THE CONTRIBUTION OF AGROFORESTRY TO HOUSEHOLD FOOD SECURITY AND INCOME GENERATION IN MASWA DISTRICT, SHINYANGA REGION.

BY

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ABSTRACT

The present study was conducted in Maswa District, Shinyanga Region during September to December 2006 with objective of evaluating the contribution of agroforestry to household food security and income generation. The method involved all the three divisions in the district with two wards per each division, two villages per each ward and ten households from each village randomly selected. Three NGOs, ten farmer groups and ten businessmen were also involved. Data collection was done through reconnaissance survey, questionnaire administration and field survey. Results indicated that 34%, 28%, 15%, 14% and 6% of household food supply in the district actually come from agroforestry, agriculture, livestock, business and employment respectively, although apparently expressed dependence of 98%, 30%, 23% and 13% for agriculture, employment, livestock and agroforestry respectively. The results also indicated that only 31% and 30% of agroforestry and non-agroforestry households were food secure. Of the household income 38%, 24%, 18%, 13%, 3%, 2% and 2% actually come from employment, agroforestry, business and agriculture respectively, though expressed dependence of 46%, 22%, 18% and 86% for employment, agroforestry, business and agriculture respectively. Of the agroforestry systems, three technologies of mixed intercropping, integrated tree-pasture (*ngitili*) and tree-bee interaction were undertaken with the integrated tree-pasture technology being the most widely adopted. Land scarcity, component competition and lack of knowledge indicated to be the main factors that affected agroforestry adoption and contribution to household food security and income. Reinforcement of available local institutions,

knowledge provision on component arrangement and market availability for agroforestry products appeared as the main interventions required to improve agroforestry technologies performance. Based on results and discussion, it has been recommended that, indigenous knowledge be emphasized for protecting trees, need to have clear land tenure, extension staffs recruitment and rain water harvesting on *Ngitili* be given attention to ensure water and pastures availability.

DECLARATION

I, MASANJA DEOGRATIAS SHILABU, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work, and has never been submitted, nor concurrently being submitted for a degree award in any other university.

..... 23/09/2008.....

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The above declaration is confirmed by

..... 23/9/2008.....

Prof. L. L. L. Lulandala Date

(Supervisor)

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LIST OF ABBREVIATIONS AND SYMBOLS

AEO	Agriculture Extension Officer
ANOVA	Analysis of variance
a.s.l.	above sea level
CRS	Catholic Relief Service
^{o}C	degree Celsius
DADP	District Agriculture Development Programme
DALDO	District Agriculture and Livestock Development Officer
DNRO	District Natural Resources Officer
et al	and others
GDP	Gross Domestic Product
ha	hectare
HASHI	Hifadhi Ardhi Shinyanga (Shinyanga Soil Conservation Programme)
HH(s)	Household(s)
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
hrs	hours
i.e.	that is
IKs	Indigenous Knowledge
kg	kilogram
km	kilometre
km^2	square kilometre
LGB	Large Grain Borer

LSD	Least Significant Difference
lts	litres
m^3	cubic metre
MDC	Maswa District Council
mg	milligram
MLHUD	Ministry of Land, Housing and Urban Development
mm(MM)	millimetre
N	nitrogen
NGOs	Non-Governmental Organizations
NMB	National Microfinance Bank
NWFPs	Non-Wood Forest Products
OC	Organic Carbon
P	Phosphorus
pH	Hydrogen ion concentration
r	Replicate (number of observations)
RWH	Rain Water Harvest
RWSSP	Rural Water Supply and Sanitation Programme
S^2	Sample variance
SACCOS	Saving and Credit Cooperatives Societies
s.e.d.	Standard error of difference
SHZ	Southern Highlands Zone
spp	species
SUA	Sokoine University of Agriculture
t	tons

$t_{0.05}$	table value at 5% level of significant
TANESCO	Tanzania Electricity Supply Cooperation
TARP II-SUA	Tanzania Agriculture Research Project Phase Two of SUA
TRL	Tanzania Railways Limited
Tshs	Tanzanian shillings
TTCL	Tanzania Telephone Cooperation Limited
URT	United Republic of Tanzania
US$	United States Dollar
VEO	Village Executive Officer
WALEO	Ward Agriculture and Livestock Extension Officer
WFO	Ward Forest Officer
WMUU	Wizara ya Mipango, Uchumi na Uwezeshaji
WVT	World Vision Tanzania
yr	year

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Agroforestry is a system of land use where woody perennials are deliberately integrated on the same land management unit along with annual agricultural crops and/or animals, sequentially or simultaneously, with the aim of obtaining diverse outputs on a sustained basis (Huxley and Ranasingher, 1996). In agroforestry systems, there are both ecological and economical interactions among the different components (Lulandala, 2004). It facilitates the enhancement and diversification of production systems products and further permits interactive resource conservation, improvement and sustainability. As a result it contributes to the livelihood of the community which largely depends on agriculture and/or livestock keeping.

According to Bakengesa (2001), agroforestry was recognized in the late 1970's as a sustainable land use system although existing for years as a traditional land use practice. Different indigenous agroforestry systems, such as agrosilviculture and silvopasture have been in practice in Maswa and Shinyanga region as a whole from the beginning of crop production and proved to sustain people due to its ability to restore the soil and water resources, as a result increased crop yields. The agrosilvopastoral system involved individually farmed arable plots and communally or privately owned grazing lands (Kamwenda, 1999). These traditional approaches resulted in appropriate environmentally friendly and sustainable technologies.

Silvopastoral system is a mechanism used to restore the goods and services of woods and grasslands to improve land use, conservation and livelihood security. This traditional practice (Kaale *et al.*, 2002), well known as *Ngitili* (Sukuma term meaning "enclosure") was developed by people who depended on livestock as mobile bank accounts contribute to needed cash expenses and buying food during lean times. It encompass retaining of an area of standing hay until the rain season ends, the area remains closed to livestock at the onset of rain season and opened up at the peak of dry season (Kaale *et al.*, 2002; Mugasha *et al.*, 1996). *Ngitilis* have enhanced the availability of fodder, wood products and environmental conservation at the local level, contributed to soil conservation and an improvement in agriculture and livestock production, hence food supply and income generation.

At present, traditional agroforestry systems are losing due to disruptive changes and increasing pressures on natural resources due to the population pressure since as population grow, the demand on natural resources also increases, the results of this and of the socio-economic developments automatically influence the forms and systems of land use. That is why many programmes and projects emerged to improve these traditional agroforestry systems and the introduction of modern systems. In Shinyanga region (Bakengesa, 2001; Kaale *et al.*, 2002) the Hifadhi Ardhi Shinyanga (HASHI) project, which means 'soil conservation' in Kiswahili, was established in 1986 with the aim of working with local people to identify areas requiring urgent land restoration, and then to restore them according to customary practices.

Although agriculture remains as the major base of employment and livelihood of about 80 % of the Tanzania population (Kashuliza *et al.*, 2002; Myaka *et al.*, 2003; Sicilima, 2003), of these, 20.4% are food poor while 38.7% of them live below the basic poverty line (Myaka *et al.*, 2003). This has mostly been contributed by a drop of production in the agriculture sector, particularly because of the rapid degradation of land productivity due to soil erosion and some of them being located in drought prone areas where agriculture is uncertain and often uneconomical. On the other hand, agricultural practices undertaken by farmers contributed to the poverty-related environmental pressures and resource degradation that indeed need an introduction of disincentives for controlling environmentally damaging agricultural practices (Alexandratos, 1995). Communal tenure with the associated high human and livestock densities and continuous grazing (Moleele and Perkins, 2002; Makepe, 2006; Solomon *et al.*, 2006; Higgins *et al.*, 1999; Vetter *et al.*, 2006) has led to undesirable vegetative changes and more worryingly accelerated soil erosion.

In Maswa district for example, most of fertile lands have already been put under cultivation while expansive dry-land agro-pastoral land use system has also exacerbated an already serious problem of clearing land for cultivation which has extended up to marginal lands. These lands are cultivated year after year with less appropriate techniques or lack of resource inputs; hence these poor agricultural husbandries caused the soil to be unable to maintain its fertility (Msanya *et al.*, 1999). The result is wide spread land degradation and falling productivity of food and cash crops as well as livestock sector, thus food insecurity and poor income. Also, most farmers in Maswa district and Tanzania at large have inadequate access

to means of production such as land, fertilizer inputs, improved seeds, chemicals for controlling pests and diseases, appropriate technologies and farm credit, which end-up to low-income and food-deficit as a result lead to poor agriculture productivity.

Sustainable agriculture should involve successful management of resources so as to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources (Kimbi *et al.*, 2005; Higgins *et al.*, 1999). Hence, agroforestry emerges as the most best placed to achieve this objective. The acceptance of agroforestry as a system of land management is attributed to increasing spread of tropical deforestation and ecological degradation, shortages of fertilizers and re-awakening of scientific interest in the farming systems, since it (Elevitch and Wilkinson, 2003) increase species diversity within farming systems, providing for human needs while supporting wildlife, soil microorganisms, rural communities, economic interests, watersheds, clear air, biodiversity and more.

1.2 Problem statement and justification

Agroforestry is rapidly becoming a significant resource management system with a potential of most adequately meeting farmers' basic needs due to its ability of sustaining food supply and income generation via its components diversity. Agroforestry is one of the interventions used to rehabilitate the environment in Shinyanga region (Bakengesa, 2001) whereby traditional agropastoralists had been practicing *Ngitili* as an indigenous silvopastoral system which involve traditional

strategies in grazing. This indigenous silvopasture is the only agroforestry system that some how is known by the majority on its importance in contributing to household income, however little effort is put to enhance its importance particularly on its potential to alleviate poverty (Kamwenda. 1999) and food insecurity. It has not been widely given support due to lack of information on how it contributes to the income generation and food security of households.

Also, already in many parts of the world, including the area of the present study, many farmers practice agroforestry but still remain largely unaware of the contribution it makes to their household socio-economic livelihoods, especially in relation to food security and income generation. It is, therefore, the objective of the present study to determine how agroforestry contributes to the food security and income generation of rural Tanzanian households, specifically those of Maswa district in Shinyanga region. This information is expected to act as a living pointer to their significance in the socio-economic livelihoods of Maswa rural communities and more importantly, facilitate the efforts of their dissemination promotion.

According to Lulandala (2004), agroforestry is the only, so far known, land management system that effectively integrates the main dynamic sectors of agriculture, forestry and animal husbandry for ensured better use of limited land, labour and time resources. It facilitates the enhancement and diversification in the land-unit resource products of production systems and further permits interactive resource conservation, improvement and sustainability.

It is clear that rural household's food consumption depends on their own production. efforts to produce enough are hindered by various factors; unpredictable rainfall being the major among others (even if rainfall is adequate, intensity, distribution and run-off still make it not sufficiently used in agriculture). therefore to overcome this, agroforestry has the ability to ensure conservation and prevention of run-off and conserve moisture for a long period of time (Shalli, 2003). Better life is ensured by agroforestry through its products as food, fruits for nutrition, medicinal use such as *Azaderactica indica* (Neem tree), *Lueciana* species for cattle feed. trees yield building supplies for houses as well as the source of firewood. Over 80% of energy in tropical Africa comes from fuelwood, the large majority of those who depend on the availability of firewood for cooking being the rural population (Marcoux, 2000).

Also, through agroforestry, there is reduction in the system's production inputs through in-situ soil fertility improvement, increased labour use efficiency and other measures of economic efficiency (MacDicken and Vergara, 1990). In that case, Agroforestry is indeed, the only resource management option with real and tangible opportunities of breaking the bondages of energy, food insecurity, poverty and poor and imbalanced nutrition of the developing world rural communities (Lulandala, 2004).

1.3 Objectives

1.3.1 Main objective

To assess the contribution of agroforestry to the household income and food security in Maswa District, Shinyanga Region, Tanzania.

1.3.2 Specific objectives

- To identify various sources and quantities of household food supply and income generation
- To determine the proportion of agroforestry technologies contribution to household income acquisition and food security
- To identify constraints of agroforestry contribution to food security and income generation
- To identify measures/interventions required for improving the contribution of agroforestry practices in the study area

1.4 Hypothesis

Ho; Agroforestry has no significant contribution to household income and food security

Hi; Agroforestry has significant contribution to household income and food security

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

Agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately combined on the same land management unit with herbaceous crops and/or animals, either in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economic interactions among the different components (Lulandala, 2004; Elevitch and Wilkinson, 2003). Broadly, it is the combination of silvicultural, agricultural and other land-use technologies so that their joint application will increase productivity, sustainability, equity, and achieve social goals. On the other hand, Agroforestry systems (Lulandala, 2004) are defined based on how the various agroforestry components are arranged on the landscape while agroforestry practices are the specific ways the various agroforestry systems are being operated on the landscape in practice at any particular time.

Food security, according to World Food Summit Plan of Action (WFSPA, 1996) exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept at the family level with individuals within households. Food insecure people are those individuals whose food intake falls below their minimum calorie (energy) requirements as well as those who exhibit physical symptoms caused by energy

and nutrition deficiencies resulting from an inadequate or unbalanced diet or from the body's inability to use food effectively because of infection or disease.

Agroforestry systems, as potentially sustainable land management practices that aim at increasing productivity and reducing dependence on monocropping (Huxley and Ranasingher, 1996), have been promoted for the integration of trees on farms to increase crop production and improve people's welfare. Sustainable land use through agroforestry ensures sufficient production to meet the needs of the present and future populations, thus alleviating poverty while conserving the land resources. Agroforestry assigns a pivotal role in efforts to ensure food security and income generation through increasing the quantity, quality and variety of products supplied, thus creating employment, food supplies and income earning opportunities for the poor. Agroforestry is more than agriculture in meeting basic human needs (Alexandratos, 1995).

Agroforestry also provides for strong ecological influences on the production systems and has a moderating influence on the possible extremities in the climatic conditions which could affect crop yields (Lulandala, 2004) and, therefore ensure food security and income at household level. The inclusion of compatible and desirable wood perennial species on farmland results in a marked improvement of soil fertility due to an increase in organic matter content from leaf litter and other plant parts, and nitrogen fixation in the case of legumes which enriches the soil. Also, tree roots indicated to be potential to recover nutrients leached beyond the reach of food crops (Vanlauwe *et al.*, 2002).

According to MacDicken and Vergara (1990), through agroforestry, there is a year-round distribution of employment and improved distribution of labour requirement over a longer period of time and create more opportunity for earning greater than one income per year, hence eliminate the peaks and valleys in labour employment, rather continuity than seasonality of incomes and benefits to the household families. Rural poverty is in part caused by highly seasonal economic activities associated with annual crops and lack of productive employment.

2.2 Various sources and quantities of household food supply and income

2.2.1 Sources and quantities of food supply and income

Agriculture and livestock keeping are the most important economic activities in Maswa district, over 95% of district dwellers are depending on these enterprises for their livelihood (DADP, 2006/07). In Tanzania, agriculture remains as the major base of employment and livelihood of about 80% of the population (Kashuliza *et al.*, 2002; Myaka *et al.*, 2003; Sicilima, 2003). Different farming systems, agroforestry being one of them are used in Maswa for the purpose of food supply and income generation, whereby either a single or more than one crops are planted on the same piece of land. Other sources are like non-farm activities as a case of traders, employment in public and private sectors, mining and the like. However, observations (Shalli, 2003) indicated that, household's dependence on business, wages and salaries, and remittances for cash income has increased in Tanzania.

Agriculture sector has been affected by many factors that cause less productivity per unit area, among them being low input use, drought, pests and diseases attack,

poor genetic potential, poor farm tools and poor husbandry due to lack of knowledge of modern agricultural practices (SUA, 2006). The use of agriculture inputs in farm activities in Tanzania show that, 27% of farmers buy fertilizer and only 18% buy pesticides as a result productivity per unity land and labour is low (United Republic of Tanzania – URT, 2001). A study by Mwalukasa (2003) revealed that, following liberalization of agricultural inputs, cooperatives have severely reduced their pesticide procurements and private traders have apparently been uninterested in entering the market, at the same time, the majority of private traders (93.3%) who entered in this business sold insecticides on cash basis at market prices. Franzel and Scherr (2002) reported that successful adoption of new technologies depends, among other factors on agricultural input supply.

A research agenda for 2005 – 2010 pointed out that, Tanzania's agriculture has remained subsistence farming of small holders with an average holding of only 0.2 ha per household, the major limitation of the size of the land holding and utilization is the heavy reliance on the hand hoe which sets limitations on the area of crops that can be grown using family labour (SUA, 2006). Other results (Nhembo, 2003) show the use of hand hoe was one of the causes for low crop yields. Also, Hatibu *et al.*, (1999) found that, the area under cotton cultivation in Shinyanga has been decreasing year after year due to, among several reasons, unreliability of markets and low profitability due to low yields, high production costs and low prices of cotton. Again, agriculture extension services as one of the prime movers of the agriculture sector by improving the productivity of agricultural systems, raising the income of farm families and improving the quality of life of rural farm households

(Rutatora and Rwenyagira, 2005) are of great importance in knowledge provision on modern agriculture practices since poor agricultural practices make soil unable to maintain its fertility (Msanya *et al.*, 1999; Solomon *et al.*, 2006) thus low production per unit area. Good crops husbandry and appropriate intensification (Msikula, 2003) are necessary for improved land productivity and agro-biodiversity conservation.

Livestock also plays a great role to household food supply (through exchange for food) and income generation, particularly to livestock keeping societies not withstanding problems facing livestock sector, such as inadequate pastures, water and diseases infestation. The high potentiality of livestock to household food supply and income generation is threatened by problems of poor management and marketing strategies. Thus, livestock contribution to household food supply and income indicated to be low not withstanding the huge number of animals kept in Tanzania. Observation revealed that (Shalli, 2003), income contributed by livestock sector was only 27.7% while the livestock products contribution was about 30.7% of the annual diet; and livestock contribution to Gross Domestic Product (GDP) was only 18% (Kurwijila *et al.*, 2002). It is further postulated that if a household keeping local chicken at better husbandry, income could be increased to $ 600 per annum.

A research agenda for 2005 – 2010 revealed that, health related livestock problems are one of the most important single factor limiting the productivity of livestock and is one most important factor afflicting heavy stock losses in sporadic and

epidemic proportions (SUA, 2006). Also, about 99% of the national herd (cattle, goats and sheep) is traditionally kept and there is no land demarcated for livestock grazing, this herd is characterized by low production coefficients (Myaka *et al.*, 2003), as a result contributing meagerly to the household income. According to the land policy (MLHUD, 1995), all land in Tanzania is public and vested in the president as a trustee on behalf of all citizens. This makes grazing land to be owned communally. Under communal grazing system no individual farmer take initiative to manage the range even when a farmer knows that the grazing land is under pressure or overgrazed, neither does this system encourage collective management of the grazing resources (Higgins *et al.*, 1999; Solomon *et al.*, 2006). As a result, communal grazing changes substantially the composition and structure of woody plant communities (Higgins *et al.*, 1999). Heavy grazing is thought to be inevitable in communal rangelands because of the problems inherent in communal ownership of the resource where individual benefit is maximized at the expense of the community (Makepe, 2006; Vetter *et al.*, 2006).

On the other hand, increase in human population has increased pressure on land resource and therefore created problems of rangelands for animal grazing. Land use pressures in many cases, affect nomadic populations with repercussions in environmental degradation and social insecurity resulting into resources use conflicts due to different land use pressures (Higgins *et al.*, 1999; Makepe, 2006; Moleele and Perkins, 2002; Vetter *et al.*, 2006). Changes in land use and insecurity as well as encroachment of undesirable plant species reduced grazing lands and restricted pastoral mobility, thus diminishing carrying capacities of rangelands

(Moleele and Perkins, 2002; SUA, 2006), and hence resulted in overgrazing and land degradation. Again, in Maswa district, periods of dry and wet seasons influence the quality and quantity of pastures and of particular important is during dry season when livestock keepers in the district face a drastic shortage of pastures.

Different findings have proved on the importance of agroforestry as a good source of household income and food supply. A study by Makawia (2003) revealed that, there is a significant difference in nutritional status between agroforestry and non-agroforestry households, this is due to the fact that, agroforestry systems provide more varieties of food products. Huxley and Ranasinghe (1996) pointed out that yields of seasonal and annual intercrops in Srilanka under coconut with cassava (*Manihot esculenta*) was 11 tons/ha, sweet potatoes (*Ipomea batatas*) 4.8 tons/ha, cowpeas (*Vigna unguiculata*) 0.8 tons/ha and groundnuts (*Arachis hypogea*) 1.3 tons/ha. In Togo, hedgerows indicated to increase maize grain production from 2774 kg/ha to 3786 kg/ha (Tossah *et al.*, 2006) while alley cropping systems in Benin (Aihou *et al.*, 2006) found to produce on average 107% more grain than the initial values on degraded site.

It is reported that, in areas whereby communities depend on forest products the contribution of forest to household food security and income is obvious. Forest products revealed to provide income for regular household's expenditure when farmers run out of agricultural crops (Kajembe *et al.*, 2004). Non-wood forest products (NWFPs) for example found to contribute about 13% by weight to household food consumption and about 8% to total household income (TARP II –

SUA, 2004). It was also noted that about 59% of the income from NWFPs was used for buying food items. According to Hill (2007), it has been estimated that, 80% of the population of the developing world use NWFPs to meet health and nutritional needs, household income and the total value of world trade in NWFPs is estimated at US$ 1,100 million. A study revealed also that, small-scale NWFPs based enterprises in Zimbabwe for example employed 237 000 people.

Also, forests play a role in energy provision as it is virtually believed that, all of Tanzania's wood fuel comes from forests, over 90% of all round wood harvests are for fuelwood and charcoal, and much of the demand for fuelwood is satisfied through deforestation (SUA, 2006), while in Africa, 80% of the round wood produced is used as fuelwood and charcoal (Marcoux, 2000). However, the community participation in forest establishment is low as compared to the rate of harvest, thus many areas are greatly affected by deforestation caused by cutting of trees for firewood, agriculture land expansion on forest land and overgrazing. In Vietnam, for instance, the forest area declined by 75% between 1968 and 2003, and 60% of this loss was attributed to needs for agricultural land (Binh *et al.*, 2005). A study by Sinha and Suar (2003) revealed that, community participation in forest activities was significantly higher in indigenous community forest management. Values of livelihood security from forest and avoidance of free riding emerged as important factors on people's participation in forest management.

2.2.2 Trend of food supply and income generation

The trend of per capita income in Tanzania for the period of 7 years from 2000 to 2006 indicated to increase from year to year. It is reported that, (Wizara ya Mipango, Uchumi na Uwezeshaji – WMUU, 2007) the per capita income in 2000 was Tshs: 210 231/=, in 2001 was Tshs: 231 751/=, in 2002 was Tshs: 258 925/=, in 2003 was Tshs: 287 027/=, in 2004 was Tshs: 321 010/=, and in 2005 the per capita income was Tshs: 360 865/= as well as Tshs: 399 873/= in 2006.

The average trends of food crop production in Tanzania (tons) from 1991/92 to 1997/98 for 6 major food crops of maize, paddy, wheat, sorghum, pulses and cassava indicated to fluctuate from season to season as shown in Table 1.

Table 1: Total food crops production in Tanzania

Year	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98
Tons	250 666	294 829	254 665	277 728	341 691	303 043	346 213

Source: Kashuliza *et al.*, (2002)

Another observation on productivity of major food crops in Tanzania (kg/ha) from 1994 - 2001 (Myaka *et al.*, 2003) revealed fluctuations of production from season to season. Also, according to Maswa District Agriculture and Livestock Development Officer (DALDO) reports, the trend of food crops production for the period of 5 seasons from 2001/02 to 2005/06 indicated to fluctuate from year to year with the lowest productions in 2002/03 and 2004/05 seasons (Figure 1 and Appendix 1). Fluctuations in food crops production probably could be due to many

factors affecting food sources, particularly agriculture which indicated to be a main food source in Maswa district and Tanzania in general as pointed out in 2.2.1 sub section.

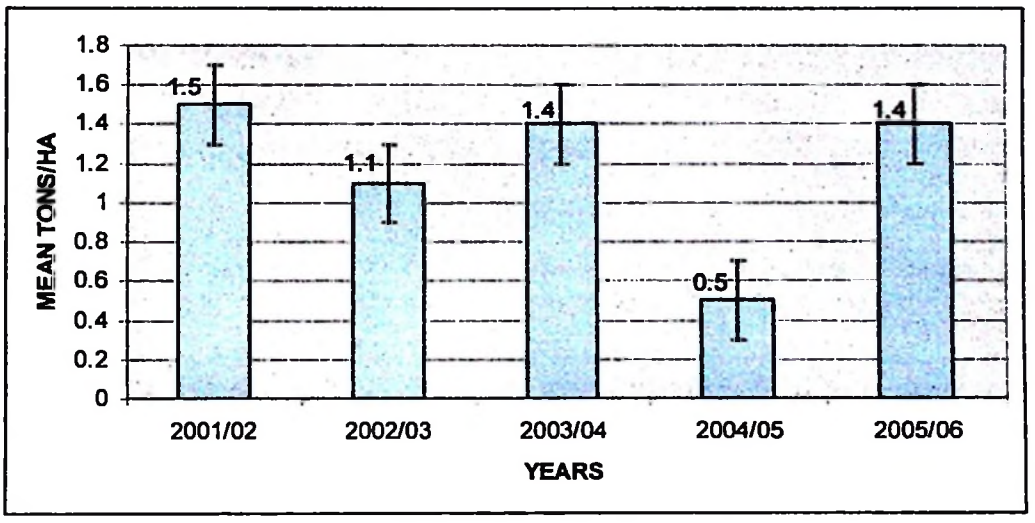

Figure 1: Mean trend of food crop production (in tons/ha) in Maswa district

2.3 The proportion of agroforestry contribution to household income and food security

2.3.1 Agroforestry technologies contribution to household income and food security

Agroforestry has proved to contribute more as compared to agriculture (monoculture) to food security and income. A study by Bonifasi (2004) found that 90% of surveyed farmers in Lushoto district were merely depending on agroforestry as the main source of income, given the average farm size of 3.1ha,

2.3 cows and 9 chicken, the annual production for agroforestry and non-agroforestry farmers was as indicated in Table 2.

Table 2: Annual production for agroforestry and non-agroforestry farmers in Lushoto District

	Maize	Beans	Banana	Cow	Chicken
Agroforestry farmers	425.9 kg	225.7 kg	163.9 bunches	999.12 lts	373.5 eggs
Non-agroforestry farmers	342.6 kg	202.1 kg	108 bunches	701.1 lts	338.6 eggs

Source: Bonifasi (2004)

Makawia (2003) also indicated that, 85% of 413 kg/yr/farm from agroforestry systems were consumed at household level. However, the harvests of food crops are far below the recommended yield per unit area when agronomic practices are properly adhered (Table 3).

Table 3: Recommended crop yields per hectare in Tanzania

Crop	Maize	Sorghum	Rainfed paddy	Irrigated paddy	Fresh sweet potatoes	Cotton
Yield (kg/ha	5000	1200	4000 - 5000	6000	20 000 - 30 000	1400

Source: Sicilima (2003)

Bonifasi (2004) further indicated that, one tree was sold either for timber or firewood fetching prices ranging between Tshs: 10 000/= to 20 000/=, the average household annual net income was Tshs 664 992 (665.0 US$) and 547 608 (547.6 US$) for farmers practicing and not practicing agroforestry respectively, while the

income per capita was Tshs 100 756 (US$ 100.8) for farmers practicing and Tshs 82 971 (US$ 83.0) for farmers not practicing agroforestry, compared to the average national per capita income of 242 000/= in 2000 (URT, 2000). Also Kaale *et al.*, (2002) pointed out that most farmers (90%) in Shinyanga expressed *Ngitili* as an important source of income through selling pastures for animals grazing at the most critical time of the year. For example, in 1999 farmers at Wigelekelo village in Maswa district succeeded to earn an estimate of US$ 26 500 a year and an area of approximately 20 ha at Mwamashale village which was allowed to graze up to 50 cattle for 3 months fetched US$ 400.

A study by Msikula (2003) found that improved agroforestry systems were more economically viable than traditional agroforestry by Tshs: 140 540/= and 59 373/= per capita income respectively. In Kibaha district, the income contribution by agroforestry, non-agroforestry farms, livestock and off-farm activities were 28.5%, 27.3%, 27.7% and 16.5% respectively (Shalli, 2003). Another finding (Makawia, 2003) indicated that households earned an average of Tshs: 79 126/= per annum while the animal and tree products constituted 38 and 16% respectively of the income earned by households through selling the agroforestry products. A study by Michael (2005) in Southern Nigeria indicated the income from the sale of the agroforestry products as much as 43.6% of the total family income. Aposilviculture on the other hand indicated to increase a farmer's income by 40 – 60% (Wilkinson and Elevitch, 2007). Mastrantonio and Francis (2007) indicated that, it is possible for a hive to produce 23 kg of honey per year. In that case, there is considerable

potential for many agroforestry practices to increase farm income, meet household needs and contribute to local economic growth (Franzel and Scherr, 2002).

2.3.2 Adoption of agroforestry technologies

Agroforestry is rapidly becoming significant resource management system with a potential of most adequately meeting farmers' basic needs due to its ability of sustaining food supply and income generation via its components diversity. In many parts of the world farmers practice agroforestry at different adoption rate. A study by Lugendo (2003) revealed that, only 36.8% of the people in Tarime district adopted agroforestry. A study further revealed high adoption among individuals who had more than one income generating activities than those who depended on crop production alone and this signifies the contribution of the income in the adoption of agroforestry. In Lushoto district, 90% of surveyed farmers were merely depending on agroforestry as the main source of income (Bonifasi, 2004), and in the East Usambara mountains, about 78% of improved farmers have an average range of 10 – 200 different tree species per hectare in their plots (Msikula, 2003). TARP II – SUA (2005) indicated that 37.5% and 27.8% of farmers participating in a project adopted improved fallow and relay cropping technologies respectively while 23% and 11% of non-participants found also to adopt the same agroforestry technologies. Also, a study by Makawia (2003) in Arusha region revealed that, 24% of households that adopted aposilviculture, and 50.7% of households that adopted agroforestry technologies, had more than 10 tree species per farm.

Observations revealed that, adoption of agroforestry technologies was influenced by size of households (James, 2004; Lugendo, 2003; Mumba, 1999; Kirway *et al.*, 2003; Shalli, 2003; Bonifasi, 2004), that is the bigger the household size implies more family labour available in planting and managing trees, holding other factors constant, therefore, family size is statistically significant in influencing agroforestry adoption. Also, a study by Njoku (2005) found that gender, land ownership status, primary occupation and population pressure in South-eastern Nigeria affected adoption of agroforestry land management. Other results (Kirway *et al.*, 2003; James, 2004; Lugendo, 2003) indicated that, land size as a factor and store of wealth is the most important asset influencing adoption.

According to most African traditions and cultures, head of households are decision makers on matters including family resource use and management, hence men are more likely to adopt agroforestry than women because of the traditional bias in the local community where women are not given the right to inherit resources in which the right is more granted to males thus affecting adoption of the technology (Lugendo, 2003; Odebode, 2005). Similar observation was reported that, elders are the ones having family resource rights, thus are in a better position of adopting new technologies (Lugendo, 2003). On the other hand, young farmers were less likely to test th technology than the older ones (Mumba, 1999). Young farmers may adopt new t chnologies that fetch quick market response (Kirway *et al.*, 2003). Even within a single village, different household members may have different motivations and aspirations (Kirway *et al.*, 2003) towards adopting technologies, agroforestry being one of them. When technologies are planned and tested,

priorities must be set based on potential benefits and risks for different groups of farmers that may be able to adopt them.

2.3.3 Purposes of adopting to agroforestry technologies

Different farmers opted for different agroforestry technologies so as to meet their differing purposes, one of them being for income generation. An observation conducted to assess the effects of agroforestry technologies on quantitative livelihood aspects in Kilosa district Morogoro region (TARP II – SUA, 2005) indicated that, about 47.6% and 47.9% of participating and non-participating farmers (not included in the project but undertake agroforestry) indicated their income increased respectively. Elevitch and Wilkinson (2003) pointed out that. agroforestry has a greater long-term economic stability through diversified products, reduced risk to the farmer, increased overall yields and year-round production. and therefore. farmers adopt agroforestry since it makes an indispensable contribution on solving the priority problems with regard to food security, energy and generating additional cash income by selling the produce harvested from trees.

Agroforestry by its very nature (Lulandala, 2004) increases the cropping intensity and reduces the variability of overall yields by increasing productivity through better use of environmental resources (light, water and nutrients); hence farmers may opt to agroforestry so as to meet crop productivity due to soil improvement from tree integration on fields. An assessment on the effect of fallows on land quality and productivity (Malley *et al.*, 2004) indicated average improvements in

total soil nitrogen (N) from 0.2% to 0.35%, available soil phosphorus (P) from 10 to 19 mg/kg, and soil organic carbon (OC) from 2.1% to 2.6%. A study in Mafiga Morogoro revealed that relay cropping of *Sesbania sesban* with maize showed to multiply crop yields approximately 3 times i.e. 1.2 to 3.5 t/ha per year (Lulandala, 2004). Aihou *et al.*, (2006) found the amount of N produced in alley cropping systems was from 49 to 155 kg N/ha on degraded and non-degraded sites in Benin. In Togo, hedgerows accumulated significantly more N in the first pruning ranging from 17 kg N/ha to 185 kg N/ha with grain production from 2774 kg/ha to 3786 kg/ha (Tossah *et al.*, 2006). Also, Amara *et al.*, (2006) found that, total N accumulated by the hedgerow trees ranged from 297 – 524 kg N/ha on average.

Again, an important component that characterizes agroforestry systems is the woody perennial which provides various products including firewood that is required in meeting household energy needs. Results in Morogoro experiments with *Leuceana leucocephala* intercropped with maize and beans indicated to produce up to 71m^3/ha of wood in 2 years, sufficient for an annual firewood need of over 2 households (Lulandala, 2004). *Acacia mearnsii* and *Calliandra calothyrsus* (Malley *et al.*, 2004) produced up to 30 t/ha and 13 t/ha of firewood respectively. These quantities can be used for 6 or more months by a household. In Benin, trees on alley cropping systems produced 4.6 to 9.3 tons/ha of fresh wood (Aihou *et al.*, 2006), while in Togo, alley cropping indicated to produce between 4 and 38 /ha of fresh wood (Tossah *et al.*, 2006).

Also it is observed that, farmers particularly livestock keepers undertake agroforestry due to rangelands problems associated by different land use pressure that affect nomadic populations with repercussions in environmental degradation and social insecurity resulting into resources use conflicts due to different land use pressures. Increase in human population also increases pressure on land resource and thus creates problems of rangelands for animal grazing. Observations (Vetter *et al.*, 2006) revealed that, keeping large numbers of livestock accompanied by the growing population densities in livestock keeping areas make people strongly reliant on available natural resources for their livelihood. Therefore, livestock keepers opt to reserve land for pasture establishment to be used when pastures are scarce. A study by Mumba (1999) revealed that, in Shinyanga livestock owners were more willing to participate in rotational woodlot technology than their counter parts, thus livestock have great influence on agroforestry adoption.

2.3.4 Different agroforestry technologies and systems undertaken

Based on the component criterion (Lulandala, 2004), agroforestry has widely been classified into three broad systems of Agrosilviculture, Silvopasture and the combination of the two systems called Agrosilvopasture. Other agroforestry systems that utilize the available natural resources are such as those based on water-born natural resources (Aquosivoculture) and terrestrial insect resources (Aposilvoculture). Within agroforestry systems, different agroforestry technologies have been undertaken in Tanzania and other places in the world such as:-

2.3.4.1 Shifting cultivation

Is a land management technology (Lulandala, 2004) in which a farmer starts by clearing a virgin vegetation (forest/woodland/grassland) and cropping until the land is unable to produce satisfactory yields thus a farmer shifts to another virgin lands before finally going back to the same land.

Shifting cultivation is an effective form of sustainable land use in low-populated forested areas for nutrient regeneration as long as population pressures on limited land and resources did not draw the farmer back to the first plot before it had time to regenerate fully. It is sustainable as long as there is a reasonable fallow period of at least 15 years (Huxley and Ranasinghe, 1996). However, with the increase of population, the fallow period has been disappearing, resulting in losses of soil fertility and soil structure, and finally land degradation.

2.3.4.2 Alley cropping

Is an agroforestry practice wherein crops are grown between managed, perennial hedge rows spaced at regular intervals (Lulandala, 2004). Trees are grown in strips creating 'alleys' in between the tree rows for raising agricultural crops (Mastrantonio and Francis, 2007). During the cropping season, hedge rows are pruned to minimize competition with the developing crops and pruning can be used as mulch, green fertilizer, fodder, fuelwood or other purposes.

With careful design, this technique can also provide erosion control, windbreak, animal fodder (Elevitch and Wilkinson, 2003; Mastrantonio and Francis, 2007),

and foliage return nutrients (Amara *et al.*, 2006; Tossah *et al.*, 2006; Aihou *et al.*, 2006; Vanlauwe, 2002; Weidelt, 1993) to the soil and improve soil structure.

Suitable tree species for alley cropping in various site conditions (Amara *et al.*, 2006; Tossah *et al.*, 2006; Aihou *et al.*, 2006) may include; *Leucaena leucocephala*, *Gliricidia sepium* and *Senna siamea (*formally *Cassia siamea)*. Others are *Cajanus cajan, Flemingia congesta*, *Sesbania sesban*, *Sesbania grandiflora, Tephrosia candida* (Weidelt, 1993), *Parkia roxburghii*, *Acacia barterii* etc.

2.3.4.3 Taungya

This is a land management technology widely used in forestry management where forest plantations are intended to be established on initially virgin lands, the local communities are allowed to clear the areas and grow their non-permanent crops, while trees are planted in, and continue growing crops until the canopies of trees close their canopies and shade the crops (Lulandala, 2004; Mastrantonio and Francis, 2007). In the taungya technology, the performance of the trees may be enhanced by the cultural operations.

Farmers however are not interested in maintaining the quality of the land or tree crops because of insecurity of land tenure, the system divests local people's rights to make a living from the trees they have helped to raise, in that case, the technology has not stimulated full community participation (Huxley and Ranasinghe, 1996).

2.3.4.4 Parkland/Mixed intercropping

Is the resource management characterized by mature trees widely dispersed in cropped fields either in form of woody perennials arrangements and spacing or in irregularly scattered trees/shrubs on the landscape to enhance and stabilize crop production through improvement of soil water holding capacities, reduced evapotranspiration and contribution to the accumulation of organic matter and nutrients over long periods of time (MacDicken and Vergara, 1990).

After crop harvesting, trees are pruned to ensure that the tree canopies never get large enough to shade subsequent crops and annual shading of leaves at the outset of the rainy seasons provide litter fall to the soil underneath, at the same time allowing light to penetrate to the crops underneath. Tree species mostly grown in the parkland management technology are like *Acacia albida*, *Prosopis cineraria*, *Acacia tortilis*, *Mangifera indica* etc.

2.3.4.5 Wind break/shelter belt

This is an agroforestry technology in which woody perennials are planted on the wind-ward side of the land management to break wind or shelter envisaged problems such as wind, livestock, people, and wild animals which are likely to enter the field. Windbreaks have long been used in many areas for crop and soil protection from wind and wind erosion (Mastrantonio and Francis, 2007). Windbreak trees are perennial, arboreal and the shelterbelts are designed to optimally reduce wind speed to the benefit of crops. Decreased wind velocity

results in higher air temperature and increased relative humidity in and just above the leeward crops; the net result is a decrease in evapotranspiration.

By reducing wind velocity, windbreaks cause the deposition of airborne soil particles, lessen mechanical damage to crops, and sieve wind driven rain. depositing moisture on the windward side to the benefit of crops growing close to the windbreak (Lulandala, 2004). Tree canopy management is useful in reducing competition between the windbreak trees and crops, provided it does not interfere with the aerodynamic efficiency of the windbreak. Tree species usually used in the windbreaks are like *Eucalyptus camaldulensis*, *Azadirachta indica*, *Acacia nilotica*, *Acacia catechu*, *Leucaena leucocephala* etc.

2.3.4.6 Boundary/live fences

Vegetative fences either live or in the form of thorny prunings are planted around a land management unit of herbaceous crops or livestock, with the woody perennials, basically for protecting negative influences of human beings, animals or wind and for directing animals from bomas (Lulandala, 2004). Boundaries between fields and farms are made productive by tree or shrub planting for browse and other uses. Also fencing (Kajembe *et al.*, 2004) is reported to be important in protecting hurts and houses from strong winds and to protect field crops from livestock.

2.3.4.7 Homegardens

These are land use technologies practiced around households, involving integration of various woody perennials, herbaceous crops and/or livestock. Trees grown are

often multipurpose, providing the community with various subsistence needs. Homegardens are permanent land use systems that provide fruits, vegetables, meat, eggs, firewood, timber, ornamentals and medicines in a manner that is self-perpetuating and self-sustaining in yield, in equilibrium with the environment.

A homegarden is the famous tree-crop practice of land use combining agriculture, forestry and livestock. The overall return from a unity of land can be increased by intercropping with legumes which enrich the soil through nitrogen fixation, enhance microclimatic amelioration through the reduction of temperatures and evapotranspiration and shelter the management unit from wind (Huxley and Ranasinghe, 1996). Homegarden may also help to control soil erosion through reduction in rainfall erosivity by a multistoried tree canopy, ground cover of annual crops, legumes and shrubs and a surface litter layer, whilst providing organic matter for mulch and the improvement of soil fertility.

2.3.4.8 Contour hedges/bunds

Involve the creation of ridges or bunds of varying heights and intervals, across the slopes along contours on which woody perennials are planted (Lulandala, 2004). The practice emphasizes on soil erosion control and conservation while attempting to increase overall productivity of the site. Strips of fast-growing nitrogen-fixing hedges e.g. *Alnus spp* are planted on contours.

2.3.4.9 Silvopastoral system

This is the land management system in which the animals are the dominant feature. involving the integration of tress/shrubs into the pasture/grassland to improve its productivity (Lulandala, 2004). A silvopastoral system enhances the availability of fodder, wood products and environmental conservation at the local level (Kaale *et al.*, 2002), reducing soil temperatures and water losses and by attracting birds and mammals that add nutrients to the soil in their droppings.

2.3.5 Household food security and income status

Food security is (SUA, 2006) one of the major concerns of developing countries despite the efforts to improve food situation. According to food requirement estimate guidelines to farmers at household level issued by the Department of Food Security in the Ministry of Agriculture, Food Security and Cooperatives, an individual requires 3 bags of maize and sorghum weighed at 100 kg, 5 bags of paddy (weighed at 75 kg) and 4 bags of sweet potato dried chips (weighed at 65 kg) per year if only depends on a single crop. Food security in many developing countries is related to poverty in which households that have difficulties in accessing productive resources like land, forests, water, technology and credit are likely to be food insecure (SUA, 2006).

Although Tanzania has 39.5 million hectares of arable land, food insecurity and low income among Tanzanians have persisted mainly due to low productivity caused by several limiting factors, which among other factors include: Dominance of inappropriate technologies, heavy dependence on rain, low soil fertility, poor

crop management practices, and field and storage losses (Myaka *et al.*, 2003; Kashuliza *et al.*, 2002), as a result, 20.4% of Tanzanians are food poor and 38.7% of them live below the basic poverty line. Other findings (Keenja, 2001) indicated that, in Tanzania, 27% of the 32 million people are food insecure. It is reported that, about 14% of the harvested crops is lost to pests (SUA. 2006). Makundi and Magoma (2003) reported a loss of up to 35% by stored product pests particularly *Prostephanus truncates* (Larger Grain Borer – LGB) and *Sitophilus spp* (maize weevils) which therefore contribute enormously to reduced post harvest crop losses, and thus aggravating food insecurity in Tanzania. Also, the situation at household levels, poverty is still pervasive and largely rural where about 50% of all Tanzanians live in poor conditions. While 36% live in abject poverty, most households in rural areas are food insecure (Rutatora and Rwenyagira, 2005).

Other findings (MacDicken and Vergara, 1990; Makawia, 2003; Bonifasi, 2004) revealed the existence of a significant difference in nutritional status between agroforestry and non-agroforestry households, while a study by Msikula (2003) in the East Usambara Mountains indicated that about 68% of the improved agroforestry farmers reported to have food security, i.e. physical and economic access to food for all people at all times. This is due to the fact that, agroforestry systems provide more varieties of food products. Shalli (2003) found that, 78.3% of the households with food insecurity due to instability in food production and household income were found to be contributed mostly by unpredictable rainfall, drought being the main.

The per capita income status at the national level indicated to be Tshs: 242 000/= in 2000 (URT, 2000) and Tshs: 399 873/= in 2006 (WMUU, 2007). Observations (Lyimo-Macha *et al.*, 2005) revealed that, lack of reliable market and poor agricultural tools, outdated husbandry practices, lack of crop rotation system and poor environmental protection practices retarded income earning activities at household level, thus poverty alleviation difficulty.

2.4 Constraints of agroforestry contribution to food security and income generation

Agroforestry, although is termed as the best contributor to food security and household income, has constraints, which if not taken into consideration, can cause detrimental effects to the system and hence limit its contribution. For example, trees as main component in the system may dominate the arable crops for nutrients, growing space, solar energy and soil moisture; hence significantly reducing the yields of favoured crops (MacDicken and Vergera, 1990; Lulandala, 2004).

Competition for water and soil moisture between the components in agroforestry caused by drought as well as component competition, especially shade, leads to poor performance of agroforestry. It has been observed that competition for light is more critical than root competition for either water or nutrients (Lulandala, 2004). However the severity of the drought causes more effect from component competition. Farmers' perceptions of the effects of trees on crops, was the major constraint to the integration of trees into the farming systems in Embu and Kirinyaga districts in Kenya (Njuki, 2001). Moreover, a study by James (2004) on

socio-economic factors influencing the adoption of agroforestry practices in Nyanja division in Musoma Rural district indicated the constraints to adoption as farmers' tendency to averse risk resulting from drought, destruction by livestock, pests and diseases.

Also, trees may attract pests and diseases which may affect the crops, hinder agricultural operations and trees were explained to create bird resting and nesting grounds and therefore the associated crops become liable food sources for birds (Lulandala, 2004). Trees may adversely affect associated crops through the effects of allelopathy (inhibition effects), thus seed germination and plant growth can be inhibited by the release of these naturally occurring chemicals from roots and aerial tissues (MacDicken and Vergera, 1990). The effect depends on the concentrations as well as the combinations in which one or more of these substances are released into the environment. On the other hand, (Makumba *et al.*, 2000) *Gliricidia* punnings significantly increased crop yields, since the phytotoxins have a short life span and easily disintegrate.

Other results (TARP II – SUA, 2005) on adoption of agroforestry technologies in Kilosa district found to increase women workload by 3.8 hrs per day. The reasons for increased workload as indicated by farmers in Kilosa district included increase in household responsibilities by more time for irrigating seedlings. However, 10.7% of interviewed women observed the decrease of workload by 4 hrs per day especially due to reduced time for fuelwood collection as well as easiness in obtaining trees for building purposes. About 37.9% of the respondents also

indicated an increase for the demand of non-family labour (hired). TARP II – SUA (2005) identified that, inadequate knowledge in crop planning, land shortage, absence of by-laws to protect the planted trees, planted trees being destroyed by grazing animals and shortage of water for irrigating planted trees were the main constraints to agroforestry technologies. A study concluded that, the contribution of the agroforestry technologies to the livelihood was limited by the duration required to observe the out come, it takes time before trees to grow to a useful stage, and similarly soil fertility improvement was a long-term process.

On the other hand, land and forest tenure and regulatory systems including rules governing control and management of tree resources have been widely cited as constraints to agroforestry adoption (Franzel and Scherr, 2002). Similar observation by Njoku (2005) indicated that, land ownership status was one of the factors that affected adoption of agroforestry land management in South-eastern Nigeria. Bakengesa (2001) and Huxley and Ranasinghe (1996) suggested that, it is only when people have control over the resource base as well as having secure tenure that long-term objects such as agroforestry practices can be achieved.

Lack of knowledge on agroforestry technologies indicated to be another factor that hinders engagement in agroforestry technologies, particularly due to the fear of component competition. Successful diffusion and adoption of new agroforestry practices depend not only upon the technical performance of those practices and their fitness with farming systems, but also on the broader policy, strategies and institutional arrangements for extension and research support (Franzel and Scherr,

2002). Farmers should be empowered with skills and knowledge relevant to improving agroforestry systems, adopting and implementing them effectively (Msikula, 2003).

Markets and marketing strategies of agroforestry products is still a problem among farmers. Farmers had insufficient market information and mostly depended on businessmen for price setting. The most common problem of marketing is low prices of produce in relation to actual production costs (Lyimo-Macha *et al.*, 2005). Observations (TARP II – SUA, 2002 b) on market problems to smallholder farmers have indicated doubt to whether farmers can resist pressure from crop racketeers since capital and credit facilities were lacking in the villages and crops were bought haphazardly without standardized scale. Also Kashuliza *et al.*, (2002) pointed out that lack of access to markets is certainly influenced by the state of transport and communication facilities which prevent buying agents and/or farmers from reaching certain markets. Kirway *et al.*, (2003) found the inefficient market and seasonal variations in market prices to be affecting the acceptability of improved technologies. Other results (Franzel and Scherr, 2002) have shown that market availability for agroforestry products, market distribution networks, price and price variability and regulations have significant impacts on the diffusion and adoption of the agroforestry practices. Kashuliza *et al.*, (2002), therefore, suggested the empowerment of smallholders to organize themselves into producer organizations to enable them to form strong linkages with market actors and raise their bargaining power as a core element to ensuring fair market prices and thus improve their income.

2.5 Measures to overcome constraints

Most of the constraints in agroforestry systems are component, structural, managerial and environmental based (Lulandala, 2004). Problems like incompatibility for some components due to allelopathic effects, time and space; above ground competition for sunlight and growth space; below ground competition for soil moisture, nutrients and growth space for roots are the main limits for agroforestry to perform well. Other constraints could be like managerial problems mainly of improper maintenance schedules and, especially, manipulation of biological components. The environmental problems in agroforestry are both biological (pests and diseases) and physical (mainly edaphic and climatic) based (Lulandala, 2004). In order to overcome these, careful identification of the sources of problems, well-planned and structured systems, and proper management procedures carried out, are key measures to improve the overall system's production performance.

In agroforestry, the design and management of woody and non-woody plant mixtures poses some very interesting choices focused on how to arrange the interactive areas between trees and crops. A tree-crop arrangement is important particularly because of photosynthesis and canopy density and roughness affect water distribution and how used by plant-soil-environment system. Moreover (Lulandala, 2004), the planting of crops that differ in light requirements, root development and height allows for more efficient use of solar radiation, soil moisture and nutrients, thus increasing productivity of the agroforestry components.

A study in Kabale Uganda revealed that, managing competition between trees and crops for water, light and nutrients to the benefit of farmers is a determinant of successful agroforestry (Sande, 2003). Also, proper timing of pruning incorporation well in advance of crop planting may reduce the phytotoxic effect (Makumba *et al.*, 2000). Competition between agroforestry components may, however be minimized by the proper selection of tree species to be combined in the system to avoid nutrient and moisture competition.

Management of natural resources for sustainable agricultural production among agricultural and livestock communities was sustained principally through the use of indigenous knowledge systems (IKs) developed over the generations to manage environmental resources (water, light and nutrients). Studies (Langill, 1999; Kaale *et al.*, 2002; Makepe, 2006; Odebode, 2005; Sanginga *et al.*, 2006; Rist and Guebas, 2006) have shown that, for interventions to be sustainable there must be active involvement of the people for collective action, by-laws implementation and linking with local government structures so as to increase the ability of communities to manage and transform opportunities for collective action. Langill (1999). and Welzel and Lykke (2006) pointed out that empowering local institutions seems to be an effective and sustainable way of managing resources. Another observation in Same district (Hatibu *et al.*, 1999) showed that, adoption of soil and water conservation practices was affected by many factors including rules and regulations and their enforcement.

Also, knowledge provision on component arrangement and management is of prime importance to reduce component competition. A study on soil-water dynamics in cropping systems containing *G. sepium*, pigeon peas and maize in Southern Malawi had indicated *G. sepium* trees pruned before and during the cropping season not to deleteriously compete for water with associated crops while water use efficiency was improved (Chirwa *et al.*, 2006). Competition between trees and crops was reported to be minimized through the intensive tree pruning, planting of trees in furrows and crops on ridge (Makumba *et al.*, 2000). In that case, farmers should be given knowledge on proper component arrangement and management so as to raise agroforestry productivity (Shalli, 2003), hence contribute to household food supply and income generation. It is suggested that, the governments should allocate adequate resources and improve working environment for the extension staff (Myaka *et al.*, 2003; Sicilima, 2003).

Non Government Organizations (NGOs) have indicated a great role in knowledge provision i.e. extension service and ensured sustainable extension service after the termination of their activities. A study by Sonoko (2001) revealed that, extension service at Mogabiri farm extension centre through farmers-to-farmers extension approach, reached over 75%, and was efficient in terms of supervision frequency and coverage though technical aspects such as animal and crop diseases, pregnancy diagnosis and dystocia became difficult to be solved by that approach. However, NGOs have demonstrated that it is possible to train farmers who can train other farmers, in this way reduces the over reliance on government extension staff (Sicilima, 2003). Also, TARP II SUA (2002 a) indicated the importance of farmers

groups in the dissemination and adoption of technologies by pointing out that. through farmers groups, services such as education and extension were provided at the appropriate time whereby extension services were able to reach more farmers at less cost. Farmers groups were seen important as it helps farmers to solve some of the major problems such as lack of capita, unreliable market channels for crops and livestock products, availability of monetary services at farmers level e.g. saving and credit banks.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Description of the study area

Descriptions of the area of study have been classified into six sections namely: Location, population, climate and soils, physical features and topography, infrastructure and institutional structure, and economic activities.

3.1.1.1 Location

The study area is located in Maswa District, in Shinyanga Region, Tanzania, South-east of Lake Victoria and North-east of Shinyanga town. Maswa district (Figure 2) is one of eight districts in Shinyanga region. It is bordered by Meatu district on the East, Bariadi and Magu districts on the North-west and North, Kishapu district in the South-east and Kwimba district in the West (DADP, 2006/07).

The district is located between latitudes 2^0 45' and 3^0 18' South of the Equator, and longitudes 33^0 00' and 35^0 00' East of Greenwich with land size of about 339 800 ha (3398 km^2). The elevation varies from 1200m in the West to 1500m a.s.l. in the East. Administratively, the district is divided into three divisions namely: Mwagala, Nung'hu and Sengerema with 18 wards and 104 registered villages.

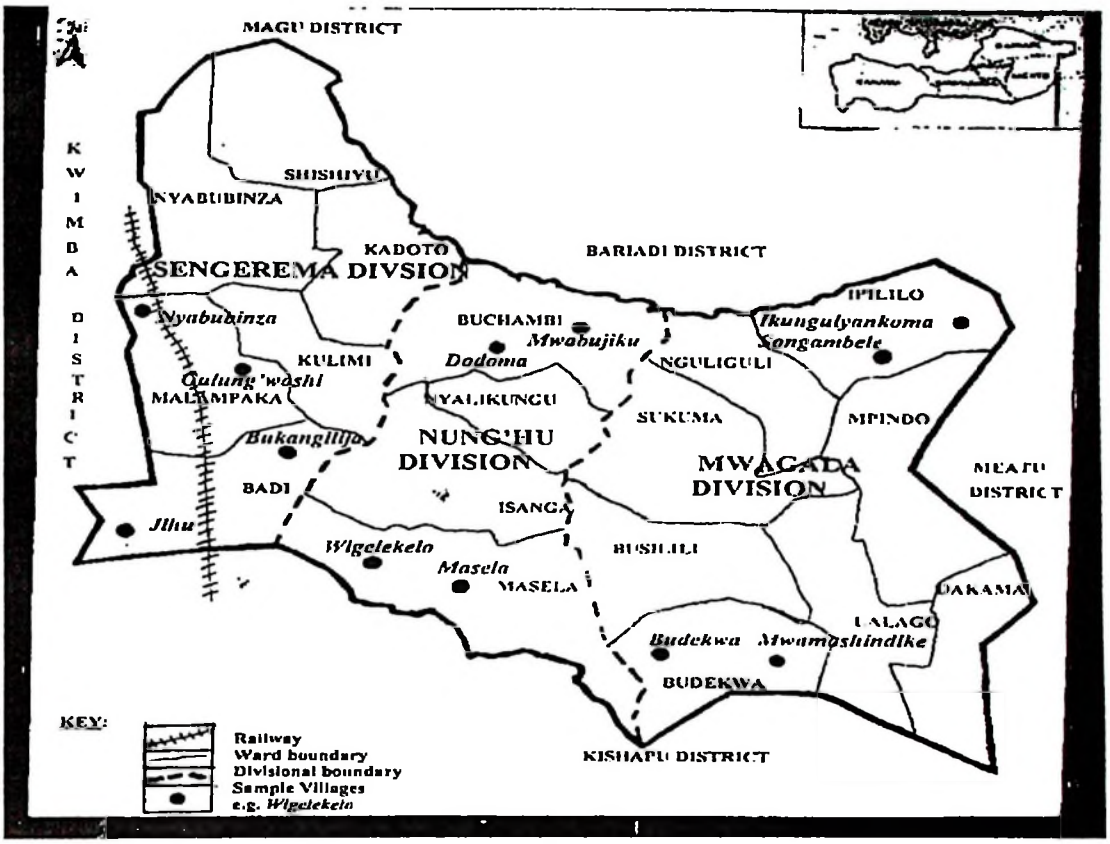

Figure 2: Sketch map of Maswa district indicating ward and divisional administration, and sample villages

3.1.1.2 Population

The 2002 National census indicated the district population to be 304 402 whereby the number of male was 146 643 and female were 157 759 (DADP, 2006/07). This census indicated the annual population growth rate of 2.3% which was below the Shinyanga Regional growth rate of 3.3% and National growth rate of 2.9%. Currently, the district population is estimated to be 333 389, with the average population density of 89 people per square kilometer.

3.1.1.3 Climate and soils

Maswa District, according to DADP (2006/07), has a semi arid climate with unimodal rainfall pattern of between 600-1000mm with an average of 750mm per year. Rainfall (Figure 3 and Appendix 2) is generally erratic and there is no clear pattern and characterized by highly unreliable conventional rainstorms causing considerable differences in rainfall both in terms of space and time, occurring mainly within a period of approximately 5 months, that is late October to early May and characterized by 2 weeks to 1 month dry spells in January and February.

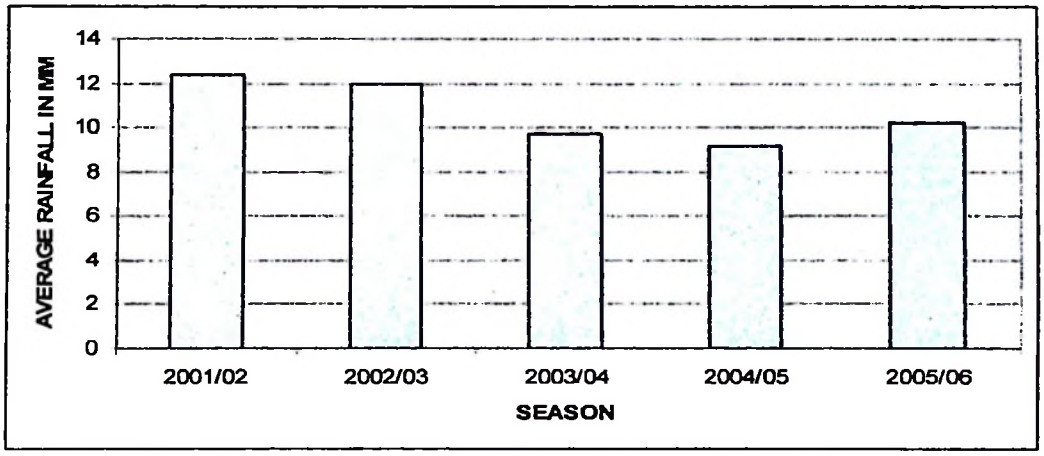

Figure 3: Mean rainfall data for the period of five years in Maswa District

Ecologically, the district is divided into three agro-ecologic zones namely zone I, zone II and zone III (Figure 4). Zone I is a high rainfall potential area with rainfall of 800 – 1200mm/year. It includes Ipililo, Kadoto, Nyabubinza and Shishiyu wards as well as some villages in Kulimi and Buchambi wards. Major food crops grown are maize, paddy, sorghum and sweet potatoes while cash crops are cotton and paddy. Zone II is a medium rainfall potential area having rainfall between 600 –

800mm/year. It comprises more than 50% of the total district area, occupying Badi, Busilili, Isanga, Malampaka, Nguliguli, Nyalikungu and Sukuma wards, including some villages in Masela, Mpindo, Kulimi, Budekwa and Buchambi wards. Apart from maize, paddy, sorghum and sweet potatoes to be grown as food crops, cotton and paddy are also grown as cash crops. Zone III is a low rainfall potential area with 400 – 600mm of rainfall per year. Dakama and Lalago wards lay in this zone together with some villages in Masela, Mpindo and Budekwa wards. Major crops grown, apart from the crops grown in other zones, it is in this zone where pearl millet is cultivated, and cotton and paddy remain as cash crops.

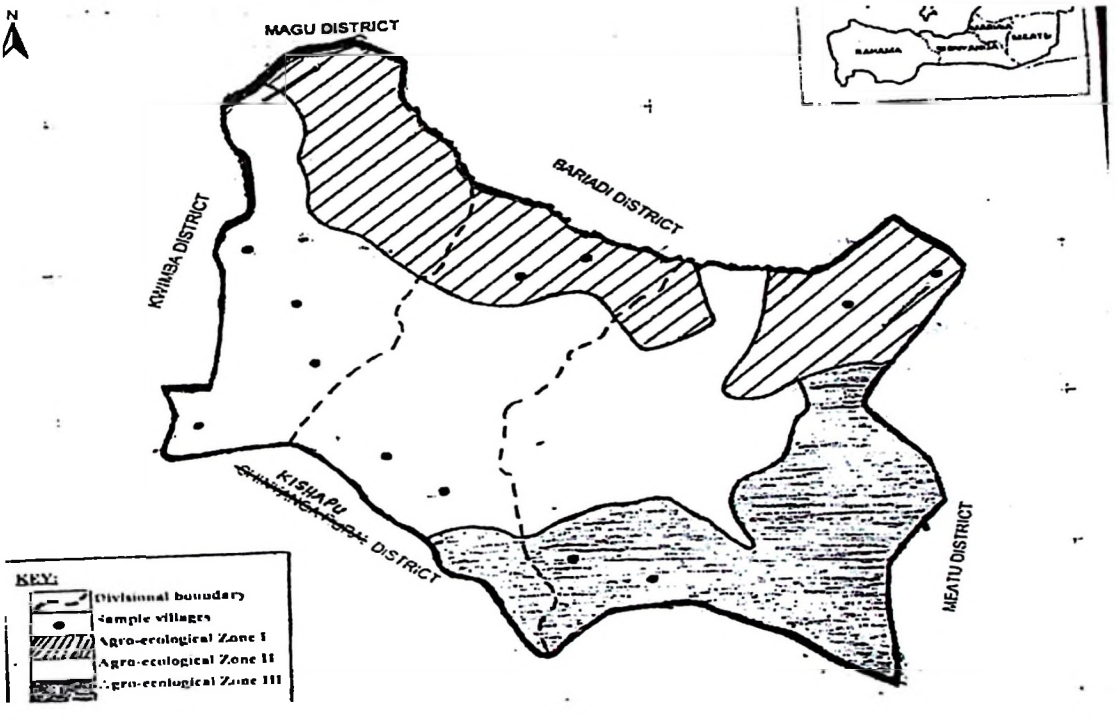

Figure 4: Sketch map of Maswa district showing Agro-ecologic zones

Temperature is relatively constant throughout the year with mean daily temperature ranging from 21 – 26^{0}C. August and September being the warmest months while cool days are experienced towards the end of the rainy period in May and June.

Soils in Maswa district have pH of 6.33 on average of generally loamy sand texture. Soils with vertic properties commonly vertisols (*mbuga* soils) are found at the bottom of the catena. Vertisols, sodic planasols and gleyic solonetz constitute about 50 – 60% of the soils in the area. These soils are further classified into seven types as identified in local terms as: *Luseni, Isanga, Kikungu, Ibushi, Itogolo, Ibambasi* and *Mbuga.*

Luseni and *Isanga* soils are commonly found on the hill flanks and contain up to 70% sand. The soils are easily workable and highly susceptible to erosion. *Kikungu* soil contains clay and a loam mixture thus is fertile. *Ibushi* soil is a dark calcareous loam which is fertile, well drained and easily workable. *Itogolo* is a loamy soil with low permeability, very hard when dry and very soft when wet. It is also susceptible to crusting and has impermeable sub-soil. *Ibambasi* is a hardpan, sandier soil with heavy run-off, very difficult to work and most sensitive to drought. Farmers in Maswa normally use this soil for mud brick making while the subsoil used as roofing materials for *tembe. Mbuga* (black cotton soils) are found at the bottom of the slopes and encompass different soil types. It is normally black in colour and very fertile, highly susceptible to water logging condition as it receives the excess water from the surrounding slopes.

3.1.1.4 Physical features and topography

The topography consists of undulating plains interspersed with large areas of *mbuga* flats except the central ridge running from West to East (i.e. from Malampaka to Maswa game reserves) and isolated rock outcrops. The district also

has isolated hills, some of them are: Itulu, Jilungu, Longana, Kilungu, Duguya, Gula, Nyambiti and Madiwa.

The natural vegetation consists of isolated tall trees and shrubs scattered on uplands and lowlands with woody vegetation and various grasses. The area also is experiencing a high rate of deforestation through extensive clearing of forests and grass for agricultural production, livestock grazing, thatching grass and cutting of trees for poles and firewood.

The area is crossed by many seasonal rivers and tributaries, some of the major seasonal rivers being Shimiyu, Sola, Makomelo and Maganju which empty their water into Lake Victoria through Shimiyu River. Others are Ndala, Ishika, Ntunga, Ng'wag'hole empting water into lake Victoria through Ng'wame river in Kwimba and Misungwi districts; while Itinje, Magogo, Manonga, Tamanu, Sangang'walugesha and Ng'wandete which empty water into Lake Eyasi through Sibiti river in Meatu district.

3.1.1.5 Infrastructure and institutional structure

There are three main roads which reach the district from Mwanza via Misungwi, Shinyanga and Lamadi junction on the Mwanza-Musoma highway via Bariadi, which total 241.7 km, hence connecting the district with other districts and regions. Also, the area can be reached by the Mwanza - Dar-es-Salaam railway through the Malampaka railway station in Maswa district. The area can also be reached by air via Mwanza and Shinyanga airports and then by roads. Within the district, different

divisions, wards and villages can be reached through 362.3 km all weather and seasonal roads.

The district has 25 charcoal dams out of which only 10 are operating, 17 boreholes of which two are operating, 523 shallow wells and one big Zanzui dam which supply tape water to Maswa town and to 6 neighbour villages (DADP, 2006/07).

Maswa district has a fair number of institutes namely: 6 Agro-Vet Shops, Sibuka Radio FM, Meteorological Sub-station, National Microfinance Bank (NMB), TTCL, Celtel, Vodacom, Tigo, TANESCO, Railway (TRL), Post, Rural Water Supply and Sanitation Programme (RWSSP), Urban Water Board, Maswa District Council (MDC), Central Government, CARE (T), FINCA, World Vision Tanzania (WVT), Catholic Relief Service (CRS), 22 SACCOs and 71 Primary Societies. The district has also 6 local auction markets located at Shanwa, Senane, Lalago, Malampaka, Jija-Bilishi and Mwabayanda (S) villages where, among other goods and services, agricultural crops, agroforestry products and live livestock are sold.

3.1.1.6 District economic activities

Out of 339 800 ha in the district, arable land is 237 500 ha (70%), of which only 81% is under cultivation, 17 700 ha (5%) is forest reserve and 84 600 ha (25%) is mountainous and rocks which is used for grazing. Another, 5262.6 ha of arable land is reserved as standing hay (*Ngitili*) for livestock grazing (DADP, 2006/07).

Agriculture and livestock keeping are the most important economic activities in the area. Over 95% of district dwellers are depending on these enterprises for their

livelihood and land is basically used for crop and livestock production which is traditionally owned. The overall average of farm size is about 8 ha per household. Food crops grown are mostly maize, rice, sorghum, sweet potatoes, cowpeas, common beans and chickpeas, while cotton and rice are the main cash crops. In recent times, sunflower, pigeon peas and groundnuts have been promoted as other cash crops.

Livestock kept in the district are cattle, goats, sheep, poultry and donkey. The livestock census of 1984 shows that, there were 264 819 cattle, 78 101 goats and 118 410 sheep in the district with an annual growth rate of 1.2% for cattle, 1.16% for goat and 1.03% sheep. Due to frequent shifting of livestock looking for pasture and water including also continuous selling for food and other family needs, the total population, mainly cattle might have changed. It is estimated that the total number of cattle may range between 300 000 to 350 000 (DADP, 2006/07). Most land in the district is ploughed with oxen, some farmers have started planting behind the ox-drawn implements and weeding by interrow cultivators (ox-weeders). Also, the use of ox-carts to ferry crops and other goods is increasing.

The per capita income in Maswa district was about Tshs: 88 000/=, with total district income from agriculture, livestock, trade and other economic activities estimated at Tshs: 24 billion (DADP, 2006/07). According to formal communication with Mr. Shija Maduhu (the Acting District Planning Officer, 2006), the percentage of people who live below or just above the poverty line in the

district was 38%. The district does not have major and medium scale industries except four cotton ginneries with one oil pressing plant. Others are small-scale industries like: Rice milling machines, oil extraction, grinding, carpentry, metal works and tailoring.

3.1.2 Tools and equipment

Tools and equipment used during conducting field work were: weighing scale, tape measure, questionnaire, note book and pen. Weighing scale was used to weigh amount of foods harvested from farmers' fields, head load firewood and charcoal jute. One to five bags of crops from farmers and businessmen were weighed as representative of the total produce (depending on the amount stored), and then the average weight calculated before converted into total amount of bags. Head loads of firewood and charcoal jutes found at households and with businessmen were weighed to get the weight of each, then calculated average weight and multiplied to the total head loads and charcoal jutes.

Tape measure was used to measure space used to integrate tree-crops and trees on *Ngitili*, as well as length and width of farm land. Also, tape measure was used to measure 10x10m plots on *Ngitili* whereby, number of trees found within a plot was used to calculate total trees in the respective area.

Three questionnaires were used as tools when collecting information at district and ward level (Appendix 3), Household level (Appendix 4), and NGOs and farmers'

groups (Appendix 5) while note book was used to note down information observed during reconnaissance and field surveys.

3.2 Methods

3.2.1 Sample size and sampling procedure

Sample size of 120 households, four District Agriculture and Livestock Officers, one District Forest Officer, six WALEO, two WFO, three NGOs, ten farmers groups and ten businessmen were involved in the study, which comprised of all the three divisions in the district of Mwagala, Nung'hu and Sengerema, with two wards per each division, two villages per each of the selected ward and ten households from each selected village (Appendix 6). At each level, the allocation was carried out randomly.

A list of wards and villages found at the DALDO's office was used to select wards and villages randomly by using random numbers found on CASIO scientific calculator (fx – 82 TL). Also, a list of households found in VEO registry was used to select households randomly. Random selection was also applied when selecting NGOs and farmers groups to be involved whereby a list of each was found at the DALDO and DNRO offices. Apart from random selection of samples, other factors were considered in selection of samples such as representation of agro-ecological zones in the district, potentiality of the area and remoteness in terms of market accessibility, in that case, objective selection was employed in those cases. Businessmen were selected based on their availability and products sold.

3.2.2 Data collection

Data collection was carried out through three procedures namely Reconnaissance survey, questionnaire administration and field survey.

3.2.2.1 Reconnaissance survey

Reconnaissance survey included introduction at the district, division, ward and village levels about the research, days of stay, what data required from respective offices and households, how many divisions, wards, villages and households to be involved. Also, during reconnaissance survey, general information about district total area, area under agriculture, livestock, forest and other uses, temporary and permanent rivers, water availability, infrastructure, communication services, total population, economic activities, average income per year in a district and poverty level were collected.

3.2.2.2 Administering questionnaire

Data collection was done by means of single and group interviews whereby household heads (including even other members of a family) were interviewed using a prepared questionnaire (Appendix 4) to determine their farming practices, number of dependants, various sources and quantities of income and food, source of firewood, its availability and price; amount of food and income obtained from sale of agroforestry components (amount in kg per year, months of availability and its prices), sales from agriculture farms and non-farm activities (amount in kg per year, months of availability and its prices), problems which face agriculture and livestock sectors; ways used to overcome; pests and diseases which affect crops

and their control measures employed; land tenure systems used; purpose of adopting agroforestry, components integrated, problems with agroforesry and solutions used to overcome, use of agroforestry products; input availability and number of livestock and its products sales.

Information gathered at district, wards and village levels were: general information of district location, types of soils, crop production for five years back, average crops prices, input availability, number of livestock and its price, market availability, food security status, agroforestry practices and poverty situation in a district. Farmers' group interview comprised women and youth groups involved in agroforestry, agriculture, livestock and environmental issues. Activities undertaken by respective NGOs and businessmen, employment opportunities in and/or outside a village, land tenures systems, land problems, environment issues and training were included in a study.

3.2.2.3 Field survey

Apart from interviewing individual households, visits to respective farmer's fields were done to have personal observations on agroforestry practices in the area, component arrangements and management. Field surveys involved measurement of farm areas with agroforestry and agriculture practices where harvests had come from, counting the number of wood perennials per unit area, identifying tree species agroforestry technologies and their components. Also, field survey involved a visit on firewood sources. A transect walk crossing a village was done to see fields, physical features and land degradation situations.

3.2.3 Data analysis

Tables, pie-charts and histograms were used to report different data obtained during a study. Analysis of Variance (ANOVA) at 0.05 and 0.01 significance levels were used to determine the differences between the agroforestry and non-agroforestry sources of household income and food security. Also, the ranking and separating of the significantly differing mean results was based on the Least Significant Difference (LSD). The formula adopted was: $LSD = t_{0.05}*s.e.d.$; Where as s.e.d. is the standard error of difference = $(2*s^2/r)^{1/2}$.

CHAPTER FOUR

4.0 Results

4.1 Various sources and quantities of household food supply and income generation

4.1.1 Sources of household food supply and income generation

The results on the various sources and quantities of household food supply and income generation in Maswa district are presented in Table 4 (details in Appendices 7 and 8). The results on the people's relative dependence on each source of food supply and income are presented in Table 5 (details in Appendices 9 and 11) and the analysis of variance (ANOVA) values are presented in Appendices 10 and 12. On average, agroforestry and agriculture indicated to be the main sources of household food supply in Maswa District followed by livestock and business. Employment on the other hand, is the main source of household income followed by agroforestry and business. However, most of the households depend on more than one food and income sources.

The low showing of agriculture which is indicated by the majority of the households (i.e. over 98% and 86% as food and income sources respectively) in the study area as the main base of livelihood of most smallholder farmers, is probably due to the nature of the crops (i.e. herbaceous), limited range of per unit area benefits (i.e. mostly monocultures) and unfavourable climatic conditions prevalent in the district. The expressed higher people's dependence on agriculture (Table 5) while the practice is different is perhaps due to the general feeling of most people that agriculture is the main source of livelihood.

Table 4: The various sources and quantities of household food supply and income generation in Maswa district during 2006

Sources	Food supply Average bags*/HH/yr	Income source Average Tshs/HH/yr
Agriculture	9 ab	257 194 d
Agroforestry	12 a	490 776 b
Beekeeping/Honey	-	30 000 f
Business	5 bc	365 950 c
Employment	2 c	776 686 a
Forest	1 c	61 910 e
Livestock	5 bc	35 000 f
Total	**34**	**2 017 516**

*Bags from business, employment, forest and livestock sources were obtained through buying food using money earned from respective sources.

NOTE: Means in the same column that are followed by the same letter do not differ significantly ($P > 0.05$)

Table 5: Mean percentages of peoples' dependence on each source of food supply and income in Maswa district during 2006

Sources	% mean on food supply	% mean on income
Agriculture	98 a	86 a
Agroforestry	13 b	22 bc
Business	6 b	18 bc
Employment	30 b	46 b
Forest	1 b	13 bc
Honey	-	1 c
Livestock	23 b	2 c

NOTE: Means in the same column that are followed by the same letter do not differ significantly ($P > 0.05$)

4.1.2 Trend of various sources of household food supply and income generation

The results on the mean trend of contribution by the various sources of food supply and income from 2001/02 – 2005/06 are presented in Figure 5 and 6, details are shown in Appendices 13 and 15 respectively. The analysis of variance (ANOVA) details are presented in Appendices 14 and 16 respectively.

The trend in food supply indicated to have been more or less constant from season to season with a slight drop in production in the 2002/03 period. Rainfall intensity and distribution probably could have been the factor of this drop. The mean trend in household income generation indicated to continually increase from 2001/02

towards 2005/06 mainly as a result of the escalating prices of the products, o especially agroforestry based and increases in the salaries (Appendix 15).

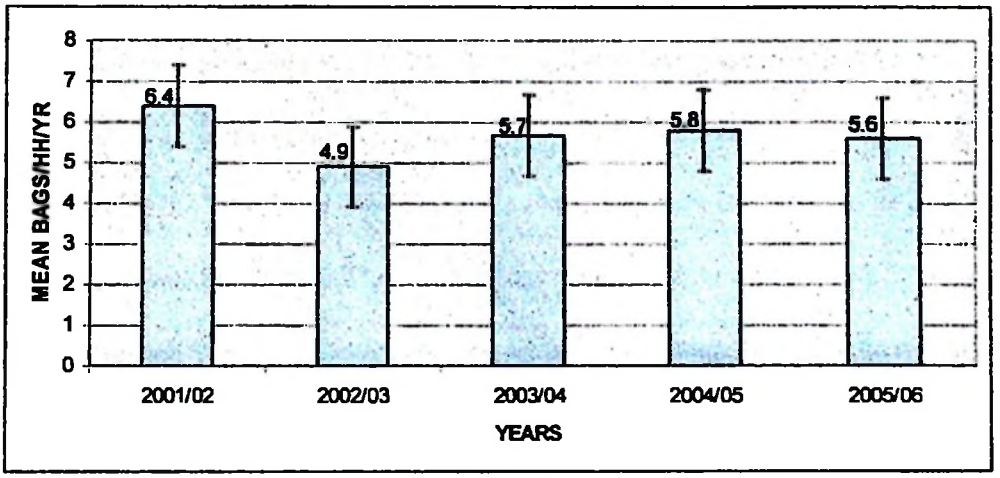

Figure 5: Trend of production for various sources of food supply (mea bags/HH/year)

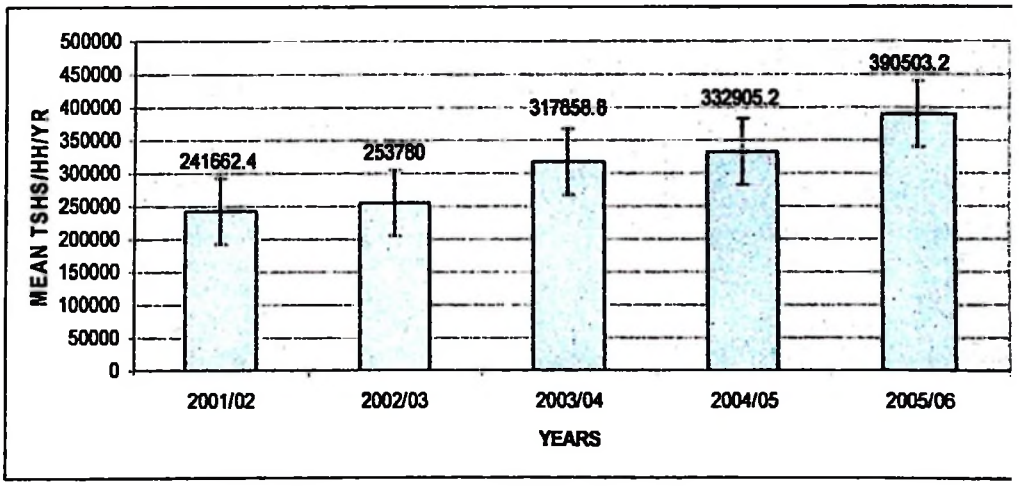

Figure 6: Trend of income from various sources (mean Tshs/HH/year)

4.2 The contribution of agroforestry and its technologies to food supply and income generation

4.2.1 Contribution of household food supply and income generation sources

The results on the contribution of agroforestry to household food supply and income generation among the various sources of community livelihoods in Maswa district are presented in Table 6. On average, agroforestry and agriculture indicated high proportions on the contribution to household food supply in Maswa district followed by livestock and business. Employment on the other hand indicated high proportion on the contribution to household income followed by agroforestry and business.

Table 6: The proportions of various sources of household food supply and income in Maswa District during 2006

Sources	Food supply Percentage	Income source Percentage
Agriculture	28 ab	13 bc
Agroforestry	34 a	24 ab
Beekeeping/Honey	-	2 c
Business	14 bc	18 bc
Employment	6 c	38 a
Forest	3 c	3 c
Livestock	15 bc	2 c
Total	**100**	**100**

NOTE: Means in the same column that are followed by the same letter do not differ significantly ($P > 0.05$)

Table 7 (with their details in Appendix 17) presents the relative importance of the various agroforestry technologies being practiced in the district. It will be noted that the agroforestry technologies that are being undertaken in Maswa district include: Mixed intercropping, integrated tree-pasture management famously known as *Ngitili* in the study area, and tree-bee interaction. Although agricultural crop production and animal husbandry go hand in hand as equally important economic activities in the area, agrosilvopasture was not undertaken due to free grazing in the crops fields following crop harvests. Of the agroforestry technologies, integrated tree-pasture management indicated a higher proportion on the contribution to household food supply while mixed intercropping indicated a higher proportion on the contribution to household income followed by tree-bee interaction though statistically are not significantly different.

Table 7: The proportions of agroforestry technologies contribution to household food supply and income in Maswa District during 2006

Agroforestry technologies generation	Food supply	Income
	Percentage	Percentage
Mixed intercropping	31	48
Integrated tree-pasture	69	13
Tree-bee interaction	-	39
Total	**100**	**100**

4.2.2 Adoption of agroforestry technologies in Maswa District

The results indicated that, about 22% of households found in Maswa district adopted different agroforestry technologies (Tables 8). Nung'hu and Mwagala divisions indicated to be leading with 30% and 22.5% households that deal with

agroforestry technologies respectively, followed by Sengerema division having only 12.5% of households with agroforestry technologies. Within the agroforestry technologies, integrated tree-pasture (*Ngitili*) indicated to be more adopted by people in Maswa district than mixed intercropping and tree-bee interaction. However, analysis (ANOVA) shown in Appendix 18, indicated that, these differences in adoption of agroforestry technologies in divisions were not statistically significant.

Table 8: Mean percentage of people who have adopted agroforestry technologies in Maswa district during 2006

	Agroforestry technologies			
Division	Mixed intercropping	Integrated tree-pasture	Tree-bee interaction	%
Mwagala	5	17.5	0	22.5
Nung'hu	7.5	22.5	0	30
Sengerema	5	5	2.5	12.5
Mean % at district	5.8	15	0.8	22

Components integrated on agroforestry practices in a study area included food and cash crops as well as livestock/pasture and varieties of indigenous and exotic tree species (Appendices 19 and 20) retained in farms with different agroforestry technologies.

Results in Table 9 represent the distribution percentage of the local communities practicing agroforestry in the three agro-ecological zones found in the district whereby agro-ecological zone I has more proportions of people practicing

agroforestry. This means that, probably the potentiality of an area and climatic factors play a role in influencing the adoption of agroforestry technologies. However, these differences indicated to be not significant statistically.

Table 9: Distribution of the proportions of the local communities practicing agroforestry

Agro-economic zone	Percent
I with high rainfall	30
II with medium rainfall	17
III with low rainfall	20
Mean %	22

The results in Table 10 show the different factors that influence the adoption of different agroforestry technologies in Maswa district. The need for availability of firewood, good pastures and income indicated to have high motivation in adopting agroforestry technologies in the district.

Table 10: Factors that motivated farmers in adopting agroforestry technologies in Maswa district

Factors of adoption	Percentage
Adequate pasture availability	27 a
Good source of household income	23 ab
Source of firewood	28 a
Soil improvement	13 bc
Timber and pole supply	9 c
Total	100

4.2.3 Agroforestry household's income and food security status

The results on average household income and food security status for agroforestry and non-agroforestry households are shown in Tables 11 and 12 (details are indicated in Appendix 21). Both the per capita income and food security indicated to be more with agroforestry households when compared with non-agroforestry households per year throughout the district. This is probably due to higher productivity and product diversity in agroforestry fields compared with non-agroforestry fields (Table 13) that have perhaps limited number of crop products per unit area. However, these differences of income and food security indicated to be not significant statistically.

Table 11: Annual household income status in Maswa district during 2005/06 period

Ward	Agroforestry farmers Income per capita (Tshs: '000)	Non-agroforestry farmers Income per capita (Tshs: '000)
Budekwa	80.159 b	115.484 a
Ipililo	119.013 b	98.239 ab
Masela	91.964 b	82.378 b
Buchambi	74.834 b	78.921 b
Malampaka	187.5 a	84.453 b
Badi	143.699 ab	53.398 c
At District	106.883	84.457

NOTE: Means in the same column that are followed by the same letter do not differ significantly ($P > 0.05$)

Table 12: Food security status of households in Maswa district during 2005/06 season

	% of food secure HHs	% of food insecure HHs
Agroforestry farmers	31	69
Non-agroforestry farmers	30	70
Average	30	70

Table 13: Agroforestry and non-agroforestry average yields per unit hectare (kg/ha)

	Agroforestry fields	Non-agroforestry fields
Maize	1387	876
Sorghum	1102	774
Cotton	920	713
Mean	1136	788

Source: Survey data, 2006

4.3 Constraints of agroforestry contribution to food security and income generation

The results on constraints of agroforestry contribution to household food security and income generation are indicated in Table 14 (detailed in Appendix 22), and the Analysis of variance (ANOVA) details are presented in Appendix 23. Land scarcity for undertaking agroforestry (especially *Ngitili*) appeared to be the main significant factor that affects adoption of agroforestry ($P<0.01$). Other factors in order of importance were fear of component competition, lack of knowledge on agroforestry technologies and availability of common forests.

Table 14: Mean percentage of the factors affecting agroforestry adoption in Maswa District during 2006

Factors affecting agroforestry contribution	Mean %
Agromechanization restriction	3 c
Available common forests	12 bc
Birds settlements	2 c
Component competition	17 b
Drought	4 bc
Fire setting	2 c
Invaders on trees/grass	7 bc
Lack of land	41 a
Lack of knowledge	12 bc

However, probably lack of knowledge on agroforestry technologies particularly on component arrangement and management might be a main causative agent. Figure 7 and 8 (detailed on Appendix 24) show the proportion of extension service in the district which indicated to be low and that most farmers are not reached with the services; as a result they lack knowledge.

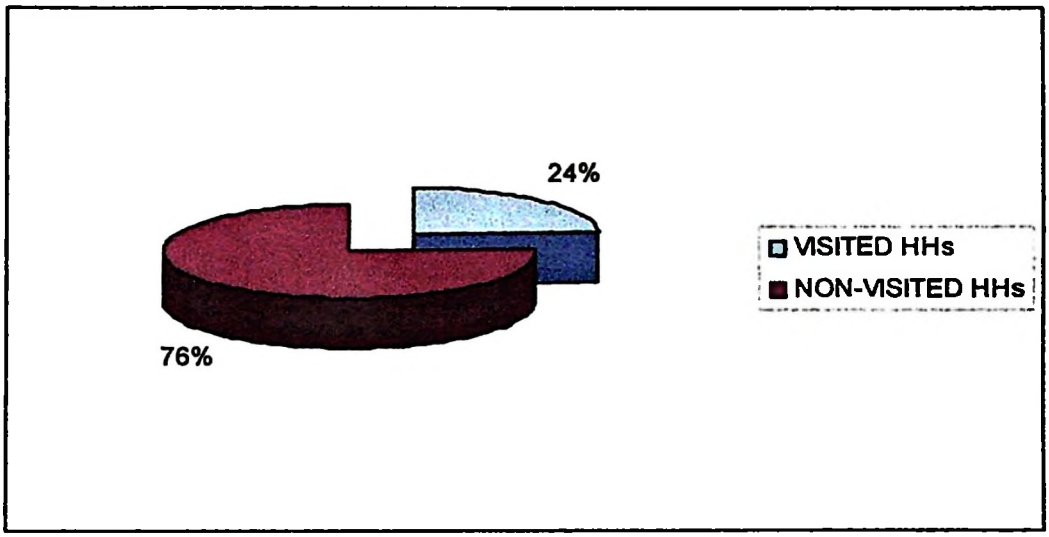

Figure 7: Percentage of visited and non-visited households by the extension agents in Maswa district during 2006

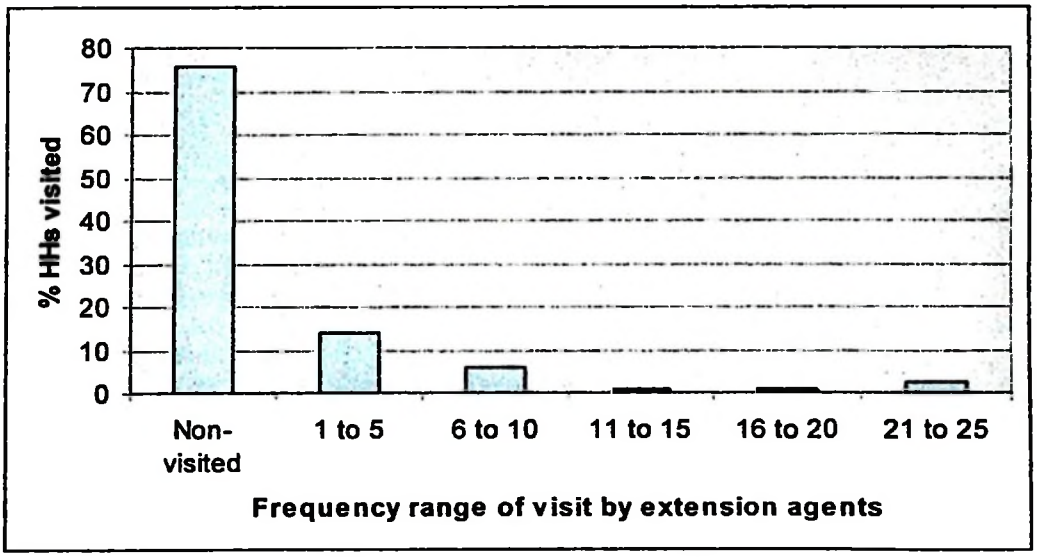

Figure 8: Percentage of frequency range to households visited by extension agents in Maswa district during 2006

4.4 Interventions required for improving the contribution of agroforestry to food security and income generation in Maswa District

Results in Table 15 (detailed in Appendix 25) represent different measures that the local communities in the district indicate, if undertaken, might improve the performance of agroforestry technologies contribution to household food security and income generation in the study area. The analysis of variance (ANOVA) presented in Appendix 26 indicated that ($P<0.01$), reinforcement of the available local institutions (mainly the use of *sungusungu* on *Ngitili* protection) is the main significant intervention. Other interventions in order of importance are knowledge provision on proper component arrangement and ensured market availability for agroforestry products.

Table 15: Mean percentage of interventions for improving agroforestry performance in Maswa

Interventions for improving agroforestry contribution	Mean %
Close monitoring and inspection	8 b
Involvement of NGOs on knowledge provision	5 b
Knowledge provision on component arrangement and management	24 ab
Promotion of market for agroforestry products	10 b
Reinforcement of local institutions protection	46 a
Support of farmers groups	7 b

CHAPTER FIVE

5.0 Discussion

5.1 Various sources and quantities of household food supply and income generation

The results on the various sources and quantities of household food supply and income generation in Maswa district are presented in Tables 4 and 5, Figures 5 and 6 with their data and statistical details in Appendices 7 to 15. On average, agroforestry ranked highest in contributing to household food security per year as compared to other sources, and second to employment on household income. However, the dependence on agroforestry in the district appeared to be low compared to some places identified by other studies. In Lushoto district, for example, 90% of farmers were merely depending on agroforestry as the main source of income (Bonifasi, 2004). The relative low dependence on agroforestry in Maswa district is believed to be due to its general low adoption rate by the district community.

In spite of its low adoption, agroforestry appeared to supply higher amounts of food and income. This is due to the fact that, agroforestry by its nature (Lulandala, 2004) increases the cropping intensity and reduces the variability of overall yields by increasing productivity through better use of the environment resources (light, water and nutrients) and soil improvement from tree integration, it has a greater long-term economic stability through diversified products thus increased overall yields and year-round production. Also, most farmers practicing agroforestry apart from tree integration adhere to some agronomic recommendations like planting on proper spaces and use of organic manure.

Agriculture appeared to be the most significant dependent source of food supply and income generation for the communities in the district since on average about 98% and 86% of households in the district depends on it for their food and income respectively. According to DALDO (DADP, 2006/07), over 95% of the district population are depending on agriculture (and livestock keeping) for their livelihood. The importance of agriculture is also explained at the national level, whereby the dependence of Tanzanians in agriculture sector as a source of livelihood is about 80% (Kashuliza *et al.*, 2002; Myaka *et al.*, 2003; Sicilima, 2003). Nevertheless, the contribution of agriculture to household food supply and income in terms of quantity was low compared to agroforestry (for food supply), and employment, agroforestry and business (for income generation).

This low contribution of agriculture to household income and food supply is probably caused by the unfavourable climatic conditions prevalent in the district which has poor rainfall distribution and intensity (DADP, 2006/07) which lead to frequent crop failures especially due to their being annual in nature. Also, as reported by other studies (SUA, 2006), low input use, pests and diseases attack, poor farm tools (i.e. hand hoe) and poor husbandry could be the other factors affecting agriculture sector thus lowering its contribution to household income and food supply. Observations by Lyimo-Macha *et al.*, (2005) revealed that, outdated husbandry practices, lack of reliable market and poor agricultural tools, lack of crop rotation systems and poor environmental protection practices retard agricultural productivity. A report by United Republic of Tanzania (URT, 2001) indicated the use of agricultural inputs in farm activities in Tanzania was only 27%

for fertilizers and 18% pesticides. As a result, productivity per unit land and labour is low. Also, it is reported that, about 14% of the harvested crops is lost to pests (SUA, 2006). Other studies (Makundi and Magoma, 2003) indicated a loss of between 30% and 35% by stored product pests particularly *Prostephanus truncatus* (LGB) and *Sitophilus spp* (maize weevils), thus contributing enormously to reduced post harvest crop losses and therefore aggravating to food insecurity in Tanzania.

Also, in a research agenda for 2005 – 2010 (SUA, 2006). Msanya *et al.*, (1999) and Solomon *et al.*, (2006) pointed out the major limitations that make Tanzania's agriculture (including that of Maswa) by the small holders to remain subsistence thus low production per unit area.

Forest and beekeeping indicated to have less extent of people depending on them for their livelihood, thus low amount of household food supply and income generated from the two sources. This could be due to the fact that, the community itself is not a forest dependant for its livelihood, few farmers opt to sale firewood for buying food mostly during food shortages otherwise forest products are intended for day-to-day household needs such as buying kerosene, medical requirement, salt and the like. A study by Kajembe *et al.*, (2004) revealed that, forest provides income for regular household's expenditure when farmers run out of agriculture crops. Other studies (TARP II – SUA, 2004; Hill, 2007) indicated the importance of forest, particularly NWFPs on household food supply and income generation. This indicates that forestry has a big and indispensable role to play in

household income generation and in improving food security if their resources are fully utilized.

The contribution of livestock to household food supply and income also encountered to be low not with standing of the percentage of livestock keepers and the huge number of animals kept as compared to some places identified by other studies whereby food supply and income contributed by livestock was 30.7% and 27.7% respectively (Shalli, 2003). One of the prevailing characteristics of livestock keepers in Maswa district that led to low contribution was that farmers do not keep for the market but just for subsistence and look for market when there is a problem. Myaka *et al.*, (2003) pointed that, low genetic potential of the indigenous livestock is one of the major causes for low productivity. Also, probably problems such as tick born and sporadic diseases outbreak, inadequate pasture and water (especially during dry period) could be other factors which lead to low animal productivity thus lower amount contributed to household food security and income.

Keeping large numbers of livestock accompanied by the growing population densities in livestock keeping areas as it is in the district make people strongly reliant on available natural resources for their livelihood, thus creating competition on resource use (Higgins *et al.*, 1999; Makepe, 2006; Moleele and Perkins, 2002; Vetter *et al.*, 2006). This situation creates problems of rangelands for animal grazing with land use pressures resulting into resources use conflicts, thus diminishing carrying capacities of rangelands (Moleele and Perkins, 2002; SUA,

2006). In that case, the livestock sector is affected in terms of production potential hence lower amounts contributed to household food security and income.

Despite of the low contribution, the livestock sector plays an important role in the social, cultural and economic attachments to farmers in Maswa district. It is the source of energy for draft, paying dowry, symbol of wealth, reserved bank, hunger mitigation and source of organic fertilizer for their crops; thus livestock have great influence on agroforestry adoption. A study by Mumba (1999) revealed that livestock owners were more willing to participate in rotational woodlot system in Shinyanga than their counter parts.

Results on the mean trend of household food supply and income generation for various sources from 2001/02 – 2005/06 are presented in Figures 1, 4, 5 and 6, and details in Appendices 1, 2, 6 and 15). Trends of household food supply from various sources (and that of agroforestry) indicated to have been more or less constant notwithstanding a drop in production in 2002/03. This situation appeared to coincide with the mean trend of food crops production in the district for the same period with the exception of 2004/05 which indicated a big difference. Rainfall data in the district also indicate to support the trend of food crops production with the exception of 2002/03 data in which, probably rainfall distribution might be the factor. Findings by Kashuliza *et al.*, (2002), Myaka *et al.*, (2003), Shalli (2003) and SUA (2006) revealed that, heavy dependence on rain is among the limiting factors of food production.

The mean trend of household income generation indicated to have increased from the year 2001/02 to 2005/06. This trend in household income in the district indicated to coincide with the increase in the per capita income at the national level (WMUU, 2007). Business and employment indicated to have been the most significant contributor to the household income in the first two seasons and from the third to the fourth seasons agroforestry jumped in by contributing higher amount followed by business and employment though it shown a drop in 2005/06. A drop in the agroforestry contribution to income generation in 2005/06 could have been due to the fact that, data collection was undertaken (September to November) when income from agroforestry (particularly *Ngitili*) was still taking place. *Ngitili* are closed off for pasture regeneration during January/February to June/July and opened for grazing during August/September to December/January (Mugasha *et al.*, 1996). The increase in agroforestry income contribution indicated to be due to the fact that, some of the people in the district have recently recognized the economic importance of agroforestry in view of the current economic bases than previously when it was almost exclusively based on livestock (Bakengesa, 2001).

5.2 The contribution of agroforestry and its technologies to food supply and income generation

Results in Tables 6 to 13 (detailed in Appendices 17 to 21) represent the contribution of agroforestry and its technologies to household food supply and income generation. On average, agroforestry ranked highest proportion in contributing to household food security per year as compared to other sources, and second to employment on household income. The contribution of individual

agroforestry technologies to the overall household food supply indicated that, *Ngitili* contributed more to food supply than mixed intercropping due to the fact that, grazing in *Ngitili* were exchanged for food during the famine time when food crops performance was poor due to drought. In that case more amount of food (in terms of bags) was exchanged per unit area as compared to the amount harvested from mixed intercropping. However, the amount generated to household income was less for *Ngitili* compared to other technologies, probably due to the following reasons: first, most *Ngitili* were used to graze family animals with the exception of few farmers who reserved *Ngitili* for economic purposes and secondly, data collection was undertaken (September to November) when income from *Ngitili* was still taking place.

Results in Tables 8 to 10 represent the adoption of agroforestry technologies in the district by indicating that, only 22% of households in the district adopted agroforestry, with the higher adoption rate observed in the Mwagala and Nung'hu divisions. Agro-ecological zones existing in the district revealed to influence adoption. This means that, the potentiality of an area and climatic conditions play a role in the adoption of agroforestry technologies. The adoption of agroforestry technologies in the district was indicated to be constrained by many factors including lack of land (particularly for *Ngitili* establishment) and fear of component competition caused by lack of knowledge on component arrangement and management.

Among the technologies practiced in the district, *Ngitili* indicated to be adopted by more farmers compared to other technologies; this is due to the fact that, farmers have recognized the importance and its potential on livelihood for the communities in the district as it is known that the area of study is greatly affected by deforestation caused by many factors including agricultural land expansion, overgrazing and cutting of trees for firewood. Therefore, *Ngitili* has become the only alternative for meeting firewood, pasture and income requirements, of which these factors appeared to be the most motivations to the adoption of agroforestry technologies.

Integrated tree-pasture (*Ngitili*) which involved the integration of woody perennials with grass or pasture is an old practice in the study area used for grazing animals during the dry season and closed off in the wet season in order to allow the vegetation to regenerate. Farm size of *Ngitili* appeared to be variable among farmers, ranging from 0.4 to 56 ha. However much improvement of *Ngitili* indicated to be done during the HASHI programme which started in 1986 and most farmers realized its importance than before (Kaale *et al.*, 2002; Bakengesa, 2001). *Ngitili* is becoming an important practice in the area for income earnings. It was found that, previously *Ngitili* was only undertaken by livestock keepers for pasture production particularly during the dry period when pastures become scarce in supply (Bakengesa, 2001). It is only recently that even families having no livestock do reserve *Ngitili* in exchange for money. Therefore, this indigenous silvopasture is the only agroforestry system that some how its importance in contributing to household income is known by the majority of the farming community.

Mixed intercropping involved the integration of woody perennials with agricultural crops only in which trees were integrated with maize, sorghum or cotton. The space used for trees was variable: 3mx4m, 3mx6m, 4mx5m and irregular arrangement. The number of trees counted per unit area was also variable, ranged from 98 – 186 per hectare as compared to farmers in the East Usambara Mountains who have an average range of 10 – 200 different tree species per hectare in their plots (Msikula. 2003). Tree-bee interaction is the management of woody perennials in integration with the bees. However, it was observed that, the tree-bee interaction technology (aposilvoculture) was less practiced in the district due probably to low understanding on its potentials. A study by Wilkinson and Elevitch (2007) reported of a successful beekeeping activity that yielded high value products to have increased farmer's income by 40 – 60%, with the average production for a hive of about 23 kg of honey per year (Mastrantorio and Francis, 2007).

Different factors indicated to influence farmers in the district in adopting agroforestry technologies, among them included the need for firewood, adequate pasture availability and good sources of income appeared to be the most significant factors. The area of study is faced by a shortage of grazing areas (pastures), hence reserved lands (*Ngitili*) become the primary sources of pastures, especially during the dry period. Deforestation prevailing in the district created inadequate firewood availability; therefore, adoption of agroforestry technologies ensured firewood availability at the household level. Results from other studies (Lulandala, 2004; Malley *et al.*, 2004; Aihou *et al.*, 2006; Tossah *et al.*, 2006) indicated also the significance of agroforestry in meeting firewood requirements at household level.

For example, results from Mafiga (in Morogoro) experiments with *Leuceana leucocephala* intercropped with maize and beans indicated that a well managed alley farming system with a 3333 trees/ha could produce up to 71m^3/ha of wood in 2 years in addition to normal crop yields (Lulandala, 2004). This amount is sufficient for an annual firewood need of over two households.

Another factor that accelerated farmer's adoption of agroforestry technologies in the study area was the incentive for soil improvement. This argument was supported by the production of crops per unit area between agroforestry and non-agroforestry farms. Also other studies (Lulandala, 2004; Tossah *et al.*, 2006) supported this argument by indicating the increase of productivity when trees were integrated on a land management system. A study in Mafiga Morogoro revealed the relay cropping of *Sesbania sesban* with maize showed to multiply crop yields by approximately 3 times i.e. 1.2 to 3.5 t/ha per year (Lulandala, 2004). Also assessments on the effect of agroforestry on land quality and productivity indicated average improvements in total soil nitrogen, available soil phosphorus and soil organic carbon (Malley *et al.*, 2004; Aihou *et al.*, 2006; Amara *et al.*, 2006). These prove that trees when integrated with crops have ability of improving soil fertility and structure for crop productivity (MacDicken and Vergara, 1990; Weidelt, 1993).

Also, this study indicated the per capita income and food security status for agroforestry households to be higher as compared to non-agroforestry households. However, the differences appeared to be statistical not significant. This difference may be due to, apart from differences in the production per unit area, species

diversity in agroforestry systems and thus outputs diversity is attained (Elevitch and Wilkinson, 2003; Lugendo, 2003; Huxley and Ranasinger, 1996) which lead to more produce. Other studies (Bonifasi, 2004; Msikula, 2003) also observed the difference in income contribution between farmers practicing and not practicing agroforestry. However, these per capita income were far below the per capita income at national level which appeared to be Tshs: 242 000/= in 2000 (URT, 2000), while in 2004, 2005 and 2006 the per capita income were Tshs: 321 010/=, Tshs: 360 865/= and Tshs: 399 873/= respectively (WMUU, 2007).

Food security status for agroforestry and non-agroforestry households in the district indicated to coincide with the percent rate reported by Maswa DALDO on Rapid Vulnerability Assessment for 2006/07 market year which indicated 70% households and 30% households as food insecure and secure respectively. At national level, Keenja (2001) and Myaka *et al*., (2003) indicated that, only 27% and 20.4% of Tanzanians were food poor respectively.

5.3 Constraints of agroforestry contribution to food supply and income

The results on constraints of agroforestry contribution to household food supply and income generation are presented in Table 14 (details in Appendices 22 and 24) and Figures 7 and 8. Lack of land and/or ownership for agroforestry establishment (especially *Ngitili*) appeared to be the most significant factor that affects engagement on agroforestry thus made the system not to provide full contribution to household food supply and income. Land and forest tenure and regulatory systems, including rules governing control and management of tree resources have

been widely cited as constraints to agroforestry adoption (Franzel and Scherr, 2002; James, 2004; Lugendo, 2003; Njoku, 2005). A study by TARP II SUA (2005) revealed that land shortage was among the reasons as to why farmers do not adopt agroforestry technologies. It is only when people have control over the resource base and secures tenure that long-term objectives can be achieved (Bakengesa, 2001).

Also, competition for water and soil moisture between the components as well as above ground competition especially shade increased disappointment to farmers. Trees as the main component in the system may dominate the arable crops for nutrients, growing space, solar energy, soil moisture and may significantly reduce the yields of associated crops (MacDicken and Vergara, 1990). During the present study, it was observed that, some farmers decided to uproot *Leucaena leucocephala* trees from the field because of the overcrowding and therefore caused light/shade competition to crops. Farmers' perceptions of the effects of trees on crops, as it had also been observed by Njuki (2001) in Embu and Kirinyaga districts Kenya, was said to be the major constraints to the integration of trees into the farming systems.

Another factor is that, agroforestry was not well known to most farmers in the district, thus lacked knowledge on agroforestry arrangement and management. A study found that extension services were not adequate since only 24% of households in the district were visited by extension staffs in 2005/06. More contact was observed only when there were problems which needed immediate action by the extension staff especially livestock disease cases. This low percent of contact

was far below that achieved in Dodoma whereby about 47% of the people got extension services (Nhembo, 2003) while in Tarime, extension services reached 75% through the use of farmer-to-farmer extension approach (Sonoko, 2001). The main reasons of low extension services in Maswa district as explained by extension staffs themselves were: insufficient personnel and lack of transport. On the average, there was only one Agriculture Extension Officer (AEO) per ward with only 8 Forest staff in the whole district. Also there were only 5 AEOs out of 18 at ward level with motorcycle transport and 2 forest staff out of 8 at district level identified to have that transport. This made some of the staff not to be available all the time, and therefore becoming difficult for them to reach more farmers.

It should be remembered that, extension service, according to Rutatora and Rwenyagira (2005) is one of the prime movers of the productivity of the systems, thus raising the income of farm families and improving the quality of life of rural farm households. Successful diffusion and adoption of new agroforestry practices depend not only upon the technical performance of those practices and the way they fit in farming systems, but also on the broader policy, strategies and institutional arrangements for extension and research support (Franzel and Scherr, 2002). Farmers should be empowered with skills and knowledge relevant to improve, adopt and implement effectively agroforestry systems (Msikula, 2003). Knowledge is considered as important factor in relation to natural resource utilization and conservation, and hence facilitates adoption and implementation of technologies (Kamwenda, 1999; Kirway *et al.*, 2003; TARP II – SUA, 2005). In that case, extension service should be effectively supported by the national

governments (including local governments) by ensuring sufficient numbers of extension staff particularly at the village and ward levels, provided with incentives and training on the basis of skill gap analysis.

Livestock keeper's invasions on crop fields, especially during dry season when agricultural crops have been harvested, to browse on the trees while other people invade agroforestry plots/fields and cut trees without the permission of the owners at the same time livestock keepers invade *Ngitilis* for grazing. During the study it was observed that in some villages, all land was regarded as a common grazing land, thus turning all grasslands as well as farm fields after crop harvests into open grazing areas where livestock keepers were free to graze and invade agriculture fields, all grazing land was a free access for all. This retarded progress of individuals who were willing to develop their farms into agroforestry by integrating trees with food crops. Other studies revealed that, under communal grazing systems no individual farmer takes an initiative to manage the range even when a farmer knows that the grazing land is under pressure or overgrazed, neither does this system encourage collective management of the grazing resource (Higgins *et al.*, 1999; Solomon *et al.*, 2006), as a result, communal grazing changes substantially the composition and structure of woody plant communities (Higgins *et al.*, 1999). Heavy grazing is thought to be inevitable in communal rangelands because of the problems inherent in communal ownership of a resource where individual benefits are maximized at the expense of the community as a whole (Makepe, 2006; Vetter *et al.*, 2006).

Other problems with agroforestry technologies were the restriction of agromechanization by trees whereby tree roots found a few centimeters below the soil surface restrict ox-plow share and discs to penetrate at a required depth. Lulandala (2004) revealed that, trees in agroforestry systems may hinder agricultural operations. Also there was another problem of fire setting which go out of control to *Ngitili*. Also trees were said to create bird resting and nesting grounds and therefore the associated crops become liable food sources for birds.

5.4 Interventions/corrective measures required to overcome the constraints

Results on different measures that if undertaken might improve the performance of agroforestry technologies contribution to household food supply and income generation are presented in Table 15 and Appendix 25. Reinforcement of protection local institutions revealed to be the most significant intervention to improve the performance of agroforestry technologies in the district. It was observed that, local institutions and by-laws formulated by community assemblies (*Dagashida*) were used to protect *Ngitili* whereby fines (well known as *michenya*) of either money or live-animal was charged to an individual found to misuse *Ngitilis* and time was set for payment. Also, *kutulijiwa* (exclusion from others) was done whereby an individual was not allowed to visit or being visited by other villagers, and if she/he gets problems or matters such as *msiba* (funerals), marriage or *ilima* (communal cultivation assistance) was not allowed to attend or others to attend to her/him until she/he paid; with *sungusungu* (traditional village guards) being the main implementer. However, in some places these local institutions and by-laws were

not well implemented and/or communities not involved thus *Ngitilis* were misused hence affected their performance.

Various studies (Langill, 1999; Kaale *et al.*, 2002; Makepe, 2006; Odebode, 2005; Sanginga *et al.*, 2006; Rist and Guebas, 2006) have shown that, for interventions to be sustainable there must be an active involvement of the people for collective action, implementation of by-laws and linking with local government structures so as to increase the ability of communities to use available opportunities for collective action. The use of by-laws to protect the planted trees has been reported to be most useful in the adoption of new technologies including agroforestry (TARP II – SUA, 2005; Hatibu *et al.*, 1999). Indigenous knowledge in Sahelian West Africa was found to be useful in providing information on endangered species and thereby assisting regeneration, reforestation and conservation strategies (Wezel and Lykke, 2006) as also has been observed in the *Ngitili* technology management in Shinyanga region (Kaale *et al.*, 2002). Therefore, reinforcement of available indigenous knowledge for sustainable adoption of technologies requires community participation and strategies which ensure effective and sustainable ways of managing resources (Sinha and Suar, 2003; Rist and Guebas, 2006).

Most important, farmers should be made knowledgeable on component arrangement and technology management in order to reduce competition since managing competition between trees and crops for water, light and nutrients to the benefit of farmers is a determinant of successful agroforestry operation (Sande, 2003). Chirwa *et al.*, (2006) and Makumba *et al.*, (2000) revealed that, competition

between trees and crops was minimized through the intensive tree pruning and planting of trees on proper arrangement and management. In that case, knowledge in proper component arrangements and management is a vital corrective measure in order to raise agroforestry productivity, hence contribution to household food supply and income generation. In addition agroforestry will ensure better use of the limited land resources in the district if undertaken effectively (Lulandala, 2004).

This study also found that, market for agroforestry products was a problem in the area and in addition, there was no standard scale used to value them. It found that, farmers lacked markets and marketing strategies for their agroforestry products, because they had insufficient market information and mostly depended on businessmen for price setting, hence the marketing system was imperfect and farmers received little market value for their products compared to the agents and retailers who gained the profits in the marketing channel. TARP II – SUA (2002 b) observed the market problems to smallholder farmers result from lack of capital and credit facilities in the villages, and that crops were bought haphazardly without standardized scale. Hatibu *et al.*, (1999) and Lyimo-Macha *et al.*, (2005) pointed out that, unreliability of markets and low prices of the products are among the most common problems affecting marketing and farmer's income in relation to actual production costs.

Lack of access to markets (Kashuliza *et al.*, 2002) is certainly influenced by the state of transport and communication facilities which prevent buying agents and/or farmers from reaching certain markets. Kirway *et al.*, (2003) and Franzel and

Scherr (2002) found that, inefficient market and seasonal variations in market prices affected the diffusion and adoption of improved technologies. Therefore, the empowerment of smallholders to organize themselves into producer organizations to enable them to form strong linkages with market actors and raise their bargaining power is a core element to ensuring fair market prices and thus improving their income (Kashuliza *et al.*, 2002).

It was reported that, invasion on agroforestry fields (especially *Ngitili*) and private forests was done by intruders in absence of the owners to a particular area especially during the mid day and sometimes at night. In that case, owners opt to make close monitoring and regular inspections to their fields and forests so as to oversee and notify any invasion and when the invader was court, necessary measures were taken. But when owners were reluctant in carrying out regular inspections, the invaders were happy since they found a loophole of fulfilling their needs on what they do not own. These invasions retard agroforestry performance and hence affect its contribution to household food supply and income. Therefore, regular inspection was a necessary intervention to make sure that agroforestry fields and forests were free from unauthorized users. Huxley and Ranasinghe (1996), and Sinha and Suar (2003) found that, security of the forests and avoidance of free riding emerged as important factors for community participation in tree planting and management.

Farmers groups found in the district indicated to play a great role in agroforestry and environmental conservation activities. Farmers groups were seen as important

means for innovation dissemination because a technology was introduced to more people at the same time; hence facilitated the few extension staff to reach more farmers (Sonoko, 2001; TARP II SUA, 2002 a). Also, groups were seen important in solving some of the major problems such as lack of capital, unreliable market channels for crops and livestock products, availability of monetary services at farmers level such as savings and credit banks (TARP II SUA, 2002 a). Therefore, effort should be made to promote and support farmers groups in terms of training and incentives so that knowledge disseminated on agroforestry technologies could be easily adopted.

NGO activities were pointed to be of beneficial impact to farmers since they disseminate knowledge, and thus become of significant importance in transferring agroforestry technologies. Activities implemented by different NGOs in the district were aimed at improving food security and raising income at household level through increased production. Also, NGOs were involved in the education provision on *Ngitili* establishment and management, aposilvoculture, soil and water conservation through making contour bands, pasture improvement and dry season feeding. Sonoko (2001) revealed that, NGOs were efficient in terms of farmer's supervision frequency and coverage. Therefore, NGOs play an important role in knowledge transfer to farmers apart from inputs and incentives provision (Sicilima, 2003). In that case, there should be a way of motivating and facilitating NGOs and private investors in terms of extension staff and monetary incentives so as to enable them invest into extension services.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the results and proceeding discussion, the following conclusions have been reached:-

- The main sources of sustenance both for food and income in Maswa district are agriculture, agroforestry, business, employment and livestock; agroforestry being the main contributor to household food supply and second to employment in income generation, though people still think agriculture is the main source of livelihood.
- Agroforestry adoption in the district indicated to be low compared to other places, mainly due to the fact that benefits are not encouraging and people do not fully recognize the differential advantages agroforestry has compared to other sources of household food supply and income generation.
- Although there was a slight gain in household income overtime, the trend in food supply remained more or less constant over the 2001 to 2006 period due to stagnation in the rate of agroforestry adoption. This situation calls for an urgent review in the currently being disseminated agroforestry technologies with a view of adopting more diversified technologies with more tangible multiple and diversified benefits.
- Agroforestry has indicated to be more reliable and stable source of household food security and income due to its diversity and capacity to

spread the systems outputs over different seasons of the year, reduction in the need for inputs for improving systems productivity and sustainability.

- ❖ Inadequate knowledge on component arrangement and systems management have shown to be the major factor that constraint agroforestry contribution to household food security and income generation in Maswa district.
- ❖ The reinforcement of local institutions such as *sungusungu* and community assemblies are the interventions urgently required in improving the performance of agroforestry technologies in Maswa district.

6.2 Recommendations

Based on this study, the following recommendations have been reached:-

- Indigenous knowledge (IK) should be given due attention on management of natural resources, especially on protecting trees.
- There is a need for farmers to have land tenure and trees security which in turn will motivate them to participate in the adoption of agroforestry technologies.
- There is an urgent need for the district to allocate adequate financial resources for the improvement of the working environment for extension staff (houses, transport etc), recruitment of staffs at village levels, and NGOs be formally integrated into the extension system.
- Rain Water Harvesting (RWH) in the *Ngitili* should be given due attention so as to ensure availability of water and pasture by capturing running water.

- Research work suggested in a district are: - Screening and evaluation of existing tree species for suitability in grass production, soil regeneration and provision of favourable conditions for grass growth, and to study the amount of water uptake from soil by different tree components so as to derive a convenient inter- and intra-row space between agroforestry components to be used on drier areas like Maswa.

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APPENDICES

Appendix 1: Maswa district crops production trend for a period of five years (2001/02 – 2005/06)

Crops	2001/02		2002/03		2003/04		2004/05		2005/06	
	Ha	Ton	Ha	Ton	Ha	Ton	Ha	Ton	Ha	Ton
Maize	31 190	18 714	32 155	5627	36 978	12 880	48 652	6780	41 582	21 830
Rice	17 956	31 423	14 509	18 282	12 002	11 884	20 716	12 976	9784	14 089
Sorghum	34 447	20 668	26 792	10 716	37 963	23 953	36 054	12 962	29 118	19 800
P/millet	2626	1536	2298	1287	3118	2494	4508	2340	3669	2494
Cassava	2297	5730	1895	4502	1908	5502	8912	1980	8316	18 711
S/potato	20 137	60 411	17 059	30 692	18 589	49 261	21 340	29 870	19 950	53 865
G/nuts	9036	6327	9628	3369	9588	3424	12 471	4365	6979	3851
Cotton	-	21 633	-	22 800	-	18 432	-	37 012	-	45 481

Appendix 2: Rainfall Availability in Maswa District from 2001/02 – 2005/06

Month	2001/02		2002/03		2003/04		2004/05		2005/06	
	MM	Day	MM	Day	MM	Day	MM	Day	MM	Day
September	-	-	-	-	-	-	41.0	6	3.3	1
October	85.3	6	44.2	4	36.5	5	33.7	4	8.8	3
November	47.1	11	195.2	16	45.5	12	68.0	14	58.0	8
December	97.5	13	190.0	10	148.6	15	186.6	19	36.4	6
January	133.8	15	65.2	6	136.9	14	91.4	10	60.3	6
February	252.3	10	42.3	7	133.6	16	75.3	6	10.3	7
March	247.1	12	140.7	15	215.8	16	102.7	11	183.0	13
April	202.7	12	214.9	16	157.8	14	139.0	8	180.0	8
May	95.1	4	126.6	11	131.6	12	62.2	9	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-	-	-
Total	929.6	75	1019.1	85	1006.3	104	799.9	87	552.1	52
Average	12.39		11.99		9.68		9.19		10.2	

Appendix 3: Questionnaire at District, Ward and Village level

1. General Information

Number of Divisions..... Wards..... Villages..... Households.....

Location of a district; latitudes..... longitudes..... Meters (a.s.l.).....

Average rainfall per annum..... Temperature.....

Type of soils.....

District total area.....km^2. Area for agriculture.....km^2.

Area for livestock.....km^2. Area under forest.....km^2.

For habitant.....km^2 for other uses.....km^2

Total population..... Male..... Female.....

Average income per year in a district..... % of poverty level < 1 US$ a day.....

Infrastructure availability.....

Communication services.....

2. Agriculture

What type of crops grown in a district.....

Food crops production in a district (Kg)/Hectare:

Year	Maize	Rice	Sorghum	Potatoes	Cassava	Others
2001/02						
2002/03						
2003/04						
2004/05						
2005/06						
Total						

What factors hinder agriculture in the district.....

.....

Input availability 2001/02 – 2005/06 (Tones):

	Type of input	2001/02	2002/03	2003/04	2004/05	2005/06
Required						
Supplied						
Deficit/ addition						

What are the most pests and diseases affect crops:

	Maize	Rice	Sorghum	Potatoes	Cassava	Others
Pests						
Diseases						

What control measures used: For pests.....

For diseases.....

Food security status in the district:

Number of household with food insecurity in a district

Season/year	Acute	Mild	Secure	Total
2001/02				
2002/03				
2003/04				
2004/05				
2005/06				
Total				

What are the causes of food insecurity.....

Frequency of occurrence; often.....sometimes.....

Which months are likely for shortage of food .....

What are the problems with food storage (i)..... (ii)..... (iii).....(iv).....

What efforts undertaken to fight food insecurity at district level.....

Is there any market for agricultural products in a district? Yes/no... Which.....

Average crops prices (Tshs) 2001/02 – 2005/06:

	Maize	Rice	Sorghum	Potatoes	Cassava	Others
2001/02						
2002/03						
2003/04						
2004/05						
2005/06						
Total						

3. Livestock

Livestock	Amount	Price/animal	Total (Tshs)
Total			

4. Agroforestry

Is there any agroforestry programme in a district? Yes/no.....

If yes, what are the components involved.....

Aim of the programme.....

How many farmers involved.....

How many farmers (in percent) have adopted.....

Constraints.....

Measures for improvement.....

If no, why.....

Appendix 4: Questionnaire at District, Ward and Village level

A. BACKGROUND INFORMATION

Name of respondent.....village.....ward.....

sex.....age.....marital status.....education.....occupation.....

years of stay in a village.....family size.....me.....fe.....

Adults..... Children..... labour force.....

B. FARMING ACTIVITIES

1. Which crops do you grow (i)..... Ha... (ii)..... Ha.....

(iii).....Ha.....(iv).....Ha..... (v).....Ha.....

2. Crop yield (kg/Ha):

	2001/02	2002/03	2003/04	2004/05	2005/06
Family size					
Maize					
Rice					
Sorghum					
Potatoes					
Cassava					
Others					

NB: If there is an increase or decrease in crop yield, why?

3. Do you keep livestock.....yes/no; if yes, which types (i) cattle.....No.....

(ii) Goat.....No.....(iii) Sheep.....No...(iv) Chicken....No...(v)

Others.....No...

4. Sale of livestock products (Tshs)

	2001/02	2002/03	2003/04	2004/05	2005/06
Cattle					
Goat					
Sheep					
Chicken					
Others					
Total					

5. Where do you sell agricultural and livestock products.....

6. What problems do you face with agriculture .....

7. What problems do you face with livestock.....

8. What solutions do you take to overcome both agricultural and livestock problems (i)..... (ii)..... (iii)..... (iv).....(v).....

9. What type of labour used for agriculture activities.....

10. What are the most pests and diseases affect crops:

	Maize	Rice	Sorghum	Potatoes	Cassava	Others
Pests						
Diseases						

11. What control measures used: For pests.....

For diseases.....

12. What are the uses of agricultural and livestock products (i).....

(ii)..... (iii)..... (iv)..... (v).....

13. What inputs do you use on agriculture

Input	**Unity**	**Price**	**Where obtained**	**Affordability**

14. Do you get any farm credits? Yes/no.....If yes, from where.....

15. Which farm implements do you use during:-

	Land preparation	Planting	Weeding	Harvesting	Processing
Farm implement					

C. FOOD SECURITY STATUS

1. What are the sources of food at your family?

	1	2	3	4	5
Source					
Amount					

2. How many meals a day do your family get.....

3. What composition of meals per day.....

4. Which month of harvest.....

5. How much have you stored; crop (i)....kg (ii)....kg (iii).....kg (iv).....kg (v)...kg

6. Which storage structures do you use to store harvests.....

7. What are the storage problems.....

8. How do you overcome them.....

9. How many months do your food cover.....

10. Which months do food shortage mostly occur.....

11. At which frequency often....., or sometimes.....

12. What are the factors that causes food insecurity at family level.....

13. What do you do to overcome food shortage.....

D. HOUSEHOLD INCOME STATUS

1. What are the sources of household income? (i).....(ii).....

(iii).....(iv).....(v).....(vi).....

Sources		(i)	(ii)	(iii)	(iv)	(v)	(vi)
2001/02	MA						
	AI						
2002/03	MA						
	AI						
2003/04	MA						
	AI						
2004/05	MA						
	AI						
2005/06	MA						
	AI						
Total							

NB: MA=Months of availability AI=Average Income

2. What are the causes of poverty.....

3. Is there any land problems.....

4. What land tenure system used.....

E. AGROFORESTRY PRACTICES

1. Do you practice agroforestry.....yes/no

If yes, which agroforestry subsystem practice.....

Why such type.....

Purpose of adopting agroforestry.....

When started agroforestry.....

Where obtained a knowledge.....

Which types of trees are used.....

Which types of crops are used.....

What other components involved.....

What problems with agroforestry.....

What solutions are used to overcome.....

Where do you sell agroforestry product.....

2. Use of agroforestry products:

Product	**Used for**	**Unity**	**Price per unity**	**Total amount**

3. Months of availability:

PRODUCT	MONTHS OF AVAILABILITY

4. What are the benefits of agroforestry (i) food..... (ii) fuelwood/charcoal.....
(iii) Income..... (iv) Employment..... (v) Fruits..... (vi) Poles.....
(vii) Timber..... (viii) Others..... If no, why.....

5. What is the source of household firewood.....
How much used per day..... Average price (Tshs).....

6. Do extension staff visit you?
How many times a week/month/year

Appendix 5: Questionnaire for NGOs and groups (apart from the household questionnaire)

A: GENERAL INFORMATION

Name of a group.....village.....ward.....

Group members:

Age category	sex	marital status	education	occupation

B: ACTIVITIES OF A GROUP

1. What types of activities do a group involved with.....
2. What are the benefits obtained from a group.....
3. What are the employment opportunities in and/or outside a village.....
4. What are the household income sources .....
5. Who control utilization of household income .....
6. What is the food security status at your village.....
7. How do you overcome food insecurity.....
8. Is there any land problems for agriculture in the village.....
9. If yes; what are they.....
10. What type of land tenure system in the village.....
11. Are there any land degradations in a village..... If yes; what are they.....
12. What are the source of firewood .....
13. What its availability situation.....
14. What are common price (Tshs) of firewood.....

Appendix 6: List of villages involved in a study in Maswa District

Division	Ward	Village
Mwagala	Budekwa	Budekwa, Mwamashindike
	Ipililo	Ikungulyankoma, Songambele
Nung'hu	Masela	Masela, Wigelekelo
	Buchambi	Dodoma, Mwabujiku
Sengerema	Malampaka	Gulung'washi, Nyabubinza
	Badi	Bukangilija, Jihu

Appendix 7: Various sources and quantities of household food supply per year in Maswa district in 2006

Sources		Average bags/HH/yr	Average	Percentage
Agriculture	Maize	17.5		
	Sorghum	6.8		
	Rice	11.3		
	S/potatoes (dry chips)	5.4		
	Horticulture	5.4		
	Sub total	46.4	9.3	27.5
Agroforestry	Maize	9.8		
	Sorghum	6.7		
	Ngitili	18.3		
	Sub total	34.8	11.6	34.3
Business	Traditional doctor	5.0		
	Retail shop	2.5		
	Petty trading	9.5		
	Mama lishe	2.0		
	Sub total	19.0	4.8	14.2
Forest	Firewood	1.0	1.0	3.0
Livestock		5.0	5.0	14.8
Salaries	Civil service	4.0		
	Private/NGOs	4.5		
	Casual labour	1.9		
	Sub total	10.4	2.1	6.2
Total			**33.8**	**100**

Appendix 8: Average household income per year from different sources in Maswa district as per 2006

Sources		Average quantity Sold/HH/yr	Average price (Tshs)	Total income (Tshs)/HH/yr	Average income/HH	%
Agriculture	Cotton	1801 kg	367	660 945		
	Rice	223 kg	650	144 997		
	Maize	4 bags	33 000	132 833		
	Horticulture	-	-	90 000		
	Sub-total			1 028 775	257 194	13
Forestry	Firewood	96.4 head load	600	57 820		
	Charcoal	11 bags	6000	66 000		
	Sub total			123 820	61 910	3
Beekeeping	Honey	25 lt	1200	30 000	30 000	2
Livestock	Oxen	2 Ha	17 500	35 000	35 000	2
Business	Bicycle maintance	-	-	228 498		
	Traditional doctor	-	-	445 490		
	Retail shop	-	-	488 248		
	Petty trading	-	-	404 784		
	Mama lishe	-	-	262 730		
	Sub-total			1 829 750	365 950	18
Employment	Civil service	12 months	112 403	1 348 840		
	Private/NGOs	12 months	69 726	836 706		
	Casual labour	-	-	144 511		
	Sub-total			2 330 057	776 686	38
Agroforestry	Cotton	1302.1 kg	393	511 464		
	Ngitili/grass	4.3 Ha	95 978	414 184		
	Firewood	51 head load	600	30 600		
	Charcoal	5.8 bags	6 000	35 106		
	Beekeeping	600 lt	1200	720 000		
	Orange	1.2 Ha	1 027 750	1 233 300		
	Sub-total			2 944 654	490 776	24
	Total			7 862 077	**1 908 273**	**100**

Appendix 9: Mean percentages of peoples' dependence on various sources of food in Maswa district during 2006

Sources/Wards	Budekwa	Ipililo	Masela	Buchambi	Malampaka	Badi	Average
Agriculture	95 a	100 a	100 a	90 a	100 a	100 a	98 a
Agroforestry	15 b	10 b	15 b	20 b	5 b	15 bc	13 b
Business	0 b	0 b	15 b	0 b	15 b	5 bc	6 b
Employment	25 b	10 b	30 b	25 b	45 b	45 b	30 b
Forest	0 b	0 b	0 b	0 b	5 b	0 c	1 b
Livestock	20 b	25 b	15 b	15 b	25 b	35 bc	23 b
LSD	41.2	44.5	41.9	38.9	42.2	43.0	41.9

NOTE: Means in the same column that are followed by the same letter do not differ significantly ($P > 0.05$)

Appendix 10: ANOVA for Agroforestry contribution to Food Security

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit 0.05*	*F crit 0.01*	*Remarks*
Rows	37850	5	7570	153.4459	2.602987	3.854957	Significant
Columns	466.6667	5	93.33333	1.891892	2.602987	3.854957	Not Significant
Error	1233.333	25	49.33333				
Total	39550	35					

Appendix 11: Mean percentages of peoples' dependence on various sources of income in Maswa district during 2006

Sources/Wards	Budekwa	Ipililo	Masela	Buchambi	Malampaka	Badi	Average
Agriculture	90 a	85 a	90 a	60 a	90 a	100 a	86 a
Agroforestry	20 b	25 bc	25 bc	35 ab	5 c	20 bc	22 bc
Business	10 b	45 b	25 bc	0 b	20 bc	10 c	18 bc
Employment	25 b	45 b	45 b	50 a	55 b	55 b	46 b
Forest	10 b	15 bc	10 c	15 b	20 bc	10 c	13 bc
Honey	0 b	0 c	15 bc	0 b	0 c	0 c	1 c
Livestock	0 b	0 c	0 c	0 b	5 c	5 c	2 c
LSD	33.8	32.7	33.4	27.4	35.6	39.2	33.7

NOTE: Means in the same column that are followed by the same letter do not differ significantly ($P > 0.05$)

Appendix 12:ANOVA for Agroforestry contribution to Income generation

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit 0.05*	*F crit 0.01*	*Remarks*
Rows	32595.24	6	5432.54	54.76	2.420523	3.473477	Significant
Columns	419.6429	5	83.92857	0.846	2.533555	3.699019	Not Significant
Error	2976.19	30	99.20635				
Total	35991.07	41					

Appendix 13: Trend of production for various sources of food supply in Maswa district (mean bags/HH) from 2001/02 – 2005/06

Sources	2001/02	2002/03	2003/04	2004/05	2005/06	Mean
Agriculture	7.9 a	6.7 ab	9.2 ab	10.4 a	9.3 ab	8.7 a
Agroforestry	9.5 a	7.0 a	11.0 a	8.6 ab	11.6 a	9.5 a
Business	8.0 a	7.5 a	6.5 ab	6.3 ab	4.8 b	6.6 ab
Employment	3.0 b	3.5 b	1.5 b	2.5 bc	2.1 b	2.5 b
Forest	1.0 b	1.0 b	1.0 b	1.0 c	1.0 b	1.0 b
Livestock	9.0 a	3.5 b	5.1 b	5.9 b	5.0 b	5.7 ab
Mean	6.4	4.9	5.7	5.9	5.6	
SEM	1.4	1.1	1.6	1.5	1.6	
LSD	4.3	3.2	4.9	4.4	4.7	4.3

NOTE: Means in the same column that are followed by the same letter do not differ significantly (P > 0.05)

Appendix 14: ANOVA for trend of food supply from various sources

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit 0.05*	*F crit 0.01*	*Remarks*
Rows	283.96	5	56.792	28.52197	2.71089	4.102685	Significant
Columns	7.1646667	4	1.791167	0.899556	2.866081	4.43069	Not Significant
Error	39.823333	20	1.991167				
Total	330.948	29					

Appendix 15: Trend of income from various sources in Maswa district (mean Tshs/HH) from 2001/02 – 2005/06

Sources	2001/02	2002/03	2003/04	2004/05	2005/06	Mean
Agriculture	215 632 c	209 070 d	207 424 d	205 416 d	257 194 d	218 947 d
Agroforestry	144 710 d	281 480 c	487 230 a	494 100 a	490 776 b	379 659 c
Business	442 000 a	396 670 a	468 570 b	475 560 b	365 950 c	429 750 b
Employment	325 970 b	336 080 b	376 950 c	421 850 c	776 686 a	447 507 a
Forest	80 000 e	45 600 e	49 120 e	67 600 e	61 910 e	60 846 e
Total	1 208 312	1 268 900	1 589 294	1 664 526	1 952 516	
Mean	225 662.4	253 780	317 858.8	332 905.2	390 503.2	
SEM	64 596.8	60 537.6	83 459.2	83 930.2	119 486.3	

NOTE: Means in the same column that are followed by the same letter do not differ significantly (P > 0.05)

Appendix 16: ANOVA for trend of income from various sources

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit 0.05*	*F crit 0.01*	*Remarks*
Rows	3920.318	4	980.0796	6.252727	3.006917	4.772578	Significant
Columns	814.4904	4	203.6226	1.299075	3.006917	4.772578	Not Significant
Error	2507.91	16	156.7444				
Total	7242.718	24					

Appendix 17: The quantities and proportions of agroforestry technologies contribution to household food supply and income in Maswa District during 2006

	Agroforestry technologies	Food supply Average bags/HH/yr	Average	%	Income generation Total income	Average	%
Agrosilviculture	Tree-maize	9.8			-		
	Orange-sorghum	6.7			1 233 300		
	Tree-cotton	-			511 464		
	Sub-total	16.5	8.25	31	1 744 764	872 382	48
Silvopasture	Grass/*ngitili*	18.3			414 184		
	Fuel energy	-			65 706		
	Sub-total	18.3	18.3	69	479 890	239 945	13
Aposilviculture	Tree-bees	-	-	-	720 000	720 000	39
	Grand total	**34.8**	**26.55**	**100**	**2 944 654**	**1 832 327**	**100**

Appendix 18: ANOVA for agroforestry technologies adoption in Maswa District during 2006

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit 0.05*	*F crit 0.01*	*Remarks*
Rows	62.42	2	31.21	1.192663	6.944272	18	Not Significant
Columns	332.0867	2	166.0433	6.345201	6.944272	18	Not Significant
Error	104.6733	4	26.16833				
Total	499.18	8					

Appendix 19: Tree species integrated in mixed intercropping in Maswa district during 2006

Scientific name	Common name	Uses
Leucaena leucocephala	Lucerna	Fe, Gz, Fw, Pl
Moringa oleifera	Drumstick	Fe, Md
Sesbania sesban	Sesbania	Fw, Fe
Azadirachta indica	Neem	Md, Pl, Sd, Ot
Melia azedarach	White cedar	Sd, Pl, Fw, Fe
Citrus sinensis	Orange	Fr, Fw
Acacia nilotica	-	Fw, Gz, Sd, Fe
Grevillea robusta	Grevilea	Fw, Fe, Pl

Key: Fe = fertilizer, Fw = Firewood, Gz = Grazing (fodder), Md = Medicine,

Ot = Ornamental, Pl = Pole, Sd = Shade.

Appendix 20: Tree species integrated in tree – pasture interaction in Maswa district

Local name	Scientific name	Uses
Mihale	*Acacia nilotica*	Firewood, Graze, Shade, Fertilizer
Misuha*		Firewood, Kraal
Masubaia	*Vitex mombassae*	Firewood, Kraal
Migu	*Acacia polyacantha*	Firewood, Shade, Pole
Migunga	*Acacia tortilis*	Firewood, Graze, Pole, Shade, Fertilizer
Mahushi*		Firewood, Pole, Shade, Graze
Misayu*		Shade
Malula	*Acacia seyal*	Firewood, Pole, Kraal
Nsongoma	*Senna siamea*	Firewood, Pole, Shade, Medicine
Mikaratusi	*Eucalyptus spp*	Pole, Medicine, Timber, Firewood
Malugaia	*Acacia mellifera*	Firewood, Kraal
Magwata	*Acacia Senegal*	Firewood, Kraal
Lusina	*Leucaena leucocephala*	Fertilizer, Graze, Firewood, Pole, Shade
Miyuguvugu*		Firewood, Shade
Mkwaju	*Tamarindus indica*	Firewood, Fruits, Medicine, Shade
Mishishi	*Afzelia quanzensis*	Pole, Firewood
Nkoma	*Grewia bicolor*	Pole, Firewood
Mpogolo	*Albizia camara*	Pole, Medicine, Shade
Mfabakazi	*Spathodea campanulata*	Firewood,
Mitundulu	*Dichrostachys cinerea*	Firewood, Kraal

Key: * Trees not found their Scientific names during a study

Appendix 21: Food security status at ward level in Maswa district during 2005/06

		Agroforestry farmers				Non-agroforestry farmers			
Ward	Village	No. people	Bags	Food secure HHs	Food insecure HHs	No. people	Bags	Food secure HHs	Food insecure HHs
Budekwa	M/ndike	11	52.55	1	1	96	301.9	1	7
	Budekwa	11	24.3	0	2	86	313.25	3	5
	Sub total	22	76.85	1	3	182	615.15	4	12
Ipililo	Songambele	13	69.6	1	1	62	275.75	4	4
	Ikungulyankoma	68	173.75	1	2	60	168.25	0	7
	Sub total	81	243.35	2	3	122	444.0	4	11
Total at Division		**103**	**320.2**	**3**	**6**	**304**	**1059.15**	**8**	**23**
Masela	Masela	5	26.25	1	0	91	460.3	5	4
	Wigelekelo	37	80.5	0	4	58	111.5	0	6
	Sub total	42	106.75	1	4	149	571.8	5	10
Buchambi	Mwabujiku	30	102.8	2	2	100	257.25	0	6
	Dodoma	32	88.0	0	3	40	199.5	3	4
	Sub total	62	190.8	2	5	140	456.75	3	10
Total at Division		**104**	**297.55**	**3**	**9**	**289**	**1028.55**	**8**	**20**
Malampaka	Nyabubinza	0	0	0	0	74	268.3	3	7
	Gulung'washi	12	77.15	1	0	85	412.5	6	3
	Sub total	12	77.15	1	0	159	680.8	9	10
Badi	Jihu	0	0	0	0	103	343.0	2	8
	Bukangilija	34	105.5	1	3	98	295.0	1	5
	Sub total	34	105.5	1	3	201	638.0	3	13
Total at Division		46	182.65	2	3	360	1318.8	12	23
Total at District		253	800.4	8	18	953	3406.5	28	66

Appendix 22: Mean percentage of the factors affecting agroforestry adoption in Maswa district in 2006

Factors	Budekwa	Ipililo	Masela	Buchambi	Malampaka	Badi	Mean
Invaders on trees/grass	4.8 bc	9.5 b	7.7 bc	19.2 b	0 c	4.2 c	7 bc
Agromech restriction	0 c	0 b	7.7 bc	3.8 c	0 c	4.2 c	3 c
Drought	0 c	0 b	11.5 bc	3.8 c	9.5 c	0 c	4 bc
Birds settlements	0 c	0 b	3.9 c	3.8 c	4.8 c	0 c	2 c
Competition	19.0 b	9.5 b	15.4 b	15.4 bc	23.8 b	16.7 b	17 b
Fire setting	4.8 bc	0 b	0 c	3.8 c	0 c	4.2 c	2 c
Lack of land	52.4 a	61.9 a	42.3 a	30.8 a	38.1 a	20.8 ab	41 a
Common forests	0 c	9.5 b	11.5 bc	11.5 bc	9.5 c	29.2 a	12 bc
Lack of knowledge	19.0 b	9.5 b	0 c	7.7 c	14.3 bc	20.8 ab	12 bc
LSD	16.5	18.6	12.2	8.9	12.2	10.3	13.1

NOTE: Means in the same column that are followed by the same letter do not differ significantly ($p > 0.05$)

Appendix 23: ANOVA for factors affecting agroforestry adoption in Maswa district

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit 0.05*	F crit 0.01	Remarks
Rows	7341.05	8	917.6313	15.24646	2.18017	2.992981	Significant
Columns	0.005926	5	0.001185	1.97	2.449466	3.51384	Not Significant
Error	2407.461	40	60.18652				
Total	9748.517	53					

Appendix 24: Frequency of extension services in Maswa District during 2005/06

Division	Ward	Frequency of visit by extension staff per year per respondents						
		1 – 5	6 – 10	11 – 15	16 – 20	21 – 25	subtotal	not-visited
Mwagala	Budekwa	2	1	0	0	0	3	17
	Ipililo	3	0	0	0	0	3	17
Total-division		**5**	**1**	**0**	**0**	**0**	**6**	**34**
Nung'hu	Masela	3	1	0	0	1	5	15
	Buchambi	2	1	0	1	0	4	16
Total-division		**5**	**2**	**0**	**1**	**1**	**9**	**31**
Sengerema	Malampaka	3	3	1	0	1	8	12
	Badi	4	1	0	0	1	6	14
Total-division		**7**	**4**	**1**	**0**	**2**	**14**	**26**
Total – district		**17**	**7**	**1**	**1**	**3**	**29**	**91**
Percentage							**24**	**76**

Appendix 25: Mean percentage of the interventions of improving agroforestry performance in Maswa

Interventions	Budekwa	Ipililo	Masela	Buchambi	Malampaka	Badi	Mean
Enforce local institutions	14.3 b	50.0 a	77.8 a	66.7 a	14.3 b	50.0 a	45.5 a
Knowledge provision	28.6 a	50.0 a	22.2 b	0 c	28.6 a	16.7 b	24.4 b
Involvement of NGOs	14.3 b	0 b	0 b	0 c	14.3 b	0 b	4.8 b
Assist farmers groups	14.3 b	0 b	0 b	0 c	28.6 a	0 b	7.2 b
Market availability	28.6 a	0 b	0 b	0 c	14.3 b	16.7 b	9.9 b
Regular inspection	0 c	0 b	0 b	33.3 b	0 c	16.7 b	8.3 b
LSD	12.5	30.0	36.3	32.5	12.5	21.2	24.2

NOTE. Means in the same column that are followed by the same letter do not differ significantly (P > 0.05)

Appendix 26: ANOVA for interventions of improving agroforestry performance in Maswa district

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit 0.05*	*F crit 0.01*	*Remarks*
Rows	7429.889	5	1485.978	4.95391	2.602987	3.854957	Significant
Columns	0.0025	5	0.0005	1.67	2.602987	3.854957	Not Significant
Error	7499.016	25	299.9606				
Total	14928.91	35					