SOCIO-ECOLOGICAL FACTORS INFLUENCING PRODUCTIVITY OF LOCAL SILVOPASTORAL TECHNOLOGY IN MAGU DISTRICT

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN MANAGEMENT OF NATURAL RESOURCES FOR SUSTAINABLE AGRICULTURE OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

ABSTRACT

The present studies were carried out in Magu district during the period in order to determine the extent of adoption, limiting Socio-Ecological factors that influence productivity of local Silvopastoral technology and corrective measures required to improve the adoption of the technology. The methods include random and systematic field and social surveys. The results indicated that there are a number of people adopting the technology though its status is not evenly spread throughout the district. The socio-ecological factors influencing the productivity of the technology and the reasons for their occurrence were observed. Main constraints hindering the technology and the suggested measures to mitigate the constraints were revealed. Following the discussion, it was generally concluded that Ngitili Silvopastoral technology has the potential of improving the ecology of the site, where trees, grass and herbs/forbs are growing together. In addition, it was recommended that extension and training is needed to stimulate and elicit indigenous change of attitudes and approaches to resource management, to impart knowledge and skills to the main key players in local Ngitili Silvopastoral fodder reserves and agroforestry technologies in general.

DECLARATION

I Malimi Justine Mabimbi.Lutandula, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been nor concurrently being submitted for a higher degree award in any other University.

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30/10/2009

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The above declaration is confirmed

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ABBREVIATIONS

AFO	-	Agricultural Field Officer
CRBD	-	Complete Randomized Block Design.
DALDO	-	District Agricultural and Livestock Development Officer.
DGDP	-	District Gross Domestic Product
FAO	-	Food and Agriculture Organization of United Nations.
HADO	-	Hifadhi Ardhi Dodoma.
HASHI	-	Hifadhi Ardhi Shinyanga.
HIMA	-	Hifadhi Mazingira.
ICRAF	-	International Centre for Research in Agroforestry.
LFO	-	Livestock Field Officer
LSD	-	Least Significance Difference.
LVEMP	-	Lake Victoria Environmental Management Project
MFSP	-	Magu Food Security Project.
MNTE	-	Ministry of Natural resource, Tourism and Environment
NGO	-	Non-governmental organization.
NORAD	-	Norwegian Agency for International Development
PAFO	-	Principal Agricultural Field Officer
PLFO	-	Principal Livestock Field Officer
SCAPA	-	Soil Conservation and Agroforestry Project Arusha.
SPSS	-	Statistical Package for Social Sciences.
TZS	-	Tanzanian shillings.
URT	-	United Republic of Tanzania.

CHAPTER ONE

1.0 INTRODUCTION

This chapter provides the background information (1.1), problem statement and justification of the research (1.2), the general and specific objectives (1.3), research questions (1.4) and its hypotheses (1.5). Where deemed appropriate, further subdivisions are made accordingly.

1.1 Background Information

In most parts of developing countries, rural people maintain trees and pastures in the fields and homes in order to provide:- fruits/food, medicine, fuel, fodder/pasture, building materials, saleable commodities and for the conservation of soils. However, there has been a lot of exploitation in the natural forests and trees or pastures on farms; and very little has been done to ensure regeneration and sustainability of productivity until recently when several programs for agroforestry and soil conservation were started (Ahlback, 1986).

There are traditional farming systems which are being practiced in various parts of the world which when known and documented can assist in either transfer of the knowledge or improvement on it in order to increase productivity on land which is becoming scarce while the population is increasing (Swamminathan, 1987).

In Tanzania the potential of private and communal local tree and pasture reserves (Ngitili) for soil conservation and livestock production have been appreciated by the government, NGOs, farmers, and implementers of programmes such as the Soil conservation and Agroforestry Project HASHI in Shinyanga, Vi Agroforestry in Mwanza and Mara regions, HADO in Dodoma, HIMA in Iringa, Soil conservation and Agroforestry Programme

(SCAPA) in Arusha (Moshi, 1997; Mugasha *et al.*, 1996; Otysina and Asenga, 1994; 1993).

Under agropastoralism the most prevalent land use system is Silvopasture (Jordan, 1992). The Wasukuma local Silvopastoral technology of Magu District, involves individually farmed arable plots and communally or privately owned grazing lands. Cattle ownership indicates social status and financial capital. The animals provide milk and manure, and of increasing importance in the system is the use of animals for draft power (Mugasha *et al.*, 1996; Jordan, 1992). Silvopastoral technology (Silvipasture) is the complementary relationship between trees and pasture in a forest product and livestock production system. It takes many forms and is adaptable to a variety of smallholder farms and pastoral systems throughout the world (Nair, 1985; Lulandala, 2006).

1.2 Problem Statement and Justification

In the past, Magu District had been extensively forested with woodland and bushland species, such as tree species of the genera Acacia, Brachystergia, Albizia, Commiphora, and Dalbergia, also pastures such as Chloris, Cynodon, Eragrostis, Panicum, Cenchrus and Elephant grass species dominated the district. However, massive deforestation through shifting cultivation and most recently extensive grazing, and uncontrolled wild fire incidences, constitute, today. a major environmental threat in the district including; the decline in soil fertility and the subsequent low crop yields, shortage of dry season fodder, woodfuel, construction poles and severe wind and soil erosion (MNTE, 1995).

Many indigenous Agroforestry systems in Tanzania and in Tropical Africa in general, have not been documented. and some are being lost (Moshi, 1997; Nair, 1983; O'Kting'ati, 1985; King, 1979) The International Centre for Research in Agroforestry

(ICRAF) in 1983, set aside as its main global mission, to make an inventory of the existing Agroforestry systems, to describe and document them, so as to devise a way to improve their productivity (Nair, 1983). Gathering and synthesizing of information about indigenous Agroforestry systems in Tanzania fall within this broad mission of ICRAF, the few inventories carried out have indicated entry points for improvements (Moshi, 1997; Mugasha *et al.,* 1996; Otysina and Asenga, 1994; 1993).

In Magu district, traditional agropastoralists had been practicing 'Ngitili', a local Silvopastoral technology. 'Ngitilis' are farmer led initiatives that evolved out of traditional strategies in grazing land. It involves retaining areas 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 dry season, to allow the livestock get dry season fodder (Mugasha *et al.,* 1996; Otysina and Asenga, 1994; Maro, 1995) These Ngitilis are also regarded as dry season fodder reserves (Otysina and Asenga, 1994). In Magu District Ngitilis are extensively practiced; but there are no records of studies which have been conducted on the aspects of productivity, socio-ecological and conservation values such as fodder production that mitigate environmental degradation at the same time. Although this local Silvopastoral technology is well known among the Wasukuma agropastoral community and the local staff in Magu, it is little known by the majority of the agropastoral societies in Tanzania. Furthermore, the Ngitili structural features, functional relationships, technological specifications, productivity and suitability, are neither well defined nor documented in a scientific literature. Thus, there is need to assess and determine the factors influencing the productivity of this technology in terms of biomass of the plants and calf mortality rates of the livestock which the district faces. This also will lead into suggestions of various mechanisms to improve the situation. The information from this study will also be of use to policy makers, and rural development planners and extension workers in both governmental and non-governmental organizations working with community groups.

1.3 Objectives

1.3.1 General objective

Determination of the socio-ecological factors influencing productivity of the local Silvopastoral technologies in Magu District.

1.3.2 Specific objectives

i. To determine the current status and productivity of the local Silvopastoral technology and its trend over the past five years.

ii. To examine the socio-ecological characteristics and how they affect the productivity of the local Silvopastoral technology.

iii. To identify the constraints to scaling up the local Silvopastoral technology and possible mechanisms of intervention for improvement

1.4 Research Questions

i. What is the local Silvopastoral technology widely adopted/preferred by the local community in this area?

ii. What are the socio- ecological factors influencing the productivity of the local Silvopastoral technology?

iii. What are the possible mechanisms which can prevent the decline in productivity of the technology?

iv. How do adopting farmers benefit from Silvopastoral technology?

v. What are the main constraints to scaling up the local Silvopastoral technology?

vi. How do people's livelihood activities affect the local Silvopastoral resources

1.5 Research Hypotheses

Ho: Socio-ecological factors have no significant influence in productivity of the local Silvopastoral technology.

Hi: Socio-ecological factors have significant influence in productivity of the local Silvopastoral technology.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter provides reviews on the general view of local Silvopastoral system (2.1) socio-ecological characteristics of the local Silvopastoral user (2.2) scaling up of the local Silvopastoral technology (2.3 and the suggested mechanisms, which can mitigate the problems (2.4). Where appropriate, some subsections have been further subdivided accordingly.

2.1 General View of Silvopastoral System

Silvipasture also referred to as Silvopastoral system, is an agroforestry system that involves the incorporation of tree or shrub management with animals or pastures (Burley, 1987). It is also defined as a system that involves cropping of trees and grazing, under storey grasses and bushes, in forests and plantations (Tejwan, 1987). This can be local or exotic. The animal in this system is a dominant feature. Extensive Silvopastoral systems on rangeland, usually involve the selective protection and management of naturally occurring trees and shrubs of particular value to animals (Rocheleau *et al.*, 1988). In the study area, a Silvopastoral subsystem or practice exists and is an indigenous practice of natural resource management known as Ngitili. 'Ngitili' is a Sukuma word meaning enclosure. It is an indigenous practice commonly practiced in Shinyanga and Mwanza Regions in Tanzania mainly for dry season grazing. The practice has been evaluated and confirmed to meet sustainable levels of production of dry-seasonal fodder supplies, food security and mitigation of land degradation basing on FAO criteria. (Kamwenda, 2002).

2.1.1 The productivity of the local Silvopastoral technology

Productivity is defined as the quantity of output(s) per unit inputs, for a unit of time. In many places of the world, the implementation of Silvopastoral technology has resulted into sustainable and efficient land use alternatives. Silvopastoral technologies have been used to sustain and diversify production in marginal lands, in arid and semi arid zones, and low fertility soils; they have been used for the production of a number of wood products and alleviation of the dry season fodder supply shortage (Ormazo'bal, 1991).

Otysina and Asenga (1994) reported the potential role of browse trees and shrub species in supplementing the animal diets, Browse species from trees are recognized by the farmers in Magu District, for their role in providing dry season fodder at the peak of dry season."Ngitili'' traditional fodder reserves, seem to have great promise to farmers of Magu, where dry season fodder, woodfuel, and food shortage remain to be the greatest problems in the semi arid agropastoral society (Otysina and Asenga, 1994). These Ngitili have the ability to produce both dry season fodder and woodfuel, and can reclaim the degraded soil (URT, 1990). Goromela (1996) reports the increase of production of milk and gain in weight for the animals supplemented with dried tree leaves under browse of local goats.

Deforestation, reduced soil fertility and productivity, declining forage quality and quantity and general environmental degradation are some of the major land use constraints that have resulted from the human pressure that has put on the land (Mohamed-Saleem and Fitzhugh, 1993). In recent years, degradation has been intensifying. About 80% of the rangelands are moderately degraded. More than half of this area is located in the tropical and sub-tropical regions of the planet (NRC, 1990). These conditions directly influence plant and animal productivity thereby affecting income and nutritional status of the families and national economy. From this, it is clear that a holistic management approach must be implemented to preserve the accelerating deterioration of this precious resource.

Productivity in terms of biomass in plants, milk yield, pasture production, mortality rates in animals and sustainability of land management systems are among the potentials of local Silvopastoral technology. Biomass production has been found to be 3 420 kg/ha only sufficient to stock 1.5 Lu/year (Otysina et al, 1996). Biomass production varies with season, the dry season being the most critical period. All types of animals graze 'Ngitili', however, this depends on the size of the Ngitili and feed scarcity (Rubanza, 1999). Priority is given to calves, oxen, milking cows, and sick animals (Otysina and Assenga, 1993).

Ngitili or local Silvopastoral practices are low in productivity because of overgrazing and poor quality forage species composition (Issae, 1997). They are, not fully exploited. The grasses flourish during the wet season, but easily disappear during the dry months. On the average, the plant communities on local Silvopastoral practices are composed of 89.5% grass, 6.4% forbs and 4.1% trees (Issae, 1997). *Cynodon dactylon* is the dominant grass specie. It is a highly productive fodder but low in quality. Bogdan (1977) cited by Issae (1997) reported low crude protein content (1.4%) during the dry season. This is the season when Ngitili are generally grazed. The system/technology is constrained by insecurity due to lack of proper land tenure systems, overuse of grazing lands, lack of fertilizer application and low fodder quality (Nyamrunda, 1997).

Calf mortality rate can be defined as the proportion of calves that die out of a given number of calves that are born in a given period. Calf mortality has recently been reported as an important parameter in animal farming productivity (Araudoba, 1993; Kifaro, 1995). It is mainly influenced by adaptability of cattle to nutrition, diseases, and management practices. Milk letdown in dairy cattle under small holders in the tropics is normally induced by the presence of calves at milking. In addition, milk production in zebu cattle is influenced by the presence of the calf due to high maternal instances in this group of cattle (Nicholson, 1984, Majubwa, 1987). Due to this reason milk production cannot be sustained after the death of the calf. It can therefore be concluded that calf mortality in zebu cattle is more serious parameter as far as milk production and animal productivity are concerned.

2.1.2 The trend of local Silvopastoral technology

There are two types of local Silvopastoral technologies, which can be identified. Private and Communal Ngitili. These differ in size and management. Individual or private Ngitili are located around homestead, along lowland river ways and on-farm lands away from homestead (Brandstrom, 1985; Maro, 1995; Msangi, 1995). Brandstrom (1985) noted the homestead locations to be more preferred for calf grazing during the wet season. The communal Ngitili exist in Magu district, which were established during villagization era (Maro, 1995; Otysina, 1994). However, individual ownership pattern of Ngitili is reported to have positive implication in management, improvement and development, as farmers would be more willing to undertake development work on their own land (Msangi, 1995).

The classification of Silvopastoral conditions refers to defferences in the botanical composition of the plants in the various Silvopastoral formations. That is assessment of the herbage production and species component of the current year, season or month as compared to the average production established by previous records. It depicts the amount and stability of the herbage and reflects quantity (a measure of stocking rate) and quality (a measure of output) of livestock products. In describing the Silvopastoral condition, four classes are identified: excellent – when the vegetative cover is normal with productive, vigorous plants and a good mulch cover between grass tufts. This denotes 75-100% carrying capacity of the Silvopastoral potential; good the better herbage species predominate but less desirable plants are noted , bare spots may be visible because fewer seedlings survive and some soil erosion takes place, herbage production is between 50-75% of capacity; fair undesirable species are dominant in many places and bush encroachment may be serious in other places, the palatable grasses and herbs are weakened, not highly productive and develop few seeds, there are many bare spots with gully erosion, 25-50% of normal stocking capacity and poor sparse and unstable vegetative cover, little mulch and heavy soil and wind erosion, severe encroachment of weedy species, especially woody plants, the desirable grasses, herbs and forbs found in protected places, no more than 25% of potential stocking capacity, cattle likely to be in poor condition (Crowder and Chheda, 1982).

Trend refers to the direction of change in Silvopastoral condition. That is improving or declining. It can be noted by the density and composition of the vegetation, as well as the vigour and growth characteristics of the plants. Adverse trend can be noted by; replacement of desirable species by inferior types; decreased herbage production of individual plants and the sward in general; reduced litter on the soil surface with signs of soil erosion and decline in stocking capacity and decrease in animal weight gains (Crowder and Chheda, 1982).

2.2 The Socio-Ecological Characteristics of Local Silvopastoral Users

Harcharic (1997) commended that, "sustainable Silvopastoral management is the most important concept of our time that directly affects the future of all the worlds' trees and pastures or animals and the entire world's people. The socio-cultural dimension of local Silvopastoral management provides the great challenge to users. In that regard O'Kting'ati

(1985) reported Silvopastoral technologies to provide many benefits to farmers and society, with a good combination of tree species and pastures or animals.

A number of ecological aspects existing in local Silvopastoral technology include-

(i) Protection of water

Through their foliage and litter falls, trees in Silvopastoral technology favour slow but total infiltration of rainwater, particularly in dry areas. The capacity of trees to retain water precipitations is made very effective (Gottle and Sene, 1997; Kilahama, 1994).

(ii) Protection of soils

Maro (1995), Kilahama (1994) and Msangi (1995) reported the effectiveness of Ngitili traditional fodder reserves, to conserve and protect the soils, and reclaim degraded land. The tree and pasture canopy cover, slow down the wind, while its dense network of roots holds the soil in place. This characteristic protects the soils against wind, water erosion and land movement (Gottle and Sene, 1997).

(iii) Pests and diseases

The presence of trees on a local Silvopastoral technology or land management units, attract wild animals and insects, that in turn can cause problems to the associated crops and livestock (Otysina and Asenga, 1994). The authors reported that trees provide readily available food nesting and resting sites for birds that destroy agricultural crops like millet, sorghum and maize.

(iv) Amelioration of local climates

Trees have definite practical effects on the neighboring human settlement and animals under pasture (Gottle and Sene, 1997). This capacity is important in protecting inhabitants from dusty winds (Msangi, 1995: Maro, 1995: Kilahama, 1994). Through the control of wind velocity, trees may retain solid suspension (Gottle and Sene, 1997).Climatic factors such as temperature have an influence and affect chemical composition of tropical feeds. High temperature results in rapid physiological maturation characterized by formation of high proportion of cell wall component (Van Soest, 1994). Nutrient absorption is also restricted under high moisture stress and high intensity induces rapid physiological maturity accompanied by the formation of high-lignified tissues (McDonald *et al*,. 1995). On many parts of the tropics under natural soil fertility conditions, and up to about two months of growth after the onset of the rains, the crude protein content in the forage grass is well above 7%. With un-interrupted growth due to high heat intensity, the grasses rapidly mature and crude protein content drops drastically reaching values of 4% - 6% after 3-5 months (Crowder and Chheda, 1982).

(v) Conservation of habitats and biological diversity

Local Silvopastoral technology under arid and semi-arid land, have direct physical and biological diversity, species composition and their abundance are high in Ngitili fodder reserves (Otysina, 1994).

2.3 Scaling Up the Local Silvopastoral Technology

Scaling up is the sum of all activities, principles and methods that facilitate adoption of Silvopastoral innovations leading to their adaptation resulting in wide spread impact inside and sometimes outside target areas in a given ecosystem (Bunderson *et al*,. 2002). Accelerating impact can be achieved by selecting the most effective (in terms of both cost and time) means of adoption (Makaya, 1999) cited by Bunderson *et al.* (2002). It is insisted that Silvopastoral technologies and output have to be socially acceptable, economically viable, environmentally friendly and economically sustainable (Bunderson *et al*,. 2002). Adoption is a gradual process, which involves sequential steps. Van de Ban and Hawkins (1996) identified five stages of adoption as:

- Awareness stage in which the farmer or potential innovator hears about the innovation for the first time.
- Interest building stage in which farmers seek more information about the innovation.
- Evaluation stage in which farmers weigh the advantages and disadvantages of using the innovation.
- Trial stage in which the farmers test the innovation on small scale to avoid risk associated with using innovations.
- Adoption stage in which the farmers apply the innovation on large scale in preference to the old technologies.

Individual in the social system do not adopt an innovation at the same time and same rate. Most agricultural innovations change or are modified in the process of adoption and diffusion. Feder and Slade (1984) emphasized that during the initial phase of adoption, larger farmers are likely to allocate more resources to the acquisition of information and will therefore posses higher levels of cumulative information at any given period, other factors held constant. They further advocate that a certain level of cumulative information must be attained before adoption of innovation takes place. These imply farmers with better access to information and more human capital endowments in form of formal and informal education and experience will adopt earlier than others. Thus, in reality farmers all over the world, seldom adopt complete packages and rarely comply exactly with the recommendations made when it comes to their specific needs.

2.4 Suggested Mechanisms which can Mitigate the Problems

Major efforts lie on the part of the Silvopastoral scientists for synthesizing site-specific technologies and on the part of policy makers to develop suitable infrastructure for the disposal of diversified products produced from such technologies (Kajembe and Munyikombo, 1998). Otysina (1994) reported a number of perceived ways to improve the Ngitili technology including , introduction of improved fodder grasses, planting of fodder trees, rotational grazing and destocking , thinning of existing tree grass growths, expansion of Ngitili coverage areas, and introduction of by-laws protecting these Ngitili. Along with the provision of improved multipurpose trees/ grasses, there should be a need to train farmers to plant, conserve and manage local trees and pastures (Otysina, 1994).

CHAPTER THREE

3.0 MATERIALS AND METHODS

This chapter explains the materials (3.1) and methods (3.2) involved during the research period. In case of materials, they include location of the study area, its climate, land use, vegetation and its vegetative cover. Methods involve sampling procedures applied, data collection in which the reconnaissance, social and field surveys were practiced during the research.

3.1 Materials

3.1.1 Location of the study area

The study was carried out in Magu District (Fig. 1), Mwanza Region, which is one of the semi- arid regions in the country. It lies between 2 ^{0}, 10' and 2 ^{0}, 50' South of the Equator and between 33 ^{0} and 34 ^{0} East of Greenwich with an area of 4800 Km^2 (Magu District Council, 2006). The district is divided into 6 divisions, 27 wards and 124 registered villages. According to the National Population Census conducted in August 2002, its population was estimated to be 431 771 people then with an annual growth rate of 2% and a population density of 90 people per Km^2. The district has 765 hamlets and 70 065 households. It is projected that the district's population should be more than 90% of the population that is engaged in agriculture and livestock keeping with the two sectors together making a contribution of about 85% to the DGDP. The DGDP averages about TZS. 20 874 965 000 and per capita income is TZS. 48 450 (Magu District Council 2006).

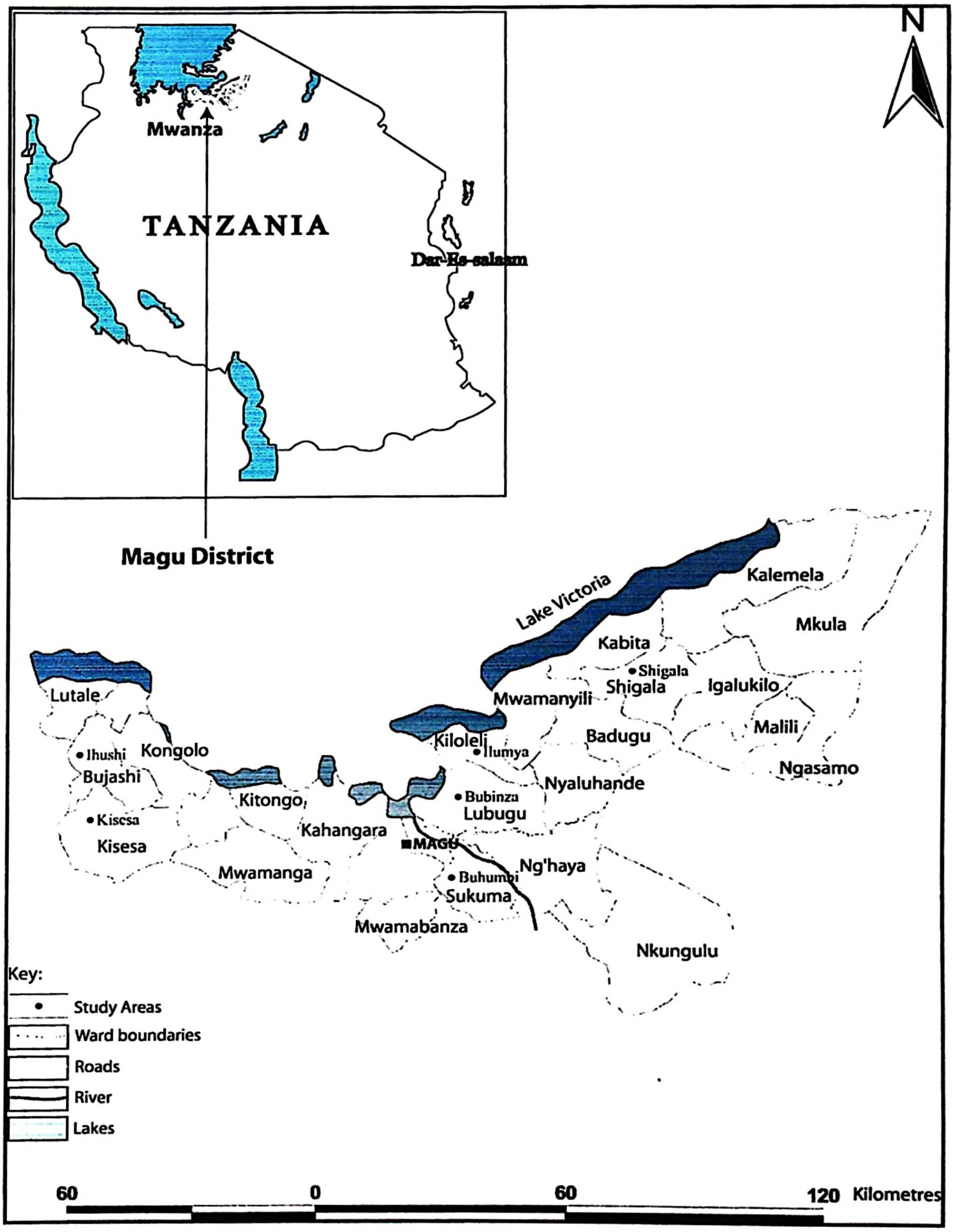

Figure 1: Map of Magu District showing study villages with inset of Tanzania.

Source: Modified from Magu District Profiles (2006)

3.1.2 Climate

The rainfall in Magu district is bimodal with the mean annual rainfall of 800 mm. Currently, the rain is erratic and unreliable. Low and unreliable rainfall is the rule with crop failure especially maize production very frequent. The average temperature for the district is 30^0C during the dry season and 17 ^{0} C during the rain season. The annual mean temperature is 23.5 ^{0} C. A large portion of the district soil is granite inselbergs with a progression of yellow-red hill sands to the poorly drained dark grey loam sands and clays (in valleys and low – lying plains) (Magu District Council, 2006).

3.1.3 Land Use

Most of the people in the district are agropastoralists. The district has an arable land area of 307 500 ha. Out of this area, grazing occupies 150 900 ha. Cultivation occupies 135 900 ha while 20 700 ha are reserved for settlements and natural resources use. The remaining 172 500 ha are covered by Lake Victoria. Cultivation and grazing take up to 90% of the economical activities and trading centers take 5% while fishing takes 5%. Fishing is done in the lake on small – scale. The food crops grown are sorghum, rice, cassava, sweet potatoes, maize and legumes. Cash crops are rice and cotton. A greater portion of the district is in the lee-ward side therefore suffers droughts occasionally. Livestock are cattle, sheep, goats, chicken, and donkeys. (Magu District Council, 2006).

3.1.4 Vegetation

The district is dominated by protected areas "Ngitili" with local Silvopastoral species mainly being Acacia species, *Tamarindus indica*, *Albizia commiphora*, *Afzelia quanzesis* and various tree species, intermixed with Cynodon , Panicum , Chloris, Cenchrus grass species which are grazed by livestock during the dry seasons. These Ngitili areas are owned either individually or communally. There is a separation between grazing lands and cultivation lands. Most of the district is covered by the open grasslands. The Forestry sector has conserved 8 170 hectares of natural reserves/woodland (Ngitili), and planted 17 227 209 trees since the official inauguration of the National Tree Planting Programme in 1999. There is one game reserve, with an area of Km^2 65.72 (Magu District Council, 2006).

3.2 Methods

3.2.1 Sampling procedures

Three divisions were selected randomly. These divisions were Busega, Itumbili and Sanjo. From each division two wards were randomly selected. In Busega division, Shigala and Kiloleli wards were selected. In Itumbili division, Lubugu and Sukuma wards were selected while Kisesa and Bujashi wards were selected from Sanjo division. One village from each ward was randomly selected. The villages were Shigala, Ilumya Bubinza, Buhumbi, Kisesa and Ihushi respectively. For each village twenty households were randomly selected for the study. In total the study dealt with 120 households.

3.2.2 Data Collection Methods

3.2.2.1 Reconnaissance Survey

This was used during self- introduction to the locality concerned and explaining the main objective of study to the leadership. The people involved in local Silvopastoral activities, leadership, environmental committee, various extension workers, NGOs operating in the area were identified at this juncture. It was at this point that the sample households were picked.

3.2.2.2 Social survey

During survey, both primary and secondary data were collected. Primary data were collected via interviewing heads of the twenty selected households in each village, using household questionnaires (Appendix 3). Data collected through this method included background information, local Ngitili Silvopastoral size, local Silvopastoral technology adoption, Silvopastoral components, local Silvopastoral benefits, constraints of local Silvopastoral, respondent's views on the factors influencing the productivity of local Silvopastoral technologies and mechanisms to avert them in order to improve the situation.

The secondary data were obtained from various books, journals, published and unpublished documents and reports at the Region, District, Internet and Libraries.

3.2.2.3 Field survey

The survey was carried out in the study area to confirm the information obtained during the interview. Also the survey assisted the researcher to have a general picture on the various local Silvopastoral technologies adopted and types of tree/pasture/livestock species being practiced by the community through visiting some of the farmer's protected areas "Ngitili". In some of these Ngitili, transects were formed and by using the quadrats at prescribed intervals, plots were put in order to determine the biomass (productivity) particularly determination of pasture production in tones per hectare of the plants available in the Ngitili was carried out. Other data collected included identification of the tree, grass and forbs species. In case of livestock, the productivity in terms of assessing the calf mortality rates among the farmers with, and farmers without Ngitili. In addition, milk production in terms of litres per cow per milking period records for the past five years were taken including the current year (2007) price of milk per litre.

3.2.3 Data Analysis

The data concerning the socio-ecological factors influencing productivity of local Silvopastoral technologies were summarized, coded and processed to give information relating to issues on productivity status and trend in the local Silvopastoral technology in the study area.

The Statistical Package for Social Sciences (SPSS) was the main tool used to obtain frequency distribution and cross tabulation of responses from interviewed respondents. The sample data were then related to the total population. The cross tabulation was used to determine the relationship between variables. Thereafter research findings were put into categories based on the research objectives. Presentation was done using tables

Analysis of variance was carried out using Completely Randomized Block Design (CRBD). Data in percentages were changed into arcsine angles before subjecting them to statistical analysis and subsequently testing for significance. Further to this, Least Significance Difference (LSD) was used to separate the differing treatment means. The differing treatment means were subsequently labeled by different letters.

CHAPTER FOUR

4.0 RESULTS

This chapter presents the results on the current status and productivity of the local Silvopastoral technology (Ngitili) and its trend (4.1), socio-ecological characteristics and how they affect the productivity of the local Silvopasture users (4.2) and the constraints to scaling up the technology and possible mechanisms of intervention for improvement (4.3).

4.1 The Current Status and Productivity of the local Silvopastoral Technology and its Trend in Magu District

4.1.1 State of adoption of the Ngitili Silvopastoral technology

The results on the current level of adoption of the local Ngitili Silvopastoral technology in Magu District and its trend of adoption over the past four years 2003-07 are presented in Tables 1 and 2 and the details are in Appendices 1 and 2 respectively. It will be noted that currently approximately 24% of the communities in the district have adopted the technology although the adoption status is not evenly spread throughout the whole district. The communities in the Ihushi part of the district seem to accept it more readily (approximately 48%) than the other parts possibly due to the effect of the initiatives of the Vi- Agroforestry Project in the former area. There is a progressive decrease of status of adoption from Ihushi to Ilumya villages (Tab. 1) probably because of the presence of the agroforest projects in some of the areas while other villages do not have.

Table 1: Status of adoption of the technology in the Magu district

Village	Percentage Means of respondents
Ihushi	47.9a
Buhumbi	25.5a
Bubinza	24.9a
Shigala	17.2b
Kisesa	16.1b
Ilumya	12.3b
Total	**143.9**
Overall mean	**24.0**

Key: a and b letters denote differing treatment means where there is least significant difference

Similarly, to note is the fact that the rate of adoption has been increasing by 3% annually since 2003 (Tab. 2) an indication of the increased realization of the value of the technology by the Magu District communities.

Table 2: The trend of adoption of the technology in Magu district

Year	Percentage Means of adoption
2007	24.2a
2006	21.4b
2005	18.5c
2004	15.1c
2003	13.9d

Key: a b c and d letters denote differing treatment means where there is least significant difference

4.1.2 Benefits gained through local Silvopastoral technology in 2007

The current study has shown that the local Ngitili Silvopastoral technology is providing additional social and economic benefits to the persons' living in the district (Tab. 3). It should be noted that there is a big variation among the annual milk production in various villages though statistically (p<0.005) there is no significant difference in milk production among the villages Tables 3 and 4.

Table 3: Current milk yield by the Ngitili technology users in Magu district (2007)

Villages	Number of cattle/village	Annual milk yield in litres/village	Income gained in Tzs
Shigala	3 362	3 580a	895 000
Ilumya	3 056	2 426a	606 500
Kisesa	2 616	2 300a	575 000
Bubinza	1 973	1 840b	460 000
Buhumbi	1 867	1 100c	275 000
Ihushi	1 594	1 040c	260 000
Total means	**4 251**	**2 048**	**63 477 667**

Price of milk was Tzs. 250 per litre.

Key: a b and c letters denote differing treatment means where there is least significant difference

This has shown that the local Ngitili Silvopastoral technology participants had extra annual income of Tzs 5 445 667 compared to non- local Ngitili Silvopastoral participants (Tab. 4 and App. 4) respectively. However, the total estimated annual milk production including technology and non-technology users was 486 080 litres with the total income of Tzs 121 509 667.

Table 4: Current milk yield by non- Ngitili technology users in Magu district (2007)

Village	Number of cattle/village	Annual milk yield in litres/village	Income gained in Tshs
Shigala	2 523	2 971a	742 750
Kisesa	1 963	2 692a	673 000
Ilumya	1 886	2 044a	511 000
Bubinza	1 803	1 641b	410 250
Buhumbi	1 698	9 89b	247 250
Ihushi	1 072	8 95b	223 750
Total means	**1 824**	**1 872**	**58 032 000**

Key: a and b letters denote differing treatment means where there is least significant difference

*** Estimated annual milk production in Magu District**

	Mean annual production per village	Number of villages	Total milk yield in litres	Total income Tzs
Ngitili users	2 048	124	253 952	63 477 667
Non-Ngitili users	1 872	124	232 128	58 032 000
Total	3 920	124	486 080	121 509 667

Similarly, the trend of milk production in the past four years since 2003-07 has shown a progressive increase by 48% (Tab. 5). This is probably caused by either the increased use of the technology or increase in the animal population or both.

Table 5: Trend of milk yield in litres through the practice in Magu district

Years	Milk yield means in litres/year
2007	126 955a
2006	109 327b
2005	85 767b
2004	72 540c
2003	66 547c

Key: a b and c letters denote differing treatment means where there is least significant difference

Table 6: Pasture production of green (Weight and moisture) in tones per hectare

Villages	Means of pasture production in tones/ha/village
Bubinza	1.142a
Ilumya	1.113a
Kisesa	1.050a
Shigala	0.969a
Ihushi	0.957a
Buhumbi	0.953a
Total	**6.184**
Overall mean	**1.031**

Key: a letter denotes differing treatment means where there is no least significant difference

The overall mean production of green pasture in the district through the technology is approximately 1.031 tones per hectare. (Tab. 6).

It was also investigated that after air-drying the fodder for 24 hours, the mean production was observed to be 0.857 tones per hectare in the district. . This is indicated in Table 7 and Appendix 7.

Table 7: Pasture production (Air dried weight) in tones per hectare per year

Sample Villages	Means of pasture production, tha^{-1}
Ilumya	0.981a
Bubinza	0.942a
Kisesa	0.868a
Shigala	0.810a
Buhumbi	0.773a
Ihushi	0.770a
Total	**5.144**
Overall mean	**0.857**

Key: a letter denotes differing treatment means where there is no least significant difference

Other benefits that are obtained from the application of the technology to the communities according to the respondents are fuelwood production (45.8%), fodder production (41.7%), income generation through selling Silvopastoral products like building poles (10.8%), and food production for example fruits (1.7%) of the community do obtain from the products of the technology. Table 8 and Appendix 8 signify this. The community in the district mostly benefits fuelwood and fodder production.

Table 8: Other benefits gained through the technology application in the district

Benefits	% Means of respondents
Fuelwood production	45.8a
Fodder production	41.7b
Income through selling Silvopastoral products eg poles	10.8c
Food production like fruits	1.7c

Key: a b and c letters denote differing treatment means where there is least significant difference

4.1.3 Calf mortality rate before starting local Silvopastoral technology

The results on the calf mortality in the sample villages of the district are presented in Table 9 and Appendix 9 respectively. It was observed that the highest mortality rate of the calves in the district was 20% and most farmers i.e. (82.5%) in the district. faced high calf mortality rates, which ranged between 11% and 20% and the problem was wide spread throughout the district (Tab. 10) before practicing the Ngitili technology. This was probably caused by the deficiency in pastures during the dry seasons, which resulted into many deaths especially in young animals. Other possible causes were diseases like diarrhea, pneumonia, post weaning stress and general weakness.

Table 9: Calf mortality rate before practicing the technology in the district

Calf Mortality Rates %	% Means of respondents
11-20	82.5a
6-10	15.8b
<5	1.7c

Key: a b and c letters denote differing treatment means where there is least significant difference

4.1.4 Calf mortality rate after practicing local Silvopastoral technology

Table 10 and Appendix 10 indicate various observations obtained from different farmers in the district concerning calf mortality rate after effecting local Ngitili Silvopastoral areas for the sake of fodder production to their animals during dry season. The current overall mean of calf mortality rate after introduction of the technology in the district is approximately 8% (Tab. 10) as compared with 10% that was given by the District Livestock Development Office during the survey.

Table 10: Current calf mortality rate in the district

Villages	% Means of calf mortality rates
Buhumbi	8.7a
Shigala	8.3a
Ihushi	8.0a
Kisesa	7.7a
Ilumya	6.3a
Bubinza	6.3a
Total	**45.3**
Overall mean	**7.6**

Key: a letter denotes differing treatment means where there is no least significant difference

However, Table 11 and Appendix 11 showed a very big drop of the death rate of (<5%) that was observed by many farmers (51.7%) in the district after practicing the technology. About (38.3%) of the farmers observed the decline in calf mortalities ranging (6-10%) after practicing the technology while a small number (10.7%) of farmers observed the calf mortality rate ranging (11-20%) after introduction of the technology in the district.

Table 11: Calf mortality rate after practicing the technology in the district

Calf Mortality Rates %	% Means of respondents
<5	51.7a
6-10	38.3b
11-20	10.0c

Key: a b and c letters denote differing treatment means where there is least significant difference

4.2 The Socio-Ecological Characteristics affecting the Productivity of Local Silvopastoral Technology

4.2.1 The socio-ecological factors influencing the productivity of the local Silvopastoral technology

Table 12 and Appendix 12 show the socio-ecological factors influencing the local Ngitili Silvopastoral technology and how they affect its productivity among the area of study. All of them influence more less equally the productivity of local Silvopastoral technology among the users in the district.

Table 12: Socio-ecological factors influencing productivity of technology

Factors	Percentage Means of respondents
Soil erosion	22.5a
Overpopulation	18.3a
Overstocking	17.5a
Climatic variations	16.7b
Implementation of by-laws	14.2b
Low understanding of environmental knowledge	10.0b
Theft	0.8c

Key: a b and c letters denote differing treatment means where there is least significant difference

4.2.2 Reasons for occurrence of socio-ecological factors influencing Silvopastoral technology

Table 13 and Appendix 13 refer to reasons for happening of these socio-ecological factors influencing productivity of local Silvopastoral technology as responded by different farmers in the area of study. In this study, the potential of local Ngitili Silvopastoral practice for its role in soil conservation and its general benefits in the society was expressed in Table 12. The reasons that influenced highly the technology were lack of environmental knowledge (33.3%) and the poor range management practices (27.5%) in the district. Others were uncontrolled birth rating system (18.3%) in order to avoid problems of land scarcity. Poor agricultural practices (17.5%) also inhibit sustainable agriculture. Shortages of extension services (1.7%) concerning agriculture and forest management in the district and poverty of the community (1.7%) influence minimally the occurrence of the socio-ecological factors.

Table 13: Reasons for socio-ecological factors occurrence in the district

Reasons	Percentage Means of respondents
Lack of environmental knowledge	33.3a
Poor range management practices	27.5a
Uncontrolled birth rating system	18.3a
Poor agricultural practices	17.5a
Shortage of extension services	1.7b
Poverty of the community	1.7b

Key: a and b letters denote differing treatment means where there is least significant difference

4.3 Constraints to Scaling Up and Possible Mechanisms to Mitigate the Problems

4.3.1 Constraints hindering local Silvopastoral technology

Table 14 and Appendix 14 show different constraints, which hinder scaling up of the local Silvopastoral technology in the area of study. It was revealed that land scarcity (37.5%) and the unreliable climatic (30.9%) conditions are the main influencing factors with the low income of the community (20.6%) and land tenure (20%) being the following constraints. Pests, diseases (3.3%) and distance to location of the technology (0.8%) playing the least influences. from the homesteads.

Table 14: The relative effect of the factors that influence the productivity of the Silvopastoral technology in the district

Constraints/Factors	Percentage Means of respondents
Land scarcity	37.5a
Unreliable climate	30.9a
Low income	20.0b
Land tenure	7.5b
Pests and diseases	3.3c
Long distance to working place	0.8c

Key: a b and c letters denote differing treatment means where there is least significant difference

4.3.2 Suggested measures to mitigate the hindering constraints

Table 15 and Appendix 15 present the various solutions suggested by farmers in order to alleviate the problem. When they were asked the action which should be taken in order to mitigate the problems, (27.5%) recommended for involvement in the provision of environmental knowledge in the area, (18.3%) suggested the provision of birth control knowledge, while (17.5%) asked to be provided with the expansion of extension services in the area. Livestock destocking (15.8%) could also be the possible solution to mitigate the problem including the range management improvement (11.7%). Village leaders were also urged by the researcher to strengthen the various by-laws (9.2%) which have been formed to control the disaster in the district.

Table 15: Suggested measures for the constraints mitigation

Suggested measures	Percentage Means of respondents
Provision of environmental knowledge	27.5a
Provision of birth control knowledge	18.3b
Expansion of extension services	17.5b
Livestock destocking	15.8b
Range management improvement	11.7c
Strengthening of village by- laws	9.2c

Key: a b and c letters denote differing treatment means where there is least significant difference

CHAPTER FIVE

5.0 DISCUSSION

This chapter discusses about what has been observed during the research period. It explains about the current status and productivity of the technology and its trend (5.1) in the study area. It tells about the adoption rate of the technology in that area, benefits gained through the technology application, mortality rates of the calves, the factors influencing the productivity of the practice, reasons for occurrence of these factors (5.2) and the constraints to scaling up and the possible mechanisms to mitigate these problems (5.3).

5.1 The Current Status and Productivity of the Local Silvopastoral Technology and its Trend in Magu District

5.1.1 Rate of adoption of local Silvopastoral technology

In classifying Silvopastoral practice for potential productivity under good management, it is necessary to know whether the vegetation is improving or deteriorating. This requires knowledge of the desirable natural and naturalized plants species, their competitiveness and desirable densities, acceptability to animals, tolerance to drought and trampling. Weedy species can serve as indicators of the degree of deterioration. Information about soil characteristics, particularly inherent fertility, is important concerning maintaining vegetative cover for sustained herbage growth and as a safeguard against erosion. Long-term knowledge of climatic patterns as well as the weather of current year are needed in making estimates and predictions of the local Ngitili Silvopastoral stocking capacity. From this point of view, with reference on Tables 1, 2 Appendices 1 and 2 drought in the area in year 2003 resulted into scarcity of grazing materials and hence threatened the health of the livestock. Extension services were focused to the villagers to advise them to engage in reserving areas for the fodder production in order to rescue their animals. Farmers responded gradually since that year and the rate of adoption increased yearly. This can be observed in Table 1 where the overall mean of adoption in the district is (24.0%). This can be verified by the analysis of variance ($p<0.05$) (Appendix 1) which resulted into F-calculated (11.96) which is greater than the tabulated one (2.71). Another reason for higher adoption rate in that period was due to the initiatives of the Vi-Agroforestry Project, which was started in 1999 in some of the wards like Bujashi. Lubugu, and Shigalla in the district. The year 2007 was the seventh of implementation period of the project in the area and hence influenced many farmers to participate more. Other afforestation projects, which intensified extension services and provision of various incentive systems in the district, were Forest Resource Management Project (FRMP), CARITAS-MWANZA and Magu Food Security Project (MFSP), which provided various incentives like training, tree seeds and basic nursery inputs to farmers owning private Ngitili and capacity building of the extension staff. The F- calculated in Appendix 2 (13.38) is larger than the tabulated one (2.87) meaning that the trend of adoption was increasing yearly from (13.2%) up to the current year 2007 which is (36.6%).This is shown in Table 2. However, farmers' informal discussions report a decline in dependence on natural communal rangelands for the dry season fodder supplies. The majority of adopters in local Ngitili Silvopastoral technology do practice around homestead. The study by Dewees (1992) in Malawi and study by Axelsson and Hagborg (1994) in Karatu district in Tanzania also found that Ngitili were mostly practiced around the home plots. This phenomenon of practicing this technology in the district is attributed to the problem of category of livestock using the fodder which in most cases are calves, nature of farming practices, land scarcity, extra demand of labour and insecurity of rights.

5.1.2 Benefits gained through local Silvopastoral technology

The results from Table 3 in relation to Appendix 3 show that ($p<0.05$) the F-calculated (0.15) is less than the tabulated (3.32). However there is a progressive decrease in milk production in litres from Shigalla to Ihushi villages because of the livestock population distribution in the wards. For instance, Shigalla village has more livestock than Ihushi and hence more milk production. However, Ihushi farmers adopted the technology compared to Shigalla probably because of the possession of small numbers of livestock which enabled them to have areas to practice the technology. In case of milk yield through the technology in the district (Table 5 and Appendix 5) statistically ($p<0.05$) the (F-calculated 7.65 is greater than the tabulated 2.86). This has been caused by the higher number of households in the district to indulge fully in the technology yearly. For example, milk production mean through the technology in the district in year 2003 was 66 547 litres compared with 126 955 litres year 2007. Pasture production is another benefit from the technology for the farmers' animals. The F-calculated (0.005) is less than the tabulated one (3.33) However, there is a progressive decrease in production from Bubinza to Buhumbi villages due to the geographical positioning of the areas among the wards Bubinza and Ilumya villages are located at the Lake Victoria shore hence get chance of receiving rains to sustain the plants. Similarly, in case of pasture production (air-dried weight) in tones per hectare among the wards in the district analysis ($p<0.05$) the F-calculated (0.08) is less than the tabulated one (3.33). The progressive decrease in production from Bubinza and Ihushi villages has been caused by the geographical location among the areas.

Fuelwood production was the highest least significant benefit ($p<0.05$) at which the F-calculated (14.51) is greater than the tabulated one (3.15) hence significant difference in other benefits gained among the wards, which farmers get from the technology. This implies that the fuelwood production is an important aspect (Table 8 and Appendix 8) to the farmers especially in semi-arid areas where forests have deteriorated severely. . Otysina *et al.* (1996) and Nshubemuki (1998) elaborate fuelwood yields and requirements per individual for Acacia species. From a tree of 5 to 6 years old, it produced 10 to 15 tonnes of fuelwood per hectare, which was enough to sustain a family of 6 to 8 persons for 2 years at a daily use of 1kg per person. This shows that a household having one hectare of trees will have the ability to sustain its fuelwood requirements and has excess to sell for income generation A number of similar studies in Shinyanga by Msangi (1995), Maro (1995), Kilahama (1994) and Otysina and Asenga (1994) report similar perceived benefits of local Silvopastoral reserves Most of trees that now exist in local Silvopastoral practice are believed to influence grass production and general fodder situation. This is why fodder production for their animals ranks second to fuelwood production.

Livestock are used as both a bank and insurance amongst the rural people. Livestock are associated with a number of customary and cultural roles such as bride payments and various ceremonies including funerals. About (100%) of the households surveyed, were livestock keepers. All of them were experiencing fodder insufficiency. Field observation indicated that fodder was very scarce during the dry season especially from July to September. Most of the land in dry season is bare. Some of the cows were observed feeding *on Acacia arabica* pods under the scattered trees in the area. The high percent of livestock keepers obtaining fodder from trees planted conforms to the findings by Hausler (1990) who found that many farmers have become self-sufficient in fodder through private or community grazing lands. The field observation clearly showed that natural trees of Acacia species scattered in the area were the major sources of fodder during the dry season.

It is also appreciated that if farmers could put more efforts on fodder trees, it could be more beneficial to them. The practice improves milk production, animal health and manure. Results show that all adopters in the study area who have started reserving areas some four years ago are harvesting enough fodder. The results table 3 also indicate that all tree species were useful for fuelwood.. Farmers were asked to give trends of level of milk production per cow per day for the past four years. The majority said it was increasing probably because of the proper livestock management resulting from adequate extension services, and supplement of fodder supply from the local Ngitili Silvopastoral practice. Study by ICRAF (1996) and Gatsi *et al.* (2000) have shown higher level of milk production after the improved fodder production.

5.1.3 Calf mortality rate before starting local Silvopastoral technology

The percentage of calves that died for the years 2003-07 to that of the total births for the same period was considered. Sex differences were not considered because most farmers could not recall well about these sexes of the dead calves. There are many factors influencing calf mortality including adverse environmental and management factors that predispose calves to diseases and subsequent deaths and other factors specific to individual farmers affected death rates. In epidemiological studies, only few factors have been specifically associated with increased mortality. The most important ones are season, herd size and factors related to management and care (personal calving for the calves), housing factors and effect of feeding particularly colostrums (Simensen, 1982). The statistical analysis ($p<0.05$) observed there was the significant difference of calf mortality rates occurrences among the wards in the district. This was probably caused by the deficiency of pasture during the dry season, which resulted into many deaths especially in young animals. Other possible causes were diseases like diarrhea, pneumonia, post weaning stress and general weakness In addition, Table 9, Appendix 9 indicate deaths of these animals showing an obvious drop of livestock productivity being caused by the shortage of fodder productivity in that specific area. In the traditional sector, calf mortality is often as high as 50% (Williamson and Payne, 1978). In the study area, the District Agricultural and Livestock Development Officer stated Magu District the current calf mortality rate is 10%.

5.1.4 Calf mortality rate after practicing local Silvopastoral technology

Livestock mortality and morbidity can directly reduce both income flows from livestock activities by cutting output and, more importantly, the financial investment value of the livestock assets themselves. It was revealed currently that ($p<0.05$) there is no significant difference in the effect of calf mortality occurrence among the wards in the district as it spreads evenly. At the same time (51.7%) of the farmers observed the calf mortality rate ranging from (<5%). The (38.3%) of the participating community in the technology observed the range of (6-10%) while the least number (10%) observed the highest mortality range of (11-20%) This indicates the importance of fodder availability throughout the year to the wellbeing of livestock in the district, hence a great impact of Silvopastoral productivity in the community. Yongolo *et al.* (1982) reported that East African farmers face a problem of supplementation because after being weaning calves are exposed to poor and insufficient pasture, which impose stress, thus calves become susceptible to diseases like pneumonia, gastroenteritis, hypomagnecaemia and white muscle disease. Due to this fact, the calf mortality rates after practicing local Silvopastoral technology have dropped to some extent so long as animals are allowed to graze in these plots particularly during the dry seasons.

The progressive fall in calf mortality from Buhumbi to Bubinza villages is probably due to other predisposing factors such as application of ectoparasite control measures for instance availability of dips in the area.

5.2 Socio-Ecological Characteristics Affecting the Productivity of Local Silvopastoral Users

5.2.1 The socio-ecological factors influencing the productivity of local Silvopastoral technology

O'Kting'ati (1985), Nair and Sreedharan (1986), succinctly elucidated the socio-ecological functional aspects of local Silvopastoral systems, for income generation and provision of subsistence needs. They reported that forests and trees deliver the functions of protection or conservation expected from it only. However, forests and trees in the Silvopastoral system, if allowed to grow with sufficient strength and vigour, can encounter physical forces affecting soils through water erosion. However, there seems to be other factors besides the listed ones. That is why the Analysis of Variance ($p<0.05$) (Appendix 5) indicated the F-calculated value (1.49) to be less than the tabulated one (2.42) and therefore no significant difference.

Soil erosion seems to be the factor that affects productivity in local Silvopastoral much as about (22.5%) of the technology participants mentioned. Moshi (1997) and Johansson (2001) in the West Usambara reported the problem of poor soil fertility that, the permanent cropping system of an area can result into continuous removal of nutrients from the soil through crops, weeds, fodder, and trees. This reduces the productivity of the Silvopastoral technology. Therefore, to arrest this problem, farmers have to ensure constant replenishment of the soil nutrients through manuring by allowing their animals to graze in the Ngitilis where fodder has to be available and abiding to the recommended soil erosion control measures. Overpopulation of the area of study scored (18.3%) as second factor to influence productivity of the technology followed by overstocking (17.5%). Overpopulation pressure observed in some areas in Magu District concur with earlier reports (O'Kting'ati, 1985). Other factors are climatic conditions (16.7%) especially the unreliable rainfall that is a common problem in the district. As stated earlier the district receives the rainfall of 800mm per annum. This rainfall is always not reliable in such a way that can cause failure in plants growth hence affect productivity of the technology. Weakness in implementation of village bylaws (14.2%) concerning natural resource reservation grounds can result into great conflicts among the farmers. Low understanding on environmental knowledge (10%) and theft (0.8%) of the Silvopastoral products done by those who do not have are the social characteristics that can cause the Ngitili to be fire burnt and therefore reduce the productivity. All areas faced by these factors result in low productivity provision of the technology.

5.2.2 Reasons for occurrence of socio-ecological factors influencing Silvopastoral technology

Farmers in Magu District are aware of the land degradation problem and the impact on crop production, pasture or fodder availability and visible landscape changes such as deforestation, drying up of water sources and soil erosion (Maro, 1995; Otysina and Asenga, 1994).In this study the potential of local Silvopastoral practice for its role in soil conservation and its general benefits in the society was expressed in Table 6, Appendix 6.. However, it has been revealed that lack of environmental knowledge of farmers in the district have shown the highest least significant difference. Under the diagnostic survey conducted in Magu, farmers also have caused environmental degradation through poor range management practices which are accompanied by large number of livestock that exceed the available grazing area and therefore cause overgrazing of the place.

Nevertheless, farmers have developed a number of strategies to acquire dry season fodder supplies, while mitigating environmental degradation at the same time. Uncontrolled birth rate in the human population is another reason for socio-ecological factor occurrence because it has resulted into higher population that requires expansion of residential areas and crop farming areas hence reducing the areas for the technology.

Other reasons include poor agricultural practices that involve activities, which do not consider sustainable agriculture and hence lead to land degradation. Poor extension services especially in the fields of agriculture, livestock and forest has played a big problem in combating the environmental problems. Poverty of the community has forced them to indulge in environmental degradation practices such as thatch grasses cutting, charcoal making, building poles and fuelwood harvesting. All these activities affect a lot the productivity of the technology in the district.

5.3 Constraints to Scaling up and Possible Mechanisms to Mitigate the Problems

5.3.1 Constraints hindering local Silvopastoral technology

In Silvopastoral system, livestock have great contribution to meet income and food security of farm households, however low productivity is the major impediment for achieving the objective; (Kurwijila *et al.*, 2002). Pastoralists face many problems in livestock production. It was revealed (Table 14, Appendix 14) that land scarcity of the farmers is caused by the nature of competitive land uses, making farmers pre-occupied with clearing of trees and bushes for expansion of crop and livestock production on one hand therefore affect Silvopastoral productivity. The merits of Silvopastoral intervention in making many agricultural systems more robust, can be clearly seen on the less well endowed areas where rainfall is erratic, the soil is less infertile, topography is difficult and farmers have limited land and capital resources (Sanchez, 1995).

These problems require serious attention in order to sustain the Silvopastoral technology existing in the area. The following ranking problem is the unreliable climate (drought). Drought has persisted in the district for almost three consecutive years since 2004, seriously affecting agricultural and Silvopastoral products. Largely severe and prolonged drought, which causes gradual replacement of the more palatable grasses and shrubs by undesirable species, especially when combined with mismanagement of the technology. Poor land tenure also is another constraint mentioned by the respondents in the study area. According to Ngigwana (1993), land tenure system is the big problem in Tanzania and other African countries. Often traditional grazing lands are owned communally and livestock are grazed on communal basis. In this system, there are no limitations to the number of livestock one can bring to graze. This situation has lead to overstocking and overgrazing causing environmental degradation resulting into low Silvopastoral productivity in such areas. Some respondents lamented about pests and diseases as another constraint. The damage caused by rabbits, hares, rats and other small rodents, which consume forage result into low productivity within the technology.

The late dry season is the most stressful period to have fodder. During this period, pasture supply gets to its lowest level, especially in years with insufficient amount of rainfall. Other mentioned constraint was long distance to working place, which is also the last constraint. Some farmers practice the technology in places, which are located very far from the residential areas. This requires them to walk with their animals for a long time resulting into weakening of animals' health thus a decrease in productivity.

5.3.2 Suggested solutions to mitigate the problem

Multidisciplinary cooperation with other disciplines like livestock, agriculture, community development and others should be encouraged for more advice to promote agroforestry activities (Irwin, 1997).. Furthermore, many people in the district suggested provision of environmental knowledge to the community. This can be done through extension workers and the politicians in the district. The health extension workers can give birth control knowledge. If it will be effective, it will result into few people who will seek for new residential areas and land for crop production. Expansion of extension services at least to every ward will bring a great impact in the fields of agriculture, livestock and forest. Destocking of the livestock in the area (Table 15, Appendix 15) will result into minimal land degradation incidences as well as improvement of the range management to produce sufficient fodder for the animals.. Finally, the strengthening of the village bylaws will restrict villagers to graze their livestock freely in the reserved areas. Bylaws also will restrict villagers to initiate unplanned fires in the locality. Emphasis of these bylaws in the district will promote growth of grasses for livestock, trees and shrub enough fodders.

According to MNRT and IUCN (2005), regeneration of trees in Ngitili is largely through coppicing regrowth and root suckers rather than through seeds. Farmers in Magu are aware of land degradation problems, and the impact on crop production, pasture or fodder availability and visible landscape changes such as deforestation, drying up of water sources and soil erosion (Maro, 1995) Through Ngitili farmers will conserve land as well as will have enough fodder for their livestock, trees for household use and income generation through sale of products, including milk and fodder production thus higher Silvopastoral practice productivity.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Based on the obtain research results and preceding discussion the following conclusions have been reached:

- Major identified problems in Magu include the shortage of land for grazing, drought, soil erosion wood based products, vegetation deterioration, conflicting land uses, overpopulation and wastage of resources by cultivating unproductive land which lead to slow stepping in the rate of adoption of the technology.
- Socio-economically, very little is needed to practice the local Ngitili Silvopastoral technology, as compared to other agroforestry practices in the district as far as the trend of adoption is concerned.
- Negligible capital investment is needed as the technology is compatible with traditional local practices, which are more or less a routine.
- The solutions to many of the problems identified in the study, depend on one hand, to the technical and communication skills of the extension services and on the other hand to the involvement of the farmers at all stages of planning and implementation, to make Ngitili technology integrated with experience and practical knowledge which already local people have.
- Institutional bodies e.g. Governmental and Non-governmental organizations are deemed responsible and instrumental in addressing and alleviating the current land use policy dilemmas. that lead to environmental problems, affecting the adoption and sustainable development of local Ngitili Silvopastoral technology, under land use suitability classification.

6.2 Recommendations

Following the discussion and conclusions reached it has bee recommended that:

6.2.1 Recommendations for immediate application:

- Extension and training is needed to stimulate and elicit indigenous change of attitudes and approaches to resource management, to impart knowledge and skills to the main key players in local Ngitili Silvopastoral fodder reserves and agroforestry technologies in general.
- Training of extension agents and NGOs staff, on how to advise farmers on resource management and sustainable environmental resource utilization that will not degrade the environment.
- Training of staff in local institutions, direct in touch with farmers e.g. Vi-Agroforestry and Magu Food projects to have competent and multi-disciplinary staffs in environmental forestry and rural development at grass root level.
- Training of farmers in local Silvopastoral technology, to have demonstratable leadership in on-farm practices.
- Youth education through programmes for school teachers, as to ensure them are trained to teach agroforestry and conservation, or practice agroforestry in their schools.
- Involving politicians, administrators and village leaders in agroforestry practices to ensure the conservation messages are taken up through political and local government institutions.
- Environmental exhibition, encompassing exhibits, films; cultural groups and so on in order to raise awareness and publicity on sustainable environmental resource management.

- Farmers visits and study tours to enable pioneer farmers especially women and schools acquire hand on experience.
- Participatory Rural Appraisal, where farmers should evaluate themselves on performance related to their environmental resources to come up with participatory management plan.

6.2.2 Recommendations for further research:

- Research is needed to identify, test and facilitate adoption of suitable local Silvopastoral technologies.
- Research on indigenous knowledge, attitude and practices that can be useful as s package in the strategic planning for the local Silvopastoral land use e.g. on Ngitili.
- Research on economics of rangelands and near emerging patterns of pastoralism.
- Capacity building for national and local researchers within the conservation programmes like Vi-Agroforestry and Magu Food Security projects with emphasis on collaboration with universities and institutions such as TAFORI,so as to attain quality research work.
- Screening and evaluation of the multi-purpose trees (MPTs), for selection based on suitability, to increase fodder, woodfuel and environmental conservation in local Ngitili Silvopastoral technology.
- Research on the carrying capacity of the rangelands and suitably rating for land utilization types.

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APPENDICES

Appendix 1: Distribution of respondents by rate of adoption of the technology

Villages	**Percentage of adopters (Years)**				
	2003	**2004**	**2005**	**2006**	**2007**
Shigala	8.6	9.5	15.8	23.7	28.3
Ilumya	3.7	5.2	7.5	14.0	31.0
Bubinza	14.9	17.3	26.6	29.2	36.4
Buhumbi	20.0	22.8	25.8	29.3	29.7
Kisesa	5.2	9.9	14.6	21.9	28.8
Ihushi	26.7	40.0	48.9	58.4	65.3

Villages	**Mean value changed to arcsine angle**					**Total**	**Means**
	Years						
	2003	**2004**	**2005**	**2006**	**2007**		
Shigala	17.05	17.95	22.95	29.13	32.14	**118.69**	**23.7b**
Ilumya	11.09	31.11	15.89	21.97	33.83	**113.89**	**20.5b**
Bubinza	22.71	24.58	31.05	32.71	37.11	**148.16**	**29.6a**
Buhumbi	26.56	28.52	30.53	22.46	44.37	**151.4**	**30.3a**
Kisesa	13.18	18.34	22.46	27.9	44.37	**114.34**	**22.9b**
Ihushi	31.11	39.27	44.37	49.84	53.91	**218.46**	**43.7a**
Total	**121.7**	**159.73**	**166.72**	**194.32**	**222.47**	**864.94**	

ANOVA TABLE

SOV	Df	SS	MS	F-values	F-tab.
Treatment	5	1487.933	297.5865	11.96	2.71
Block	4	1369.071	342.2677		
Residual	20	497.311	$24.86 = S^2$		
Total	29	3354.315			

LSD (Least Significant Different)

$Lsd = (tv.\alpha)\ S_d$.

$Sd = \sqrt{2S^2/r}$

$Sd = \sqrt{2*24.86/6}$

$Sd = 2.8$

Hence $Lsd = (1.725)\ (2.8) = 4.83$

Appendix 2: Trend of adoption of the technology in Magu district Percentage of adopters

Year	Village						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
2003	8.6	3.7	14.9	20.0	5.2	26.7	**79.1**
2004	9.5	5.2	17.3	22.8	9.9	40.0	**104.7**
2005	15.8	7.5	26.6	25.8	14.6	48.9	**139.2**
2006	23.7	14.0	29.2	29.3	21.9	58.4	**176.5**
2007	28.3	31.0	36.4	29.7	28.8	65.3	**219.5**
Total	**85.9**	61.4	**124.4**	127.6	**80.4**	**239.3**	**719.0**

Mean value changed to arcsine angle

Year	Village						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
2003	17.05	11.09	22.71	26.56	13.18	31.11	**121.7**
2004	17.95	31.11	24.58	28.52	18.34	39.23	**159.73**
2005	22.95	15.89	31.05	30.53	22.46	44.37	**166.72**
2006	29.13	21.97	32.71	22.46	27.9	49.84	**194.32**
2007	32.14	33.83	37.11	44.37	32.46	53.91	**222.47**
Total	**118.69**	**113.89**	**148.16**	**151.4**	**114.34**	**218.46**	**864.94**

ANOVA TABLE

SOV	Df	SS	MS	F-values	F-tab.
Treatment	4	1110.11	277.52	**13.38**	2.87
Block	5	1606.43	321.29		
Residual	20	414.66	$20.7 = S^2$		
Total	**29**	**3131.20**			

LSD (Least Significant Different)

$Lsd = (tv.\alpha)\ S_d.$

$Sd = \sqrt{2S^2/r}$

$Sd = \sqrt{2*20.7/6}$

$Sd = 2.6$

Hence $Lsd = (1.725)\ (2.6) = 4.48$

Appendix 3: Current milk yield through the Ngitili practice users in the district

Means of milk production in litres

Villages	**Division**				
	Busega	**Itumbili**	**Sanjo**	**Total**	**Means**
Shigala	10740	0	0	10740	3580
Ilumya	7280	0	0	7280	2426
Bubinza	0	5520	0	5520	1840
Buhumbi	0	3300	0	3300	1100
Kisesa	0	0	6900	6900	2300
Ihushi	0	0	3120	3120	1040

ANOVA TABLE

SOV	**Df**	**SS**	**MS**	**F-values F-tab.**
Treatment	5	1353844	2707169	0.15 3.32
Block	2	8337778	4168889	
Residual	10	169696090	16969609=S 2	
Total	**17**	**79387712**		

Appendix 4: Current milk yield through the non-Ngitili practice users in the district

Means of milk production in litres

Villages	Division				
	Busega	Itumbili	Sanjo	Total	Means
Shigala	8912	0	0	8912	2971
Ilumya	6131	0	0	6131	2044
Bubinza	0	4923	0	4923	1641
Buhumbi	0	2966	0	2966	989
Kisesa	0	0	5714	5714	1905
Ihushi	0	0	2692	2692	897

ANOVA TABLE

SOV	Df	SS	MS	F-values	F-tab.
Treatment	5	8754759	1750952	0.14	3.32
Block	2	5305376	2652688		
Residual	10	121323060	12132306=S^2		
Total	17	**35383195**			

Appendix 5: Trend of milk yield in Magu district Milk production in litres

Year	Village					
	Shigala	Kiloleli	Lubugu	Sukuma	Kisesa	Bujashi
2003	4080	2880	4800	2520	2880	2160
2004	5580	4200	4440	2040	2520	2280
2005	7500	3780	5040	2400	3180	3000
2006	9540	6420	5040	3780	4560	2400
2007	10740	7280	5520	3300	6900	3120

ANOVA TABLE

SOV	Df	SS	MS	F-values	F-tab.
Treatment	4	80269707	9088013	7.65	2.86
Block	5	36352053	16053941		
Residual	20	23742827	1187141= S^2		
Total	**29**	**140364587**			

LSD (Least Significant Different)

Lsd = (tv.α) S_d.

Sd= $\sqrt{2S^2/r}$

Sd = $\sqrt{2*1187141/6}$

Sd = 629.1

Hence Lsd = (1.725) (629.1) = 1085.2

Appendix 6: Pasture production green (Weight and moisture) in tones per hectare

Weight of pasture production

Villages	Division				
	Busega	**Itumbili**	**Sanjo**	**Total**	**Means**
Shigala	2.907	0	0	2.907	0.969
Ilumya	3.340	0	0	3.340	1.113
Bubinza	0	3.426	0	3.426	1.142
Buhumbi	0	2.859	0	2.859	0.953
Kisesa	0	0	3.149	3.149	1.050
Ihushi	0	0	2.873	2.873	0.957

ANOVA TABLE

SOV	Df	SS	MS	F-values	F-tab.
Treatment	5	0.10426	0.021	0.005	3.33
Block	2	0.00673	0.003		
Residual	10	38.45189	3.845= S^2		
Total	17	**38.56288**			

Appendix 7: Pasture production (Air-dried weight) in tones per hectare

(Air-dried weight) in tones per hectare

Villages	Division				
	Busega	Itumbili	Sanjo	Total	Means
Shigala	2.431	0	0	2.431	0.810
Ilumya	2.944	0	0	2.944	0.981
Bubinza	0	2.827	0	2.827	0.942
Buhumbi	0	2.318	0	2.318	0.773
Kisesa	0	0	2.603	2.603	0.868
Ihushi	0	0	2.311	2.311	0.770

ANOVA TABLE

SOV	Df	SS	MS	F-values	F-tab.
Treatment	5	0.1189	0.0237	0.008	3.33
Block	2	0.0177	0.0088		
Residual	10	26.6878	2.6687= S^2		
Total	**17**	**26.8244**			

Appendix 8: Other benefits gained through practicing local Ngitili Silvopastal technology

Percentage of respondents

Benefit	Villages						Total
	Shigala	**Ilumya**	**Bubinza**	**Buhumbi**	**Kisesa**	**Ihushi**	
Income through selling silvopastoral products	35	5	5	0	0	20	**65**
Fuelwood production	20	25	60	45	65	60	**275**
Fodder production	45	60	35	55	35	20	**250**
Food production	0	10	0	0	0	0	**10**
Total	**100**	**100**	**100**	**100**	**100**	**100**	**600**

Mean value changed to arcsine angle

Benefit	Villages						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
Income through selling silvopastoral products	36.27	12.92	12.92	0	0	26.56	**88.67**
Fuelwood production	26.56	30.0	50.77	42.13	53.73	50.77	**253.96**
Fodder production	42.13	50.77	36.27	47.87	36.27	26.56	**239.87**
Food production	0	18.44	0	0	0	0	**18.44**
Total	**104.96**	**112.13**	**99.96**	**90.0**	**90.0**	**103.89**	**600.94**

ANOVA TABLE

SOV	Df	SS	MS	F- value (calculated)	F-Tabulated
Treatment	3	6658.91	2219.64	14.51	$F_{0.05}$, 3,15 = 3.29.
Block	5	96.68	19.34		
Residual /Error	15	2295.20	$153.01 = S^2$		
Total	**23**	**9050.79**			

LSD (Least Significant Different)

Lsd = (tv.α) S_d.

Sd= $\sqrt{2S^2/r}$

Sd = $\sqrt{2*153.01/6}$

Sd = 7.14

Hence Lsd = (1.753) (7.14) = 12.51

Appendix 9: Distribution of respondents concerning calf mortality rate before practicing the technology

Rate	Villages						
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	Total
<5%	0	0	0	0	5	5	**10**
6-10	5	15	40	5	10	20	**95**
11-20	95	85	60	95	85	75	**495**

Mean value changed to arcsine angle

Rates	Villages						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
<5%	0	0	0	0	12.92	12.92	**25.84**
6-10	12.92	22.79	39.23	12.92	18.44	26.56	**132.86**
11-20	77.08	67.21	50.77	77.08	67.21	60.0	**399.35**
Total	**90.0**	**90.0**	**90.0**	**90.0**	**98.57**	**99.48**	**558.05**

ANOVA TABLE

SOV	Df	SS	MS	F- value (calculated)	F-Tabulated
Treatment	2	12332.22	6166.10	51.53	$F_{0.05,2,10}$ = 4.10
Block	5	36.34	7.27		
Residual /Error	10	1196.50	119.65=S^2		
Total	**17**	**13565.06**			

LSD (Least Significant Different)

Lsd = (tv.α) S_d.

Sd= $\sqrt{2S^2/r}$

Sd = $\sqrt{2*119.65/6}$

Sd = 6.32

Hence Lsd = (1.812) (6.32) = 11.45

Appendix 10: Current percentage means of calf mortality rates in the district

Percentage means of calf mortality rates

Villages	Division				
	Busega	Itumbili	Sanjo	Total	Means
Shigala	25	0	0	25	8.3
Ilumya	19	0	0	19	6.3
Bubinza	0	19	0	19	6.3
Buhumbi	0	26	0	26	8.7
Kisesa	0	0	23	23	7.7
Ihushi	0	0	24	24	8.0

Mean value changed to arcsine angle

Villages	Division			Total	Means
	Busega	Itumbili	Sanjo		
Shigala	30.0	0	0	**30.00**	**10.0a**
Ilumya	25.84	0	0	**25.84**	**8.6a**
Bubinza	0	25.84	0	**25.84**	**8.6a**
Buhumbi	0	30.66	0	**30.66**	**10.22a**
Kisesa	0	0	28.66	**28.66**	**9.55a**
Ihushi	0	0	29.33	**29.33**	**9.78a**
Total	55.84	56.5	57.99	170.33	

ANOVA TABLE

SOV	Df	SS	MS	F-values	F-tab.
Treatment	5	7.235	1.447	0.005	3.33
Block	2	0.404	0.202		
Residual	10	3237.657	323.765= S^2		
Total	**17**	**3245.296**			

Appendix 11: Distribution of respondents concerning calf mortality rate after practicing the technology

Percentage of respondents

			Village				
Rate	**Shigala**	**Ilumya**	**Bubinza**	**Buhumbi**	**Kisesa**	**Ihushi**	**Total**
<5%	0	50	85	90	55	30	**310**
6-10	80	25	15	10	35	65	**230**
11-20	20	25	0	0	10	5	**60**

Mean value changed to arcsine angle

Rate	**Village**						**Total**
	Shigala	**Ilumya**	**Bubinza**	**Buhumbi**	**Kisesa**	**Ihushi**	
<5%	0	45.0	67.21	71.56	47.87	33.21	**264.85**
6-10	63.44	30.0	22.79	18.44	36.27	53.73	**224.67**
11-20	26.56	30.0	0	0	18.44	12.92	**87.92**
Total	**90.0**	**105.0**	**90.0**	**90.0**	**102.58**	**99.86**	**577.44**

ANOVA TABLE

SOV	**Df**	**SS**	**MS**	**F- value (calculated)**	**F-Tabulated**
Treatment	2	3030.77	1515.38	2.94	$F_{0.05},2,10$ =4.10
Block	5	66.95	13.39		
Residual /Error	10	5154.09	515.41		
Total	**17**	**8251.81**			

Appendix 12: Distribution of respondents concerning socio-ecological factors % of respondents on socio-ecological factors

Factor	Villages						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
Overpopulation	20	5	25	0	20	40	**110**
Soil erosion	15	5	45	45	25	0	**135**
Theft	0	0	5	0	0	0	**5**
Overstocking	0	5	15	10	30	45	**105**
Low understanding of environmental knowledge	40	0	0	20	0	0	**60**
Implementation	15	10	5	25	25	5	**85**
of village bylaws	10	75	5	0	0	10	**100**
Climatic variations							

Mean value changed to arcsine angle

Factor	Villages						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
Overpopulation	26.56	12.92	30.0	0	26.56	39.23	**135.27**
Soil erosion	22.79	12.92	42.13	42.13	30.0	0	**149.97**
Theft	0	0	12.92	0	0	0	**12.92**
Overstocking	0	12.92	22.79	18.44	33.21	42.13	**129.49**
Low understanding of environmental knowledge	39.23	0	0	26.56	0	0	**65.79**
Implementation of village bylaws	22.79	18.44	12.92	30.0	30.0	12.92	**127.07**
Climatic variations	18.44	60.0	12.92	0	0	18.44	**109.8**
Total	**129.81**	**117.2**	**133.68**	**117.13**	**119.77**	**112.72**	**730.31**

ANOVA TABLE

SOV	Df	SS	MS	F- value (calculated)	F-Tabulated
Treatment	6	2343.57	390.59	1.49	$F_{0.05,6,30}$ =2.42
Block	5	47.83	9.57		
Residual /Error	30	7818.49	260.62		
Total	**41**	**10209.89**			

Appendix 13: Distribution of respondents concerning reasons for socio-ecological factors

% of respondents on there reasons for socio-ecologicalfactors occurrence

Reason	**Village**						**Total**
	Shigala	**Ilumya**	**Bubinza**	**Buhumbi**	**Kisesa**	**Ihushi**	
Uncontrolled birth rating system	20	5	25	0	20	40	**110**
Poor agricultural practices	20	5	0	45	25	10	**105**
Poor range management practices	0	15	60	10	30	50	**165**
Lack of environmental knowledge	50	70	10	45	25	0	**200**
Shortage of extension	10	0	0	0	0	0	**10**
services	0	5	5	0	0	0	**10**
Poverty of the community							

Mean value changed to arcsine angle

Reason	Village						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
Uncontrolled birth rating system	26.56	12.92	30.0	0	26.56	39.23	**135.27**
Poor agricultural practices	26.56	12.92	0	42.13	30.0	18.44	**130.05**
Poor range management practices	0	22.79	50.77	18.44	33.21	45.0	**170.21**
Lack of environmental knowledge	45.0	56.79	18.44	42.13	30.0	0	**192.36**
Shortage of extension services	18.44	0	0	0	0	0	**18.44**
Poverty of the community	0	12.92	12.92	0	0	0	**25.84**
Total	**116.56**	**118.34**	**112.13**	**102.7**	**119.77**	**102.67**	**672.17**

ANOVA TABLE

SOV	Df	SS	MS	F- value (calculated)	F-Tabulated
Treatment	5	4481.74	896..35	3.54	$F_{0.05},5,25 = 2.60$
Block	5	49.15	9.83		
Residual /Error	25	6326.75	$253.07=S^2$		
Total	**35**	**10857.64**			

LSD (Least Significant Different)

$Sd = (tv.\alpha)\ S_d.$

$Sd = \sqrt{2S^2/r}$

$Sd = \sqrt{2*253.07/6}$

$Sd = 9.18$

Hence $Lsd = (1.708)\ (9.18) = 15.67$

Appendix 14: The relative effect of the factors that influence productivity of Silvopastoral technology

Percentage of adopters on constraints hindering

Problem/Constraint	Village						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
Low income	15	15	15	15	40	20	**120**
.Land tenure	15	15	10	5	0	0	**45**
Long distance to working place	0	0	0	5	0	0	**5**
Land scarcity	55	25	25	45	25	50	**225**
Pests and diseases	0	0	5	0	10	5	**20**
Unreliable climate	15	45	45	30	25	25	**185**

Mean value changed to arcsine angle

Problem/Constraint	Village						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
Low income	22.79	22.79	22.79	22.79	39.23	26.56	**156.95**
Land tenure	22.79	22.79	18.44	12.92	0	0	**76.94**
Long distance to working place	0	0	0	12.92	0	0	**12.92**
Land scarcity	47.87	30.0	30.0	42.13	30.0	45.0	**225.0**
Pests and diseases	0	0	12.92	0	18.44	12.92	**44.28**
Unreliable climate	22.79	42.13	42.13	33.21	30.0	30.0	**200.26**
Total	**116.24**	**117.7**	**126.28**	**123.97**	**117.67**	**114.48**	**716.35**

ANOVA TABLE

SOV	Df	SS	MS	F-value (calculated)	F-Tabulated
Treatment	5	6313.93	1262.79	16.74	$F_{0.05,5,25} = 2.6$
Block	5	18.04	3.61		
Residual /Error	25	1885.80	$75.43 = S^2$		
Total	35	8217.77			

LSD (Least Significant Different)

$LSD = (tv.\alpha)\ S_d.$

$SD = \sqrt{2S^2/r}$

$SD = \sqrt{2*75.43/6}$

$SD = 5.01$

Hence Lsd = (1.708) (5.01) = 8.56

Appendix 15: Distribution of respondents concerning suggested solutions for problem mitigation

% of respondents concerning suggestions for solution to mitigate the problem

Suggestion	Villages						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
Livestock destocking	10	10	0	0	30	45	95
Provision of environmental knowledge	20	65	10	45	25	0	165
Expansion of extension services	15	10	0	45	25	10	105
Strengthening of village bylaws	35	10	5	0	0	5	55
Range management improvement	0	0	60	10	0	0	70
Provision of birth control knowledge	20	5	25	0	20	40	110

Mean value changed to arcsine angle

Suggestion	Villages						Total
	Shigala	Ilumya	Bubinza	Buhumbi	Kisesa	Ihushi	
Livestock destocking	18.44	18.44	0	0	33.21	42.13	**112.22**
Provision of environmental knowledge	26.56	53.73	18.44	42.13	30.0	0	**170.86**
Expansion of extension services	22.79	18.44	0	42.13	30.0	18.44	**131.8**
Strengthening of village bylaws	36.27	18.44	12.92	0	0	12.92	**80.55**
Range management improvement	0	0	50.77	18.44	0	0	**69.21**
Provision of birth control knowledge	26.56	12.92	30.0	0	26.56	39.23	**135.27**
Total	**130.62**	**121.97**	**112.13**	**102.7**	**119.77**	**112.72**	**699.91**

ANOVA TABLE

SOV	Df	SS	MS	F- value (calculated)	F-Tabulated
Treatment	5	1181.39	236.28	0.72	$F_{0.05},5,25 = 2.60$
Block	5	77.28	15.46		
Residual /Error	25	8097.14	323.89		
Total	**35**	**9355.81**			

Appendix 16: Questionnaires

A. GENERAL INFORMATION

A1. Name of enumerator ....

A2. Date of interview ....

A3. Division/Ward ....

A4. Village name ....

A5. Household No...

B. BACKGROUND INFORMATION

B1. Respondent Name/Number ....

B2 Sex ....01 Male 02 Female

B3 Age ....Years

B4. Marital status. ... ...01.Married 02 Single 03 Divorced 04 Widow

B5. Ethnic group ....

B6. Religion affiliation ....

B7. Level of education............01 No formal education 02 Primary education

03 Secondary education 04 Post secondary education 05 Adult education

B8. Social status ....01 Common woman/man (farmer) 02 Leader

03 Government employee

B9 Composition of the household

No	Name	Sex	Age
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

B 10 Occupation of head of household ....01 F7arming 02 Schooling

03 Paid employee 04 Business (specify).........05 Others (specify)..........

C DRIVING FORCES FOR LOCAL SILVOPASTORAL TECHNOLOGIES

C1 Do you have local silvopastoral field? ....01 Yes 02 No

C2 Since when did you start reserving the area? ....Year

C3 Where do you reserve an area? ....01 Around homestead 02 In the private farm

03 Communal farm 04 Others (specify) ....

C4 What is the size of area of your private ngitili?..Ha

C5 What is the size of the area of the communal ngitili?..................................Ha

C6 Do you keep livestock? 01 Yes 02 No

C7 Since when did you start keeping livestock? ....Year

C8 Where do you keep your livestock? ....01 Around homestead 02 In the farm

C9 Why did you start practicing local silvopastoral technology? 01 Production of fuelwood 02 Earn money 03 Production of fodder 04 Food production 05 Construction timber 06 Others (specify) ....

C10 What was the calf mortality rate before practicing ngitili technology in your farm?

C11 What is the calf mortality rate after introducing ngitili technology in your farm?

C12 For your own experience what are the main problems hindering local silvopastoral technologies in your village? ....01 Low income 02 Land tenure 03 Lack of labour 04 Long distance to working point 05 Land scarcity 06 Pests and diseases

07 Unreliable climate 08 Others (specify)

D BENEFITS AND COSTS OF LOCAL SILVOPASTORAL IMPLEMENTATION

D1 You have said you do practice silvopastoral technology?......01 Yes 02 No

D2 Do you plant trees/pastures your own or you hire casual labour? 01 Own labour 02 Hired labour 03 Grow naturally

D3 Where do you graze your livestock besides ngitili? 01 Common grazing land 02 Own grazing land 03 Others (specify) ....

D4 Is the fodder sufficient throughout the year? ....01 Yes 02 No

D5 If no, which months in a year have problems for feeding them? ....

D6 Do you think practicing ngitili has alleviated the problem of fodder? 01 Yes 02 No

D7 To what extent does it alleviate the problem?..

D8 What tree and grass species do you plant for fodder? ....

D9 What other uses do you obtain from the available products? ....01 Timber. 02 Poles 03 Fruits 04 Medicines 05 Fuelwood 06 Others (specify)

D10 Are there restrictions imposed to the people on the use of the resources from the local silvopastoral technology? ....01 Restrictions to enter reserved areas 02 Restrictions to use certain piece of land 03 Others (specify) ....

D11 Is there any tax imposed in the use of reserved products to other farmers who don't have these areas? .... 01 Yes 02 No 03 I don't know

E RESOURCE USE / ALLOCATION

E1 Do you own land ? ....01 Yes 02 No

E2 How much do you own in total ? ....ha.

E3 How much land do you put in 01 Livestock ....ha

02 Trees ....ha 03 Pastures 04 Others (specify) ....

E4 Who owns the land in the community ? 01 Man 02 Woman 03 Both 04 Family members.

E5 Who controls over the land use decision in the family ? 01 Husband 02 Wife. 03 Both 04 Family members

E6 How is labour divided in the family ? 01 Husband activities........................ 02 Wife activities............. 03 Both.............. 04 Children.........

E7 Which activity consumes more time and money of the family ? ....01 Livestock 02 Trees 03 Crop production 04 Others (specify) ......

F CONSTRAINTS TO LOCAL SILVOPASTORAL PRACTICE AT HOUSEHOLD.

F1 Have you ever received any training on silvopastoral technologies ? 01 Yes 02 No

F2 If yes where and for how long ? ....

F3 If no where did you acquire the knowledge and skill of managing the technology?............................

F4 Why did you engage in local silvopastoral technologies ? ....

F5 What did your wife / husband contribute in silvopastoral performance ? 01 Provided money to purchase seeds /seedlings / breeding stock 02 Gave insight how to plant trees / pastures / keep livestock 03 Labour 04 Did nothing 05 Others (specify)

F6 Employment status in local silvopastoral practice ....

01 Unpaid family/Workers 02 Paid casual labour 03 Others (specify)

F7 Does it happen that you face labour shortage for the practice management ?.

01 Yes 02 No

F8 If yes does your wife / husband / children give any support ?.............01 Yes 02 No

F9 If no in F8 why do you think your wife / husband / children don't help you ?

F10 What difficulties faced you when establishing the local silvopastoral technology?..

F11 What socio-ecological factors influence the productivity in running silvopastoral activities at your farm?...

F12 What could be the reasons of the factors above?.......................................

F13 What do you think could be solution for the problems mentioned above.

....

Thank You for Your cooperation

G CHECKLIST FOR EXTENSION WORKERS (FOREST, LIVESTOCK OFFICERS)

G1. For how long have the local silvopastoral practices been promoted in the area?

G2. What are the current local silvopastoral extension approaches used in this area?

G3 What is the level of adoption of local silvopastoral technologies being promoted in this area for last five years?

Local Silvopastoral Technology	Year				
	2002	2003	2004	2005	2006
	No.of adopters	No.of adopters	No.of adopters	No.of adopters	No.of adopters
Total					

G4. What constraints does the community face in implementing silvopastoral technologies?

G5. What extension approaches do you think would be appropriate in helping to promote local silvopastoral in this area?

G6 What was the calf mortality rate of the farmers before introducing ngitili technology in their farms ?

G7 What was the calf mortality rate of the farmers after introducing ngitili technology in their farms ?

Thank You for Your cooperation.

H.CHECKLIST FOR DISTRICT/VILLAGE LEADERS

H1. Who are promoting local silvopastoral practices in your area of management?

H2. What is the level of adoption of local Silvopastoral technologies being promoted in this area for last five years?

Local Silvopastoral Technology	Year				
	2002	2003	2004	2005	2006
	No.of adopters	No.of adopters	No.of adopters	No.of adopters	No.of adopters
i. ii. iii. . .					
Total					

H3. What kind of local silvopastoral products do the communities benefit?

a) ....

b) ....

c) ....,,

H4. Is there any problem(s) in productivity regarding the local silvopastoral practices? 1. Yes 2.No

H5. If yes, what are the main causes of this/these problem(s)?

a) ....

b) ....

c) ....

H6. In your views(s) what could be done for the success to promote the productivity in silvopastoral practices in this area?

a) ………………………………………………

b) ………………………………………………

c) ………………………………………………

d) ………………………………………………

Thank You for Your coop

Appendix 17: Tree species available in the district

No.	Scientific name	Common name	Local name
1	*Acacia arabica*	Egyptian thorn	Mdubilo (P)
2	*Acacia nilotica*	Egyptian thorn	Mgunga
3	*Acacia polycantha*	White thorn	Migu L P S
4	*Acacia Senegal*	Three thorn	Ngwata L
5	*Acacia seyal*	White thorn	Ilula L P
6	*Acacia tortilis*	Umbrella thorn	Ngunga L P S
7	*Afzelia quanzesis*	Pod mahogany	Mkola
8	*Albizia camara*	Mahogany bean	Mpogolo L
9	*Azandratica indica*	Neem tree	Muarobaini
10	*Brachystergia spp*	Bean pod tree	Muombo S
11	*Caccia seyamea*	Murray red gum	Nsongoma L
12	*Dalbergia melanoxylm*	African blackwood	Mpingo L
13	*Dichrostachyus cinerea*	Mkulagembe	Ntundulu L
14	*Erythrina abyssica*	Kaffir boom	Mpilipili L
15	*Eucalyptus spp*	Red river gum	Mkaritusi
16	*Gliricidia sepium*	Mexican lilac	Mgirisidia
17	*Grewia bicolor*	Mkomalendi	Nkoma L Fr
18	*Leucaena leucocephala*	Mlusina	Lusina L P S
19	*Kigelia africana*	Sausage tree	Ng'wicha L Fl
20	*Mangifera indica*	Mango	Nyembe
21	*Sesbania sesban*	River bean	Msesibania L S
22	*Tamarindus indica*	Tamarind	Nshishi L Fr
23	*Trichilia emetica*	Cape mahogany	Nsuguta L

Key for browsable parts of the tree forage L (Leaf), S(Seed), P(Pods), Fr(Fruits), F(Flower)