ANALYSIS OF "NGITIRI" AS A TRADITIONAL SILVOPASTORAL TECHNOLOGY AMONG THE AGROPASTORALISTS OF MEATU, SHINYANGA, TANZANIA

BY

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ABSTRACT

A diagnostic survey was conducted in Meatu district agropastoral land use system, to iteratively refine the "ngitiri" (a traditional fodder reserve under silvopasture system) among the agropastoralists of Shinyanga, Tanzania. The study was based on a descriptive diagnosis and design (an ICRAF methodology), to identify the components, structure, management and the technological specifications of the "ngitiri". The diagnostic survey was complemented with a blend of qualitative land evaluation and descriptive socio-economic and ecological evaluation of the silvopasture land use. The qualitative land evaluation, was conducted based on the four mapping units of vegetation strata, established through photo interpretation of current satellite imagery, vegetation maps and ground truth surveys (DRDP, 1997). Out of the four strata, two were combined to form three effective sampling strata for diagnostic survey. Sixty household individuals were purposefully selected, (twenty from each of the three effective sampling strata), among individuals practising "ngitiri" system, whereas three representative "ngitiri" were purposefully selected from the vegetation cover types of the representative effective sampling strata. The data were collected using the ICRAF Diagnostic and Design methodology and the FAO Guideline for Land Evaluation. Twenty multidisciplinary individual staff, involved in land husbandry were purposefully selected for triangulation, from a number of departments in the districts. The Statistical Package for Social Science (SPSS) programme, content structural analysis and categorisation of social information, together with suitability

rating, were used in data analysis. The social survey and resource assessment methods of triangulation of information, was employed in content structural analysis of social information. The study identified the specification for "ngitiri", comprising of; 17 commonly grazed fodder grasses, 25 commonly browsed herbs and forbes, and 25 browsable tree species. The district suitability rating for extensive grazing and community forestry were established, together with extension and research, needed for sustainable ecological land use under "ngitiri" silvopasture practice. Among the tree species found in "ngitiri" fodder reserves, 88% had an environmental role to play in the agropastoral ecosystem. Among the 60 informants interviewed, 95% indicated the potential of "ngitiri" to mitigate dry season fodder shortage, and supported the use of "ngitiri" to supply dry season fodder, while 85% supported "ngitiri" to have potential for mitigating environmental degradation. Among the 20 purposively selected professional staff, all indicated "ngitiri" to have potential for production and supply of dry season fodder, and mitigating environmental degradation, when properly used and managed. The survey identified and prioritised overgrazing, drought, termite attack, seedling mortality, lack of title deeds, encroachment, tsetse flies, water scarcity, tick borne diseases, lack of veterinary services, cattle rustling and land scarcity as the major problems affecting silvopasture land use. The study establishes the gaps for sustainable "ngitiri" management, improvement and potential silvopasture suitability rating. Furthermore, the study points some basic needs to brigde the gaps in extension, research and policy reforms, with respective recommendations.

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DECLARATION

I **GERALD JONES KAMWENDA**, do hereby declare to the Senate of The Sokoine University of Agriculture that the work presented here is my original work, and that it has not been submitted for a higher degree in any other University.

Signature.....

Date: 27/10/1999

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DEDICATION

This work is dedicated to my father Jones Kamwenda and my mother Diana Kamwenda, who sacrificed a lot towards my education.

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ABBREVIATIONS AND ACRONYMS

ANAFE	African Network for Agroforestry Education
DALDO	District Agriculture and Livestock Development Officer
D and D	Diagnostic and Design methodology
DHV	Dwars, Heederic en verhey, consulting engineers
DRDP	District Rural Development Programme
ETP	Evapotranspiration potential
P	Mean monthly rainfall
HASHI	Hifadhi Aridhi Shinyanga
ICRAF	International Centre for Research in Agroforestry
ILACO	International Land Development Consultants
MNTE	Ministry of Natural resource, Tourism and Environment
RPRA	Rapid participatory rural appraisal
SUA	Sokoine University of Agriculture
SPSS	Statistical package for social science

CHAPTER 1

1.0 INTRODUCTION

1.1 Background information

Agropastoralism as an important land use system in many countries, is becoming more so as more pastoralists settle, in response to the pressure on their traditional grazing pattern. Under agropastoralism the most prevalent land use system is silvopasture (Jordan, 1992). The Wasukuma agropastoral system of Shinyanga, involves individually farmed arable plots and communally or privately owned grazing lands. Cattle ownership indicates social status and financial capital. The animals provide milk and manure, and of increasing importance in the system is the use of animals for drought power (Mugasha et al., 1996; Jordan, 1992).

In the past, Shinyanga region had been extensively forested with woodland and bushland species, such as Acacia species, Brachystergia species, Albizia species, Commiphora species and Dalbergia species. However massive deforestation through shifting cultivation, tsetse flies control campaign in early 1920's, and most recently extensive grazing, constitute today a major environmental threat in this region (Misana, 1996). Environmentally derived threats in this region include; the decline in soil fertility and the subsequent low crop yields, shortage of dry season fodder, woodfuel, construction poles and severe wind and soil erosion (MNTE, 1995).

1.2 Justification of the study

Many indigenous agroforestry systems in Tanzania and in tropical Africa in general, have not been studied in detail and documented, and some are being lost (Moshi, 1997; Nair, 1983; O'Kting'ati, 1985; King, 1979). The International Centre for Research in Agroforestry (ICRAF) in 1983, set aside as its main global mission, to make an inventory of the existing agroforestry systems, to describe and document them, so as to devise a way to improve their productivity (Nair, 1983). Gathering and synthesizing of information about indigenous agroforestry systems in Tanzania falls within this broad mission of ICRAF, the few inventories carried have indicated entry point for improvements (Moshi, 1997; Mugasha et al., 1996; Otysina and Asenga 1994; 1993; O'Kting'ati, 1985 and O'Kting'ati et al., 1984). In Shinyanga region, traditional agropastoralists had been practising "ngitiri" as an indigenous silvopastoral system. "Ngitiri" are farmer led initiative that evolved out of the traditional strategies in grazing. It encompass retaining of an area of standing hay until the rain season ends, the area remain closed to livestock at the onset of rain season and opened up at the peak of dry season, to allow the livestock get dry season fodder (Mugasha et al., 1996; Otysina and Asenga, 1994; Maro, 1995 and Leach and Mearns, 1988). These "ngitiri" are also regarded as dry season fodder reserves (Otysina and Asenga, 1994). In Shinyanga region, "ngitiri" are extensively under practice; and a number of studies have been conducted on aspects of productivity, socio-economic evaluations, ecological evaluations and conservation values such as fodder production that mitigate

environmental degradation at the same time. Although this indigenous silvopasture technology is well known among the Sukuma agropastoral community and the local staff in Shinyanga, it is little known by the majority of the agropastoral societies in Tanzania and in Africa at large, particularly on its potential to alleviate the dry season fodder shortage, while at the same time mitigating environmental degradation. Further more the "ngitiri" structural features, functional relationship, the technological specification and its suitability, are neither well detailed nor documented in a scientific literature.

Between 20% - 30% of the livestock in Tanzania are found in Shinyanga, and 18% of the land in Shinyanga is utilised for livestock keeping. Meatu district in Shinyanga region, has the highest number of livestock, totalling to 1 104 627 according to URT (1996) projections. The impact of grazing is very severe in this district than the rest of Shinyanga region (Mugasha et al., 1996; URT, 1996). The pressure on grazing land in Shinyanga is quite intense and will continue to become worse, given the high growth rates of livestock of 3%-5% per annum, short duration of grasses, and lack of multiple land use planning (MNTE, 1995). For sustainable land resource utilisation and management, there must be fundamental changes in all disciplines related to land use, with the need to incorporate multiple land use approaches such as silvopasture system (Temu, 1994). Meatu district needs reappraisal of its forestry sector versus livestock production systems (MTNE, 1995).

1.3 Objectives

The overall objective of the present study was to carry out a descriptive diagnostic and design survey for "ngitiri" (traditional dry season fodder reserves) specifications, which at the same time mitigate environmental degradation among the agropastoralists of Meatu, Shinyanga, Tanzania. The specific objectives were:

- To conduct qualitative and descriptive evaluations of indigenous ecological knowledge and socio-economic values of sustainability aspects of "ngitiri" system, which contribute to soil conservation.

- To identify the specifications of "ngitiri" traditional fodder reserves and make an inventory of components, structure and management practices.

- To conduct a qualitative land evaluation of the silvopasture land use (Community forestry and extensive grazing) so as to draft a potential suitability classification for the district.

- To identify areas of extension and research needs for appropriate improvement and management of the "ngitiri" traditional fodder reserves.

1.4 Limitations and assumption of the study

1.4.1 Limitations of the study

The study is restricted to descriptive diagnostic and design survey of a case at micro level and meso level, specific for dealing with household and farm level management respectively. The macro Diagnostic and Design survey that deal with more large scale areas was not dealt with. The land evaluation for suitability classification of the silvopasture land use (Forestry and extensive grazing) is based on qualitative land evaluation for the potential land use suitability classification, this ignores the current land use which is not based on suitability classification.

Though the study is confined to Meatu district, which reflect to a large extent the various representative cases of animal and tree interface found in Tanzania, the result of this study is not going to be a representative of all cases of tree and animal interfaces but rather a preliminary treatment, hence more site specific comparative studies need to be done in other areas.

1.4.2 Assumptions under the study

It is assumed under this study that:

- The "ngitiri" traditional fodder reserves which are based on indigenous ecological knowledge, and their respective socio-economic values are appropriate for sustainable management of woodlands, and rangelands soil conservation, hence their improvement will facilitate sustainable soil conservation efforts.

- Reform measures on some aspects of management of "ngitiri"and interventions on soil conservation, are needed by farmers, these will improve the role and awareness that woodlands play to local communities living in the respective areas, through appropriate reseach and extention. The most promising reform measure should be the potential suitability rating and classification, for the district silvopasture land use.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Conventional agroforestry systems

As Nair (1993) and Lundgren (1982) point out, agroforestry systems stresses two common characteristics, common to all agroforestry systems, that separate them from other land use practices, namely:

i) The deliberate approving of woody perennial on the same unit of land as the agricultural crops, and/ or animals, either in some form of spatial mixture or temporal sequence.

ii) There must be a significant interaction which is either positive or negative between the woody and non woody components of the system, reflecting ecological and/ or economical interaction.

Alternatively agroforestry systems can be defined as a collective name for land use systems and technologies where woody perennial namely; trees, shrubs, palms, and bamboo, are deliberately combined with agricultural crops and/ or animals in some form of temporal or spatial sequence.

In agroforestry systems there are both ecological and economical interactions between the different components (Nair, 1993; Lundgren, 1982; Rocheleau, 1988). On the other hand Leakey (1996) defines agroforestry systems to be dynamic, ecologically based, natural resource management system, that through the integration of trees in farm and rangelands, diversifies and sustains small holder production for increased social, economical and environmental benefits.

2.1.1 The silvopasture system

Silvopasture system, also referred as silvopastoral system, is an agroforestry system, that involve the incorporation of trees and shrub management with animals (Burley, 1987). It is also defined as a system that involve cropping of trees and grazing, under storey grasses and bushes, in forests and plantations (Tejwan, 1987).

2.1.1.1 Productive functions of silvopasture system

In many places of the world, the implementation of silvopasture systems, have resulted into sustainable and efficient land use alternatives. Silvopasture systems have been used to sustain and diversify production in marginal lands, in arid and semi arid zones, and low fertility soils, they have been used for the production of a number of wood products and alleviation of the dry season fodder supply shortage (Ormazo'bal, 1991).

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

Table 1:The effect of supplementing "blended goats" fed with *Cenchrus ciliaris* hay, with dried tree leaves, on milk yield and body weight changes, in does and kids.

	Hay & *Delonix elata*	Hay & *Albizia* harvey	Hay & *Gerewia similis*
Total milk yield	25± 0.3	2.4 ± 3	4.2± 0.3
Daily gain (g/day)	43.5± 0.9	40.9± 9	51.0± 0.9

Mean within raw significantly different at $p \leq 0.05$

Source: Goromela (1996).

2.1.1.2 Protective and service functions of silvopasture

Browse species under silvopasture systems, are the best ways of utilising marginal lands, where normal crop production cannot be effective. Shrubs and trees interplanted with grasses, have the capacity to increase the carrying capacity of the pasture area (Le Houe'rou, 1980a). The extensive roots of trees and shrubs adopt well to steeply slopping slopes, where both grazing and cultivation of crops foster erosion, in doing so trees had been stabilising sandy and eroding soils, and help stabilise them against torrential and tropical wind storms. Le Houe' rou (1980a) reports the importance of browse trees and shrubs, as the biggest supply of dry season fodder in arid and semi arid areas, and montane place. Browse species enable the standing feed reserves to build up, so that herds can withstand critical periods of grass shortfalls in prolonged drought without losses of weight.

2.1.1.3 Silvopasture as an integrated land use

Studies done by Le Houe' rou (1980b) indicate that; neither grazing nor browsing alone can provide and ensure year long productivity of livestock, under this conditions the optimum number of fodder trees and shrubs are essential, to be incorporated into the silvopasture system. The elimination of browse species, which encompass mostly of trees and shrubs, leaves livestock extremely vulnerable during prolonged drought, with an unbalanced diet during the dry season. Le Houe' rou (1980b) reports that, the

optimum equilibrium of browse fodder trees or shrubs for livestock diet, should be 20% to 30% of the total fodder herbage. URT (1990) has recommended silvopasture as a promising integrated land use, as research have indicated that it can provide extra wood biomass for woodfuel, alleviate dry season fodder supply, and at the sometime mitigate environmental degradation. Otysina and Asenga (1994), report some potential multipurpose tree species, that have fodder values and can produce substantial biomass if are integrated into "ngitiri" or in rotational woodlot in Wasukuma agropastoral land use.

Table 2: Wood and twig biomass yields for *leucaena Leucocephala* and *Acacia polycantha* in four and five years old wooldlot in (t/ha).

Years	*L. Leucocephala*		*A. polyacantha*		
	Wood	twigs	wood	twigs	Total
4 years	9.06	2.63	12.73	2.91	15.64
5 years	9.44	1.38	5.95	2.01	7.96

Source:Otysina and Asenga, (1994)

2.1.1.4 Socio-economic and Ecological aspects of silvopasture

Harcharic (1997) has commented that, "sustainable forest management is the most

important concept of our time, that directly affects the future of all the worlds forests and all the world's people. If trees and forests are to deliver their full potential to sustainable development, they must be considered from a holistic view point, and managed accordingly, this requires a conceptual framework that unites sciences with social science consciousness, through sharing of experiences in implementing sustainable forest management, and to identify short-comings and gaps in our knowledge on sustainable forestry resource management for sustainable development. The socio-cultural dimension of modern forestry management provide the newest and great challenge to foresters". In that respond O'Kting'ati (1985) has reported agroforestry systems to provide many benefits to farmers and society, with a good combination of tree species and food crops or animals. He reports such combinations to be able to provide direct benefits such as food, fodder, fuel wood and shelter belts to farmers. Additionally, indirect benefits to farmers and society include reduction of soil erosion, improved utilisation of rainfall, improved soil fertility and the reduction in demand for more land, to support subsistence agriculture.

Forests and forest tree products respectively, are linked to household livelihood systems in a variety of ways. The principal features of these links are well known e.g. medicinal values, food and fodder sources among others, that indirectly enable people to survive periods of agricultural shortfalls (Msangi, 1995; Gottle and Sene', 1997).

2.1.1.5 Socio-economic aspects of silvopasture system

A number of socio-economic values and roles of silvopasture system among the agropastoral Wasukuma of Shinyanga, have been reported by Msangi (1995), Maro (1995) and Kilahama (1994) .

The socio-economic values of silvopasture systems are reinforced by the results shown in table (3) below.

Table 3: Farmers responses on the benefits of "ngitiri" in Shinyanga

Information	% Respondnts			
	Oldshy (n=32)	Mondo (n=24)	Sanya (n=24)	Total (n=80)
Fodder/pasture	46.0	46.6	51.4	48.0
Wood products	22.9	44.7	14.7	27.4
Thatching grass	25.9	7.8	22.2	18.6
Source of income	3.4	3.9	4.4	3.9
Improve soil fertility	-	-	3.4	1.0
Beekeeping products	-	-	3.4	1.0

Source: Msangi (1995).

2.1.1.6 Ecological aspects of silvopasture systems

O'Kting'ati (1985), Nair and Sreedharan (1986), succinctly elucidated the social ecological functional aspects of silvopasture systems, for income generations and provisions of subsistence needs. They report forests and trees to deliver the functions of protection or conservation expected from it only, forests and trees in silvopasture system, if allowed to grow with sufficient strength and vigour, can encounter physical forces affecting soils through water erosion. It is the same tree vigour that allows well structural architecture and rich foliage, that can counter wind erosion, provide fodder and the micro climate (Gottle and Sene', 1997). A number of ecological benefits exist, namely:

i) Protection of water

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

ii) Protection of soils

Maro (1995), Kilahama (1994) and Msangi (1995) report the effectiveness of "ngitiri" traditional fodder reserves, to conserve and protect the soils, and reclaim degraded land. The forest and tree canopy cover, slow down the wind, while its dense network of roots hold down the soil in place. These characteristics protect the soils against

wind, water erosion and land movement (Gottle and Sene', 1997).

iii) Amelioration of local climates

Gottler and Sene' (1997) report trees to have definite practical effect, on the neighbouring human settlement and animals under pasture. This capacity is important in protecting inhabitants from dusty winds (Msangi, 1995; Maro 1995; Kilahama; 1994). Through the control of wind velocity, trees may retain solid suspension (Gottle and Sene', 1997).

iv) Conservation of habitats and biological diversity

Silvopasture systems under arid land, have direct physical and biological protective functions and micro climatic amelioration, that protect the biological diversity (Gottle and Sene', 1997). The richness of the biological diversity, species diversity, species composition and their abundance are high in "ngitiri" fodder reserves (Otysina, 1994).

v) Pests and diseases

The presence of trees on a silvopasture system or land management units, attract wild animals and insect pests, that in turn can cause problems to the associated crop livestock (Otysina and Asenga 1994). The authors report trees to provide ready nesting, food, and resting for birds that destroy agricultural crops, such as millet, sorghum and maize. It has been observed that an increase in the extent of "ngitiri" conservation area and afforestation efforts, through planting trees in Meatu district, the number of tsetse flies has now increased (Otysina and Asenga, 1994).

2.2 Indigenous knowledge in agroforestry systems.

The term indigenous knowledge as used by most agroforestry researchers, refers to the decision making made on daily basis by the local people in regeneration, protection and use of trees and tree crop (Indigenous Knowledge Monitor, 1993).

According to Kajembe (1994) local people have accumulated knowledge of manipulating trees, through practices such as pollarding, lopping and pruning, and by respecting or not respecting both formal social control and common sense rules on harvesting herbs, shrubs and trees or other forestry resources, in this way local people have shown their knowledge of agroforestry.

Kajembe (1994) reports that, local people are not necessarily destructive of their environmental resources as it is believed, instead they manage and use the vegetation sustainably. There are instances where informal and formal rules exist to enhance the productivity or protection of rampant cutting of trees, as for example among the Pokot and Turkana of Kenya (Barrow, 1991) and the Wasukuma of Shinyanga (Otysina and Asenga, 1994). Among the local population in the tropics, the protection of trees and shrubs has been seen to have taken two forms; prohibition and restriction on the use of some highly valued tree species, and the protection of all trees and shrubs in reserved areas (Gerden and Mtallo, 1990). Fisher (1989) points that the concept of indigenous agroforestry management, refers to a series of practices based on consensus user rights

and agreed rules, carried out by local people living at the sustained availability of products and services from trees and crops, for today and for the future generation, these practices are normally generated by internal initiatives within the local community itself.

2.2.1 The concept of agropastoralism

Agropastoralism involves individually farmed plots and communal grazing land, under it the most important land use application system is the silvopasture system, that is mostly the extensive grazing of livestock on woodlands, rangelands and grasslands, (Jordan, 1992). Cattle ownership provide the social status and financial capital to the agropastoral community, the animals are also used for drought power, especially cattle (Mugasha et al., 1996). According to Huxley and Westly (1989) agropastoralism is defined as a land use practice with distinctive combination of land resources, technology and land users' objectives. The authors site as an example of the agropastoral land use, system such as shifting cultivation, with rotational grazing of livestock on fallow areas, and on the farms during the off-season periods to feed on crop residues, after the crops have been harvested on the farms.

2.2.2 Ngitiri as a traditional agroforestry system

"Ngitiri" is an indigenous silvopatoral technology (Malcom, 1953; Brastrom,1985). Wiersum (1987) cited in Moshi (1997) reports traditional or indigenous agroforestry systems, to have evolved through the adaptive strategies of the local farmers, to changing social economic conditions. He reveals agroforestry practice to be a very old tradition, which may have evolved over long time from the hunters and gatherers of fruits, and continued to ancient civilisation up to modern times. The ancient practices of mixing trees and agricultural crops or livestock may have originated as early as the seventh millennium. Shifting cultivation, one of the rotational practices, in which the association between trees and crops, with temporal and spatial grazing take place, is one of the reported indigenous agroforestry systems (Young, 1990).

2.2.2.1 The "ngitiri" system and its rationale under agropastoralism

"Ngitiri" are farmer led initiatives among the Wasukuma agropastoralists, evolved out of traditional strategies in grazing (Leach and Mearns, 1988). As Otysina and Asenga (1994) put it, "ngitiri" involve retaining an area of standing hay at onset of rain season, until rain season ends. The "ngitiri" area remain closed to livestock at the beginning of the wet season and is opened up at the peak of dry season; and this is reaffirmed by Musa (1981) who pointed out that the improvement of such natural pastures like "ngitiri" had been necessary if diary products and beef production levels in the country

were to be increased. In Shinyanga the most important constraint expressed by farmers which limit livestock production, is the shortage of fodder. The dry season is the most stressful period to have fodder, resource supply gets to its lowest level, especially in years with insufficient rainfall (Msangi, 1995; Maro, 1995). Basing on findings of Otysina and Asenga (1994), the dry season fodder supplies, both browse and graze, and the low quality of the existing dry grass fodder during the dry season, are the most important animal production constraints in Shinyanga region. The authors further revealed that, the practice has been for the farmer to divert the animals to crop land after harvesting, to feed on farm residues. Nevertheless, this sort of dry season fodder does not last the period of grass shortfall, and cattle has therefore been facing hardship year to year. Drought years could even be more disastrous to both cattle and human as well. Unfortunately modern supplements in the form of concentrates are not commonly used (Kessy et al., 1988). The phenomenon of plenty and scarcity of fodder supplies as reported by Osunade (1990) explains the low quality of the animals and vulnerability of the animal husbandry sector in Africa. He forecasts the dependency of the farmers on natural grazing to be with us for a very long time to come, but suggested the changes for improvement to begin now. In a study on agropastoral societies in Africa, Curtis and Ruddy (1990) report the extensive and intensive disturbances of human related activities on agropastoral environment, which have rendered these traditional systems less sustainable. The authors suggests micro and macro scale evaluation, in order to capture the cumulative effects of the local communities on agropastoral land use.

2.2.2.2 The rationale of the "ngitiri" system

The magnitude of environmental degradation and its subsequent effects due to overgrazing and haphazard exploitation of rangelands forestry resources, seem to have overwhelmed the indigenous people, who previously used to live harmoniously with these vital environmental resources (Curtis and Ruddy, 1996). These people definitely need an external assistance to redress the burden, and reverse the trend towards severe environmental degradation. However these agropastoral societies are not expecting totally alien practices, that do not recognise them for what they are used to (Osunade, 1993). Traditional management systems, such as "ngitiri" for management of pasture and livestock, should be improved for the supply of dry season fodder, protection of the environment and supply of wood based products among agropastoralists of Shinyanga. "Ngitiri" are inherent among the Wasukuma, and are capable of mitigating environmental degradation (Mugasha et al., 1996, Maro, 1995, Otysina and Asenga, 1994).

2.2.2.3 Extent of "ngitiri" in Shinyanga agropastoral land

According to Otysina (1994) studies done in Shinyanga region indicated that, 67% of the farmers own "ngitiri", while 71% had an access to use them in dry season, whereby farmers who do not have personal "ngitiri" had an access to communal or village reserves. He reports the system to be widespread and common in all of the six districts

in Shinyanga region. The author further reports the concept where natural vegetation is conserved, protected and allowed to vegetate, based on the old traditional "ngitiri" practices, to have been reintroduced to reverse the severe land degradation and deforestation by the HASHI (Hifadhi Ardhi Shinyanga) Soil Conservation Project. Discussion with farmers' groups have revealed that, with the gradual breakdown of "Ujamaa" villagization system and the influence of the HASHI in-situ conservation practices, more and more farmers are getting back to previously owned "ngitiri", while others are establishing or are willing to establish new ones. This shows the great value attached to this natural resource, silvopasture based management practice, among the Wasukuma agropastoralists (Maro, 1995). Major problems confronting "ngitiri" system today include, scarcity of land to establish new "ngitiri", encroachment of "ngitiri" by other pastoralists and low quality of fodder during the dry season attributed to low availability of quality fodder species, and the land restrictions by Government laws (Msangi, 1995; Maro, 1995). Otysina (1994) reports a number of perceived ways to improve the "ngitiri" system that include, introduction of improved fodder grasses, planting of fodder trees, rotational grazing and destocking, thinning of existing trees to encourage grass growths, expansion of "ngitiri" coverage areas, and introduction of by-laws protecting these "ngitiri". The author further reports that, the Wasukuma have good knowledge on uses of trees and browse species, however, they lack the knowledge of propagation, planting and management of trees. Along with the provision of improved MPTs and grasses, there should be a need to train farmers to plant, conserve and manage trees (Otysina, 1994).

2.2.2.4 Types of "ngitiri"

Two types of "ngitiri" can be identified, private "ngitiri" and communal "ngitiri", the two differ in size, location and management. Individual or private "ngitiri" are located around homestead, along lowland river ways and on-farm lands away from homestead (Malcom 1953; Brandstrom, 1985; Maro, 1995; Msangi 1995).

Malcom (1953) and Brandstrom (1985) noted the homestead locations to be more preferred for calf grazing during the wet season. Depending on availability of land, the size of "ngitiri" vary from 0.2 to 20 hectares, with an average of 20 hectares. "ngitiri" on farmland serve several purposes including; the provision of fodder during the dry season, soil restoration through fallowing and nutrient cycling and protection of land ownership rights (Otysina, 1994). Communal "ngitiri" are reported to be established with mutual consent of village members. They consist of large areas of 10 to 20 hectares, with an average of 50 hectares. The communal "ngitiri" only exist in shinyanga rural and Maswa districts, these were established during "Ujamaa" villages (Maro, 1995; Otysina 1994). Individual ownership pattern of "ngitiri" is reported to have very positive implication in management, improvement and development, as farmers had been more willing to undertake development work on their own land (Msangi, 1995).

2.2.2.5 Management of "ngitiri"

"Ngitiri" are traditionally established on degraded croplands and rangelands, mainly for fodder supply. The sites are demarcated during the wet season, and protected from grazing until the most critical fodder shortage period in the dry season. Initial sitting of "ngitiri" area is the responsibility of the family head, in case of the private "ngitiri", whereas a group of elders is involved in case of the communal "ngitiri". Site selection is governed by land availability, proximity to homestead, production potentials and ease of protection (Maro, 1995; Msangi 1995; Otysina, 1994; Kilahama, 1994). Studies by Kilahama (1994), Otsyina and Asenga (1994) and Maro (1995) report that, very little management is required during the rain season, other than regular protection from grazing animals. Although "ngitiri" boundaries are not rigidly demarcated, the ownership right is highly respected and protected by the local community by-laws, which employ local scouts, known as "Sungusungu", and impose heavy penalties on offenders. Recently however, the effectiveness of the community forces has declined considerably leading to conflicts and tresspassing.

2.2.2.6 Structure and composition of "ngitiri".

The main components of the "ngitiri" system are a number of distinct vegetation strata and the livestock that are traditionally grazed during dry period (Maro, 1995; Msangi, 1995). "Ngitiri" structure and composition depend on age and management. Two

distinct vegetation strata can be identified: the upper tree stratum dominated mainly by *Acacia species* and the lower herbaceous substratum of grasses, forbes and herbs. Dominant trees include *Acacia nilotica, Acacia drapanalobium* and *Orchocarpus trichocarpum* (Otysina, 1994; Otysina and Asenga 1994). Livestock interacts significantly with vegetation and plays a very significant role in the management and sustainability of the system (Kilahama, 1994).

2.2.2.7 Grazing management in "ngitiri"

Grazing under "ngitiri" normally starts from July/ August of the year after crop residues and forage in fallow areas have been depleted. Animals are removed from "ngitiri" after all the fodder is depleted, or when fodder becomes available outside the "ngitiri" (Kilahama, 1994; Otysina and Asenga 1994).

Farmers prefer to graze on communal "ngitiri" or rangelands first, and serve private "ngitiri" for later use when feed sources are exhausted (Otysina, 1994). Various rotational grazing management strategies have been developed by the Wasukuma, to ensure prolonged availability of fodder on "ngitiri" during dry season (Malcom, 1953). The most common system presently used, can be described as progressive deferred grazing, which involves demarcation of paddock for specific periods. Upon completion of fodder on particular paddock, animals are moved to a fresh paddock. Duration of grazing on a paddock depends on its size, availability of fodder and the

number of animals (Malcom, 1953; Otysina, 1994). In communal "ngitiri", demarcation of paddocks and movements of animals between paddocks, is controlled by well informed and experienced elders, who apparently make management decisions on specific indicators, such as level of utilisation and availability of fodder (Kilahama, 1994).

2.2.2.8 Importance of "ngitiri" to livestock production.

In the past, private homestead "ngitiri" were grazed mostly by calves, oxen and lactating cows (Malcom, 1953). However, the persistence of dry season fodder shortages, has increased the number and type of animals grazed in "ngitiri" (Kilahama, 1994). Although all types of animals including small ruminants (sheep and goats) are now grazed on these reserves, most farmers would prefer to graze only oxen and calves, on both private and communal "ngitiri" (Otysina, 1994). Seemingly as reported by Otysina (1994), "ngitiri" are important source of fodder for animals in the dry season, also "ngitiri" grazing minimises weight loss, improves condition of oxen just before the onset of the cultivation season, increases the animals survival and possibly increases milk yield among lactating cows.

2.2.2.9 MPTs management and utilisation on "ngitiri"

Malcom (1953) and Brandstrom (1985) report the concept of "ngitiri" to have primarily aimed at enhancing grass production, large trees that would possibly deter fast grass growth were destroyed, special multipurpose and fodder trees had till todate, been protected on "ngitiri". Most often tree species contribute to fodder for livestock, especially goats and to a lesser extent cattle, after most of the grasses has been grazed. In recent times, a number of multipurpose trees are considered not hazardous in terms of reintroducing tsetse flies. Acacia species is the most dominant tree species in all of the "ngitiri" in Shinyanga districts (Otysina, 1994).

2.2.2.10 Implication of "ngitiri" in agroforestry

As the National agroforestry task force (1988) reported, the traditional "ngitiri" system together with the underlying ecological and management concepts, provide a valuable opportunity and a basis for development of a sustainable silvopastoral agroforestry system in Sukumaland. Earlier Diagnostic and design surveys by the National agroforestry task force (1988), identified scarcity of fodder in dry season, scarcity of fuelwood and poles, and the declining soil fertility and soil degradations, as being the most important land use constraints in the Wasukuma agropastoral system. The "ngitiri" by virtue of their composition mainly trees, shrubs, grasses and their interaction with livestock constitute an ideal agroforestry system capable of

eliminating most of the above constraints. Kilahama (1994) and Maro (1995) report the extensive traditional knowledge base to be existing among farmers, regarding the values of trees and grasses, ecological bases of "ngitiri" location and management, and general acceptance of the system, this has provided valuable potential tools for developing parallel agroforestry technologies, such as fodder banks and improved fallow systems. In addition to the development of sustainable silvopastoral systems, it is also possible that the "ngitiri" system analogy, could be valuable for developing other agroforestry technologies on crop lands, which could combine fodder production as well as soil fertility restoration in space and time (Mugasha et al., 1996).

2.2.3 "Ngitiri" traditional fodder reserves as a silvopasture technology

A technology refers to a type of agroforestry techniques, such as hedge row intercropping, fodder bank or home gardens (Rocheleau and Mearns, 1988). More narrowly, the technology may refer to the specific variants of agroforestry techniques, such as maize - leucaena alley cropping, and finally technology may refer to an established practice such as pruning or pollarding (Huxley and Westly 1989). Silvopasture technology in that sense, could encompass "ngitiri" traditional fodder reserves (Lulandala, 1997; Mugasha et al., 1996). Traditional "ngitiri" system, along with the underlying ecological and management concepts, provide a valuable opportunity and a basis for development of sustainable silvopastoral agroforestry systems in Sukuma-land (Mugasha et al., 1996).

A review of past "ngitiri" management system (Malcom, 1953; Brandstrom, 1985; Maro, 1995; Otysina and Asenga, 1993; Msangi, 1995; Kilahama, 1994) indicate "ngitiri" to be very popular among the Wasukuma of Shinyanga since 1920's. Each cattle owner in Shinyanga region reserved grassland in the fallow arable land, partly to supply thatching grass, but mainly for livestock pasture. Trees are reported to have an added advantage in agropastoral Shinyanga, through providing valuable dry season forage, especially during the late dry season, when other sources of fodder are not locally available (Maro, 1995). The knowledge about various tree species and their importance among farmers in rangelands management for silvopasture, has been described as of long history on Shinyanga (Kilahama, 1994).

2.2.3.1 Sustainability aspects of "ngitiri" traditional fodder reserves

Maro (1995), Otysina and Asenga (1994), report a number of issues for longterm sustainability of the "ngitiri" fodder reserves, in the Sukuma agropastoral systems, that require more focus on rural settings, general farmers' influence and the control of the biophysical environment. The authors basing on their studies, recommend for sustainable development of "ngitiri" system, the following issues:

i) Formulation of land use policy and guidelines for different land uses such as forestry, livestock production and agriculture, to reduce the conflicting land use interests, among the agropastoral communities.

ii) Studies on impact assessment and policy issues on different land use practices and accumulated traditional knowledge, that will provide incentives to conservation effort.

iii) Attempts to assess the impact of cropping strategies on land degradations, and the most effective traditional management practices to address the problems of livestock production.

iv) Further investigation of the biological aspects such as species diversity, composition, and impacts of the introduced utilisation strategies.

v) In situ conservation for sustainable production relying on socio- economic and ecological functions of an ecosystem.

2.2.3.2 Constraints to livestock production in Shinyanga

Farmers have indicated a number of constraints under traditional silvopasture system, that limit or influence livestock production in Shinyanga (Maro, 1995). The most common constraints affecting the animal production include the shortage of fodder/ pasture, incidence of diseases and scarcity of water (table 4) below.

Table 4: Farmers' response on constraints to livestock production in Maswa and Meatu Districts

Rank	Problem/constraints	% Respondents
1	Shortage of pasture	35.4
2	Livestock diseases	28.7
3	Shortage of water	15.5
4	Lack of Vet. Medicines	6.6
5	Land scarcity	4.4
6	Cattle rustling	1.7

Source: Maro (1995).

2.2.3.4 Constraints to management of "ngitiri"

Msangi (1995) reports a number of constraints affecting the traditional "ngitiri" system, both under private and communal ownership respectively, in Shinyanga region (Table 5) below.

Table 5: Problems which limit ownership and use of private "ngitiri" in 3 divisions of old Shinyanga

Constraints	% Respondents			
	Oldshy (n=32)	Mondo (n=32)	Sanya (n=24)	Total (n=80)
Invaders	40.7	34.8	30.0	35.2
Land scarcity	33.3	39.1	10.0	27.4
Encroachment	14.8	8.7	13.3	12.3
Land insecurity	3.7	8.7	20.0	10.8
Fire hazards	-	-	16.7	5.6
Tree cutting	-	4.3	3.3	2.5
Harbour ticks	3.7	-	3.3	2.3
Conflicts	3.8	-	-	1.2
Ovegrazing	-	4.3	-	1.4
Encroachment	-	-	3.3	1.1

Source: Msangi (1995).

Msangi (1995) reports no significant differences among the various divisions studied, towards identified problems and use of private "ngitiri" among the divisions, indicating that, these problems uniformly affect the cross sectional profile of the agropastoral land users in Shinyanga. Generally "ngitiri" reserves, seem to have common problems that affect them, and need an immediate solution to solve the crisis if the "ngitiri" system is to be sustained as a potential solution to dry season fodder supplies, that mitigate environmental degradations simultaneously (Msangi, 1995).

2.3 Diagnosis and design methodology in agroforestry research

The diagnostic and design (D & D) methodology is an ICRAF research methodology, which aim at developing agroforestry technologies, whose design are tailored towards the needs and conditions of the land users. The D & D methodology aims at the need in want of solution, and the potential in want of exploitation, the aim being to assist the researchers, development planners and extension agents to plan and implement effective research programs and development projects (Raintree, 1987; nair, 1993). As Scherr (1991) points out, D & D has been used as a starting point for researchers under ICRAF, to forge a common understanding of the land use priority topics requiring more indepth diagnostic research.

According to MNTE (1995) under Tanzania/ICRAF research program, diagnostic survey led to the first design phases of on-farm forestry trials in Shinyanga, and is still an on-going process of diagnosis and redesign. Researchers under HASHI/ICRAF have been working together with farmers in exploratory and diagnostic trials, with new components, site configuration and management systems, to jointly design suitable silvopasture technologies and further research efforts, that will at the sometime address farmers interest on technology used or researched for, as part of the on-going process of diagnosis and re-design (Scherr, 1991; Mugasha et al., 1996). D & D as a descriptive and a multi method research approach, emphasizes more on collection of more information on agroforestry components and systems technology.

The methods encompassed under D & D are namely; consultative process with farmers, field observations, socio-economic and ecological surveys, and on-farm participatory experimentation (Scherr, 1991).

2.4 Land evaluation methodology for suitability classification

Land evaluation is a process of collating and interpreting basic inventories of soil conditions, vegetation, climate and other aspects of land in order to identify and make comparison of promising land use alternatives, according to terms applicable to the objective of the evaluation (FAO, 1977; 1979; 1993). According to FAO (1977), land evaluation can be qualitative or quantitative land evaluation. In qualitative evaluation economics may be employed in general terms, without calculation of cost and return. Furthermore evaluation is made in terms relevant to the physical, economic and socio-context of the area concerned as regional climate, need for employment, land tenure, socio-economic and political acceptability.

2.4.1 Land suitability

According to FAO (1993), land suitability embodies recognition of the facts that, different kinds of land uses have different kinds of land use requirements, an example could be an alluvial flood plain with impeded drainage, this is normally more suitable for rice cultivation, but not suitable for many forms of agriculture or forestry.

The land itself and the land use, are equally fundamental to land suitability evaluation. Suitability rating is assessed by comparing the required biophysical or social input and the benefits obtained (FAO, 1993; 1977; 1979). Land suitability on the other hand, refers to the fitness of a given tract of land for a defined land use. Differences in the degree of land suitability are determined by the relationship (actual or anticipated), between benefits and required inputs associated with the use of the tract in question (FAO, 1993; 1977; 1979). Furthermore, FAO (1977) points out two kinds of land suitability, which can be expressed in quantitative terms or qualitative terms, namely; the current land suitability classification and the potential land suitability classification. According to FAO (1993) land suitability should reflect the sustained use of the land, whereby the aspect of environmental degradation should be taken into account, when assessing suitability, for example; a land use can appear highly suitable in short run, but likely to lead to soil erosion, progressive pasture degradation, or adverse changes in river regimes down stream, such consequences would outright short term suitability, and make the land to be classified as not suitable.

2.4.2 Land use alternatives

Land use alternatives are forms of land use, that appear to be relevant for consideration under the general social, economic and physical conditions prevailing in the survey area. These are precisely different as the intensity of survey permits. Land use alternatives can be such as community forestry visa vis extensive grazing under the

silvopasture land utilisation type (FAO, 1993).

2.4.3 Land quality

Land use quality are complex attributes of land, which act in manner clearly distinct from the actions of most other land qualities in their influence on the suitability of land for specific kind of land use (FAO, 1993; 1979; 1977; Kashangwa, 1989). Some examples of land qualities for extensive grazing could be climatic hardship affecting animals and nutritive value of grazing land among others (Kashangwa, 1989).

2.4.4 Land characteristics

Land characteristics are the attributes of land that can be measured or estimated, examples used in silvopasture among others are; nutrient availability, erosion hazard, growing period, sufficiency of energy, drinking water, sufficiency of pasture for grazing and sufficiency of water for pasture growth (Kashangwa, 1989).

i) Growing period

The growing period is the period on duration of the year, when both temperatures and soil moisture availability permit crop growth. The growing period as defined by FAO (1977; 1979) is when rainfall (P) is greater than half of Evapotranspiration potential (ETP), that is; $P > \frac{1}{2}$ ETP.

Given:-

ETP = Evapotranspiration potential

½ETP = Half evapotranspiration potential

p = Mean monthly rainfall

ii) Sufficiency of energy

Sufficiency of energy, also referred as temperature regime, considers the effects of temperature on plant and animal husbandry. The temperature regime are assessed from that of monthly mean temperature and maximum temperature.

iii) Sodicity (Excess of Salts)

Sodicity refers to the two hazards that may arise through accumulation of salts, salinity or the saturation of the exchangeable complex of sodium, that affects crops through inhibiting the uptake of water. Moderate salinity level retard growth and reduce yields, whilst high levels kills plant and may cause the affected areas to be barren of plants (FAO, 1976, cited by Kashangwa, 1989).

iv) Sufficiency of water for pasture growth

Sufficiency of water for pasture takes into account the effective soil depth and Rainfall availability (McRae, 1988, cited in Kashangwa, 1989).

v) Drinking water

The suitability of land for extensive grazing, is influenced by the number of water sources for drinking that are reliable (Kashangwa, 1989). Meatu district has two lakes, namely Lake Eyasi and Lake Kitangiri, there also a number of seasonal streams and locally dug dams. (DALDO, Personal Communication 1997). The district has a number of potential water sources for bore wells (DHV and ILACO, 1975). Suitability (S1) and moderate suitability (S2), depend on the reliability of these sources for rating (Corker, 1983 cited in Kashangwa 1989).

vi) Sufficiency of nutrients

Nutrients availability is affected by the level of oxygen and water supply, erosion hazards, soil drainage and aspects of soil management (Kashangwa, 1989). Under land evaluation, nutrients availability can be assessed using measurements derived from single sample sites within large variable mapping units, that can be considered to be a representative analysis (FAO, 1993). As reported by London ed (1984), ILACO B.V. (1981) and McRae (1988), cited in Kashangwa (1989), sufficiency of nutrients takes into account the percentage base saturation, the cation exchange capacity (C.E.C.) and the soil reaction (pH class).

vii) Sufficiency of pasture for grazing

Sufficiency of pasture in an area is dictated by the vegetation type (Kashangwa, 1989). According to corker (1983) as reported in Kashangwa (1989), four vegetation types are

distinguished in the land evaluation process, for miombo and savanna woodlands, namely; dense bushes and shrubs with scattered thickets, grassland with scattered medium to low trees and thorns, high grassland with scattered medium to low trees and dry grass land, water logged during rain season, with spots of thorn bushes.

viii) Erosion, degradation and other hazards

The land assessment under qualitative land evaluation for erosion, degradation and water logging, are based on visual observations and interpretation, where the suitability rating for the extensive grazing, considering erosion hazard take the form of:

Suitable S1; Slope angle < 5%

Observed risk: slight

Consistency: Firm or Hard

Moderately suitable S2; Slope angle 5 - 20%

Observed risk: moderate

Consistency: friable

Not suitable N; Slope angle > 20%

Observed risk: severe

Consistency very friable or compacted.

Slight: Soil with stable structure completely covered by grass and tree vegetation.

Moderate: Soil with partial cover of grass and trees, a moderately stable structure but with some areas such as stream channels

Severe: Where sheet, galley and other forms of erosion are common, and mostly with poor vegetation such as arable land with little natural vegetation already affected by sheet and galley erosion (FAO, 1976, cited in Kashangwa, 1989).

The combining of the individual land quality to give a general land mapping unit suitability, for a specific land use, is based on the principal of limiting condition, bearing in mind what improvement is economically practical (FAO,1977; 1993; Kashangwa, 1989).

2.4.5 Land utilisation types

Land utilisation type is any use of land, defined in detail than a major kind of land use. The degree of detail varies with the scale and intensity of the study. Further more, land utilisation type is an outcome of preliminary survey and discussion with development authorities during land evaluation. Land utilisation types encompass identifying relevant land use, the purpose and the scope of the study FAO (1993; 1979; 1977). The assessment for land utilisation type is contingent in the overall socio-economic and physical conditions of the area (FAO, 1993; 1979; 1977). For instance Kashangwa (1989) reported that the land utilisation type can be the community forests and the extensive grazing in range lands of agropastoral society, whereby indigenous knowledge is employed with low labour intensity on freehold rangelands.

Three major kinds of land utilisation types can be identified in Meatu, namely; small rainfed arable agriculture, extensive grazing and community forestry, but more than one kind of use may be undertaken on the same area of land, for example a mixed farming system where arable crops and livestock production or forestry are undertaken on the same area of land, either in spatial integration, in sequential integration or in line such as grazed bush fallow followed by arable farming (Kessy et al., 1988; Mugasha et al., 1997). For Meatu district, Mugasha et al.(1997) and Kessy et al.(1988) report the following land utilisation types:

i) Small rainfed arable agriculture

The subsistence crops in this district are sorghum, maize, cassava, sweet potatoes and pigeon peas. The common cash crop is cotton. Rice is grown for subsistence but incase of good harvest the surplus may be sold. Shinyanga Region Cooperative Union is the main market for crops, but there are also private markets. The farming practice is of low capital intensity, members of the family are the source of labour input, but some extra labour can be hired at peak periods such as during harvesting of cotton. Animal power is generally widely used, and tractors are mainly for transport. Traditional method are dominant in the production of subsistence crops.

ii) Livestock production

Livestock husbandry lies on large areas of semi-arid natural grazing. In this livestock husbandry, two practices can be differentiated, one is the semi nomadic; where the owners migrate between the dry season and the wet season to grazing areas. The alternative is practised by the more or less settled cultivators who own livestock. For this later practice, there is an integration of livestock and crop production. Livestock provide manure for fertilizer, drought power for cultivation and transport, while feeding on the crop residues on farms.

iii) Community forestry

This land utilisation type, mainly comprises of the natural vegetation, such as scrubby degraded woodland, near settlements and isolated individual trees/shrubs. The common vegetation in this district is *Acacia* woodlands and thickets. Most of the north - eastern part of the district is declared a game reserve, and is therefore not used for community forestry requirements. There are patches of miombo woodland, Julbernedia and Brachystergia communities in the central part of the district.

2.4.6 Land qualities for livestock and community forests

A number of land qualities exists related to animal production and community forestry (FAO,1977; Kashangwa, 1989). Burley (1987) defines silvopasture as an agroforestry system, that involve incorporating trees and shrubs management with animal

husbandry, in temporal or spatial arrangement. Alternatively silvopasture is an agroforestry land use system that involve grazing under storey trees, shrubs or grasses, with the lopping of trees in forests or plantations. Tejwan (1987), Kashangwa (1989), FAO (1993; 1977; 1979), define the community forests in agropastoral land use system as being any land that is unsuitable for crop production or grazing, particularly because of the high risk of soil erosion, or other land degradation type. Generally, land is allocated as community forestry in decision based on land conservation or wood based product supply shortage. Community forestry are based on the use of public land for tree growing to meet community needs (Leach and Mearns, 1988).

2.4.6.1 Land qualities for livestock

The land qualities for livestock production include; productivity of grazing land, climatic hardship affecting animals, endemic pests and diseases, nutritive value of grazing land, toxicity of grazing land, resistance of soil to erosion under grazing pressure, and availability of drinking water (FAO, 1993; 1977; 1979; Kashangwa, 1989). The estimation of land qualities is based on empirical combination, which takes into account that; if only one land characteristics is found to express the land quality of interest effectively, then is used to express it (FAO, 1977; 1979; 1993; Kashangwa, 1989).

2.4.6.2 Land quality for community forestry

All sites classed as unsuitable for animal grazing or not opted for arable rainfed agriculture, particularly because of the high risk of soil erosion or other types of land degradation are generally located to community forestry, where land conservation is taken as the basis of decision. Land suitability for community forestry can be graded into "S1" and "S2" categories (FAO,1977; 1979; 1993; 1976, cited in Kashangwa, 1989). Suitability (S1) category applies to mapping units where there is no limitation to tree species planting and growth of exotic trees. The moderately suitability category (S2) is used to sites where there is a marked limitation such as sodic soils, and only those indigenous trees adopted to those condition can grow (FAO, 1977; 1979; Kashangwa, 1989).

2.4.7 FAO principles of land evaluation

Kashangwa (1989) and FAO (1993) report the FAO framework for land evaluation to be based on six principles:

i) Land suitability is assessed and classified with respect to specific kind of land use.

ii) Comparison of the outputs obtained and the inputs needed on the different types of land use is made.

iii) Interdisciplinary approach is required, such as; soil conservation, land use, farming systems and sociology among others.

iv) Evaluation is made in terms relevant to the physical economic and social context of the area considered.

v) Suitability refers to use on sustained basis, suitability assessment should take account of hazards of soil erosion and other types of soil degradation.

vi) Evaluation involves comparison of more than one kind of use.

The end result of evaluation is a number of clear recommendations, with alternatives on appropriate type of land use, together with their consequences.

CHAPTER 3

3.0 STUDY AREA DESCRIPTION

3.1 Location

The study was conducted at Meatu district, located in Shinyanga region of Tanzania. The district is bordered by Bariadi district in the North, Maswa and Shinyanga rural districts in the west, Tabora region in the south and Singida and Arusha in the east. The district covers 8,871 km^2. The central railway line passes through Shinyanga, connecting the Dar es Salaam city with the Mwanza municipality. Shinyanga is also connected to Tabora, Burundi, and Rwanda via road network. An earthroad connects Meatu district to Shinyanga regional head quarters (Appendix19).

3.2 Physical features

Altitude varies between 1000 m - 1500 m above sea level, with detached hills and grassy mbugas (URT, 1996). The soils are mainly red to yellowish, freely drained tropical soils, often referred to as latisols. The major soil types found in the district include; ferric luvisols, Acrisols and chromic cambisols, according to FAO classification. In low lying areas, often referred as "mbugas", black grey clays or (vertisols) are found, often fringed by mottled sandy soils (Kessy et al., 1988; URT, 1996; Otysina and Asenga, 1993).

3.3 Climate

The district has high evapotranspiration rates, with erratic rainfalls, usually very unpredictable (URT, 1996; Otysina and Asenga, 1993). Most of the rainfall falls between October and May, with two minor seasonal peaks in December and March to April. The dry season, May to November receives a total precipitation of under 50mm per year. Precipitations which occur in short duration storms, is lost through quick surface run off and high evapotranspiration rates (URT, 1996; Otysina and Asenga, 1993). The maximum monthly temperature varies between 27.6% to 30.2°C. The monthly evaporation rate exceeds the monthly rainfall almost every months (MNTE, 1995).

3.4 Population and socio-economic aspects

The population of Meatu is dominated by Wasukuma, who are traditionally agropastoralists. Economic activities in the area include cultivation of food and cash crops, cattle rearing and mining (Maro, 1995). According to URT (1996) livestock keeping is the second largest activity in Shinyanga, after agriculture, the 1988 census regard the district to have 159,000 people, with an annual growth rate of 2.0% and population density of 18 people per km^{-2}. In Meatu there are two dominant land use systems; the Wasukuma agropastoral system, and cotton cereal system with cattle (Kessy et al., 1988; Mugasha et al., 1996).

a) Typical Sukuma agropastoral system

This system is characterised as a land use in which the livestock plays a major role next to the agricultural component. Herd size in this system are above subsistence level, and they require extensive use of land resources. Cattle are used to provide milk for home consumption and drought power, they also fulfil the social functions (prestige and bride price). Food crops grown in the system are maize, sorghum, bulrush, millet, cassava, paddy, and chick peas. The cropping units are generally small. Gradual increase of human and livestock population has led to a number of constraints such as land shortage for grazing, soil exhaustion, deforestation, fuelwood shortage, and lack of fodder for livestock (Mugasha et al., 1996; Kessy et al. 1988).

b) Cotton - cereal system with cattle

Under this system farmers put more efforts on food production and less effort on main cash crop (cotton). The food crops are maize, cassava, sorghum, beans, paddy, chick peas, groundnuts and sweet potatoes. Farmers own cattle but the herds are smaller than the typical Sukuma agropastoral system. The main constraints are soil erosion and declining soil fertility (Mugasha et al., 1996; Kessy et al., 1988).

3.5 Vegetation cover

Native vegetation of Shinyanga is composed of shrubs (4 - 6m) high often thorny and usually deciduous, with emergent trees reaching up to 10 - 15 m high, the herbaceous layers which occupies the open spaces undergoes a severe livestock grazing pressure. The miombo woodland of Shinyanga currently are dominated by Brachystergia species, Julberdia species and Isoberlinia species. Other important species found are; *Cumbretum collinum, Baikea africana, loninocarpus capasa, Azanza garkeana, Albizia commiphora* and the *Dalbergia melanoxylon.* The vegetation is mainly Acacia woodland consisting mostly of *Acacia tortilis, Acacia nilotica*, and *Acacia polycantha*, while other important species in this agropastoral land include *Adansonia digitata* and *Tamarindus indica* (Kessy et al.,1988).

CHAPTER 4

4.0 RESEARCH METHODOLOGY

4.1 Stratification of the study area and sampling

i) Stratification of the study area

Based on the variability of vegetation cover types, which represented the intensity or pressure of use and soil erosion conditions, four vegetation cover types (strata/ mapping units) were established for qualitative land evaluation. The vegetation cover types were established by the overlaying of the district administrative map, vegetation map and the recent satellite imagery, followed by tracing and ground truth survey to justify the cover types, for stratification (DRDP, 1997). Two vegetation strata were combined to form one sampling stratum for purposive socio-economic and ecological sampling (making three effective sampling strata for socio-economic and ecological survey), this was due to the fact that one strata had no inhabitants, it was either under game reserve or highly degraded, thus creating environmental refugees.

ii) Sampling for socio-economic survey

Sixty household individuals were purposefully selected, 20 from each effective stratum, for answering the semi-structured questionnaires and questions during D & D survey. Furthermore, 20 individuals were purposefully selected from the various professional disciplines dealing with land husbandry in the district, for triangulation of the answers.

iii) Sampling for physical land evaluation

Physical land evaluation for land qualities and land characteristics was done on the four mapping units established as explained under part 4.1 above.

iv) Sampling for ethnobotanical survey and cross sectional profiles

From each of the three effective sampling strata, one representative "ngitiri" was purposefully selected for ethnobotanical survey of fodder species, vegetation vertical structure, components and composition respectively.

The village register at Meatu HASHI district office was used as the sampling frame, to select representative "ngitiri" and individual household owning "ngitiri", in each stratum.

4.2 Primary data Collection

The collection of qualitative and quantitative primary data was facilitated by descriptive diagnostic survey (appendix 3), based on ICRAF D & D methodology (Raintree, 1987). Land evaluation was based on the FAO guidelines (FAO, 1993; 1977; 1979), with a blend of qualitative socio-economic and ecological evaluation and resource assessment methods.

4.2.1 Diagnostic and design survey of the land use system

Using information available at HASHI/ ICRAF in Lubaga and Meatu centres, and information gathered from the three strata during preliminary survey on land use assessment, three kinds of land utilisation types were identified, namely; small rainfed arable agriculture, extensive grazing, and community forestry. The research team described the silvopasture land use for further diagnostic survey. The D & D involved the inventory of silvopasture production constraints, issues of sustainability aspect in land use, development strategies for each land use subsystem, and the potential roles of the traditional silvopasture technologies in application ("ngitiri") for iterative diagnosis and design. Twenty household individuals were interviewed in each strata. Whereas 20 professional staff dealing with land husbandry under different disciplines (among others; Forestry, agriculture, livestock, community development, land use planning and works) were interviewed. The socio-economic survey amployed the "Rapid participatory rural appraisal mathodology, which encompassed of:

i) Discussion with individuals and semi structured interviews

Discussion were made with individual households members owning "ngitiri". Brainstorming and structured interviews were also administered to households members (Appendix 3). A core group of three people was involved to carry out the questionnaire interviews and the Rapid Participatory Rural Appraisal.

ii) Group discussion and workshop

This was employed to encourage a collective response and to identify differences of opinion within the group (Pratt and Loizos, 1992; Kaewsonthi and Harding, 1992). Discussions were conducted in each stratum, with the village environmental committees. Professionals workshop was held (under ICRAF extension and dissemination project), to discuss agroforestry technology designs, technology achievements, and triangulation of content structural information from the field surveys, to identify land use problems, research and extension needs.

4.2.2 Ethnobotanical survey for inventory of "ngitiri" specifications

One representative "ngitiri" from each of the established effective sampling strata (3), were surveyed, rapid enthnobotanical surveys was conducted with the assistance of three local key informants and two research technicians from ICRAF, as it was applied in West Minepore, Bengal, and reported by Martin (1995) and Makonda (1997). Information on vegetation species, local name, botanical name, fodder utilisation and parts foraged, and information on any environmental role of the tree species in the "ngitiri" was obtained. During ethnobotanical survey , cross sectional profiles with plots of "10m" vertical heights and "25m" horizontal distance were established, each cross sectional profile had a length of 200m long with 8 plot of "10m x 25m". The vertical distance was measured by the use of clinometer and horizontal distance by the use of tape measure. For each plot, the cross sectional vegetation profiles were

prepared for the dorminant tree species, ethnobotanical inventory of browsable shrubs and forbes, and grazable grasses was made. Sketch drawing were then used to establish the vertical and horizontal spatial arrangement of the ngitiri cross sectional profile, with emphasis to the dominant tree components.

4.2.3 Qualitative silvopasture land use evaluation

Qualitative Land evaluation, to assess the potential of extensive grazing and community forestry in Meatu rangelands was conducted, taking into account of both the physical conditions, ecological and the socio-economic consideration. This was to ensure conservation of the environmental resources for future use, based on FAO guidelines (FAO, 1993; 1979; 1977; Kashangwa 1989), to establish potential suitability ratings. Requirements for land use and suitability rating for extensive grazing, based on established mapping units, elucidated under part 4.1 above.

4.3 Secondary data

Secondary data were obtained by consulting relevant documents, both published and unpublished, to form an overview, and identify the gaps in information.

4.4 Data analysis

The Statistical Package for Social Science (SPSS) was employed in analysing the socio-economic survey data, for categorisation into ranks, percentages and cross tabulations. The "ngitiri" descriptive technological specifications were established (components, structure, composition and management), based on ICRAF D & D guidelines (Raintree, 1987) and Huxley and Westley (1989). Useful vegetation species for fodder, were identified and categorised according to subsystem or stratum in "ngitiri". Environmental roles were attributed to tree component subsystem. A cumulative list of species was compiled and triangulated with established checklist (Mbuya et al., 1994). All fodder species encountered were grouped as trees, grasses, forbes/ herbs. Using triangulation, the content structural analysis of the diagnostic survey information was analysed, to justify the "ngitiri" descriptive structure, composition, components, technological specifications and management as an agroforestry technology, under silvopasture land use.

Suitability rating to give classes for community forest and extensive grazing was established, for qualitative potential silvopasture land use classification, based on FAO guidelines (appendix 11). The "ngitiri" silvopasture technology was iterated for each vegetation mapping unit, based on D & D and land evaluation results.

CHAPTER 5

5.0 RESULTS AND DISCUSSION

5.1 Household sample characteristics and socio-economic information

Tables 6 and 7 below, give the household and sample characteristics in Meatu.

Table 6: Sex, status in a household and level of education

Information	Zone 1 (n=20)	Zone 2 (n=20)	Zone 3&4 (n=20)	Total(n=60)
a) Sex				
Male	(12)60.0	(13)65.0	(14)70.0	(39)65.0
Female	(8)40.0	(7)35.0	(6)30.0	(21)35.0
b) Status in household				
Heads of household	(12)60.0	(14)70.0	(16)70.0	(42)70.0
Not heads of household	(8)40.0	(6)30.0	(4)30.0	(18)30.0
c) Level of education				
No formal education	(12)60.0	(10)50.0	(13)65.0	(35)58.3
Primary education	(8)40.0	(9)45.0	(7)35.0	(24)40.0
Secondary school education	(0)0.0	(1)5.0	(0)0.0	(10)1.7

Figures in parenthesis denotes number of respondents, not in parenthesis indicate percentage.

Source: Field survey (1997).

The respondent sex, education level and status in the household, were used to describe sample characteristics (table 6). The "farmers" and "respondents" are used interchangeably in the study. The survey covered 65% male and 35% female respondents. Most of the respondents (70%) were head of households. More than half of the interviewed farmers had no formal education (58.3%), while the rest (40%) had primary education, and very few respondents had secondary school education (1.7%) as shown in table 6 above.

In all strata there were more male household heads, more male respondents and more literate males than females. This is attributed to the socio-cultural dimensions of the Wasukuma community, where males enjoy more privileges than females (Maro, 1995; Msangi, 1995; Shao et al., 1992).

Sex, level of education and status of respondents (i.e. head of household or not), were considered as important factors in relation to land use and land resource conservation. Essentially equal chances were given to both men and women, in order to explore the differences in the perceptions of land degradation, the need for "ngitiri" system and conservation. However the present study covered 65% male and 35% female respondents (table 6). During interviews, male were more vocal and outspoken than women although some incidence of sharing views and opinions between men and women was observed. This disparity may reflect strong gender balance in decision making. As Shao et al. (1992) reported among Wasukuma, men are entitled to land

ownership and cattle, and through their dominance they are traditionally decision makers in the household. Women are therefore, deprived of decision making in the household, hence their contribution in the present study is relatively small. Education on the other hand, plays an important role in socio-economic development of a particular society, as a tool for transfer of knowledge and experience. Primary education system is reported to foster human creativity, and have hence been reported as having relationship with farmers readiness to integrate innovations into traditional systems of land use and management (Maro, 1995). A study of village agroforestry in Tanzania for instance, showed that farmers adoption rate of the practice through tree planting, increase with level of education (Kajembe, 1988). Availability of education of any kind in the study area is an important factor to improve farmers potentiality and creating awareness, positive attitudes towards innovation and self confidence in taking part in conservation and general environmental resource management. Substantial formal education among most of the farmers (58.3%), reflect persistent presence of awareness of "ngitiri" conservation and rehabilitation of land. This may eventually lead to effectiveness of efforts towards conservation of land resources and continued mitigation of land degradation, which is a major threat to sustainable production in the study area. These observations are similar to observation made by Maro (1995) and Msangi (1995) who suggest that, for the sustainable changes to occur in environmental resources management in Shinyanga, education must be given an emphasis. The study considered age and experience as important factors during individual and group interviews (table 7).

Table 7: Age distribution of respondents

Age class (Yrs)	21-30	31-40	41-50	51-60	61-70	71<
Frequency	3	12	16	14	10	5
Percentage (%)	5.0	20.0	26.7	23.3	16.7	8.3

Source: Field survey (1997).

Older farmers contributed more effectively on the information about "ngitiri" and the traditional land use (e.g. ownership, acquisition of land, livestock , crop production and soil management). The age of the farmers interviewed varied from 21 to over 71 years, most of the respondent were between the age of 41 to 50 years. Minimum age of interviewee farmer was 21 years, while majority were at the age between 41-50 years (table 7).

5.2 Evaluation of socio-economic parameters and indigenous ecological knowledge of relevancy to sustainability aspects of "ngitiri"system

5.2.1 Land tenure system and land ownership in Meatu district

Table 8 below, gives the status and trends in land tenure. Most farmers (75.0%) in the study area own land, where 51.7 % of farmers were assured ownership i.e. may continue to use their land for the rest of their life, while 48.3% were not certain, they may keep on cropping land for unknown period of time (table 8).

Table 8: Land ownership and security

	Zone (n=20)	Zone 2(n=20)	Zone 3&4 (n=20)	Total (n=60)
a) Land owenrship				
Own land	(14)70.0	(15)75.0	(16)80.0	(45)75.0
Do not own land	(6)30.0	(5)25.0	(4)20.0	(15)25.0
b) Onwership security				
Certain	(18)90.0	(10)50.0	(3)15.0	(31)51.7
Uncertain	(2)10.0	(10)50.0	(17)85.0	(29)48.3

Figures in parenthesis denote number of respondents, not in parenthesis indicate percentage.

Source: Field survey (1997).

5.2.2 Land acquisition, status and gender balance

Table 9 below, indicates the major ways of acquiring land. Farmers had four major ways of acquiring land, through inheritance (31.7%), government allocation (16.6%), purchasing (31.7%) and clearing of forests (20.0%), of respondents interviewed the majority (68.3%) expressed the insufficiency of land, while only (31.7%) said the land was sufficient. Most household respondents (63.3%) did not show any possibility of getting more land, whereas 36.7% of respondents were optimistic of getting more land. More than half of the respondents (65.0%) indicated that women could not own land (table 9). Parts of zone 3 & 4 are either under game reserve or highly degraded, this contribute to high insecurity among inhabitants of these zones. Zone 1 and zone 2, had more defined ownership due to well established local authorities.

Table 9: Land acquisition, status and gender balance

Information	Zone 1 (n=20)	Zone 2 (n=20)	Zone 3&4 (n=20)	Total (n=60)
a) Land acquisition				
Inheritance	(8)40.0	(5)25.0	(6)30.0	(19)31.7
Government allocation	(2)10.0	(5)25.0	(3)15.0	(10)16.6
Purchase	(6)30.0	(9)45.0	(4)20.0	(19)31.7
Cleared forest	(4)20.0	(1)5.0	(7)35.0	(12)20.0
b) Sufficiency of land				
Sufficient	(10)50.0	(3)15.0	(6)30.0	(19)31.7
Insufficient	(10)50.0	(17)85.0	(14)70.0	(41)68.3
c) Women land ownership				
Can own	(8)40.0	(9)45.0	(4)20.0	(21)35.0
Can not own	(12)60.0	(11)55.0	(16)18.0	(39)65.0
d) Possibility to get more land for "ngitiri"				
Can get more land	(6)30.0	(9)45.0	(7)35.0	(22)36.7
Cannot get more land	(14)70.0	(11)55.0	(13)65.0	(38)63.3

Figures in parenthesis denotes number of respondents, not in parenthesis indicate percentages.

Source: Field survey (1997).

Historically the land tenure in Shinyanga does not adequately consider aspects of crop production and livestock keeping, as a main and long term activities, Getahum (1992) reports the current legislation on land tenure in Shinyanga and other semi arid regions in Africa to be fragmented and incomplete, in Shinyanga customary land rights had been dominant, but have often been eroded by the statutory tenures, which have tended to exclude such traditional or customary rights. Although it is indicated that 75.0% of the respondents own land (table 8), but non of them had a title deeds, but have traditionally assumed user rights.

As indicated in tables (8 and 9), the substantial variation between individuals who own land and those who do not own land, together with the respond in the possibility to get or not getting more land, the phenomena is described in the villagization programme of 1974. During the villagization operation, farmers that were moved retained their traditional ownership rights of the land they were forced to vacate, while formers (owners) on newly settled areas (nucleated villages), were deprived of their user rights. The present relaxation on villagization policy, seem to favour some people who own land both in abandoned sites and currently settled areas (where they were forced into). Similar observation indicate that the programme created artificial land shortage in Maswa district (Maro, 1995).

It is shown that, land is transferred mainly through inheritance and purchase of user right (Table 9), most farmers acquire their land through this way. Further land allocation in the district was made possible through clearing of forests or government

allocation in Meatu district. Informal discussion reveal that, farmers usually acquired land through more than one means. This suggests that both customary rights and state land tenure system are still operating in Shinyanga. The customary rights as Maro (1995) reports, are organised in accordance with ways and customs bequeathed by the ancestors, hence people had been responsible for nature and environmental resources.

Most farmers in Meatu (68.3%) indicate their present land is not adequate to meet their needs. This may be explained by the fact that most land has poor soils. The need for increased crop production is often achieved through expansion of cultivation land (Maro, 1995). Similarly animals need large grazing areas in order to get adequate feed. Thus, shortage of land among farmers can be explained by low land productivity due to the increase in land pressure, this makes land scarcity artificial or just subjective (Maro, 1995; Brandstrom, 1985).

Insecurity of tenure is another constraint unveiled by several farmers in Meatu (48.3%), in the present land ownership system (Table 8 and 9). Group discussion revealed that village governments may take part of the land holding of farmers and re-allocated it for other uses such as construction of schools, or dispensary, without clearly defining means of compensation.

The perceived scarcity of land and absence of clearly defined land ownership rights in Meatu, seem to have a bearing on the effectiveness of "ngitiri" and general land

husbandry for sustainable production in the agropastoral system. Maro (1995) reports a similar observation in Maswa, whereby the effectiveness of in situ conservation has been hindered by the lack of clearly defined land ownership rights. Household interviews and group discussions clearly reflect that women are not entitled to land ownership. Interestingly enough as Maro (1995) reports on a similar study according to Wasukuma customs, married women are considered a man's property, and the dowry paid to their parents in terms of cattle endorses the ownership to their husbands. Traditionally for the Wasukuma, it is the man who own the cattle and the land, but few exceptions exists for divorced women or women who have never been married, they can own land and livestock. They also can have ownership of land or cattle through outright purchase, through parents, or as in the case of land allocation by the government.

5.2.3 Livestock ownership and fodder production in "ngitiri"

Table 10 below, gives information on livestock ownership status, and trend in fodder availability in Meatu for the last ten years. Livestock ownership among the 'Wasukuma' is regarded as a cultural heritage, status or symbol of wealth, nearly all farmers (91.7%) keep livestock. Among those who do not own livestock now, some had previously owned animals but have sold them due to land scarcity, famine or other household economic problems. Only 8.3% of respondents do not own livestock at present (table 10), below.

Table 10: Livestock ownership status and fodder trends for the last 5 to 10 years

Information	Zone 1 (n=20)	Zone 2 (n=20)	Zone 3&4 (n=20)	Total (n=60)
a) Livestock ownership				
Own livestock	(20)100.0	(15)75.0	(20)100.0	(55)91.7
Do not own livestock	(0)0.0	(5)25.0	(0)00.0	(5)08.3
b) Trends in fodder availability for past 5-10 years				
Fodder declining	(16)80.0	(9)95.0	(17)85.0	(52)86.7
Fodder increasing	(4)20.0	(1)05.0	(3)15.0	(8)13.3
c)"ngiriti" ownership				
Own	(12)60.0	(9)45.0	(8)40.0	(29)48.3
Do not	(8)40.0	(11)55.0	(12)60.0	(31)51.7
d) Willingness to establish "ngitiri"				
Not willing	(6)30.0	(9)45.0	(12)60.0	(27)45.0
Willing	(14)70.0	(11)55.0	(8)40.0	(33)55.0

Figures in parenthesis denote number of respondents, not in parenthesis indicate percentage.

Source: Field survey (1997).

Livestock are means of survival in the agropastoral society of Meatu, they play a central role in the economic, social and cultural lives of farmers. Maro (1995) in a similar study reports the animals to provide principal source of animal protein, by providing; milk, meat, butter, security against famine and manure. Among the respondents (48.3%) own "ngitiri", and most of them point at the trend of fodder production in general to be declining (86.7%), for the past 5 to 10 years. Although the

number of farmers who own "ngitiri" is smaller than the number of those who do not own "ngitiri" (51.7%), the majority of farmers are willing to establish "ngitiri" (55.0%), this can be described by the trend of declining fodder production or availability in the agropastoral land use (table 10). Farmers perception of fodder production indicate that, the overall fodder supply for their livestock has generally declined (table 10) for the past 5 to 10 years. The situation of having little pasture or fodder scarcity is pronounced during dry season for the high livestock numbers. Farmers informal discussion report a decline in dependence on natural rangelands for the dry season fodder supplies.

5.2.4 Constraints to livestock production

Table 11 and 12 below, give the constrains in livestock production.

Table 11: Problems in livestock production

Rank	Problem	% Respondents
1	Disease	41.8
2	Water scarcity	27.7
3	Dry season fodder supply	23.7
4	Lack of veterinary emdicine	3.4
5	Cattle rustling	1.8
6	Land scarcity	1.6

Source: Field survey (1997).

Table 12: Problems in management of "ngitiri" for livestock fodder

Rank	Problem	% Respondents
1	Overgrazing	30.4
2	Drought	26.1
3	Lack of title deeds and encroachment	15.4
4	Termite attack of transplants	10.9
5	High mortality of seedlings	8.7
6	Tsetse flies	8.5

Source: Field survey (1997).

The agropastoral system and the land tenure rights in Shinyanga are described as having contributed to the decline in tree and woody vegetation cover (Maro, 1995). In Meatu, farmers have expressed several constraints which limit or influence livestock production in their district (table 11 and 12). The most common constraints were the shortage of dry season fodder, incidence of livestock diseases, water scarcity, lack of veterinary medicines, cattle rustling and scarcity of land, these were ranked according to farmers response (table 11). In general it was stressed that, the late dry season is the most stressful period to have fodder. During this period, pasture supply gets to its lowest level, especially in years with insufficient amount of rainfall. There is also a general awareness of farmers need to manage and improve "ngitiri", however farmers expressed difficulties in their efforts towards managing and improving "ngitiri" (table 12). The problems as ranked by farmers include overgrazing of "ngitiri" (30.4%), drought (26.1%), termite attack (10.9%), high mortality of seedling (mostly MPTs)

(8.7%), lack of title deeds of the "ngitiri" (15.4%) and tsetse flies in "ngitiri" (8.5%). Otysina and Asenga (1994) and Mziray (Personal Communication, 1997) report similar observation on the increase of tsetse flies in "ngitiri", as a result of an increased efforts in environmental conservation, particularly planting of trees in "ngitiri".

5.2.5 Attitudes towards tree planting

Table 13a and 13b below, give reasons for planting trees in "ngitiri" and associated problems respectively, whereas table 14 gives the preferential areas for tree planting and "ngitiri" establishment.

Table 13a: Reasons for planting trees in "ngitiri"

Rank	Reason	Respondents score (%)
1	Increase wood products and dry season fodder	40.8
2	Shade for cattle	20.0
3	Wind break	18.0
4	Soil erosion control	8.2
5	Restoration of soil fertility	6.3
6	Land protection	4.7
7	Climate amelioration	2.0

Source: Field Survey (1997).

Table 13b: Problems associated with tree planting in ngitiri

Rank	Problem	Respondents score (%)
1	Lack of information	56.4
2	Past mortality	20.0
3	Livestock encroachment	10.9
4	Land scarcity	9.1
5	Land clearing for crop production	3.6

Source: Field Survey (1997).

Table 14: Preferential areas for tree planting

Rank	Preference	% Respondents score
1.	Around homesteads and in degraded areas	83.0
2.	Private ngitiri	7.4
3.	Communal ngitiri far from home	5.6
4.	On farms/mixed with crop	4.0

Source: Field survey (1997).

Farmers in their efforts to alleviate some of the socio-ecological problems, have opted to planting trees for a number of reasons (table 13a), but the strategy has faced a number of constraints (table 13b). These constraints (table 13b), need to be considered in order to develop sustainable production system. The present study clearly reveal that individuals and communities are actively planting trees at various preferential areas (table 14). The acceptance and popularity of tree planting had been clear, as farmers enjoy direct benefits of trees and tree products. Trees are reported to have several advantages for the agropastoralists in the study area, through the provision of valuable fodder in the late dry season, when other forage resources are not locally available

(Msangi, 1995; Kilahama, 1994). The nature of competitive land uses, make farmers pre-occupied with clearing of trees and bushes for expansion of crop and livestock production on one hand. In the other hand conservation of trees in ngitiri and tree planting in homesteads and rangelands for enrichment, have been common. Malcom (1953) in a similar study reports conflict related to ngitiri management and use to be traced back to history, whereby in the past all village areas in Shinyanga were chequered with numerous blocks of grazing reserves. According to him, this patch work organisation produced endless conflicts.

Maro (1995) and Msangi (1995) have also reported in similar studies, that security offered by the ngitiri system in dry season fodder supply, and the associated need for conflict resolution in management of ngitiri, for sustainable production in agropastoral meatu district is of great value and appreciation.

5.2.6 The potential of "ngitiri" for dry season fodder supply

Table 15 below, gives information on the attitude of respondents towards the potentials of "ngitiri" as silvopasture technology.

Table 15: Attitude towards "ngitiri"

Information	Zone 1 (n=20)	Zone 2 (n=20)	Zone 3&4 (n=20)	Total (n=60)
a) Altitude towards ngitiri				
Beneficial	(20)100.0	(19)95.0	(18)90.0	(57)95.0
Not beneficial	(0)00.0	(1)5.0	(2)10.0	(3)05.0
b) Use of "ngitiri" for Soil conservation				
Useful	(18)90.0	(20)100.0	(13)65.0	(51)85.0
Not useful	(2)10.0	(0)00.0	(7)35.0	(9)15.0
c) Need for improvement for fodder and conservation				
Be improved	(14)70.0	(14)70.0	(17)85.0	(45)75.0
Not be improved	(6)30.0	(6)30.0	(3)15.0	(15)25.0
d) Accessibility to communal "ngitiri"				
Accessible	(20)100.0	(19)95.0	(18)90.0	(57)95.0
Not accessible	(0)00.0	(1)5.0	(2)10.0	(3)05.0

Figures in parenthesis denote number of respondents, not in parenthesis indicate percentage.

Source: Field survey (1997).

Farmers in Meatu are aware of the land degradation problem, and its impact on crop production, pasture or fodder availability and visible landscape changes such as; deforestation, drying up of water sources and soil erosion (Maro, 1995; Otysina and Asenga, 1994).

In this study the potential of "ngitiri" for its role in soil conservation and its general benefits in the society as expressed by farmers were identified (table 15), It is revealed that 95% of respondents found "ngitiri" system to be generally very beneficial, 85% found the "ngitiri" system to be useful for soil conservation, 75% found the system worth improvement for fodder production and conservation. As regard to communal "ngitiri" established by villages or groups, 95% saw these "ngitiri" as accessible to them, but they recommended proper organisation of grazing pattern and routine management. The potential of "ngitiri" and attitude toward the system as perceived by respondent is very promising (table 15). Evaluation by Mugasha et al.(1996), report the "ngitiri" system with the underlying ecological and management concept, to provide a valuable opportunity and a basis for sustainable silvopasture system, in agropastoral Sukumaland. They report that "ngitiri" by virtue of their composition (trees, shrubs and grasses) and interaction with livestock, constitute an ideal agroforestry system capable of alleviating most constraints identified in the study (Table 11 and 12). Otysina (1994) report on optimum grazing pressure in "ngitiri" during dry season, to have promising results in terms of animal health, for animals grazed in "ngitiri".

5.2.7 Dry season fodder supply and soil conservation

Table 16a and 16b below, give strategies to acquire dry season fodder supply and complementary soil conservation measures in "ngitiri".

Table 16a: Strategies to acquire dry season fodder supplies

Rank	Strategy	% Respondents
1	Grazing on improve land	38.5
2	Planting trees	23.1
3	Establish more "ngitiri"	12.4
4	Destocking	9.6
5	Seek advice	7.7
6	Graze in game reserves	6.8
7	Other sources: Crop residues, sugar cane	1.9

Source: Field survey (1997).

Table 16b: Complimentary soil conservation measures in "ngitiri"

Rank	Strategy	% Respondents
1	Conserving existing trees and enrichment with MPTs	70.4
2	Practice on farm agroforestry	22.7
3	Contour ridging with planting of grasses	4.6
4	Planting of sisal	2.3

Source: Field survey (1997).

Under the diagnostic survey conducted in Meatu, farmers have developed a number of strategies to acquire dry season fodder supplies, while mitigating environmental degradation at the same time (table 16a and 16b). Mugasha et al.(1996) in their evaluation report, came up with similar strategies as recommendations to annex land degradation in Meatu, and at the same time ensure dry season fodder supply.

Similar recommendations are given by Otysina and Asenga (1993). Studies conducted by Maro (1995) on agropastoral sukumaland of Maswa and Meatu report similar strategies being perceived or undertaken by farmers, to alleviate dry season fodder supply and mitigate environmental degradation.

5.2.8 Socio-economic and ecological benefits of "ngitiri" system

Table 17a and 17b below, give the ranking for major resources of income and perceived benefits of "ngitiri" fodder reserves respectively, in Meatu district.

Table 17a: Major Sources of household income in Meatu

Rank	Sources	% Respondents score
1	Cropping	60.0
2	Livestock	30.0
3	Other sources	10.0

Source: Field survey (1997).

Table 17b: Perceived benefits of "ngitiri" fodder reserve systems

Rank	Benefits	% Respondents
1	Production of fodder/pasture	56.6
2	Wood products	27.4
3	Source of income	9.0
4	Improvement of soil fertility	5.0
5	Beekeeping	2.0

Source: Field survey (1997).

Among the major sources of income identified in Meatu, livestock production (closely related to "ngitiri" system) ranked second after crop production, followed by other sources of income namely; petty business and mining (table 17a). Farmers identified a number of ecological and socio-economic benefits derived from "ngitiri" system, either directly or indirectly. Ecological benefits include, the improvement of soil fertility, whereas income generation and direct production of goods or service were reported socio-economic benefits (table 17a and 17b). A number of similar studies in Shinyanga by Msangi (1995), Maro (1995), Kilahama (1994) and Otysina and Asenga (1994) report similar perceived benefits of "ngitiri" fodder reserves, they rank livestock production and the associated ecological system as the second activity, and livestock as the second source of income generation in Meatu. Mugasha et al. (1996) report the same, ranking livestock to be the second biggest activity in Meatu.

5.2.9 "Ngitiri" evaluation based on assumptions

The model (fig. 1) below, indicates the interlinkage myriad between ecological and socio-economical benefits of "ngitiri", based on participatory rural appraisal.

Assumption 1

The "ngitiri" traditional fodder reserves which are based on indigenous ecological knowledge, and their respective socio-economic values are appropriate for sustainable management of woodlands, and rangelands soil conservation, hence their improvement will facilitate sustainable soil conservation efforts.

The identified fodder species in appendices (6,7,8) concur with Otysina and Asenga (1994) report on sources of fodder and feed for livestock in the dry and wet season in Shinyanga. Out of 67 useful fodder species identified, 17 species (25.4%) were fodder grasses, 25 species (37%) were fodder herbs/ forbes, and the remaining 25 species (27%), were browsed trees, as shown in appendices (6,7,8). Otysina and Asenga (1994) report the local Acacia species such as *Acacia polycantha*, *Acacia nilotica,* and *Acacia albida* to be growing fairly well in "ngitiri" under Shinyanga conditions, considering the needs of local farmers to be fodder supply during dry season, fuelwood and improvement in soil fertility, a number of studies on "ngitiri" have proved the potential of "ngitiri" on the improvement of soil fertility and fodder supplies, especially the local species under traditional land use (Otysina and Asenga, 1993; Otysina et al., 1994; Otysina et al., 1996).

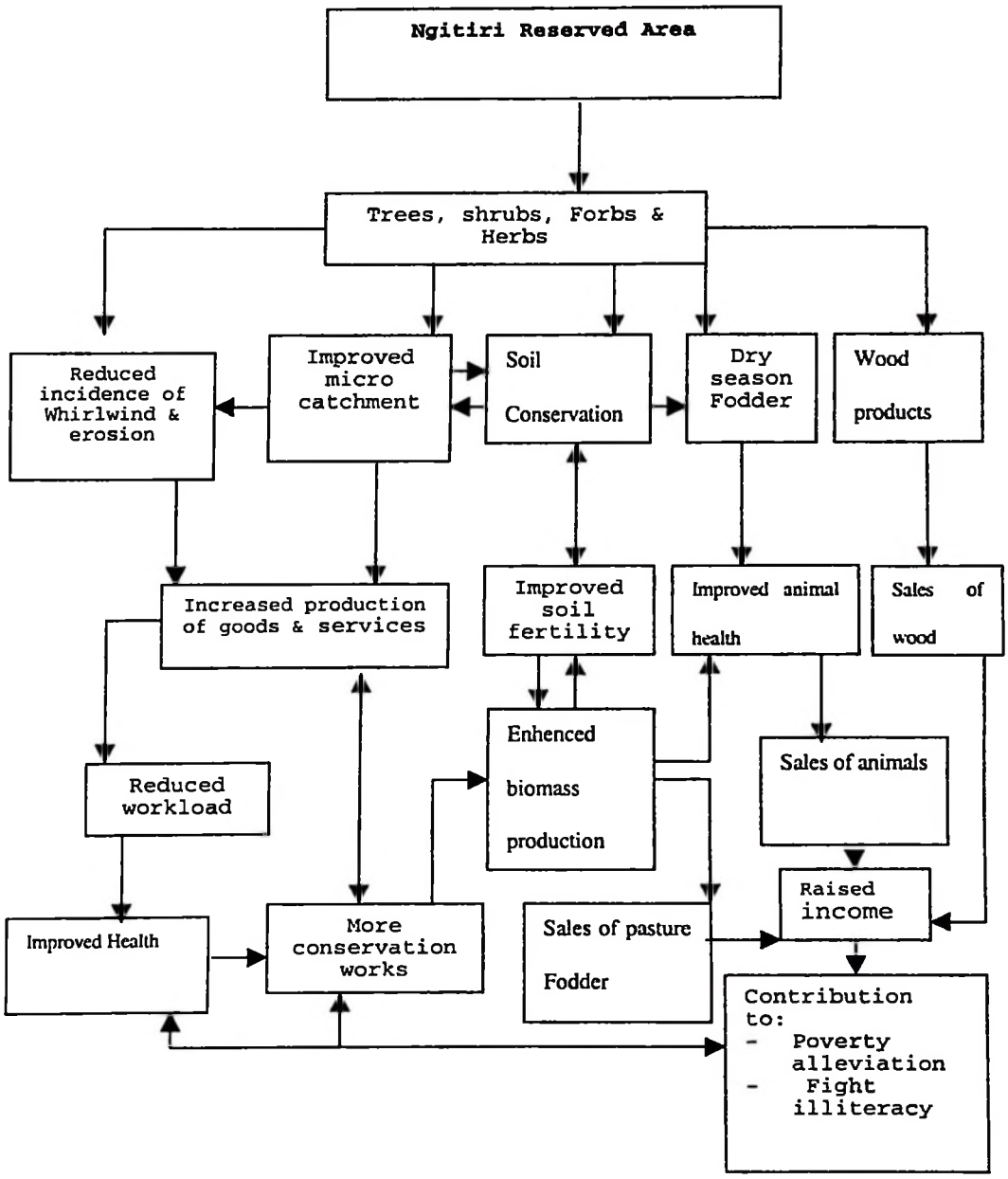

Fig. 1 The myriad interlinkage of ecological & socio-economical benefits of "ngitiri" fodder reserve.

Source: Field rapid participatory rural appraisal, Meatu (1997)

As presented in table (15), 95% of informants indicated or expressed that the "ngitiri" were beneficial to the society generally, 85% indicated "ngitiri" system to be useful for soil conservation, whereas 75% of respondents expressed their views that "ngitiri" should be improved, for soil conservation and fodder production within their agropastoral land use. More than half of the farmers (55%) are willing to establish "ngitiri" (table 10), with belief that "ngitiri" will conserve soils, generate income, improve their soil fertility and rise the level of fodder production (table 15, 17 and fig.1).

Assumption 2

Reform measures on some aspects of management of "ngitiri"and interventions on soil conservation, are needed by farmers, these will improve the role and awareness that woodlands play to local communities living in the respective areas, through appropriate reseach and extention. The most promising reform measure should be the potential suitability rating and classification, for the district silvopasture land use.

The farmers expressed a number of strategies to acquire dry season fodder supply (table 16a), and some measures to compliment "ngitiri" for soil conservation (table 16b). A number of issues are put forward by the farmers as problems that need immediate attention, the farmers point lack of information, land scarcity, livestock encroachment, land clearing for crop production and past mortalities, as hindering their efforts in tree planting in "ngitiri" and their management. Furthermore these very farmers have expressed some reasons of planting trees in "ngitiri", and their

appreciation of the "ngitiri" system (table 13a and 14). This study identifies gaps in knowledge and conflicting land uses, that need reform measures under training or extension and review of land use policy, to avoid conflicting land uses and further failures (table, 9, 10, 11, 12, 13a, 13b and 15). The most important reform measure identified by this study should be to encourage partnership with farmers in management of their "ngitiri" (woodlands), through training and extension, to solve all immediate problems on the management and improvement of "ngitiri" as expressed by farmers (table 11, 12, 13a). Long term reforms are needed to settle issues that need attention of policy makers such as land tenures. Farmers have expressed their concern which need immediate attention (table 9), that land is insufficient, women are generally not entitled to land ownership, and there are limited possibilities of getting the needed land, despite the several available ways of land acquisition. Proper land use planning is needed, that should avoid conflicting land uses, and at the same time mitigating environmental degradation in Meatu district. The farmers have shown interest in lending their partnership to solve the problems confronting them in their agropastoral system (table 16a). Participatory planning of an appropriate silvopasture land use and proper "ngitiri" system design are very instrumental in agropastoral land of Meatu, subject to reform measures in land use pattern and ownership. Land use planners need to incoporate suitability classification in land use plans.

5.3 "Ngitiri" technology specifications

5.3.1 "Ngitiri" components

The study identified two major components, namely the vegetation component and the animal component.

5.3.1.1 The vegetation component

Useful fodder grasses, forbes/ herbs and browsed trees were identified (Appendices 6, 7, 8). The tree species were further sorted out into 19 tree species that had already known or established environmental role on soil conservation and improvement (Appendix 4). Categorically the useful fodder plant species identified can be put into three major groups, namely; grasses, forbes/ herbs and trees. The plant parts used for fodder browse have been presented as L, Fr, FL, S and P for leaves, fruits, flowers, seeds and pods respectively (Appendix 8).

5.3.1.2 The animal component

The study identified four types of animals grazed in "ngitiri" (Appendix 15). Livestock interact with vegetation significantly, and plays a very significant role in the management and sustainability of the "ngitiri" system. In Meatu, natural rangelands provide the bulk of the livestock feed throughout the year. Crop residues and grazing

on fallow lands after crop harvest are other major sources of feed that compliment "ngitiri" at the beginning of the dry season (Malcom, 1953; Otysina and Asenga, 1994). " Ngiriti" provide fodder for all animal at the peak of the dry season.

5.3.2 Structure and Composition of the "ngitiri"

Two distinct strata were identified, the upper strata (dominated by *Acacia tortilis, Acacia nilotica, Acacia polycantha* and *Acacia seyal*), and the lower stratum of grasses, herbs and forbes. Field surveys for cross sectional transects of Meatu district, through the four established vegetation mapping units (appendix 10), revealed three distinct vertical cross sectional profiles and spatial arrangements of "ngitiri" (Appendices 15, 16, 17). The structure and composition of the "ngitiri" are highly influenced by age and management practices. The sustainability of the system depend on the interaction of animals with the system management. Similar observation on composition and structure of "ngitiri" is reported by Mugasha et al.(1996), the authors describe the composition of "ngitiri" to consist of grasses, trees/ shrubs with interaction of the former with animals, making an ideal agroforestry system capable of alleviating dry season fodder shortage, scarcity of fuelwood and poles, declining soil fertility and soil degradation.

5.3.3 "Ngitiri" establishment and managements

"Ngitiri" are traditionally established on degraded land and around homestead (table 14). Among respondents interviewed 83% preferred establishment of "ngitiri" and planting of trees near homestead and in degraded land, 7.4% preferred establishing "ngitiri" and planting trees on their own private "ngitiri", set aside far from homesteads (table 14). A number of respondents (4.0%) want "ngitiri" on their own farm land, this is due to the perceived benefits of "ngitiri" for improving soil fertility and supply of dry season fodder (table 17a). Very little or no management is identified by this study, Otysina (1994) report similar observation, that very little or no management is required during the rain season, once the "ngitiri" are closed for protection. "Ngitiri" boundaries are usually not rigidly marked, but ownership right are well respected and highly guarded. The "ngitiri" are protected by by-laws enforced by the local scouts, locally known as "Sungusungu" and attract penalties to offenders. The site selection for "ngitiri" establishment is influenced by land availability, proximity to homestead and the easy of protection. The potential sites are demarcated in the beginning of the wet season and it is protected from the animals. Initial sitting of the area is the responsibility of the household head. Incase of private or communal "ngitiri", a group of elders become responsible. Kilahama (1994) reports the same approach in his similar study in Shinyanga rural district, "ngitiri" areas are closed during wet season and protected from grazing until the most critical fodder shortage in the dry season. Grazing starts from July/ August, after the crop residues and fallow land have been

depleted. The most common system involve temporary demarcation of paddocks for specific periods. Upon the completion of fodder on a particular paddock, animals are moved to a fresh paddock.

Duration of grazing on a paddock depend on the size, availability of fodder and the number of animals. Similar observation of grazing management are reported by Maro (1995) and Otysina and Asenga (1993) and Otysina (1994) in Maswa and Meatu districts.

Demarcation of paddocks and the movement of animals between the paddock, is controlled by very well informed and experienced elders, who apparently make management decisions on the specific indicators such as; the utilisation level and the availability of fodder. Very high discipline is observed by the users, in respect of demarcated paddocks even though physical barriers are not established. Kilahama (1994) on similar study, reports similar observations; the Wasukuma over years have developed systematic management practices for "ngitiri" system, the management are aimed at optimising fodder and thatch grass production. The size of "ngitiri" vary from 0.2 to 20 hectares in size for the private "ngitiri", where the communal "ngitiri" have an average of 50 hectares (Maro, 1995). Under this study the "ngitiri" size were found to be highly variable and to be influenced by the population pressure. In Meatu 36.7% of respondents have possibility to have enough area to establish "ngitiri", whereas 63.3% had no possibility of getting enough area to establish "ngitiri".

The "ngitiri" system is aimed at increasing the optimal grass production and other vegetation species. Large trees which would possibly deter grass growth are destroyed. Special fodder trees are however protected in "ngitiri" as confirmed by 70.4% of

respondents (table 16b). Most of trees which now exists in "ngitiri" are believed to influence grass production and general fodder situation. Kilahama (1994) reports that, there is farmers' awareness on the concept of nutrient cycling and organic matter influences on soil regeneration, to provide favourable conditions for grass growth, rendered by trees. Plates (3,4) above indicate the various level of grazing managements.

5.3.4 Ngiriti technological specifications

Table (18) below, gives the "ngitiri" technology specifications, for Meatu district. According to FAO (1977; 1979; 1993) and Raintree (1987), the potential of an agroforestry technology is summarised in point form as being in relation to; type of subsystem design, management practices, major functional roles, justification for target location, the existing practices, possible species and technological characteristics.

In this study "ngitiri" technological specifications were diagnosed and designed (table 18), and the associated technological characteristics detailed (appendix 9). The design pulls together the most promising components, to give the "ngitiri" technology design an improved land use which meets as many of the technological specification as possible.

Table 18: "Ngitiri" system technological specifications

(A) "Ngitiri" practices and specifications for undergrowth stratum.

SUBSYSTEM I:	**Undergrowth of vegetation cover, consisting of mainly herbs and forbes.**
FUNCTIONS:	Fodder production, soil conservation, micro climatic amelioration.
LOCATION:	Communal and private "ngitiri" fodder reserve.
OUTPUT:	Browsing fodder, better cattle performance due to longer dry season fodder.
SPECIES:	Species appendix (7).
MANAGEMENT:	Rotational browsing, paddocking, cut and carry, periodic opening and closing of "ngitiri" enclosures.
SUBSYSTEM II:	**Undergrowth of vegetation cover, consisting of maily grasses.**
FUNCTIONS:	Fodder production, soil conservation, micro habitat, micro climatic amelioration.
LOCATION:	Communal and private "ngitiri" (traditional fodder reserve).
OUTPUT:	Grazing fodder, better cattle performance due to longer dry season fodder supply.
SPECIES:	Species appendix (6).
MANAGEMENT:	Rotational grazing, paddocks, cut and carry, periodic closing and opening.

(B)"Ngitiri" practices and specifications for intermediate to upper storey stratum

SUBSYSTEM III:	**Intermediate to upper storeys of mainly tree species, predominated with Acacia species.**
FUNCTIONS:	Fodder production, soil conservation, micro habitat, micro climatic amelioration.
LOCATION:	Communal and private "ngitiri" (traditional fodder reserve).
OUTPUT:	Browsing fodder, better cattle performance due to longer dry season (by lopping).
SPECIES:	Species appendix (8).

C) "Ngitiri" practice and specification for boundary planting .	
SUBSYSTEM IV:	**Boundary planting.**
FUNCTIONS:	Control tress passing and encroachment; provide fodder, fuelwood, poles and micro climatic amelioration and protection of "ngitiri" enclosures.
LOCATION:	Boundaries of communal and private "ngitiri" (traditional fodder reserve).
OUTPUT	Browsing fodder, better cattle performance due to longer dry season fodder supply (through lopping), poles and withes, micro habitat.
SPECIES:	Species include *Euphorbia tiruculi, Agave sisolana, Acacia species, some Eucalyptus spp.*
MANAGEMENT:	Enrichment planting, lopping, thinning and prunning.
D) "Ngitiri" practice and specification for animal component.	
SUBSYSTEM V:	**Animal component.**
FUNCTIONS:	Production of milk, meat, hides and income generation, interactions at tree animal interface.
LOCATION:	Communal and private "ngitiri" fodder reserve.
OUTPUT:	Milk, meat, hides and income generation, interactions at tree animal interface.
SPECIES:	Animals include cattle, goat, sheep, donkeys (Appendix 15).
MANAGEMENT:	Rotational grazing/browsing, paddocks, herding and zero grazing.

Sources: Field survey (1997).

5.4 Qualitative physical land evaluation for potential suitability classification

The results of qualitative land evaluation are based on land evaluation for extensive grazing and community forests. This is because the "ngitiri", which is the main focus of this study encompasses the rotational grazing of animals under communal or private trees or grasses. In that regard, the suitability rating for extensive grazing and community forests will effectively suit the suitability aspects for "ngitiri" as a

silvopasture system. Taking into account that the "ngitiri" system have an added advantage of extra deliberate management efforts and protection , as compared to communal forest land and extensive grazing, the optimal suitability for extensive grazing and community forests will be even more effective to "ngitiri" system.

5.4.1 Land evaluation for extensive grazing

Table 19,gives the results of land evaluation for suitability rating for extensive grazing.

Table 19: Meatu district suitability rating for extensive grazing land

Land quality for extensive grazing	Significance	Mapping units			
		Z1	Z2	Z3	Z4
Growing period	2	N	N	N	N
Sufficiency of energy	2	S2	S2	S2	S2
Sufficiency of water for pasture	1	S2	S2	S2	S2
Sufficiency of pasture	1	S2	S2	S2	N/gedf
Soil erosion and other hazards	1	N	N	N	N
Excess salts	2	S1	S1	S1	S1
Sufficiency of nutrients	2	S1	S1	S1	S1
Suitability for extensive grazing	*	N/S2	N/S2	N/S2	N/gedf

Key:

Z1, Z2, Z3, Z4 = Vegetation zones (appendix 10)

*Significance: 1 = very important; 2 = important; S1 = Suitable; S2 = Moderately suitable; N = Not suitable

Limiting factors: g = game reserve; e = erosion hazard; d = degradation severity; f = flood

Source: Ground truth field survey (1997).

The first need to decide whether the "ngitiri" technology can be used to address dry season fodder shortage and mitigation of environmental degradation simultaneously is

based on land evaluation (table 19). For the judgement to be more objective, suitability specifications of "ngitiri" took into accounts of the environmental conditions under land evaluation (appendix 11). Meatu district has very short humid period, where P > ETP, appendices (12, 13, 14). This implies that, most of the time crops survive on the stored soil moisture, therefore the growing period ceases immediately the rainfall falls below ETP. The growing period for the last five years for Meatu district ranges from 78 days to 142 days, (appendix 12, 13, 14). The growing period for the seasons 1996/97 and 1997/98 were not considered due to "La nino" and "El nino" effects respectively. This range of growing period rates Meatu district to Not suitable (N) for pasture growth (table 19 and appendix 11). Similar results are revealed by Otysina and Asenga (1994) and reported also by Hamidou (1996) in their studies on growing period for Meatu district. The district temperature regime of maximum temperature 27.6°C to 30.2°C and minimum temperatures of 15°C to 18.3°C. with mean temperature of 22.6 to 24.6°C.(MNTE, 1995), rates Meatu district as moderately suitable (S2) for pasture (table 19), based on sufficiency of energy (appendix 11). A similar study under similar semi arid conditions of Igunga, a favourable temperature regime of 16°C to 32°C maximum for Igunga district extensive grazing is reported (kashangwa, 1989). The soils of Meatu are suitable (S1), based on suitability of soil sodicity for pasture growth (appendix 11 and table 19,) with reported % exchangeable cation less than 40% (DRDP, 1997). The sufficiency of water for pasture in Meatu (table 19 and appendix 11), is rated moderately suitable (S2), based on the effective soil depth (50 - 90cm) and rainfall ranges (600 to 1000 mm per anum) for Meatu

district (DRDP, 1997). The district is rated moderately suitable (S2), based on drinking water for animals table (8) and appendix (11). Similar studies in the four zones of the district, report great potential for water harvesting and bore wells (DHV and ILACO, 1975). Meatu district is rated suitable (S1), based on sufficiency of nutrients (table 19, appendices 5, 11). The soils of Meatu are mainly clayish, with tremendous variations from hill tops to valley bottoms. The vertic soils are quite extensive in Meatu, studies by DHV and ILACO (1975) and DRDP (1997) report suitability of soils of Meatu for pasture growth. The greater part of the soils of Meatu are still regenerating, if given time have the ability to develop reasonable nutrient sufficiency status, particularly under natural regeneration of vegetative cover (DRDP, Personal communication, 1997), reaffirmed by appendices (16, 17, 19).

The study rates Meatu to moderately suitable (S2), based on sufficiency of pasture, table (19) and appendix (11). Studies by Kilahama (1994), Maro (1995), Otysina and Asenga (1994), report similar status as regard to pasture availability in the rangelands of Meatu, to be moderately suitable, and lasting only for short period, with a severe scarcity especially in dry season. In Meatu erosion hazard is severe in all places, rating the district zones (appendix 10) , not suitable (N), for extensive grazing (table, 19).

5.4.2 Land evaluation for community forests

Table (20) below, gives the results of suitability rating for community forests land utilisation type in Meatu district.

Table 20: Meatu district suitability rating for community forests land utilisation type

Mapping unit	Vegetation zone	Land utilisation type
		Community forestry
Z1	Zone 1	S1
Z2	Zone 2	S1
Z3	Zone 3	S1
Z4	Zone 4	S2/e,d,g,s

Suitability rates: N = Not suitable; S1 = suitable; S2 = Moderately suitable.

Limiting factors: e = erosion; d = degradation; g = game reserve; s = Seasonal floods.

Source: Field survey (1997); Field diagnosis and design (1997).

Mapping units Z1, Z2 and Z3 (appendix 10), are suitable (S1); implying they are suitable for community forest (table 20), the units are suitable (S1), at the potential utilisation level, since community forests can be attained when the land is protected, by encouraging natural regeneration, enrichment planting with MPTs and "ngitiri" enclosure, to reclaim the degraded land. Maro (1995) reports the possibility for extensive grazing in community forests, under strict and controlled management e.g. paddocking, rotational grazing and fallowing. Over a period of time "ngitiri" in these

units can be alternated with arable rainfed agriculture. Most farmers report high crop yields when cultivating on "ngitiri" areas, after "ngitiri" fallow period (Mziray; Personal communication, 1997). The mapping unit Z4, excluding game reserve (appendix 10), is marginally suitable (S1), for community forests, because they have an extensive and severe soil erosion. These areas are open for public grazing. Long term destocking, fallow periods of "ngitiri" and special measures such as planting crop cover i.e. sisal and Eurphobia species, to reduce the risk of soil erosion, can help improve these soils and mitigate further degradations.

CHAPTER 6

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

A diagnostic survey conducted in Meatu silvopasture land use system, to refine the "ngitiri" technology, among the agropastoralists of Shinyanga, based on descriptive D and D methodology, came up with the components, structure, management and the technological specifications for the "ngitiri" technology. The D & D survey with a blend of land evaluation and ecological survey, has revealed a number of qualitative socio-economic and ecological aspects of the "ngitiri" technology. Which need attention.

The choice of farmers to adopt "ngitiri" as an appropriate technology to cater for livestock and community forestry in Meatu, is determined by the need for certain level of production, ecological parameters and socio-economical status e.g. the daily problems of cash, fodder and food crops. Major identified problems in Meatu include; the shortage of land for grazing, drought, shortage of wood based products, soil erosion, vegetation degradation, conflicting land uses and wastage of resources by cultivating unproductive land. The burning issue revealed is the aggravated problem of dry season fodder shortage and associated environmental degradations. The technical difficulties revealed in this study, for "ngitiri" management and improvement include;

the absence of tree seedlings, the lack of proper treatment or care at early stages of tree establishment, inadequate knowledge of the site requirements of tree species (especially MPTs), the negative ecological effects of trees on the sites, the lack of integration of the produce to satisfy various end needs, and conflicting primary objectives of land management.

Social economically, very little labour is needed to practice the "ngitiri" technology, as compared to other agroforestry practices. Negligible capital investment is needed as the technology is compatible with traditional local practices, which are more or less a routine .

The "ngitiri" potentials attained after improvement by HASHI/ ICRAF program, indicate the system to have special advantages. One of these is that, it has an element of traditional system, under which bush fallow trees and grass/ shrubs are left to rejuvenate the soils, serve as wind break and for shade (if cattle are grazed in it). The "ngitiri" has the potential of improving the ecology of the site, where trees, grass and herbs/ forbes are growing together. Wood plants stabilise and protect the land, trees stabilise the soils because they are rooted deeply. In addition trees, enrich the surface soil by their litter, through deposition of their leaves, flowers, twigs and branches. Research on "ngitiri" show that the extensive ground cover of shrubs; grasses, herbs and forbes, help prevent soil erosion and facilitate water infiltration and percolation, by reducing surface run off, and increasing soil water storage.

The solution to many of the problems identified in this study, depend on one hand, to the technical and the communication skills of the extension service, and on the other hand to the involvement of the farmers at all stages of planning and implementation, to make "ngitiri" system integrated with experience and practical knowledge which already local people have. Extension agents must make clear to farmers that, the long term effect of negative traditional practices e.g. uncontrolled extensive grazing and shifting cultivation, is the result of present severe land degradation, particularly soil erosion and siltation of dams and rivers. These effects have been of gradual and of long term manifestation, farmers already under pressure of e.g. land, decline of crop production, population of both human and livestock, are unlikely to understand them or be interested in them, their interest is short term results. Institutional bodies (e.g. HASHI, ICRAF, DRDP and other NGOs), are deemed responsible and instrumental in addressing and alleviating the current land use policy dilemma, that lead to environmental problems, affecting the adaption and sustainable development of the "ngitiri" system, under land use suitability classification.

6.2 Recommendations

6.2.1 Training and extension needs

Extension and training is needed to stimulate and elicit endogenous change of attitude and approaches to resource management, to impart knowledge and skills to the main key players in "ngitiri" fodder reserves and agroforestry technologies in general, so as

to ensure dry season fodder shortage is alleviated, and environmental degradation is mitigated, the following are recommended:-

1) Training of farmers in silvopasture and other agroforestry practices, to have demonstratable leadership in on-farm practices.

2) Involving politicians, administrators and village leaders in agroforestry practices to ensure the conservation message are taken up through political and local government institutions.

3) Training of extension agents and NGO staff, on how to advise farmers on resource management and sustainable environmental resource utilisation, that will not degrade the environment.

4) Youth education through programmes for school teachers, so as to ensure school teachers are trained, to teach agroforestry and conservation, or practice agroforestry in their schools.

5) Training of staff in the local institutions, direct in touch with farmers e.g. HASHI, so as to have competent and multidisciplinary staffs in environmental forestry and rural development at grass root level.

6) Participatory Rural Appraisal, where farmers should evaluate themselves on performance related to their environmental resource, so as to come up with participatory management plans.

7) Environmental exhibition, encompassing exhibits, films, cultural groups and so on, so as to raise awareness and publicity of sustainable environmental resource management.

8) Farmers visits and study tours, to enable pioneer farmers (especially women and schools) acquire hand-on experience.

6.2.2 Research needs on appropriate silvopasture technology

Research is needed to identify, test and facilitate adoption of suitable silvopasture technologies, to achieve this the following are recommended:-

1) Evaluation of traditional environmental resource management systems, and characterizations of existing systems, as a strategy to improve the existing "ngitiri" system for adaption or adoption of improved "ngitiri" technology versions respectively.

2) Screening and evaluation of the multipurpose tree species (MPTs), for selection based on suitability, to increase fodder, fuel wood, and environmental conservation in "ngitiri".

3) Research on indigenous knowledge, attitude and practices that can be useful as a package in the strategic planning for the silvopastoral land use e.g. on "ngitiri".

4) Capacity building for national and local researchers within the conservation programmes like (HASHI), with emphasis on collaboration with universities and institution such as TAFORI, so as to attain quality research work.

5) Research on economics of rangelands and new emerging patterns of pastoralism.

6) Research on range improvement and management, through the involvement of pastoralists on on-farm participatory research in "ngitiri".

7) Research on the carrying capacity of rangelands and suitability rating for land utilisation types.

6.2.3 General recommendations

In order to ensure sustainability of "ngitiri" resource utilisation, a number of general recommendations are necessary:

1) Assessment of the potentials of "ngitiri" resources and recommendations on use according to capability.

2) Better coordination among institutions working in dryland husbandry for proper land management.

3) Collection and review of previous studies on pastoralism to identify gaps in knowledge.

4) Water harvesting through simple technologies, and simple methods of re-seeding and improving rangelands in Meatu district.

5) Need for secure land tenureship, proper range land laws, and land use planning.

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Appendix 1

CLASSIFICATION OF AGROFORESTRY SYSTEMS

Classification may take one of a combination, of four forms:

1. Ecological region (in tropics)
   - Humid/subhumid lowlands
   - Arid and semi arid lands
   - High lands
2. Structure (Nature of Components)
   - crops and trees (Agrisilvoculture)
   - Trees and pasture/animals (Silvopasture)
   - Crops and pasture/animals and trees (Agrosilvopasture)

2a. Structure (arrangement of component)
   - Spatial (arrangement of components) with time/space). e.g. Home garden, most silvopasture systems.
   - Temporal (Coincident, concomitant, sequential, overlapping)

3. Functional (mainly wood perennial)
   - Productive (eg. Food, Fodder, Fuel)
   - Protective (e.g. windbreak, shade for crops, shelter belt, soil improvement, soil conservation.

4. Social - economic basis
   - Level of technology inputs
   - Intensity of management
   - Commercial goal

Source: Leach, G and Mearns, R.(1985).

Appendix 2

DIAGNOSIS AND DESIGN METHODOLOGY.

PREDIAGNOSTIC SURVEY

1. Planing the study

    1.1 Identifying the objectives

    1.2 Specifying the area to be studied

    1.3 Identifying collaborating institutions

    1.4 Selecting and adapting the D&D methods to be used

2. Regional reconnaissance

    2.1 Identifying and describing major land units and population distribution

3. Preliminary identification and description of the land use system

    3.1 Differentiating and describing major land use systems

    3.2 Preliminary assessment of problems and constraints of land use system

    3.3 Preliminary assessment of agroforestry potential

Appendix 2 continued...

4. Site Selection

4.1 Criteria for selection

i) Severity of the problem

ii) Silvopasture potential

iii) Regional representativeness

iv) Priority district

v) Selected mapping units

vi) Selected subsystem

DIAGNOSTIC STUDY

5. Diagnostic survey

i) Identification of common land use problem

ii) Trouble shooting the silvopasture system to identify causal factors and constraints

iii) Investigating interaction between management units and process in general land scape

6. Diagnostic analysis

i) Analysis of field data for identification of key constraints and point of intervention for the silvopasture system development potential

ii) Assess sustainability problems of the silvopasture

Appendix 2 continued...

7. Silvopasture system specification

   i) Listing the specifications for the system

   ii) Listing the design constraints for the system

   iii) Listing the desirable attributes for the system

   iv) Overall development strategy for the system

TECHNOLOGY DESIGN

8. Candidate technology

   i) Feasibility of the technology to meet the system specifications (ii) Selection and prioritization of the most promising technology combinations

9. Technology specifications

   i) Components, characteristics, management and structure

   ii) Triangulation of desirable attributes of the technology with the total knowledge of the diagnosed system

10. Technology design criteria***

   i) Functions

   ii) Locations

   iii) Components

   iv) Arrangements

   v) Management

Appendix 2 continued...

EVALUATION AND REDESIGN

11. Ex-ante evaluation and redesign

    i) Checking the land users' response to the design proposal

    ii) Preliminary evaluation of productivity, sustainability and adoptability

    iii) Triangulation with the design stage *** for further modifications to accommodate the ex-ante suggestions

12. Suitability classification

    i) Classification of suitability for wider application***

    ii) Suitability tables and maps for the study area

PLANNING

13. State of knowledge review

    i) Assessing the readiness of the technology extension

    ii) Assessing the needs for further research with the technology

14. Research and extension Needs

    i) Overall plan of action

    ii) Extension activities/needs

    iii) Integration of research and extension goals and activities

    iv) Collaboration in research and extension networks

    Source:Scherr (1984;1991)

Appendix 3

QUALITATIVE ECOLOGICAL AND SOCIAL-ECONOMICAL EVALUATION OF NGITIRI FODDER RESERVE: SILVOPASTURE LAND USE

SECTION A: BACKGROUND INFORMATION

1. Code: Vegetation zone

   01: Zone 1

   02: Zone2

   03: Zone3 & 4

2. Are you the head of household ?

   Code: Household head

   01: Yes, Head of household

   02: No, not head of household

3. Gender

   Code: Sex

   01: Male

   02: Female

4. What is you age?

   Code: age

   01: 21-30 years 02: 31-40 years

   03: 41-50 years 04: 51-60 years

   05: 61-70 years 06: 71< years

Appendix 3 continued...

5. What is your major source of income?

Code: Major sources of income

01: Livestock

02: Farming

03: Other sources (Petty business, pottery, etc).

SECTION B: LAND USE TENURESHIP AND MANAGEMENT

1. Do you own land?

Code: Land ownership

01: Yes, own land 02: No, do own land

2. Are you secured with your land ownership?

Code: Land security

01: Certain 02: Uncertain

3. How did get land?

Code: Land acquisition

01: Inheritance 02: Allocated by government

03: Purchase 04: Cleared a forest

4. Is you land sufficient?

Code: Land sufficiency

01: Yes, Sufficient

02: No, not sufficient

Appendix 3 continued...

5. Can women own land?

   Code: Women land ownership status

   01: Yes, can own land

   02: No, cannot own land

6. Is it possible to get more land?

   Code: Possibility to get more land

   01: Yes, possible to get more land 02: Not possible to get more land

7. Do you own livestock?

   Code livestock ownership

   01: Yes, own livestock 02: No, Do not own livestock

8. Do you own "ngitiri"?

   Code: "ngitiri" ownership

   01: Own "ngitiri" 02: Do not own "ngitiri"

9. How do you find the trend of fodder availability for the past 5-10 year?

   Code: Trend of fodder availability

   01: Fodder has been declining 02: Fodder has been increasing

   03: Fodder has been fluctuating

10. Are you willing to establish "ngitiri" for dry season fodder production?

    Code: Willingness to establish "ngitiri"

    01: Yes, willing to establish "ngitiri"

    02: No, not willing to establish "ngitiri"

Appendix 3 continued...

11. Do you think "ngitiri" are beneficial?

    01: Yes, are beneficial 02: No, are not beneficial

12. Are "ngitiri" helpful in soil conservation?

    Code: "ngitiri" for soil conservation

    01: Yes, they are usefully for soil conservation

    02: No, they are not useful for soil conservation

13. Should "ngitiri" be improved for fodder production?

    Code: Improvement of "ngitiri"

    01: Yes, "ngitiri" should be improved

    02: No, "ngitiri" should not be improved

14. Are communal "ngitiri" accessible?

    Code: Accessibility of communal "ngitiri"

    01: Yes, Accessible

    02: No, Not accessible

SECTION C: PROBLEMS IN SILVOPASTURE LAND USE

1. What are the major problems affecting you livestock production?

    Code: Problems affecting livestock

    01: Diseases 02: Water scarcity

    03: Dry season fodder supply

Appendix 3 continued...

2. What are the major problems in management and improvement of "ngitiri"?

   Code: "ngitiri" management and improvement problems

   01: Overgrazing 02: Drought

   03: Termite attack of transplants

   04: High mortality of seedlings

   05: Encroachment/lack of title deeds

   06: Tickborn diseases 07: Bribery

3. What are the major problems in tree planting and management in "ngitiri" fodder reserves?

   Code: Problems of tree planting

   01: Lack of information

   02: Past mortality

   03: Livestock encroachment

   04: Land scarcity

   05: Land preparation for crop production

Appendix 4

LIST OF COMMON TREE SPECIES FOUND IN NGITIRI FODDER RESERVES AND THEIR ENVIRONMENTAL ROLES

BOTANICAL NAME	ENVIRONMENTAL ROLE/UTILIZATION
Acacia albida	Nitrogen fixation, shade, soil conservation, dune fixation, soil improvement.
Acacia melifera	Nitrogen fixation, soil conservation, dune fixation.
Acacia nilotica	Soil improvement, windbreak, nitrogen fixation, soil conservation.
A. polyacantha	Nitrogen fixation, ornamental, soil improvement.
Acacia saligna	Mulch, shade, soil improvement, nitrogen fixation, soil conservation.
Acacia senegal	Nitrogen fixation, shade, soil conservation, soil improvement.
Acacia seyal	Nitrogen fixation, soil conservation, soil improvement, windbreak.
Acacia tortilis	Nitrogen fixation, shade, soil conservation, soil improvement, windbreak.
A. Xanthophloea	Nitrogen fixation, soil improvement, ornamental.
Albizia gumifera	Nitrogen fixation, shade, mulch, soil conservation, dune fixation, soil
Albizia lebbeck	improvement.
B. petersiana	Mulch, Nitrogen fixation, shade, soil conservation, ornamental, soil
Azadirachta indica	improvement.
Bauhimia variegata	Shade, ornamental.
D. Mlanoxylon	Windbreak, nitrogen fixation.
E. abbyssinica	Nitrogen fixation, shade, soil conservation, ornamental, dune fixation, soil
P. curatellifolia	improvement.
P. thonningii	Mulch, nitrogen fixation.
Salvadora persica	Ornamental, mulch, nitrogen fixation.
Tamarindus indica	Shade, ornamental.
Trema orientalis	Mulch, shade, soil conservation, ornamental, dune fixation.
Ziziphus mauritania	Mulch, Nitrogen fixation, shade, soil conservation, dune fixation, soil
	improvement.
	Shade, ornamental, mulch.
	Mulch, shade, soil conservation, ornamental, dune fixation.
	Soil conservation, wind break.

Appendix 5: SOME SOIL PHYSICAL AND CHEMICAL PROPERTIES OF MAPPING UNITS

Property	Z1	Z2	Z3	Z4
Sand (%)	53.0	58.9	64.0	64.0
Silt (%)	12.0	12.6	12.9	10.0
Clay (%)	35.0	28.6	34.0	36.6
pH (1:2.5: soil: water ratio)	7.8	7.5	7.8	7.6
Organic Carbon (%)	2.5	2.2	2.2	2.2
Total N (%)	0.3	0.3	0.3	0.3
Available P (me k^{-1} soil)	4.0	4.1	4.3	4.4
Electrical Conductivity (ìs cm^{-1})	26.8	19.8	23.0	19.8
K (me $100gm^{-1}$)	0.59	0.6	0.9	0.9
Ca (me $100gm^{-1}$)	50.8	24.6	41.7	41.7
Na (me $100gm^{-1}$)	0.62	0.6	0.8	0.8
Me (me $100gm^{-1}$)	1.4	83.6	0.8	0.8
CEC (me $100gm^{-1}$)	83.5	55.0	84.4	64.4
% Base saturation	64.4	53.5	52.4	68.5

Source: DRDP, (1997); Field survey (1997).

APPENDIX 6: LIST OF COMMON FODDER GRASSES IDENTIFIED IN "NGITIRI" FODDER RESERVES IN MEATU DISTRICT

Serial Number	Botanical name
1	*Urochloa pullulans*
2	*Ruttbelia exalitata*
3	*Cynodon spp.*
4	*Cenchrus ciliaris*
5	*Digitaria milanjiana*
6	*Aristida adescensionis*
7	*Choloris roxburghiana*
8	*Dechanthium spp.*
9	*Setaria verticillata*
10	*Rynchelytrium spp.*
11	*Eragrostis spp.*
12	*Dixtyloctenium aegyptium*
13	*Henteropogon contortus*
14	*Panicum spp.*
15	*Themeda triandra*
16	*Sporobolous spp.*
17	*Rhynchelitrium spp.*
18	*Buffalochloa spp.*

Source: Field survey (1997).

Appendix 7

LIST OF COMMON FODDER HERBS AND FORBES SPECIES IN "NGITIRI" IN MEATU

Serial Number	Species botanical name
1	*Triumfetta rhomboidea* **
2	*Datura stramonium* ***
3	*Sida spp.* *
4	*Solanum incanum* ***
5	*Impome spp.* *
6	*Commelina beghalensis**
7	*Boerhavia spp.* *
8	*Conyza stricta* *
9	*Acanthosperumum hispidium* *
10	*Indigofera erecta* *
11	*Ocinum americana* ***
12	*Menchma debile* ***
13	*Erlangea spp.* *
14	*Argemone mexicana* ***
15	*Corchorus spp.* *
16	*Bidensa pilosa* *
17	*Tribulus terrestris* **
18	*Launaea cornuta* *
19	*Striga spp.* ***
20	*Trichodesma zeylanicum* ++
21	*Glycine spp.* *
22	*Amaranthus spp.* *
23	*Xanthium spp.* *
24	*Cucumis spp.* ++
25	*Claume spp.* *

*	Browsable by cattle
**	Browsable in young stages
***	Not browsed/toxic
++	Not known

Source: Field survey (1997)

Appendix 8: LIST OF COMMON BROWSED TREE SPECIES IDENTIFIED IN NGITIRI

No.	Botanical name	Vernacular name
1	*Acacia senegal*	*igwata, mkwata, L*
2	*Acacia seyal ilula*	*Iyape, Iyelu, L*
3	*Acacia nilotica*	*mdubilo, L*
4	*Acacia tortilis*	*mgunga, L,P,S*
5	*Acacia melifera*	*Mluguta, P*
6	*Acacia polyacantha*	*mugu, L,P,S*
7	*Acacia albida*	*nanda, P*
8	*Albizia camara*	*mpogoro, L*
9	*Adansonia digitata*	*Ng'wandu, L, Fr*
10	*Buhimia pentarsiana*	*mfumbi, L*
11	*Borassus sethiopum*	*muhama, Fr, L*
12	*Brachystergia species*	*muyombo, S*
13	*Dalbergia melanoxylon*	*myembe, ngeme, L*
14	*Erythrina abyssica*	*mkala, mpilipili, L*
15	*Dichrostachys cinerea*	*mutundulu, L,*
16	*Grewia bicolor*	*mukoma, L, Fr*
17	*Trichilia emetica*	*sungute, L,*
18	*Trema orientalis*	*muhowe L, Fr, P*
19	*Tramarindus indica*	*rushishi, L, Fr*
20	*Kigelia africana*	*mgwicha, L, FL*
21	*Markamia obtusifolia*	*mbapa, L*
22	*Ziziphus mauritania*	*mbapa, L*
23	*Ziziphus mucronata*	*mgugumo, L, FL*
24	*Ximenia americana*	*muhowe, L*
25	*Sclerocarya birea*	*mhonje, L, Fr*

Key for browsable parts of the tree forage:

L	Leaves	Fr	Fruits		FL
	Flowers				
S	Seeds				
P	Pods				

Source: Field survey (1997).

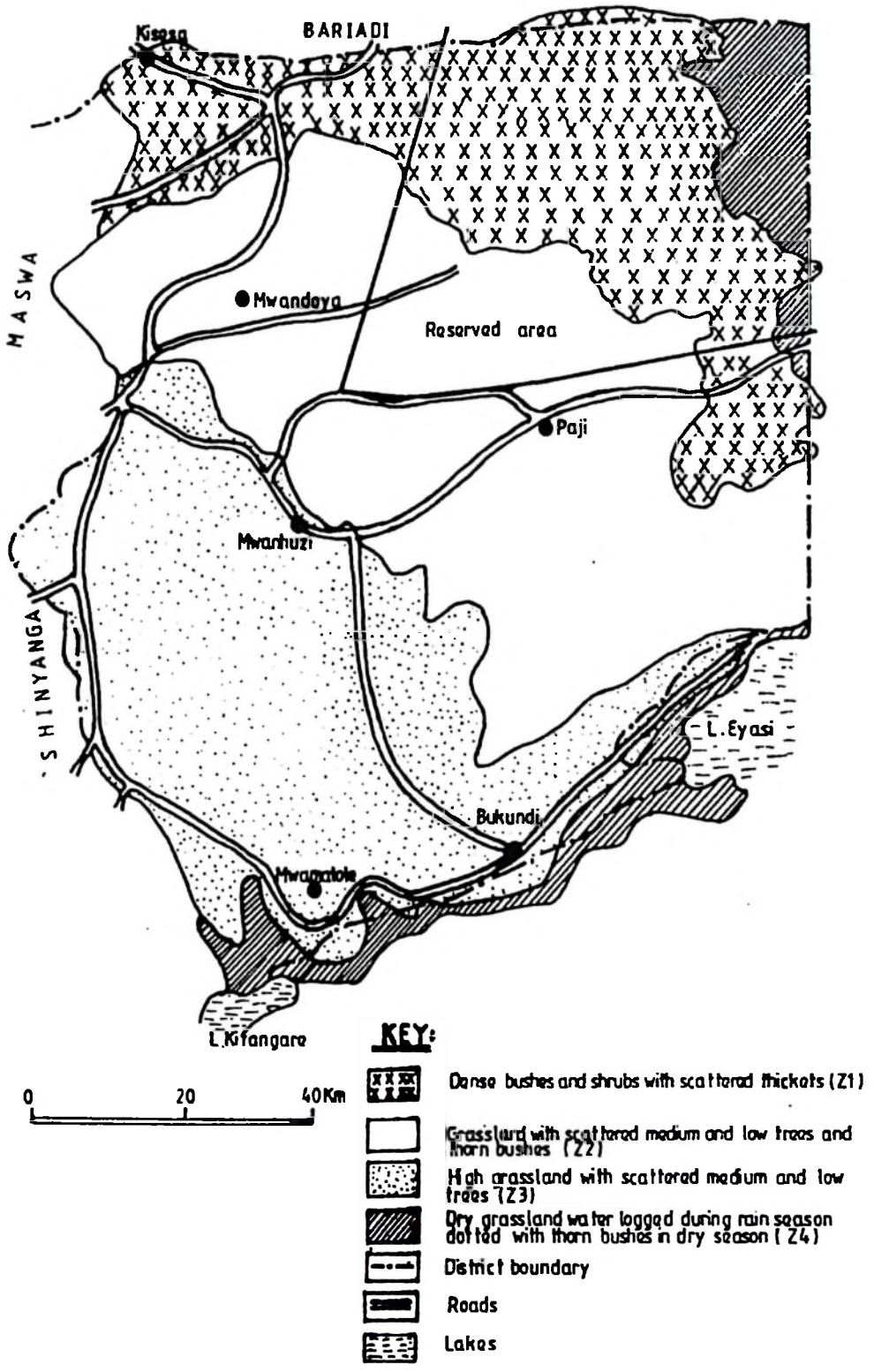
Appendix 9

CHARACTERISTICS OF "NGITIRI" SILVOPASTURE SYSTEM IN MEATU

1. Biophysical requirements	
Rainfall	600 mm to 1 200 mm per year
Altitude	1000 m to 1 500 m asl
Soil type	Clay, clay loan, sandy clay
2. Land scape organisation	
Settlement pattern	Nucleated homesteads
Grazing areas	Private/common size 20 - 50)
3. Soil economic conditions	
Livestock types	Cattle, sheep, goats, donkeys
Herd size	5 - 1000 (common size 20 - 50)
Soil fertility maintenance	Rotational grazing, paddock, cut and carry
Livestock management	Herding, Extensive rotational grazing in paddocks
4. Social economic conditions	
Population	Human 159 439; livestock 1 104 627
Marketing	Organised auctions for livestock
Land tenure	Private, communal, hired

Source: Field Diagnostic and Design survey in Meatu (1997).

Appendix 10 Vegetation mapping units for Meatu district



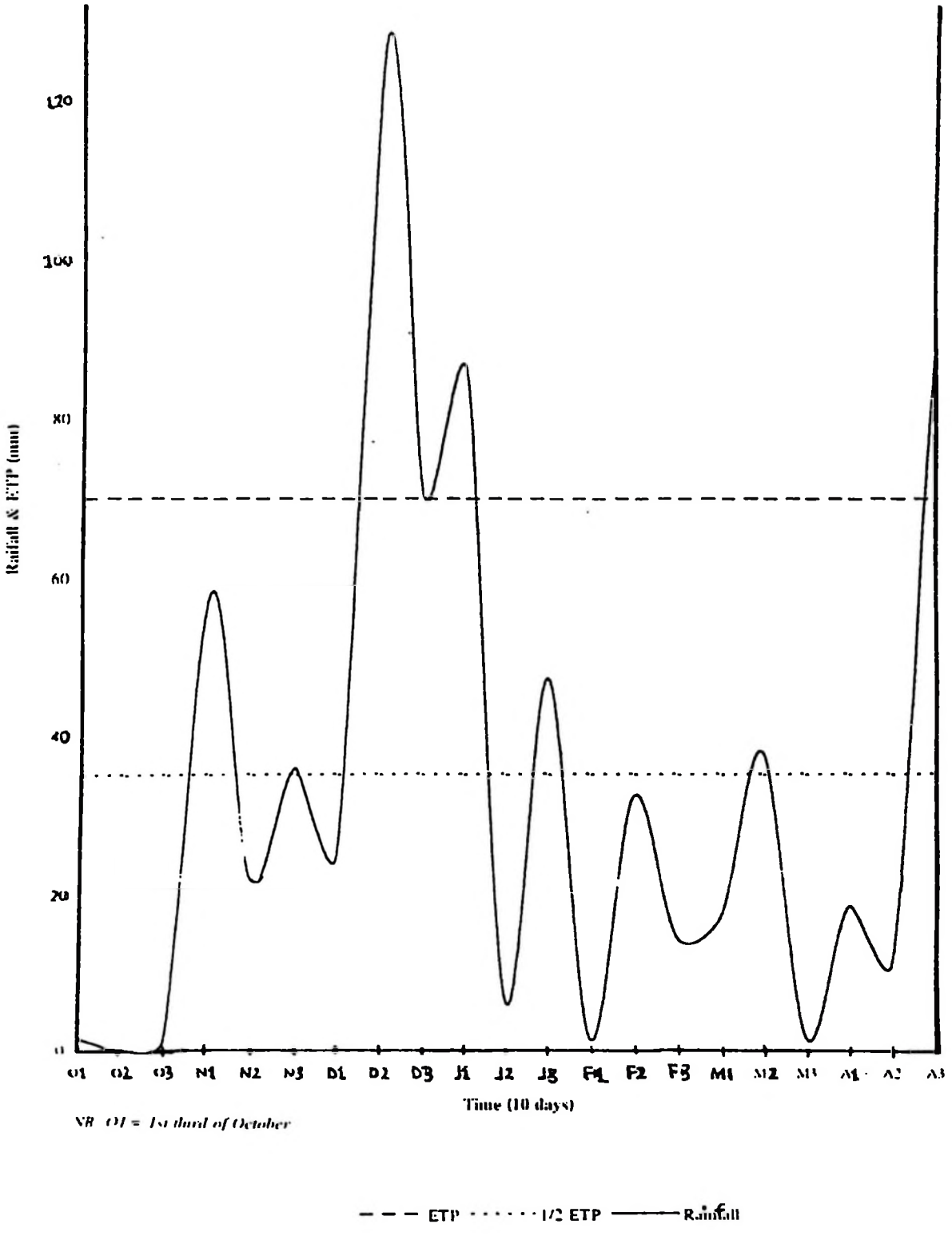
Appendix 11
REQUIREMENTS FOR LAND SUITABILITY EVALUATION FOR EXTENSIVE GRAZING.

Land quality	Land characteristic	Suitability rating			
		Unit	S1	S2	N
Growing period	Moist period	Days	>160	>160	<160
Sufficiency of energy	Mean temperature	°C	15-28	15-28	>45
	Max. temperature	°C	45	45	>45
Sufficiency of water for pasture	Rainfall	mm	7700	540-700	<540
	Effective soil depth	cm	>90	90-50	<40
Drinking water	Water sources	Days	Reliable	Reliable	*
Solidicity	% exchangeable	%	<40	40-60	>60
Sufficiency of nutrients	C.E.C.	meq/100g	>10	10-2	<2
	Soil reaction	pH class	5.5-8.5	5.5-8.5	<4.5;>9.5
	% base	%	>50	50-20	20
Sufficiency for pasture	Vegetation type	type	grassland/bushed grass	Woodland/thickets	*
Erosion/Degration hazard	Slope angle	%	<5	5-20	<20
	Observed risk	class	slight	moderate	severe
	Consistence	class	firm/hard	friable	very friable

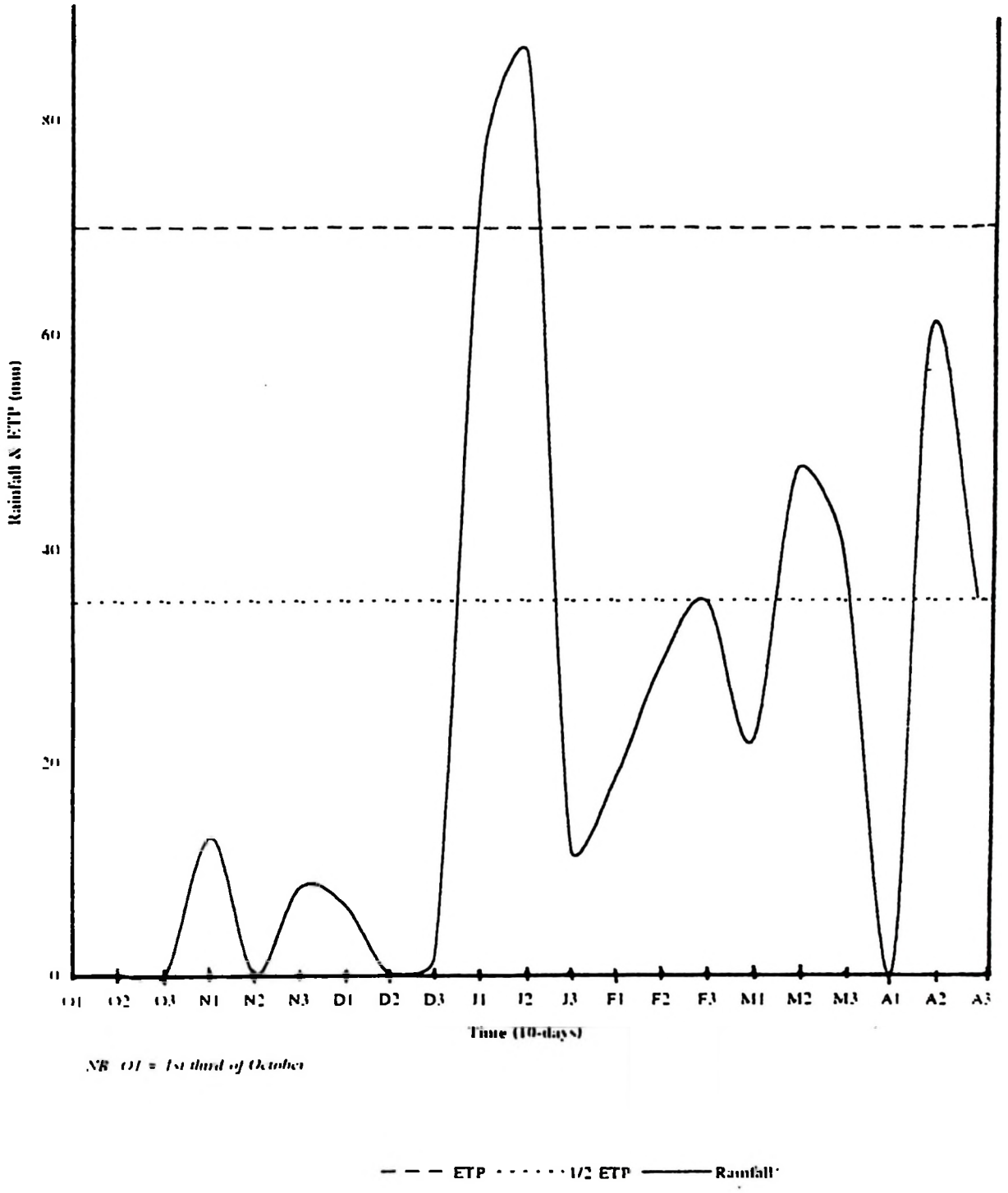
KEY:-
S1 = Suitable for extensive grazing; S2 = Moderately suitable for extensive grazing
N = Not suitable for extensive grazing; * = Non or NIL

Source: FAO (1976); Kashangwa (1989); Otysina (1994); Kessy et al. (1989); DRDP (1997); DHV and ILACO (1975); FAO (1977; 1979; 1993).

Appendix 12: Rainfall and Evapotranspiration potential at Meatu, 1994/95

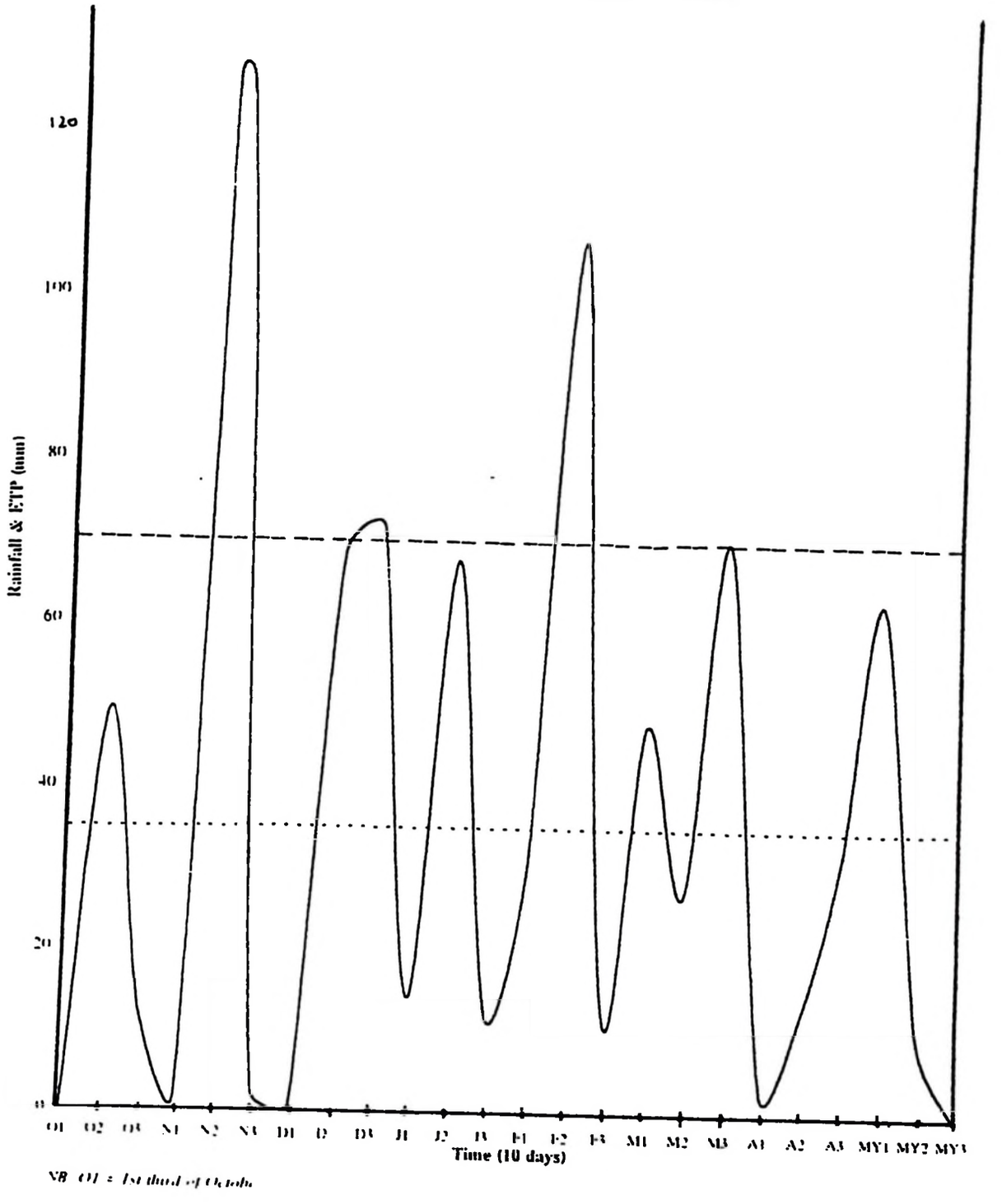


Appendix 13: Rainfall and Evapotranspiration potential of Meatu, 1993/94.



NB O1 = 1st third of October

Appendix 14: Rainfall and Evapotranspiration potential of Meatu 1992/93.



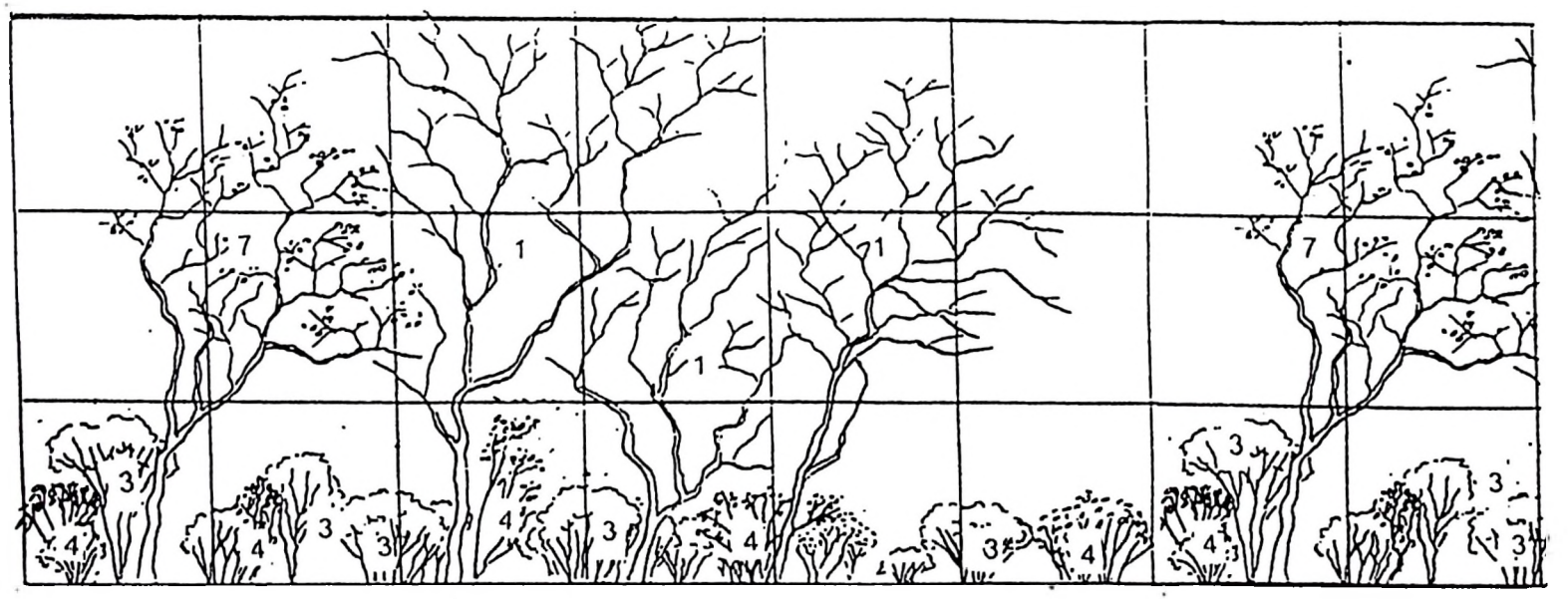
Appendix 15:

LIST OF ANIMAL COMPONENT IN MEATU

ANIMAL POPULATION MASWA/ MEATU DISTRICT*			
Cattle	Goats	Sheep	Donkeys
588 625	352 779	159 846	3 377

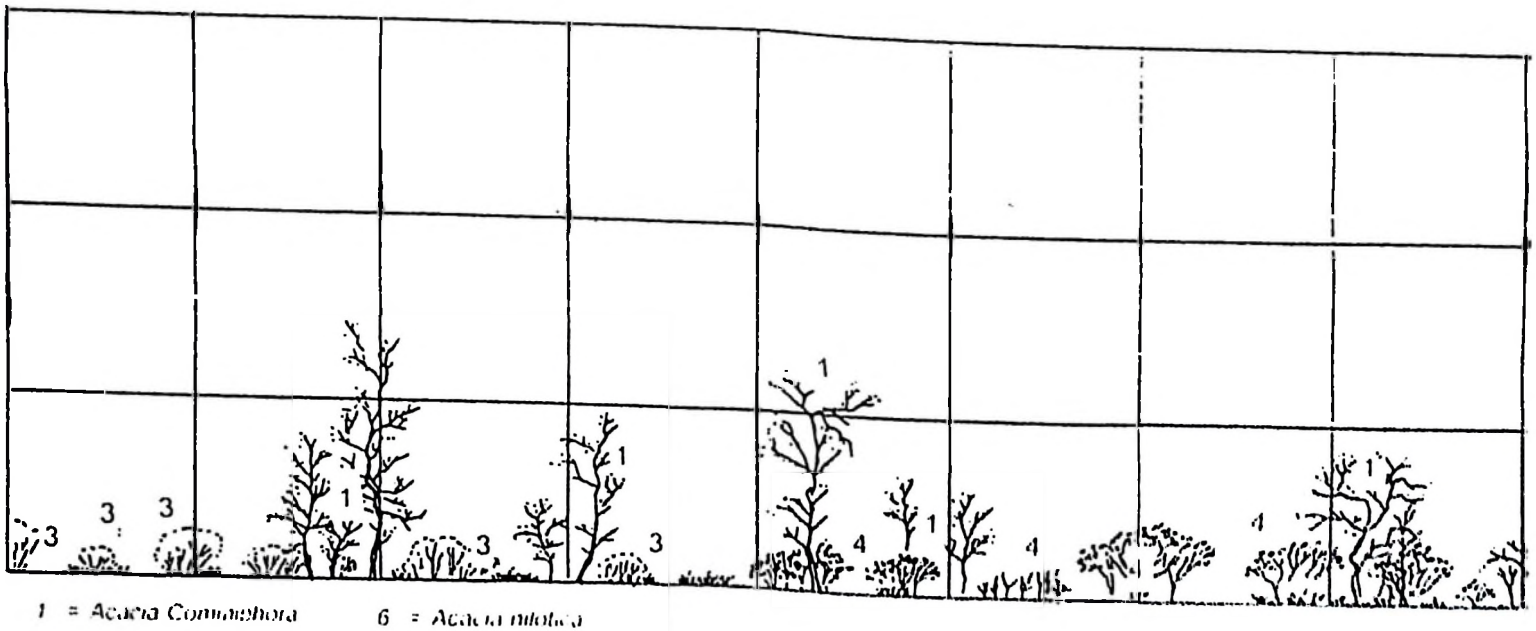
* The livestock in Meatu and Maswa districts are highly migratory between the two districts, depending on the season of the year, this justifies the census to combine the enumaration for the two districts for planning purpose.

Source: URT, 1996; Field survey 1997.



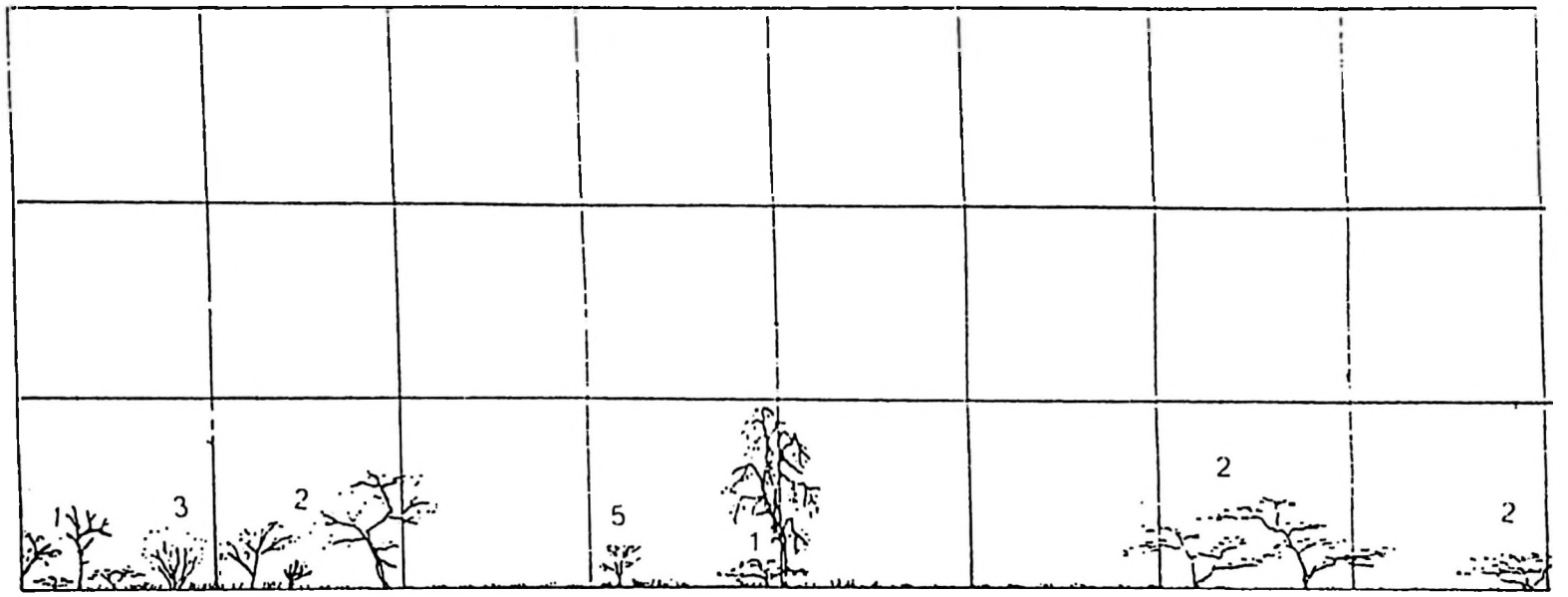
1 = *Acacia Commiphora*
2 = *Acacia Seyal*
3 = *Grewia bicolor*
4 = *Balanite aegyptiaca*
5 = *Acacia tortilis*
6 = *Acacia nilotica*
7 = *Acacia mellifera*
8 = *Acacia albida*
9 = *Acacia senega*

Appendix 16: Cross sectional profile of "ngitiri" (10 m * 25 m) showing horizontal and vertical spatial arrangement, typical of vegetation Zone 1.



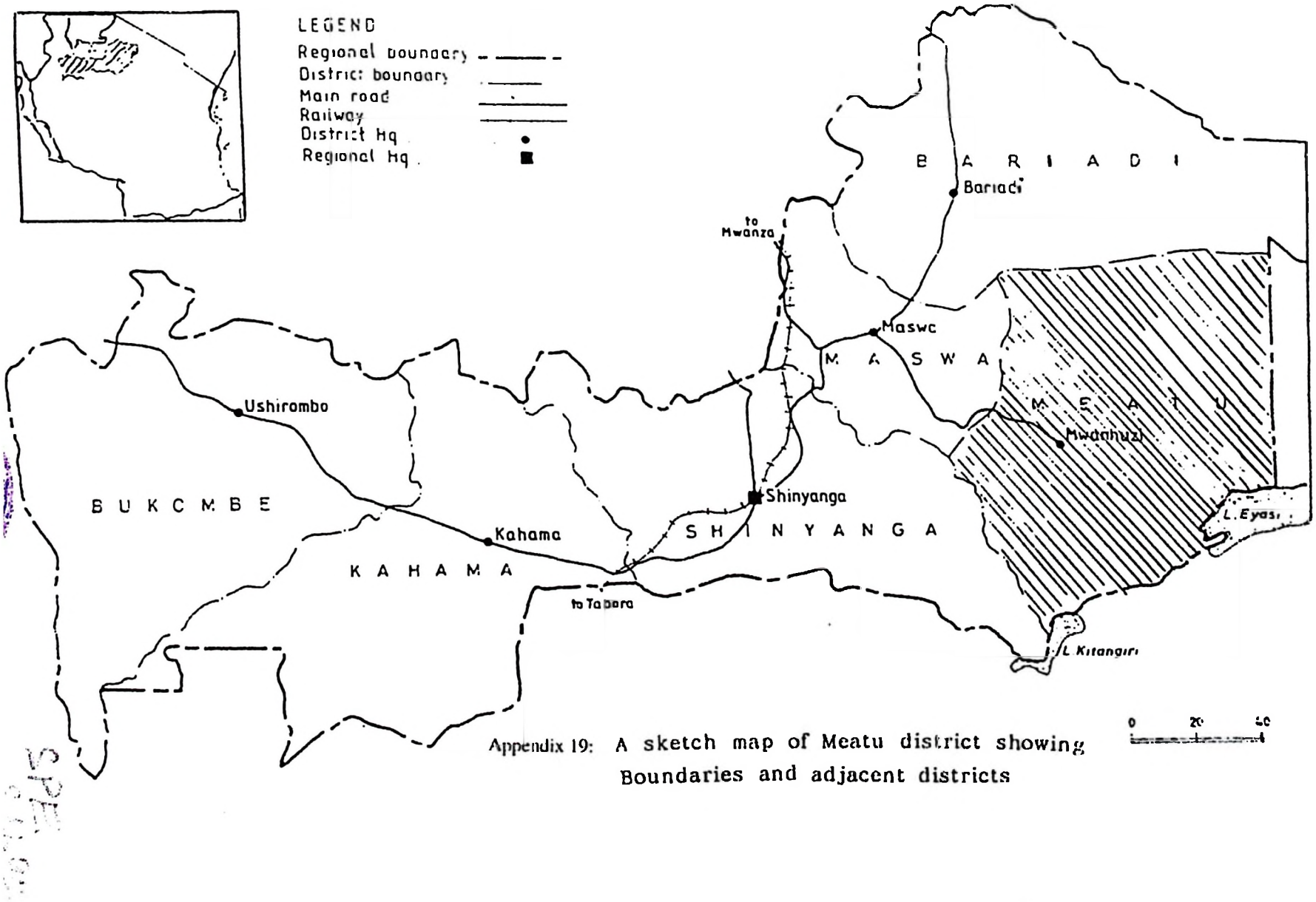
1 = *Acacia Commiphora*
2 = *Acacia Seyal*
3 = *Grewia bicolor*
4 = *Balanite aegyptiaca*
5 = *Acacia tortilis*
6 = *Acacia nilotica*
7 = *Acacia mellifera*
8 = *Acacia albida*
9 = *Acacia senega*

Appendix 17: Cross sectional profile of "ngitiri" (10 m * 25 m) showing horizontal and vertical spatial arrangement, typical of vegetation Zone 2



1 = *Acacia Commiphora*
2 = *Acacia Seyal*
3 = *Grewia bicolor*
4 = *Balanite aegyptiaca*
5 = *Acacia tortilis*
6 = *Acacia nilotica*
7 = *Acacia mellifera*
8 = *Acacia albida*
9 = *Acacia senega*

Appendix 18: Cross sectional profile of "ngitiri" (10 m * 25 m) showing horizontal and vertical spatial arrangement typical of vegetational Zone 3 and 4



Appendix 19: A sketch map of Meatu district showing Boundaries and adjacent districts