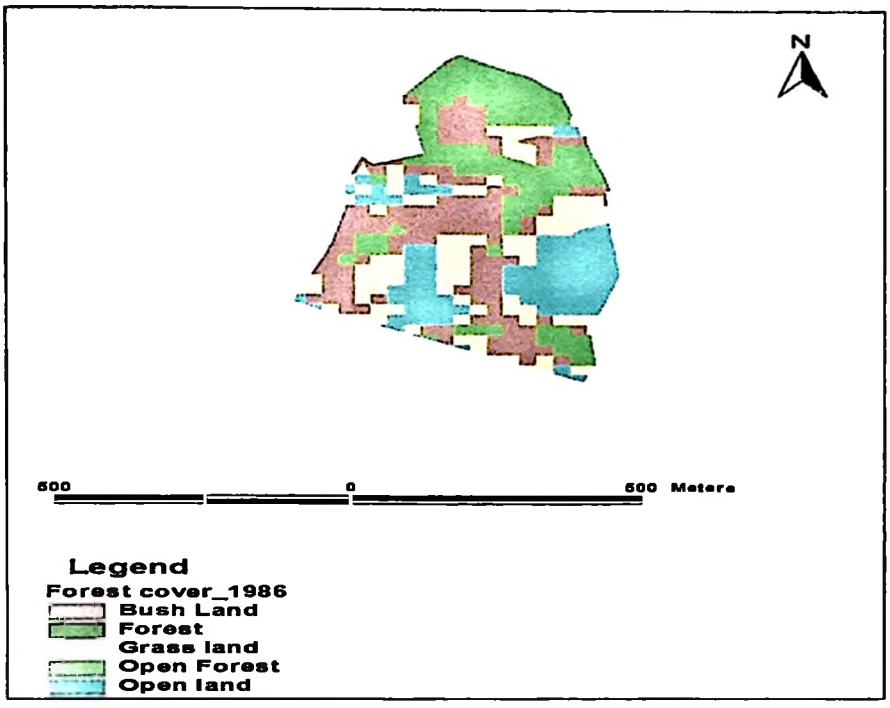


**Figure 9: Forest cover map of Mwambegwa "Ngitili" in 1986**


**Figure 10: Forest cover map of Mwambegwa "Ngitili" in 2000**

Table 5 also shows that, in 2000 when the Mwambegwa "Ngitili" was under state, semi closed forest occupied most of the area by covering 27.25 ha (85.16%) of the total area of the "Ngitili" followed by open forest 2.19 ha (6.84%), bushland 1.87 ha (5.84%), open land 0.4 ha (1.25%) and grassland occupied 0.29 ha (0.91%). The semi closed forest increased due the fact that other forest classes decreases. Grassland decreased faster at (-95.59%), followed by open land (-93.57), bushland (-79.65%) and open forest (-78.10%). These results are supported by the forest cover map of the "Ngitili" as at 1986 (Fig. 10).

### 4.1.2 Impacts of forestland tenure changes from communal to private outside HASHI on forest cover

In this category, Mussa Sambe "Ngitili" which changed from communal to private tenure regime was selected to determine forest cover changes in this tenurial system. Table 6 present forest cover changes between 1986 and 2000 in Mussa Sambe "Ngitili". Furthermore Fig. 11 and 12 shows the forest cover maps of the Mussa Sambe "Ngitili" in 1986 when was under communal tenure regime and in 2000 when it was under private tenure regime respectively.

**Table 6: Cover area and the percentage change between 1986 and 2000 for Mussa Sambe "Ngitili"**

| Forest cover classes | Communal tenure regime in 1986 | | Private tenure regime in 2000 | | Change area 1986-2000 (ha) | % change | Annual rate of change (ha/yr) | % annual rate of change |
|---|---|---|---|---|---|---|---|---|
| | Area (ha) | % coverage | Area (ha) | % coverage | | | | |
| Open land | 28.81 | 48.02 | 14.38 | 23.97 | -14.43 | -50.09 | -1.03 | -3.58 |
| Grass land | 11.02 | 18.37 | 6.72 | 11.20 | -4.30 | -39.02 | -0.31 | -2.79 |
| Bushland | 9.15 | 15.25 | 13.17 | 21.95 | 4.02 | 43.93 | 0.29 | 3.14 |
| Open forest | 11.02 | 18.37 | 12.97 | 21.62 | 1.95 | 17.70 | 0.14 | 1.26 |
| Semi closed forest | 0 | 0 | 12.77 | 21.28 | 12.77 | infinity* | 0.91 | infinity* |
| **Total** | **60** | **100** | **60** | **100** | - | - | - | - |

* division by zero

Table 6 shows that in 1986 the open land dominated the area by covering 28.81 ha (48.02%) while in 2000 when the "Ngitili" was under private tenure regime, the open land decreased to 14.38 ha (23.97%) of the total area. Also Grassland occupied 11.02 ha (18.37%) under communal tenure regime in 1986. It decreased to 6.72 ha (11.20%) under private tenure regime. The decrease of the grassland and open land forest cover classes favoured the increase of bushland, open forest and semi closed forest cover classes. Bushland increased from 9.15 ha (15.25%) under communal tenure regime to 13.17 ha (21.97%) under private tenure regime. Open forest increased from 11.02 ha in 1986 under communal tenure regime to 12.97 ha (21.62%) in 2000 under private tenure regime. Furthermore, semi closed forest increased from none existence in 1986 under communal tenure regime to 12.77 ha (21.28%) in 2000 under private tenure regime. The open land and grassland decreased by -50.09% and -39.02 respectively. The bushland, open forest and semi closed forest increased by 43.93%, 17.70% and 12.77% respectively.

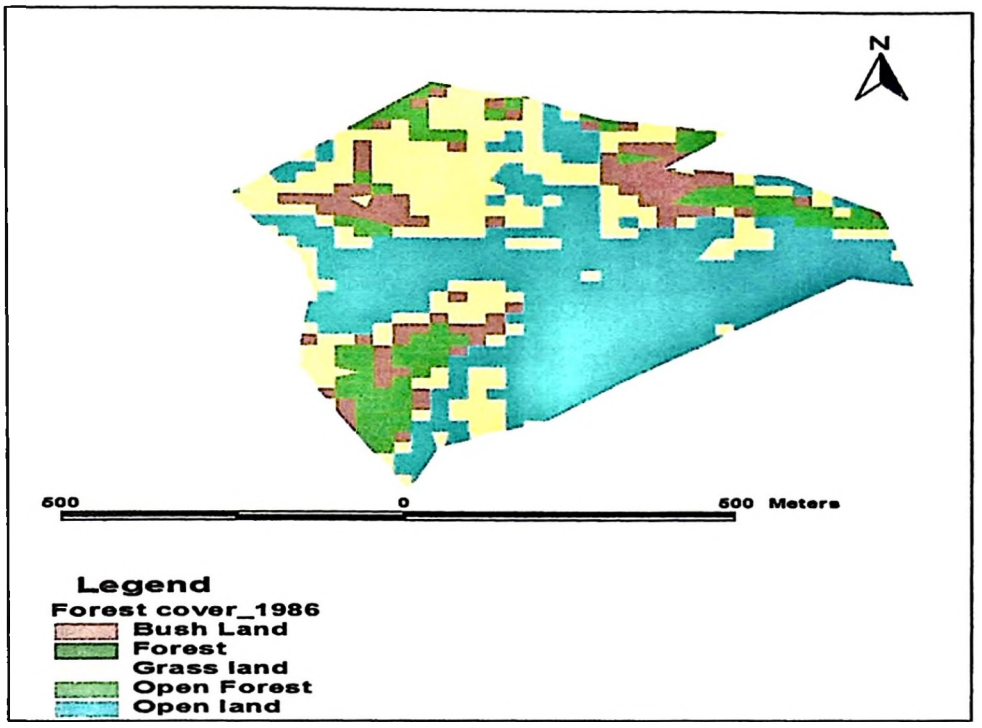


**Figure 11: Forest cover map of Mussa Sambe "Ngitili" in 1986**

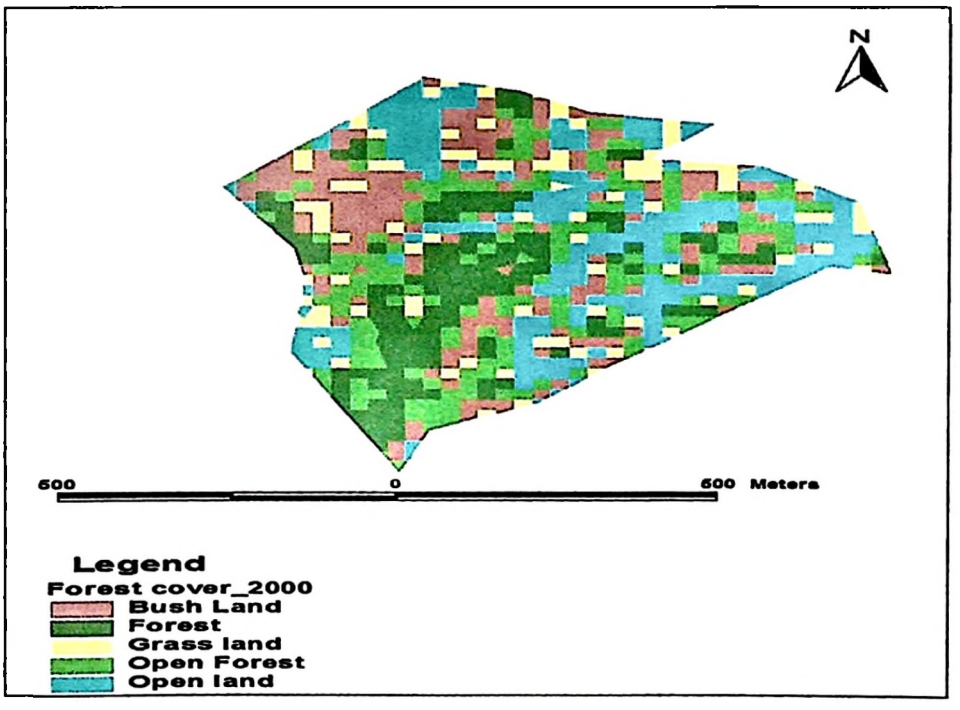


**Figure 12: Forest cover map of Mussa Sambe "Ngitili" in 2000**

### 4.2 Stocking and tree species diversity under different tenure regimes

The tenure changes from private to state under HASHI for Mwamishali and Peri urban1 "Ngitili", from communal to state under HASHI for Bulyanaga and Mwambegwa "Ngitili" and lastly from communal to private tenure regime outside HASHI for Mussa Sambe "Ngitili" impacted differently in wood stocking parameters (stand density, basal area and standing volume) and species diversity. The impact of tenure changes on stocking under different tenure regimes are described in the following sections:

#### 4.2.1 Impacts of forestland tenure changes from private to state under HASHI on stocking parameters

Table 7 shows the impacts of tenure change for Mwamishali and Peri urban 1 "Ngitili"on various stocking parameters.

**Table 7: Impacts of tenure change from private to state tenure regimes on stocking in Mwamishali and Peri urban 1 "Ngitili"**

| | Stocking parameters in 2008 | | |
|---|---|---|---|
| **Ngitili name** | **N (stems/ha)** | **G (BA/ha)** | **V ($M^3$/ha)** |
| Mwamishali | 2 337 | 7.27 | 18.19 |
| Peri urban 1 | 809. | 8.05 | 28.05 |

The table shows that, the average number of stems per hectare in Mwamishali and Peri urban 1 "Ngitili" was 2337 and 809 respectively. Moreover Fig. 13 shows the distribution of number of stems per hectare in Mwamishali and Peri urban 1 "Ngitili".

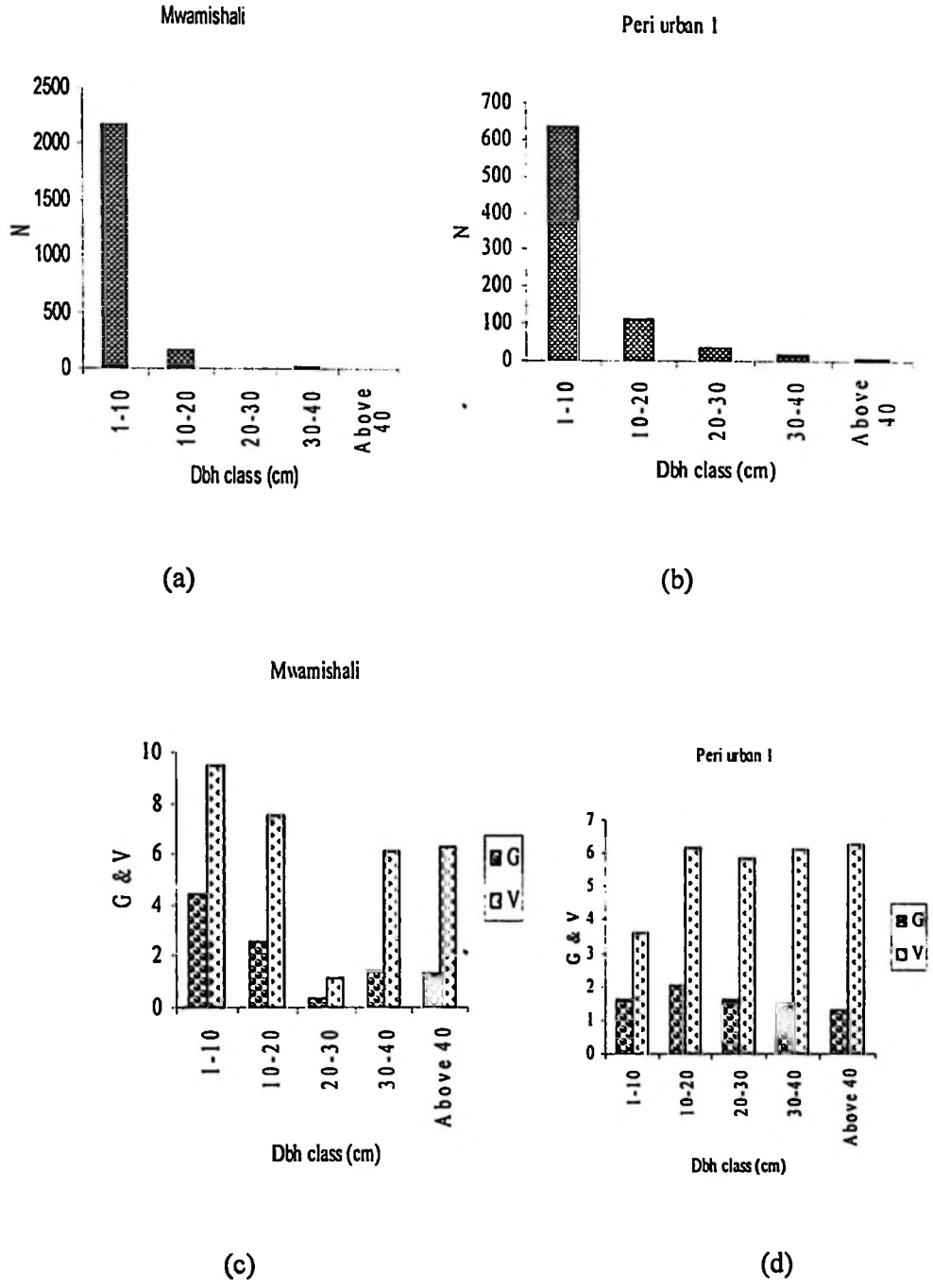


**Figure 13: Stocking parameters (N, G and V) distribution in Peri urban 1 and Mwamishali "Ngitili"**

The distribution of number of stems per hectare follows the usual expected reversed J-shaped trend with noticeable high number of trees of below 10 cm Dbh (Fig. 11). The dominance of young trees is an indication of the regeneration that occurred during closure of highly degraded "Ngitili" to allow restoration or regeneration in "Ngitili" where controlled grazing has been done. This distribution is also influenced by harvesting pressure of larger trees for firewood, charcoal, poles as observed during field work.

The number of stems per hectare found in Mwamishali and Peri urban 1 are comparable to those found by the study by Monela *et al.* (2004) who found 2 508, 2 958 and 2 602 stems per hectare in the "Ngitili" of Bukombe, Bariadi and Maswa Shinyanga region, Tanzania respectively. Furthermore, Mafupa (2006), Njana (2008), and Ngowi (2008) reported 722, 583, and 510 stems per hectare in miombo woodlands of Igombe, Urumwa, and Kimani respectively. Moreover Nduwamungu and Malimbwi (1997) reported 691 numbers of stems per hectare in miombo woodland of Kitulangalo forest reserve, Morogoro Tanzania. However, the number of stems found in Mwamishali and Peri urban 1 are relatively higher than those found in most studies.

Table 7 further shows that the volume and basal area per hectare in Mwamishali "Ngitili" was 18.19 $m^3$/ha and 7.27 $m^2$/ha respectively, while in Peri urban 1 "Ngitili" the volume and basal area was 28.05 $m^3$ and 8.05 $m^2$/ha respectively. Fig. 13 also shows the distribution of volume and basal area per hectare against Dbh classes. The general pattern of J-shaped for natural forests of mixed age and species is not followed. The distribution indicates that small trees of 1 to 20 cm Dbh contributes to more volume and basal area per hectare. This was evidenced by presence of many trees of small sizes as compared to very few larger trees. The results on volume per hectare found in this study are comparable to those obtained at Kitulaghalo forest reserve ranging from 17 to 25 $m^3$ $ha^{-1}$ (Malimbwi *et*

*al.*, 1994). This indicates that, "Ngitili" were well managed after tenure change to be as similar as in natural forest mixed age and species. In addition, basal area found in both Mwamishali and Peri urban 1 "Ngitili" area in line with those reported in Miombo woodlands in Zimbabwe and Malawi in which basal areas ranged from 7 to 25 $m^2ha$-1 (Chidumayo, 1987; Lowore *et al.*, 1994).

### 4.2.2 Impacts of forestland tenure changes from communal to state under HASHI on stocking parameters

Under this category, Bulyanaga and Mwambegwa "Ngitili" were considered in determining the impact of forestland tenure from communal to state tenure regime under HASHI with respect to stocking parameters (number of stems per hectare, basal area per hectare and volume per hectare). Table 8 presents the summarized results of stocking parameters in "Ngitili" of Bulyanaga and Mwambegwa.

**Table 8: Impacts of tenure change from communal to state tenure regimes on stocking parameters in Bulyanaga and Mwambegwa "Ngitili"**

| | Stocking parameters in 2008 | | |
|---|---|---|---|
| **Ngitili name** | **N (stems/ha)** | **G (BA/ha)** | **V ($M^3$/ha)** |
| Bulyanaga | 1 213 | 6.67 | 18.06 |
| Mwambegwa | 573 | 5.22 | 16.67 |

The table shows that the average number of stems/hectare in Bulyanaga and Mwambegwa "Ngitili" were 1 214 and 573 stems per hectare respectively. Fig.14 shows that, the distribution of number of stems per hectare follows the usual expected reversed J-shaped trend with noticeable high number of trees of below 10 cm Dbh. The dominance of young

trees is an indication of the regeneration that occurred during closure of highly degraded Ngitili to allow restoration or regeneration whereby controlled grazing was practiced. The plausible explanation is that state tenurial regime under HASHI controlled harvesting and overgrazing in both Bulyanaga and Mwambegwa "Ngitili"

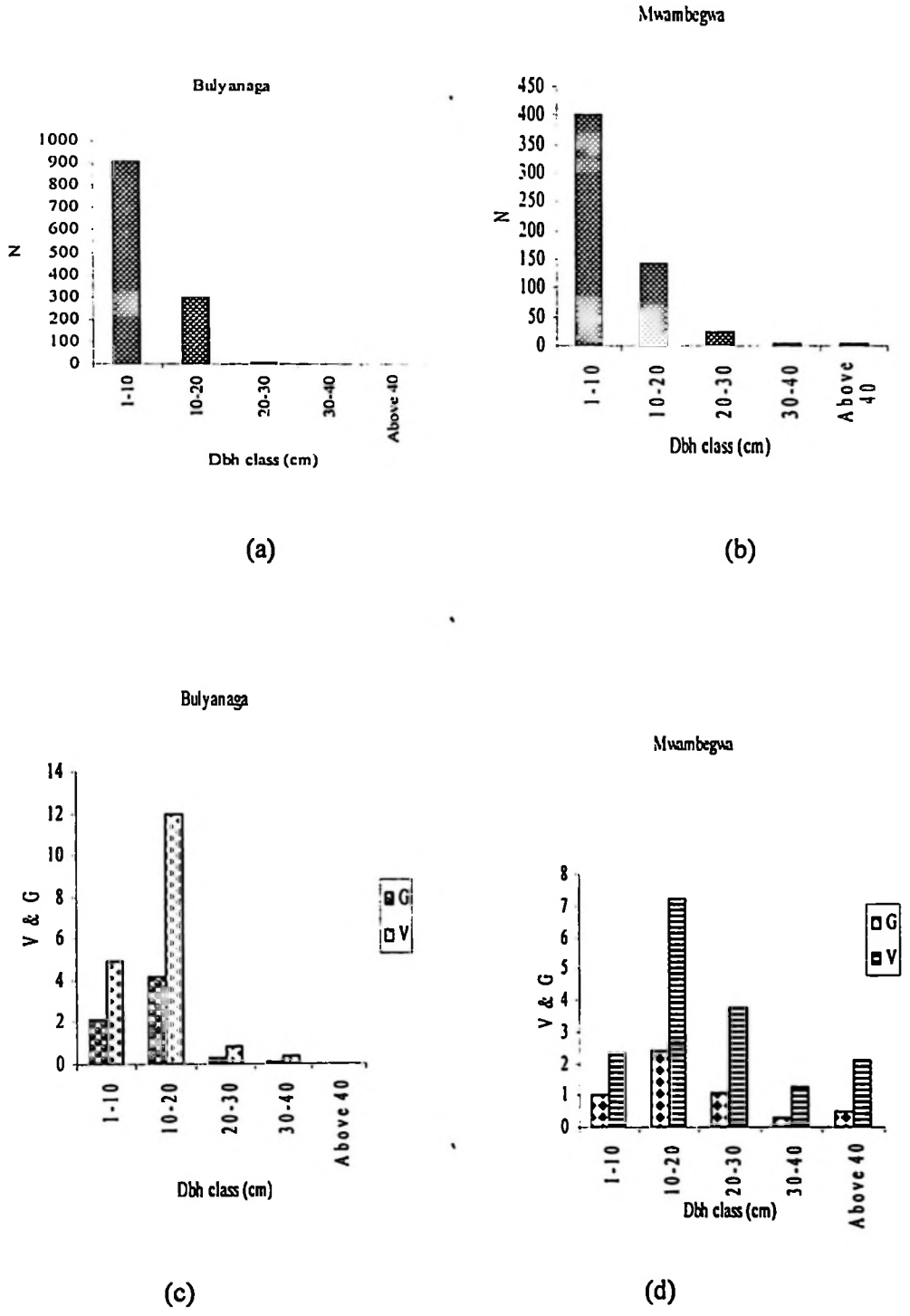


**Figure 14: Stocking parameters (N, G and V) distribution in Bulyanaga and Mwambegwa "Ngitili"**

The numbers of stems per hectare found in these "Ngitili" are in line with those reported by other studies done elsewhere in miombo woodlands. For instance Chidumayo (1993) obtained 750 stems per hectare in miombo woodland in Zambia. Malaise (1978) reported a range of 520 to 645 stems per hectare in miombo woodland in Katanga (DRC). Njana (2008) and Ngowi (2008) reported 583 and 510 stems per hectare in miombo woodlands of Urumwa and Kimani in Tanzania.

Furthermore average volume and basal area per hectare in Bulyanaga "Ngitili" were 18.06 $m^3$/ha and 6.67 Ba/ha respectively. While in Mwambegwa 'Ngitili" were 16.67 $m^3$ and 5.22 Ba/ha respectively. The pattern (Fig. 14) does not follow the normal J-shaped for natural forests of mixed age and species. The distribution indicates that small trees of 1 to 20 cm Dbh contribute more to the volume and basal area per hectare compared to larger trees of Dbh > 20 cm. The results in basal area and volume per hectare found in Mwambegwa and Bulyanaga "Ngitili" are in agreement with those found in other studies. Monela *et al.* (2004) reported a volume per hectare ranging from 6.62 to 27.02 $m^3$ $ha^{-1}$ in "Ngitili" of Shinyanga region. However they are much lower than those found in miombo woodland of mixed age and species ranging from 39 to 76 $m^3$ $ha^{-1}$ (Malimbwi *et al.*, 1994; Chamshama *et al.*, 2004).

### 4.2.3 Impacts of forestland tenure changes from communal to private outside HASHI on stocking parameters

Mussa Sambe "Ngitili" was considered in determining the impact of forestland tenure from communal to private tenure regime outside HASHI on stocking parameters (number of stems per hectare, basal area per hectare and volume per hectare). The average number of stems/hectare in Mussa Sambe "Ngitili" was 3 198 stems per hectare. The distribution of number of stems per hectare followed the usual reversed J shape with noticeable high

number of trees of Dbh below 10cm. The volume and basal area per hectare were 36.04 $m^3$/ha and 6.92 $m^2$/ha respectively. Fig. 15 also shows the distribution of volume and basal area per hectare against the Dbh classes. The pattern does not follow the normal J-shaped for natural forests of mixed age and species. The distribution indicates that small trees of 1 to 20 cm Dbh contribute more to volume and basal area per hectare as compared to larger trees of Dbh > 20 cm.

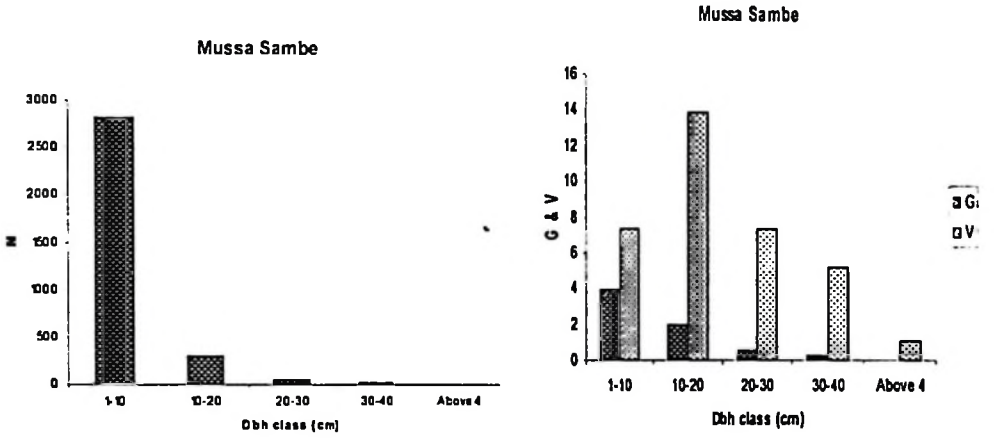


**Figure 15: Stocking parameters distribution in outside HASHI "Ngitili"**

Moreover, the number of stems and volume per hectare found in outside HASHI "Ngitili' is much greater than that found in HASHI "Ngitili". This is due to the fact that there is relatively little harvesting pressure of trees in outside HASHI "Ngitili" compared to HASHI "Ngitili". Monela (*at al.*, 2004) found 6553, 3 232, 2508, 2958, 2602, 1964 and 4253 number of stems per hectare in "Ngitili" of Kahama, Shinyanga Rural, Bukombe, Bariadi, Maswa, Meatu and Shinyanga Urban districts of Shinyanga region Tanzania. The volume per hectare found in this study is comparable to those reported in Miombo woodland of mixed age and species in which the volume per hectare ranged from 39 to 76 $m^3$/ha (Malimbwi *et al.*, 1994; Chamshama *et al.*, 2004).

### 4.2.4 Impact forestland tenure changes on tree species diversity in HASHI and outside HASHI "Ngitili"

#### 4.2.4.1 Shannon-Wiener Index (H') of trees species in HASHI and outside HASHI "Ngitili"

Table 9 shows the Shannon-Wiener Index of Diversity in HASHI and outside HASHI "Ngitili". The study revealed the Shannon-Wiener Indices of diversity of 1.15 and 2.01 in the Mwamishali and Peri urban 1 "Ngitili" respectively which changed from private tenure regime to state tenure regime under HASHI. On the other hand, the study found the Shannon-Wiener Indices of diversity of 1.88 and 0.99 in the Bulyanaga and Mwambegwa "Ngitili" respectively which changed from communal tenure regime to state tenure regime under HASHI. A Shannon-Wiener index of species diversity of 1.90 was found in the outside HASHI "Ngitili" of Mussa Sambe.

**Table 9: Shannon winner indices of diversity (H') in HASHI and outside HASHI "Ngitili"**

| Ngitili name | Tenure changes pathways | Shannon Winner Index of Diversity (H') |
|---|---|---|
| Mwamishali | From private to state under HASHI | 1.15 |
| Peri urban 1 | From private to state under HASHI | 2.01 |
| Bulyanaga | From communal to State under HASHI | 1.88 |
| Mwambegwa | From communal to State under HASHI | 0.99 |
| Mussa Sambe | From communal to private under outside HASHI | 1.90 |

The indices presented in Table 9 tell about species richness (number of species) and evenness (species distribution) (Magurran, 1998). The larger the H' value the greater the species diversity and vice versa. An ecosystem with H' value greater than 2 has been

regarded as medium to high diverse in terms of species (Barbour *et al.*, 1999). Thus, "Ngitili" in outside HASHI and some (Mwamishali, Bulyanaga and Mwambegwa) in HASHI have lower tree and species diversity. However, Peri urban "Ngitili" under HASHI has medium to high species diversity. Species noted to contribute to the observed species diversity in both HASHI and outside HASHI "Ngitili" include: *Acacia tortilis, Dichrostchys cinerea, Acacia Senegal, Acacia nilotica, Acacia polycantha, Luceana lucocephala, Delonix procera, Azandirachta indica, Senna siamea, Acacia drepanolobium, Kadaba adenotricha, Kigeria Africana and Diospyros fischeri.* Comparative studies elsewhere in Miombo woodlands have shown consistently more or less the same results. For example Monela *et al.*, (2004) reported H' value of "Ngitili" woodland ranging from 1.9 to 3.7 in all the Districts of Shinyanga region Tanzania. Furthermore, studies in miombo woodlands of Handeni Hill forest reserve, Tanga, Tanzania by Mohamed (2006) and Igombe river forest reserve, Tabora, Tanzania by Mafupa (2006) reported H' values of 3.1 and 2.90 respectively.

#### 4.2.4.2 Index of Dominance (C)

The greater the value of C the lower the species diversity and vice versa in the scale of 0 to 1 Misra (1989). Table 10 shows the values of the indices of dominance in both HASHI and outside HASHI "Ngitili". In the Mwamishali and Peri urban 1 "Ngitili" the indices of dominance found were 0.39 and 0.15 respectively. In this category of tenurial change, Mwamishali "Ngitili" has lower species diversity as compared to Peri urban 1 "Ngitili". The study also showed indices of dominance of 0.17 and 0.41 for Bulyanaga and Mwambegwa "Ngitili" respectively. Finally the index of dominance of 0.21 was found /computed for Mussa Sambe "Ngitili".

**Table 10: Indices of dominance in HASHI and outside HASHI "Ngitili"**

| Ngitili name | Tenure changes pathways | Index of dominance (C) |
|---|---|---|
| Mwamishali | From private to state under HASHI | 0.39 |
| Peri urban 1 | From private to state under HASHI | 0.15 |
| Bulyanaga | From communal to State under HASHI | 0.17 |
| Mwambegwa | From communal to State under HASHI | 0.41 |
| Mussa Sambe | From communal to private outside HASHI | 0.21 |

Furthermore, all "Ngitili" in both HASHI and outside HASHI were dominated by Acacia species including *Acacia polycantha*, *Acacia tortilis*, *Acacia seyal* and *Acacia drepanolobium*. These *Acacias* are pioneer species i.e. species that are first to colonize degraded areas. Their dominance suggests that the woodlands are recovering. However, it has been observed that the *Acacia* species such as *Acacia polycantha, A. nilotica* and *A. tortilis* are important browse species known in the region (Mlenge, 2002). It is possible therefore, that the local people managing the "Ngitili" are doing some management practices to promote regeneration of these species. This may be the case since the primary objective of "Ngitili" management systems is the provision of fodder during dry seasons for livestock.

The C values in this study are in agreement with what has been found in other studies in miombo woodlands elsewhere in Tanzania. Mafupa (2006) reported C value of 0.135 in disturbed strata of miombo woodlands of Igombe river forest reserve, Tabora, Tanzania. On the other hand, Monela *et al.*, (2004) reported C values of 0.108, 0.106, 0.164 and 0.292 for Bariadi, Maswa, and Meatu and Shinyanga Urban Districts of Shinyanga region, Tanzania respectively. At Mkindo forest reserve in Morogoro rural district, the C value

was 0.085 for the miombo woodland (Malimbwi and Mugasha, 2001). The C values of 0.092 and 0.065 were observed in public lands and reserved forest respectively for the miombo woodland at Kitulangalo near Morogoro (Zahabu, 2001). This suggests that, the C values found for Ngitili forests in the study area indicated lower species richness compared to other forests in Morogoro region.

### 4.2.5 Comparison of stocking parameters between HASHI and outside HASHI "Ngitili

#### 4.2.5.1 Comparison of wood density between HASHI and outside HASHI "Ngitili"

Table 11 shows the average numbers of stems per hectare for HASHI and outside HASHI "Ngitili". Results shows that a total of 1 214, 573, 2338 and 809 stems per hectare were found in the "Ngitili" of Bulyanaga, Mwambegwa, Mwamishali and Peri urban 1 respectively which are under state ( HASHI) tenure regimes. Furthermore 3 198 stems per hectare were observed in Mussa Sambe "Ngitili" under private tenure regime outside HASHI. Literally HASHI "Ngitili" have lower number of stems per hectare as compared to outside HASHI "Ngitili". A paired *t*-test was done to test if there were significant differences in stocking parameters between the HASHI and outside HASHI "Ngitili", and the results are indicated in Table 11.

Table 11: Comparison of stocking parameters between HASHI and outside HASHI "Ngitili"

| Stocking Parameters | Ngitili name | | Statistical test | |
|---|---|---|---|---|
| | outside HASHI | HASHI | t | P -value |
| | Mussa Sambe | Bulyanaga | | |
| N | 3 198 | 1 214 | 1.09 | 0.15 |
| G | 6.92 | 6.67 | 0.58 | 0.29 |
| V | 36.04 | 18.06 | 0.48 | 0.32 |
| | Mussa Sambe | Mwamishali | | |
| N | 3 198 | 2 337 | 1.19 | 0.13 |
| G | 6.92 | 7.27 | 0.79 | 0.22 |
| V | 36.04 | 18.19 | 1.56 | 0.07 |
| | Mussa Sambe | Peri Urban | | |
| N | 3 198 | 809. | 1.82 | 0.05 |
| G | 6.92 | 8.05 | 0.22 | 0.42 |
| V | 36.04 | 28.05 | 0.63 | 0.27 |
| | Mussa Sambe | Mwambegwa | | |
| N | 3 198 | 573 | 1.96 | 0.04 |
| G | 6.92 | 5.22 | 0.68 | 0.25 |
| V | 36.04 | 16.67 | 1.27 | 0.11 |

Table 11 indicates that no significant difference in number of stems per hectare between HASHI (Bulyanaga and Mwamishali) and outside HASHI (Mussa Sambe) "Ngitili" at $P<0.05$. Furthermore the results shows that, there was significantly larger ($p<0.05$) number of stems per hectare outside HASHI "Ngitili" of Mussa Sambe and HASHI "Ngitili" of Peri urban 1. Moreover there was significantly larger ($p<0.04$) number of stems per hectare observed between outside HASHI "Ngitili" of Mussa Sambe and HASHI "Ngitili" of Mwambegwa. The lower average stocking in the HASHI "Ngitili" of Peri 1 urban and Mwambegwa was attributed by high incidences of human disturbances

presumably for firewood collection, charcoal making and brick making. The observation was backed by the results from the PRA on forest uses where people acknowledged the harvesting of different forest products from these "Ngitili" for different uses including poles, charcoal and brick making. Also harvesting of forest products from these "Ngitili" was evident during data collection (plate 1).

**Plate 1: Wood stock harvested for different uses**

The high number of stems per hectare in the outside HASHI "Ngitili" of Mussa Sambe was probably attributed by good monitoring in this private "Ngitili".

#### 4.2.5.2 Comparison on volume and basal area per hectare between HASHI and outside HASHI "Ngitili"

Fig 16 shows the volume per hectare found in the HASHI and outside HASHI "Ngitili". The volume per hectare in HASHI "Ngitili" ranged from 16.67- 28.05 $m^3$ $ha^{-1}$ which was literally lower than found in the outside HASHI "Ngitili" (36.04 $m^3$ $ha^{-1}$).

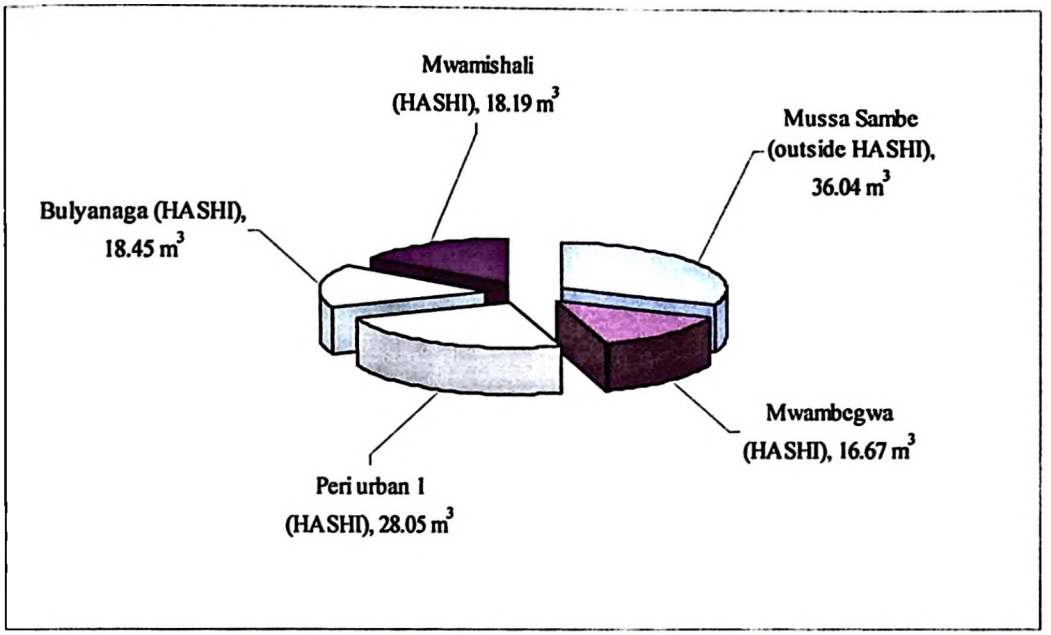


**Figure 16: Standing volume per hectare in HASHI and outside HASHI "Ngitili"**

Table 11 shows that no significant differences in volume per hectare between HASHI and outside "Ngitili". These results are comparable to those obtained in Kitulaghalo forest reserve ranging from 17 to 25 $m^3$ $ha^{-1}$. (Malimbwi *et al.*, 1994). Also they are comparable with those obtained in "Ngitili" of Shinyanga region ranging from 6.62 to 27.02 $m^3$ ha-1 (Monela *et al.*, 2004). Furthermore, Fig.1 shows the mean basal area per hectare in the HASHI and outside HASHI "Ngitili". In the HASHI "Ngitili" the mean basal area ranged from 5.22 to 8.05 $m^2$ $ha^{-1}$, while in the outside HASHI "Ngitili" was 6.92 $m^2$ $ha^{-1}$.

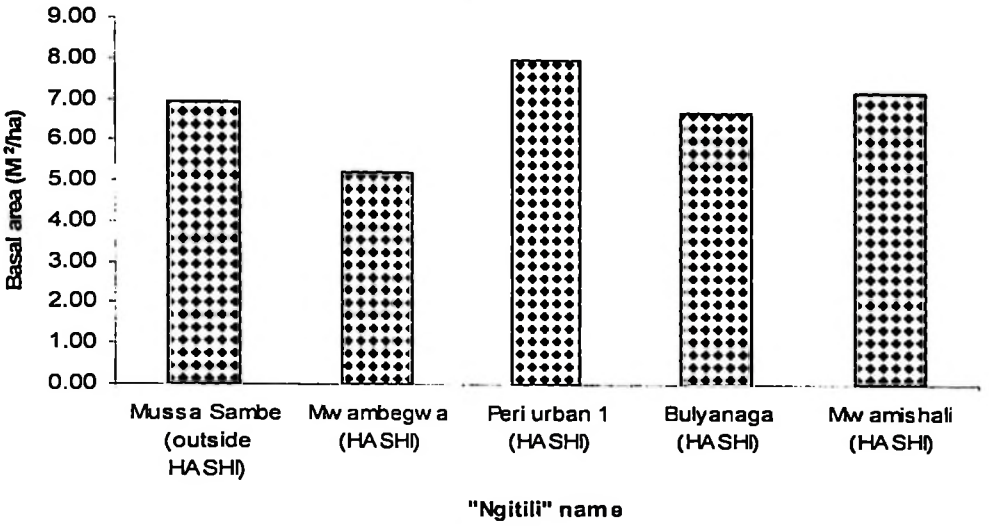


**Figure 17: Basal area per hectare under HASHI and non HASHI "Ngitili"**

Table 11 show that there is no significant difference between HASHI and outside HASHI "Ngitili" with reference to basal area / ha. HASHI was established in 1986 with the objective to determine those areas most in need of restoration, go to villagers and work with them to set aside degraded areas for restoration (Kaale *et al.*, 2003). With this background information in mind, the observed similarities between the "Ngitili" in HASHI and outside HASHI was a great achievement to the HASHI project, since HASHI dealt with the most affected "Ngitili" areas and now are of similar forest conditions. The basal area per hectare found in the HASHI and outside HASHI "Ngitili" is comparable to those reported in Miombo woodlands in Zimbabwe and Malawi in which basal areas ranged from 7 to 25 $m^2$ha-1 (Chidumayo, 1987; Lowore *et al.*, 1994). Also they are comparable to those reported by Monela *et al.* (2004), in which the basal ranged from 3.394 to 5.87 in "Ngitili" of Shinyanga region, Tanzania.

### 4.3 Forest use changes under different tenure regimes

#### 4.3.1 Impacts of forestland tenure changes from communal and private regimes to state tenure regime under HASHI on forest use

Results show that, the four "Ngitili" studied were used primarily as fodder reserves before tenure changes. Products like fire wood and local medicine were also obtained before they were degraded. Fodder from "Ngitili" was mainly used to feed young, old or sick animals unable to follow other animals to far range lands. Also fodder was used to feed cattle for milk production and feeding oxen which were mainly used for farming activities. Otherwise cattle had to move long distances (about 60km) to rangelands. Otsyina and Asenga (1994) indicated that "Ngitili" are regarded, as traditional dry season fodder reserves. Furthermore "Ngitili" before tenure change were for soil and water conservation and surface water runoff checkout. These uses of "Ngitili" before tenure changes are comparable with that reported by Mlenge (2002, 2004) indicating that, "Ngitili" were used to provide fodder for livestock especially oxen at the end of the dry season when villagers plough their land.

After tenure change from private and communal to state under HASHI, "Ngitili" were completely protected. As a result, "Ngitili" showed the sign of improvement in terms of forest cover. Information from Key informants and PRA exercises indicate that strictly only oxen and sick animals were allowed to graze in these "Ngitili". This was done perhaps to make sure that "Ngitili" recover their original forest cover after years of overgrazing. Discussion with the local communities indicates that only four Oxen were allowed to graze per farming season in each "Ngitili". After ten (10) years (1986 to 1996) of change in forestland tenure from private and communal to state tenure regime, people were able to obtain more products and services as discussed here under:

#### 4.3.1.1 Grazing rights

Grazing rights is where people who need an area for grazing pay money for obtaining that rights (Plate 3). Grazing rights is made possible through dividing "Ngitili" into grazable pieces of land for hiring. Results show that, the villagers at Peri urban 1 (HASHI) "Ngitili" hired grazing rights and earned income that amounted to TAS 45 x $10^4$ (about $ 400) in 2006. They used the amount of money for purchasing 40 bags of cements which helped them for constructing 1 classroom of two rooms and one teachers' office. Also in 2008, they constructed village government office (Plate 2) of which 80% of money was obtained from "Ngitili" through hiring grazing rights.

**Plate 2: Village office being constructed with the help of money from hiring grazing rights**

Furthermore results from discussion with key informants at Mwamishali (HASHI) "Ngitili" indicated that, they realized TAS 267 x $10^4$ from hiring grazing rights in 1996. In

all the four "Ngitili" under HASHI studied, people acknowledged the increase of revenue from hiring grazing rights. This could probably be due to higher grazable regenerants which were found in these "Ngitili" during the study (Appendix 4).

**Plate 3: Cattle grazing in the "Ngitili" after the owner of the Ngitili issued grazing rights to the cattle's owner**

The income obtained through hiring grazing rights in the "Ngitili" of Mwamishali and Peri urban 1 under HASHI are comparable to the income obtained through hiring grazing rights in HASHI "Ngitili" of Mwamatiga and Mwananogu villages in Meatu District Tanzania. The villagers surrounding the "Ngitili" of Mwamatiga and Mwananogu accrued TAS one million and TAS two millions, respectively in 1995 and 1996 from sales of grazing rights of their Ngitili (Kaale *et al.*, 2002).

#### 4.3.1.2 Availability of local medicine

Restored woodlands have also improved availability of local medicines probably as a result of tenure changes from private and communal to state tenure regime under HASHI. This meant that traditional healers can get more medicinal plants for treatment. Discussion with key informants and PRA exercises at Mwamishali, Peri urban 1, Bulyanaga and Mwambegwa "Ngitili" indicated that local medicine from trees and herbs/grasses was easily obtainable. The study showed that there were a number of footpaths throughout the area of the studied "Ngitili", indicating frequent visits by the villagers, probably among other reasons to collect local medicine. This was particularly conspicuous in the Mwambegwa "Ngitili" where trees were found debarked (mostly likely for local medicine). Some may have been debarked to get materials for beehives and for fire wood (Plate 4).

**Plate 4: Trees debarked for local medicine**

#### 4.3.1.3 Poles, Ropes and Thatching grasses

Shelter is one of the basic needs of human being. The communities around "Ngitili" under state tenure (HASHI) are getting more poles, ropes and thatching grasses for house construction compared to the period when the "Ngitili were under private and communal tenure regimes. Many villagers around Mwamishali, Mwambegwa, Bulyanaga and Peri urban 1 "Ngitili" obtain poles, ropes and thatching grasses from these "Ngitili". These construction materials derived from HASHI "Ngitili" are exploited for subsistent and commercial purposes. Key informants indicated that over the years, thatching materials had dwindled in most villages and therefore changes in tenure in "Ngitili" studied have served as a reliable and readily available source of thatching grasses. Njana (2008) in the study of miombo woodland Urumwa Forest reserves Tabora region Tanzania reported that, 95% of the households around the reserves depended on Miombo woodland from the reserves as a source of firewood for cooking, bricks making and tobacco curing.

#### 4.3.1.4 Fire wood

Firewood is the main source of energy in rural areas. In many developing countries including Tanzania, 90% of all wood is used for firewood for cooking and heating (Evans, 1992). Continuous availability of firewood was reported in the Mwamishali, Bulyanaga, Mwambegwa and Peri urban 1 "Ngitili" which are under HASHI for cooking, bricks making, local brew making and heating. Discussion with key informants at Mwambegwa "Ngitili" showed that they harvest an average of 30 cattle driven wheel barrow which is equivalent to $60m^3$ per year (Plate 5).

**Plate 5: Harvesting of fuel wood: Fruits of improved Ngitili**

During PRA exercises, a total of 634 and 400 head loads of fire wood were mentioned to have been harvested from Mwamishali and Peri urban 1 "Ngitili" respectively in 1994/95 for household consumption. Attributes of species regarded as good for firewood are those with medium to high wood density, low moisture content, low smoke yield, absence of thorns and absence of unusual fumes or smells (Abbot and Lowore 1999; Luoga *et al.*, 2002). Njana (2008) in the study of miombo woodland Urumwa Forest reserves Tabora region Tanzania reported that, 95% of the households around the reserves depend on

Miombo woodland from the reserves as a source of firewood for cooking, bricks making and tobacco curing.

### 4.3.2 Impact of forestland tenure changes from communal to private outside HASHI on forest use

#### 4.3.2.1 Grazing right

The owner of the "Ngitili" divides his/ her "Ngitili" into grazable pieces of land for hiring. Results from Mussa Sambe "Ngitili" outside HASHI indicated that, more benefits through hiring out grazing rights were obtainable. For instance, in 2005, Mussa Sambe who is the owner of the "Ngitili" hired out the rights for grazing and obtained TAS 1.6 x $10^6$ (about 1350$ ). Furthermore in 2008, he hired out grazing rights and got TAS 8 x $10^5$ (about 670$). He used the money for constructing burnt bricks residential house. Generally speaking revenue obtained from private (outside HASHI) "Ngitili" from the sale of grazing rights contributes to improvement of household livelihoods example construction of burnt brick houses and other household domestic consumption (Machanya *et al.*, 2003).

#### 4.3.2.2 Availability of local medicine

Local medicines from trees and herbs were easily available as the results of tenure changes from communal to private tenure regime. Discussion with Mussa Sambe indicated that huge amounts of local medicinal plants are currently available in the "Ngitili" as compared to the period before tenure change. In the "Ngitili", collection of local medicine by the owner is very easy as compared to the outsiders. Herbal specialists (outsiders) are required to pay money for them to collect bark and roots for local medicines. This and other factors probably complicate the whole process of local medicine accessibility in outside HASHI "Ngitili". However in "Ngitili" under state (HASHI), they not normally pay money to access medicinal plants.

#### 4.3.2.3 Poles, Ropes and Thatching grasses

Poles, ropes and thatching grasses are among the products accrued from private "Ngitili", like that of Mussa Sambe. Discussions with the owner indicated that poles, ropes and thatching grasses are collected by Mussa Sambe for them to be used for subsistence as well as for commercial basis. These products are sold to earn income because many houses in the study area are thatched by grasses. Mussa Sambe indicated that he once sold ropes, poles and thatching grasses and obtained TAS $5.6 \times 10^5$ (about 560$ ). This money helped him to purchase cement for residential house construction. Generally speaking, sales of "Ngitili" products have helped the owner in improving his household livelihood.

#### 4.3.2.4 Fire wood and Gums

Collectors of firewood for household typically target branches and stems of 3 to 5 cm diameter (Abbot and Lowore, 1999). The same is done in Mussa Sambe "Ngitili" in which branches of 3 to 5cm diameter.are normally collected for household use. Continuous availability of firewood was reported in Mussa Sambe "Ngitili" by the owner of the "Ngitili" after tenure change from community to private tenure regime outside HASHI. The firewood colleted is for different uses like cooking, bricks making and heating. Gum is normally collected from *Acacia drepanolobium* for sale. The money obtained from the sale of gums is also used to improve household livelihood.

# CHAPTER FIVE

## 5.0 CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

Based on the forest cover analysis of Landsat imageries of 1986 and 2000, the study found that open land, grass land, bushland and open forest decreased in favour of semi closed forest in both the HASHI and outside HASHI "Ngitili" after tenure change.

The stocking parameters have also drown considerable changes as a result of tenure changes for example the number of stems, volume and basal area per hectare outside HASHI "Ngitili" were 3197 stems/ha, 36.04$m^3$/ha and 6.92$m^2$/ha respectively. Whereas "Ngitili" under HASHI were found to have number of stems, volume and basal area per hectare of 1233 stems/ha, 20.24 $m^3$/ha and 6.8 $m^2$/ha respectively. Interestingly, no significant difference was observed in basal area and volume per hectare between HASHI and outside HASHI "Ngitili". However significant difference in number of stems per hectare was observed between HASHI and outside HASHI "Ngitili". Furthermore, fodder which was a dominant product in "Ngitili" for feeding young, seek and oxen animals. However, "Ngitili" changed dramatically to production of wide range of products and services including timber, thatch for roofing, hiring grazing rights, gums, firewood and medicinal herbs after tenure changes in both HASHI and outside HASHI "Ngitili". Hence the study concludes that:

(i) There has been a positive impact in terms of forest regeneration after tenure changes

(ii) Much of the impacts are found where the "Ngitili" have been managed by the state (HASHI) perhaps indicating that more commitment from the conservation authorities would rescue more forest.

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(i) There has been a positive impact in terms of forest regeneration after tenure changes

(ii) Much of the impacts are found where the "Ngitili" have been managed by the state (HASHI) perhaps indicating that more commitment from the conservation authorities would rescue more forest.

(iii) The insignificant difference between "Ngitili" under HASHI and outside HASHI in terms of stocking parameters indicates that if well managed even private "Ngitili" would lead to impressive results.

(iv) More vegetation cover were observed after tenure change in "Ngitili" management systems perhaps indicating the effectiveness of state tenure regime in restoring forest cover in the study area.

## 5.2 Recommendations

From the study findings, the following are pertinent recommendations:

**(i) The need to assess the impact of devolution on forest cover**

Devolution of management of "Ngitili" that took place in 2002 had probably caused forest cover change. A follow up study is needed to assess the impact of devolution on forest cover change in the future.

**(ii) The need to prepare management plans**

There is a need to prepare management plans for "Ngitili" outside HASHI to ensure sustainable harvesting.

**(iii) The need to carry out economic analysis in "Ngitili"**

Different forest products are being harvested from "Ngitili" as the results of tenure change, however the economic analysis of these products need to be addressed.

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# APPENDICES

## Appendix 1: Inventory plot field form

Date:..... .Village:..... Sub-village .....Ward .....

Ngitili type ..... Date establishment:.....General condition:.....

...Area:.....Transect no..... Plot number.....Plot size.....

Current tenure type.....Vegetation type.....

Ns = Number of stems, DBH =Diameter at breast height, HT = Height, Spp = Species

| S/N0. | Local name | Ns | DBH | HT | Scientific name | Regenerants | Ns |
|---|---|---|---|---|---|---|---|
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**Appendix 2: Checklists for key informants**

Dear Key informants,

You have been selected basing on your knowledge so as to provide data/ information that could be used to understand the extent of forest cover and use changes under different tenure regimes in the Ngitili of Meatu district. All the information you will provide will be for academic purposes and be treated confidentially. Therefore you are kindly requested to respond trustfully and faithfully to the following question. I thank you in advance.

1.0 What is the size of your Ngitili?

.....

.....

2.0 When was it established and by who?

.....

.....

3.0 What were the management objectives of Ngitili before 1986?

.....

.....

4.0 Kindly can you mention the use/benefits did you get from your Ngitili before 1986? Please identify each category of use

.....

.....

5.0 Are these uses have been changing over time after change in land tenure in your Ngitili in 1986?

.....

.....

6.0 If yes, can you mention each category of uses of your Ngitili after between 1986 and 2000?

.....

.....

7.0 Kindly give all uses of your Ngitili since establishment to date.

.....

.....

8.0 To what extent can these uses be related to change in tenure regime in the management of Ngitili?

.....

.....

9.0 Is the size of Ngitili increasing or decreasing over time?

.....

.....

10 If the size is decreasing, what are the factors underlying the decrease?

.....

.....

11 If the number is increasing, what are the factors underlying the increase?

.....

.....

12 In your opinions was the forest cover better/worse before 1986 or in any time between 1986 and 2000?

.....

.....

**Appendix 3: Checklist for tree species**

| Species code | Local name | Botanical name |
|---|---|---|
| 1 | Boyo | *Melicia Azidrack* |
| 2 | Gwata | *Acacia Senegal* |
| 3 | Idukelo | *Unidentified* |
| 4 | Igobeko | *Combretum longispicatum* |
| 5 | Kaguha | *Teclea simplicifolia* |
| 6 | Kaninigwe(Kalilila) | *Kadaba farinosa* |
| 7 | Lugala nyeusi | *Unidentified* |
| 8 | Makale | *Cinerea spp.* |
| 9 | Malula | *Acacia drepanolobium* |
| 10 | Manara | *Euphorbia tirucalli* |
| 11 | Masagala | *Anisotes dumosus* |
| 12 | Mbuyu (ng'andu) | *Adansonia Digitata* |
| 13 | Mdabi | *Unidentified* |
| 14 | Mdushi | *unidentified* |
| 15 | Mgada | *Albizia anthalmintica* |
| 16 | Mhale | *Acacia nilotica* |
| 17 | Migu | *Acacia polycantha* |
| 18 | Migunga | *Acacia tortilis* |
| 19 | Mihama | *Borassus aethiopum* |
| 20 | Milusina | *Luceana Luecosephala* |
| 21 | Mjoholo | *Senna siamea* |
| 22 | Mkoma | *Grewia bicolor* |
| 23 | Mponda | *Commiphora Africana* |
| 24 | Msingisa | *Maerma spp.* |
| 25 | Mtunduru | *Dichrostchys cinerea* |
| 26 | Mwalobaini | *Azadirachta indica* |
| 27 | Nangata | *Delonix Procera* |
| 28 | Ng'icha | *Kigelia Africana* |
| 29 | Subata-Masubata | *Diospyros fischeri* |

**Appendix 4: Regenerants in the "Ngitili" surveyed and their frequencies**

| Scientific name | Frequency | Forms |
|---|---|---|
| *Argemone mexicana* | 2 | Forbs/Herbs |
| *Biden pilosa* | 3 | Forbs/Herbs |
| *Cissus* | 1 | Forbs/Herbs |
| *Conyza stricta* | 19 | Forbs/Herbs |
| *Cucumis spp* | 1 | Forbs/Herbs |
| *Erlangea spp.* | 18 | Forbs/Herbs |
| *Leucas Mollis* | 22 | Forbs/Herbs |
| *Menchma debile* | 30 | Forbs/Herbs |
| *Ocimum spp* | 1 | Forbs/Herbs |
| *Sesamum angustifolium* | 1 | Forbs/Herbs |
| *Sida spp.* | 10 | Forbs/Herbs |
| *Solanum incum* | 1 | Forbs/Herbs |
| *Striga species* | 2 | Forbs/Herbs |
| *Tephrosia* | 10 | Forbs/Herbs |
| *Triumfeta rhomboiddea* | 15 | Forbs/Herbs |
| *Aristida Adencensionis* | 11 | Grasses |
| *uffalochloa* | 3 | Grasses |
| *Cetaria Verticillata.* | 8 | Grasses |
| *Choloris roxburghiana* | 5 | Grasses |
| *Cochrus ciliaris* | 9 | Grasses |
| *Cynodom spp* | 7 | Grasses |
| *Dechantium Spp* | 7 | Grasses |
| *Digitaria milanjia* | 13 | Grasses |
| *Digitaria milanjiana* | 18 | Grasses |
| *Henteropogon Contortus* | 1 | Grasses |
| *Impome sppand sporobolus* | 3 | Grasses |
| *Panicum spp* | 1 | Grasses |
| *Rhynchelitrium spp* | 3 | Grasses |
| *Ruttbelia exalitata* | 4 | Grasses |
| *Sinkrus sylialis* | 5 | Grasses |
| *Sporobolus* | 1 | Grasses |
| *Themeda triandra* | 2 | Grasses |
| *Urochloa* | 10 | Grasses |