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Trees and indigenous ecological knowledge about agroforestry practices in the rangelands of Shinyanga Region, Tanzania.

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TREES AND INDIGENOUS ECOLOGICAL KNOWLEDGE ABOUT AGROFORESTRY PRACTICES IN THE RANGELANDS OF SHINYANGA REGION, TANZANIA

BY

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ABSTRACT

This study contains a survey both of indigenous ecological knowledge, and agroforestry practices of the Kishapu and Negezi Divisions of the Shinyanga Region of Tanzania: Together with an account of related socio-economic matters. The main field work involved four villages and was conducted between May 1992 and May 1993. This was followed by an information verification phase conducted between the January and April of 1994.

The study was conducted in order to characterise and document local knowledge, as it was important to develop a sound knowledge of how farmers interact with the environment. Such a knowledge could be used to design sound extension services and as a basis for government decision making. The Wasukuma are sedentary mixed farmers combining cropping and livestock keeping. In order to assess their awareness of matters related to their livestock, pasture and trees, both structured and unstructured interviews were used, supplemented by participation observations and informal discussions.

Structured interviews revealed problems with the tenure and unequitable distribution of land: Significant differences in land holding sizes between the divisions were observed. Problems of land ownership and distribution are linked with the Government's villagisation programme which in turn is further associated with land degradation processes. In both divisions high stocking rates were noted but these are not seriously considered as detrimental to land stability; particularly among people with many cattle. A rain-fed farming system is followed and yields are affected both by low rainfall and declining soil fertility. Few farmers are trying to amend the situation by using cow-dung and scientific recommendations are hardly implemented.

Unstructured interviews revealed perceptions of tree-livestock-pasture interactions. The 'Ngitiri' System and the rangeland-tree resource base are revealed. Grasses are considered more important to cattle compared to tree forage. Management of the rangeland aims at keeping the tree density low. Furthermore, trees are not acknowledged as desirable in cropped fields, but there is potential for planting trees in order to produce fodder, fruits, poles and fuel. Unfortunately the environmental degradation rate is alarming, and Government action to address identified causal factors is suggested.

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CHAPTER 1: INTRODUCTION AND JUSTIFICATION

The geographical setting and general trends in terms of agricultural and other land-use practices in Tanzania have been summarised by Matawalo, (1992); Mgeni, (1986). Shinyanga Region is situated in the northern part of Tanzania south of Lake Victoria. The region is 50 000 km^2 in extent with a total population about 1.6 million (1988) increasing at about 3.6% $year^{-1}$. Arable land accounts for about 31 000 km^2 of the region. A further 12 000 km^2 are utilised for grazing (the rangelands). Shinyanga is one of the 11 regions in Tanzania where farmers practise a mixed farming system involving livestock-pasture-agriculture cropping (Kalma, 1989; Schanne-Saab, 1974). Many farmers prefer livestock keeping among these activities due to their social and cultural heritage. The forest area, most of it being gazetted forest reserves, is 7 500 km^2 (98% in Kahama District). Shinyanga Rural District has only 178 km^2 of forests.

Shinyanga is occupied by the agro-pastoral Sukuma people, whose mother tongue is Ki-sukuma, and who, traditionally, have depended on livestock for their economic well-being as compared to cash cropping. From cattle they get milk and meat for home consumption and cattle also provide draft-power for cultivation and transporting inputs or harvests to and from fields. Livestock are the major source of household income through the sale of animals, milk, ghee, and animal skins.

Apart from livestock-keeping the Wasukuma are engaged in cotton cultivation. Cotton has become Tanzania's second biggest foreign exchange earner and Shinyanga Region is the major cotton producer. Since most of the farmers have only one main outlet for cash accruing as a result of cotton sales - investment in cattle, there has been a sharp rise in pressure on the land. The area allocated to the successful cotton crop has expanded while more cattle were added to the herds with the income gained (Kalma, 1989; Schanne-Raab, 1974). Traditionally, the Wasukuma view cattle as their security against famine, their dowry resource and for prestige (Berry and Townshend, 1973; Schanne-Raab, 1974). Thus high stock density is one source of environmental degradation in Shinyanga.

Land-use issues in Shinyanga are complex and strongly influenced by the socio-cultural traditions of the Wasukuma. A study by Shao *et al.*, (1990) has indicated that government policies have contributed to land fragmentation. Resettlement of people in villages under the reformed land tenure system, especially "Ujamaa" and villagization (1969-1976), has contributed to land pressure and deforestation.

The region today is semi-arid (McCown *et al.*, 1979; Kalma, 1989) but some 70 years ago, Shinyanga was covered by dense woodlands which, in the absence of disturbance, developed under the prevailing climatic conditions. Today, Shinyanga supports much impoverished vegetation. O'Ktingati (1990) remarked "when we see parts of Shinyanga and Mwanza turn desert despite the relatively high rainfall, the blame is often on the inadequacy or should we say the inappropriateness of the forest policy in Tanzania." Although the forest policy may be partly responsible (Kowero and Temu, 1985) other factors are involved. Lack of adequate forest cover creates undesirable weather conditions. Deforestation alters the micro-climate (Mather, 1990) particularly in hotter and dry tropics. When natural forests are cleared the nutrients and water budget of the soil are fundamentally altered. These changes makes the soils deteriorate in terms of their physical and chemical properties and they become unproductive. Kikula *et al.* (1991) consider that rampant destruction of vegetation in Shinyanga Region explains why today most of the land is bare with poor vegetation cover. The socio-economic implications of this phenomenon include acute shortage of trees for fuel and construction.

Soil erosion problems are not new and in Sukumaland have been recognized since colonial times. Temple (1972) and Harrison (1987) draw attention to the committee formed in the 1920's and in the 1930's by the colonial administration to study various land use issues including soil erosion, afforestation and tsetse fly problems. The containment strategy suggested was educative rather than through direct intervention to improve the situation. The decision by the authorities was to rely on persuading people to adopt better land husbandry practices as opposed to carrying out extensive soil conservation schemes which demanded immense funding from central government. This was the national policy in the 1930's and 1940's. While the policy seemed to have a rational approach the outcome was not encouraging. In due course, therefore, the government, in 1945, set up a national soil conservation service to address problems related to soil erosion. These were reviewed in 1951-1952 (Hill and Moffett, 1955). Today a similar service exists within the Ministry of Agriculture and Livestock Development: the Soil and Water Conservation Unit. This unit provides technical and advisory services to farmers in all districts of mainland Tanzania. These government endeavours to improve land use husbandry have still proved problematical as efforts have been one sided - from experts to farmers without the latter being consulted for their inputs. Shinyanga today is experiencing serious soil erosion, water shortage, drought and a shrinking area of grazing land (Barrow *et al.*, 1988; Kalma, 1989; Shao *et al.*, 1990; Sommy 1990).

The rising numbers of livestock and the human population exert increasing pressure on the land and environmental conditions are still deteriorating. The government has responded by instigating a project to rehabilitate damaged areas, the **HIFADHI ARDHI SHINYANGA (HASHI)** which started in 1986. Population growth has been so rapid such that most of Shinyanga is already saturated and places which were designated as grazing areas have been converted into farming or settlement areas. This forces some herders, especially those with many cattle, to migrate to other regions in search of new pasture land. The government of Tanzania is aware of the increasing environmental problems facing the region and efforts are being made to contain the situation.

Previous studies (Shao *et al.*, 1990; Sommy, 1990) have identified characteristic features of Wasukuma rangeland management and utilisation. These include the traditional "ngitiri" dry-season grazing reserves system (Barrow, 1991) whereby land is protected from grazing for a certain period and re-opened for grazing at the end of the dry season. However, the underlying knowledge and principles applied by the farmers and herders in their rangeland management systems have not been examined. The role of trees in the Shinyanga rangelands has yet to be clarified and it has to be established exactly what the people know about various tree species in their environment. The present study on trees and indigenous ecological knowledge was therefore carried out to examine what people know about the role of trees in rangeland and the implications of such roles for livestock development. Socio-cultural factors are the main force behind the success of the "ngitiri" system. However, it was desirable to determine if any technical aspects are routinely, or in some other conscious way, carried out by the farmers and herders in Shinyanga Region. How such techniques are being done, to what extent and when they are done and what skills are required to undertake them are some of the relevant issues.

The study was limited to elicitation of indigenous ecological knowledge about the rangelands in Shinyanga Region. The focus was mainly on tree-pasture-livestock interactions and on trying to find out what people in the area know/understand about these interactions. This entailed examining the role of trees in the rangelands and assembling and appraising local knowledge in relation to what people do in terms of propagation, management and usage of trees and rangeland resources.

The importance of rangelands in Shinyanga for livestock keeping cannot be over-emphasised. Improvement of rangeland management practices so that this resource can sustain a significant and productive livestock population is an important need from both farmer and government points of view. The aspirations of both can be satisfied through adoption of proper land use practices and low cost technologies. Agroforestry is considered one viable option for the farmers to use. However, agroforestry practices vary from place to place according to ecological and socio-economic factors. In Tanzania, agroforestry practices have been used in highland areas quite successfully (Fernandes *et al.*, 1984; Forest Division, 1984; O'Ktingati *et al.*, 1984). Successful application of agroforestry practices is however, yet to be realised in the country's semi-arid areas.

Information generated through this study represents the background of indigenous ecological knowledge about trees, soils, pasture and livestock in the study area. This information can be used as a basis for addressing the problems of land degradation in the region specifically and also as a model for areas elsewhere where comparable conditions arise. Interventions offering Shinyanga Region a sustainable traditional farming-pastoral culture are sought. Agroforestry practices are attractive in enabling innovations where a significant proportion of traditional practices are complemented by technical refinements. However few agroforestry techniques have yet been developed to the point of routine usage (Kerkhof, 1990) and the need to devise more techniques is greater for semi-arid regions than anywhere else.

Before embarking on actual field work the first step was to be familiar with the Wasukuma culture and traditions. This was gained through literature about Sukumaland and her people. Furthermore, an understanding of research approaches and methodologies with emphasis on indigenous knowledge concepts and elicitation techniques was also gained through literature review. Thus development of the knowledge acquisition strategy and the field survey plan followed the indigenous knowledge acquisition approach - the multi-method technique. The study was organized in two phases. First was the main field work lasting for one year. This was followed by analysis and processing of the findings at the University of Wales, Bangor. The second field work which was for information validation/verification followed after six months of data processing. There were three specific objectives:

to assess and characterize existing ecological knowledge about trees, livestock and pastures and the extent to which this knowledge influences prevailing land-use practices.

to examine whether the indigenous ecological knowledge base varies with gender, age and social status.

to expose gaps between scientific knowledge base underlying conventional agroforestry practices and the indigenous knowledge.

CHAPTER 2. LITERATURE REVIEW ON RESEARCH CONCEPTS INDIGENOUS KNOWLEDGE AND PRACTICES

This chapter is organised in two parts. The first part (2.1) provides a context for the rationale and methodology in terms of research concepts (2.1.1) and the nature and means of studying of indigenous ecological knowledge (2.1.2). This is followed by a literature review on conditions in the study area (2.2) organised into the physical environment (2.2.1), vegetation and land-use (2.2.2) and the people (2.2.3)

2.1 Research concepts and farmers' knowledge

2.1.1 Research concepts

There is no easy or direct entry to eliciting indigenous knowledge from informants and thus no single method is regarded as the most suitable. However, the use of a multi-method approach (Gorden, 1975; calls this triangulation) using a combination of techniques (FAO, 1989; Gorden, 1975; Werner and Schoepfle, 1987) is considered most appropriate. What farmers knew or practise is dictated by the benefits likely to accrue as a result of their actions. Perceived benefits or 'values' necessitate farmers' decisions and determine priorities. However, 'value' should be distinguished from interest, attitude, feeling and belief (Dobbert, 1982; Punch, 1986). This distinction is clear from the following definitions:

- a value is considered to be what people appreciate in terms of benefits accruing to them. For instance, cattle in Sukumaland have great value due to perceived socio-economic benefits.

- interest is considered to be that force which make a person participate in a particular event or activity. For instance, farmers being interested in growing nitrogen fixing trees because they wants to improve soil fertility.

- attitude is considered to be a state of mind for liking or not liking something. For instance, responding positively to having trees in crop land indicates a favourable attitude of liking the idea or vice versa.

- a feeling is considered to be a reaction one has about something or an idea and may lead to certain actions. For instance, herders may feel that an increase of tree density on rangeland make accessibility of cattle difficult and therefore would aim at keeping tree density low.

- a belief is considered to be a universal sense of accepting something as true, untrue, good or bad for the society. For instance, Wasukuma believe that increasing population of trees on cropland would harbour birds which are related to sorghum and millet destruction.

Werner and Schoepfle, (1987) point out that in ethnographic approach to eliciting indigenous knowledge attempts are made to record the knowledge by the subject group (e.g. people involved in cropping or pastoral systems) whereas the encyclopaedic approach attempts to record the sum total of knowledge held by all the individual informants. In the latter case, how knowledge is distributed within the group is not an issue.

Which approach is appropriate depends on the type of information sought. A combination of the two techniques may be advantageous because all possibilities are considered and tried. Elicitation of indigenous ecological knowledge from informants is a complex exercise. It involves living and working from within the community being studied to win confidence from the community itself (Marshall and Rossman, 1989). According to Werner and Schoepfle, (1987) the researcher must view things through the farmers' eyes. The exercise entails being with the farmers for a long continuous time, talking and discussing field activities with them and using a variety of approaches and techniques to bring out comment and opinions. When eliciting information from informants the researcher undergoes a learning process (Bell and Hardiman, 1989) to understand components, factors and activities involved in the production systems. Johnston and Pannypackers, (1986) suggest that conversations and discussions with informants should be fully recorded.

Broadly, there are three main approaches for elicitation of information from the farmers. These and their related tools are indicated in Table 1.

Table 1: Approaches to acquire information/knowledge from the farmers and related tools.

Tool or approach	Multimethod	Ethnographic	Encyclopaedic
Structured questionnaire	X		
Semi-structured interview	X		
Unstructured interview	X	X	X
Informal discussion	X	X	X
Observation	X	X	
Diagrams	X	X	X
Sketch maps	X	X	

Structured interviews involve a structured questionnaire survey. In some literature (e.g. Moser and Kalton, 1979) structured interviews are regarded as formal surveys where both 'open' and pre-coded questions could be asked but in a specific order. These question categories differ in the form in which the answer is recorded. The interviewer has no freedom to alter the course of the interview. Answers to 'open' questions are recorded in a note book or paper while for the pre-coded questionnaire, answers are recorded in a space provided within the questionnaire.

Prepared questionnaires provide guidance in knowledge acquisition. Casley and Lury (1987) recommend the household to be the main source of acquiring information when a structured questionnaire is used. FAO (1989), Gorden (1975) and Richards (1980) acknowledge the value of the questionnaire as a tool for extracting information from informants but emphasises that it is desirable for it to be reinforced by participation in community activities and through informal discussions as well as by unstructured interviews.

Semi-structured interviews entail obtaining information from informants following a set of prepared but uncoded questions to use as a guide during the interview. The interviewer has flexibility in asking questions compared to structured questionnaires.

Unstructured interviews are categorized as informal interviews (Moser and Kalton, 1979). This technique does not follow any prepared set of questions. Questions are asked as interviewing continues and depend on informants' responses bearing in mind things sought from them. Unstructured interviews allow flexibility in asking questions. During unstructured interviews, informants' responses can be recorded in a note-book or taped. In either case the researcher picks up issues of interest as statements of fact.

Statements of facts are sentences constructed by the informant and relevant to the subject being studied. Statements of fact become a formal record of the interview and/or discussion. Statements of fact can be further classified into segments of knowledge held by informants. For instance, statements related to traditional medicine practices, statements related to resource utilization (i.e. firewood species) or statements related to pasture management and so on.

To enhance clarity and presentation of indigenous knowledge, statements of fact are grouped into 'cause-effect' and ordinary statements. For example, an increase in tree density on rangeland causes a decrease in grass biomass" is a cause-effect statement of fact. But "cattle produce milk would be an ordinary statement. The advantage with 'cause-effect' statements is that they can be presented diagramatically, linking two objects by an arrow which indicates which effects the other. "A cause-effect diagram consist of nodes and links. Nodes are objects, processes or attribute value". An object is a physical structure or item such as cattle, tree or roots. Processes are actions involving an object. For example, tree cutting on rangeland is meant to increase grass biomass. Tree cutting is a process taking place as management strategy. Attribute values are values attached to objects or processes which could be in form of increase, decrease or no change. For instance, dense tree shade causes a decrease in grass growth rate on rangeland. Both dense tree shade and growth rate are attribute values. In this case the effect of tree shade to grass growth rate would be indicated by an arrow pointing from the tree shade 'node' to grass growth rate 'node'. The arrow is annotated to explain the type of interaction taking place the objects it connects. A hierarchical presentation of 'cause-effect' statements may result from connecting several 'nodes' in a diagram (e.g. effects of trees to grass growth).

Unstructured interviews are exploratory in nature (Gorden, 1975) and offer flexibility in asking probing questions while interviewing is in progress. The researcher knows what is being sought and therefore could probe along the line. Richards, (1980) suggest that a 'gaming' approach in eliciting qualitative information is necessary. According to Richards, the researcher should stimulate informants' thoughts by suggesting "let's imagine the situation was like this or that" and letting the informant respond as if the situation existed. In this way the informant is made to think or remember past events. Bell and Hardiman (1989) emphasize that indigenous knowledge should be related and examined, especially with respect to past trends, in order to establish the relevance and usefulness to present society.

Informal discussions imply talking and discussing things with people without them feeling conscious of the interview. During informal talks, a question may be asked to obtain peoples reaction or views (e.g. why are there no trees in the village?) People could respond on this issue, freely and in a relaxed manner than if the question were asked at a formal pre-arranged meeting. In such circumstances responses are not recorded during discussion. In the event of informal talking, the researcher may identify interesting points for detailed study. It may be difficult to remember what has been said particularly when a group of people is involved but the researcher gains a general impression (e.g. why there are no trees in the village) and seeks further explanations later. Informal discussions differ from unstructured interviews in that with the latter, informants are informed in advance of the interview to be conducted and records of what is being discussed are taken.

Observations entails studying conditions and what farmers are doing within the village profile. The term village profile is used to denote the physical and social complexity of the entire village. It involves in physical terms residential areas (village centre and neighbourhood), cropped and grazing fields, forests and woodlands, types of land use systems, soils and terrain. In social terms it involves village social structure. The village social structure differentiates the villagers into social groups such as elders, women, junior and senior youths, traditional healers, security groups (e.g. Sungusungu), and people with authority/power. The social structure provides legitimate channels for effective communication and interactions among the villagers. Observations are made by walking around the village (Bell and Hardiman, 1989; FAO, 1989; Lamug, 1989) to see at first hand structural variations, current land use patterns, problems encountered by farmers and the role undertaken by different sectors of the population. Skinner, (1965) stress "causal observations are especially important in the early stages of investigation. Generalizations based upon them, even without explicit analysis supply useful ideas for further studies". Field observations and informal discussions with informants are also recommended by many others (Ellen, 1984; FAO, 1987; Munning, 1987; Punch, 1986; Walker *et al.*, 1991; Werner and Schoepfle, 1987). The researcher then has a better chance of eliciting indigenous knowledge from the farmers than when using formal structured questionnaires or interviews. Bright (1952), Casley and Lury (1987) and Richards (1980) argue that through participation observation and informal talks a researcher gains a sounder understanding of informants' attitudes and perceptions and the nature of the constraints influencing their actions in a rapidly changing environment.

A diagram is any simple, schematic device which presents information in a readily understandable visual form (Conway, 1989). Diagrams are a means whereby informants can clarify their ideas. According to Conway (1989), diagrams can readily simplify complex information which rural dwellers (especially, those who are illiterate or semi-literate) may find it difficult to explain or understand. Numerous authors (Bell and Hardiman, 1989; Conway, 1985; FAO, 1989; Gupta, 1985; Lightfoot *et al.*, 1989; MacCraken, 1988; Pretty and Scoones, 1989) have emphasized that farmers can easily illustrate what they know through simple diagrams and make their points clearer to the researcher.

A sketch map is a simple diagram which informants can use to present the physical aspect of their village profile. Specific areas for residence, public utilities (e.g. school, church, dispensary), sources of water and firewood and a range of land-use types are shown.

It is not feasible to deal with all members of a community, what is important is that a sample should generate data that reliably represents the whole population. Random, stratified random, or cluster sampling techniques may be used to meet this requirement. Moser (1958) recommended cluster sampling as it provides fair and unbiased results and can be easily administered in large communities. This technique was applied by (Hankins *et al.*, 1971) in Sukumaland. Stratified random sampling was applied by Chipungu, (1982) when studying differentiation in cattle ownership. He stratified the sample into large and small owners. Richards (1980) concluded that stratification of the communities into various categories was necessary to attain a fair representation and to increase precision (Fowler, 1993). Indigenous knowledge and experience varies according to age, sex and class affiliation of the individual members (wealth or social/political power). Furthermore, it is related to the functions and structures of the society (Hamilton, 1983; Ritzer, 1983). Stratification thus, becomes a functional necessity and provide for a sample which has the same proportions in each class as the whole population (Fowler, 1993).

Knight (1980) and Walker *et al.* (1991) identify three stages through which indigenous ecological knowledge can be elicited from a community using a representative sample. These are, in sequence specification, formalization and generalization (verification) stages.

Specification, the initial stage, is where the researcher deals with a small sample (usually of a few selected informants) to generate basic ideas to be pursued in detail at the next stage.

For the detail the formalization stage involving a larger sample, is carried out. In the process the population is stratified according to important variables such as gender. Informants are randomly sampled from each stratum for detailed interviews. The sample size of informants from each stratum depends on available time and resources.

Generalization is the final stage. At this point the researcher sets out to verify the findings of the previous stages using a much larger sample. Whether indigenous knowledge is widely distributed and coherent within the community is checked and the extent to which it is being used is estimated. According to Spedding (1988) generalization/verification process establishes the truth or accuracy of the information obtained earlier.

2.1.2 Farmers' practices, indigenous and scientific knowledge

According to Altieri (1990); Gubbels (1993) and Richards, (1980) traditional farming systems have emerged over centuries of cultural and biological evolution and represent accumulated experiences of interactions with the environment by the farming communities. Interventions and ecological adaptations in African agriculture are at their best where external agencies have interfered least (Richards, 1985). Farmers are 'on line' innovators (Chambers *et al.*, 1989) and their indigenous technical knowledge has been recognised as valid and useful (Gubbels, 1993; Richards, 1980; Riches *et al.*, 1993). Farmers have used the knowledge to sustain their livelihood.

Indigenous knowledge and traditional agricultural systems involve cultural values which help to conserve them (Altieri, 1990; Laszlo, 1991; Richards, 1980). Some authors (Altieri, 1990; Conway and Barbier, 1990; and Clowson, 1985) report that older members of the society possess more detailed ecological knowledge than young ones. O'Keefe and Wisner (1975) observed that "if one assumes that farmers' land use systems were once successful and efficient, then one needs to reconsider their recent historical development to understand why they should be so vulnerable in the current crisis" of land use systems. It has always been assumed that government officials and scientists, share the views of farmers. This is not always the case because some conflicts over what is or not desirable (Brokensha and Riley, 1980; Campbell *et al.*, 1991; Dove, 1992; Conway, 1985; Chambers, 1983; FAO, 1989; Ffolliott and Thames, 1983; Fones-Sundell, 1989; Fortmann and Rocheleau, 1985; Knight, 1980; Mbegu and Mlenge, 1984; Mgeni, 1991.; Mung'ong'o, 1991; Nair, 1991, Noronha, 1981; Richards, 1980; Sturmheit, 1990). To win the popular participation of farmers their perceptions, priorities, and practices must be established and recognized.

Attempts have been made to assemble indigenous knowledge objectively to facilitate development project planning and decision making (Warren, 1991). Warren and Cashman (1988) document the importance of indigenous knowledge for sustainable agricultural development. Barrow (1991), reporting on indigenous knowledge used by the Pokot and Turkana people engaged in pastoralism in Kenya, emphasized the importance of taking account of the rich stores of indigenous knowledge in traditional farming systems when designing rural development projects. Conway and Barbier (1990) regarded harnessing traditional techniques used by farmers to manage their resources as an important aspect to be taken into account when dealing with rural development.

Due to their complexity, structuring traditional knowledge bases is difficult. Raintree (1987) and, Bell and Hardman (1989) observe that knowledge representation is the most difficult stage of knowledge acquisition. Knowledge should be structured and presented in a form which both experts and local communities can understand. The prime objective of presentation should be clarity for the local community. Richards (1980) suggested that local knowledge bases should be structured and presented in such a form that their content meets the needs of users.

Approaches used to elicit knowledge have mainly involved rapid rural appraisal (MacCracken *et al.*, 1988) and lately participatory rural appraisal (Farrington and Martin, 1988), centred on structured and semi-structured interviews. Only in recent years have efforts been made (through expert systems approaches) to develop techniques and tools specially for use in knowledge acquisition processes. Artificial intelligence expertise has been at the forefront of these initiatives trying to produce usable computer software during the last five years (Estates *et al.*, 1992). According to Estates *et al.* (1992) expert systems (sometimes referred to as knowledge systems or advisory systems) are among the prominent products of artificial intelligence research efforts.

2.2 The study area

2.2.1 The physical environment

Sukumaland occupies specifically Shinyanga and Mwanza Regions have been traditional settlement areas for the Wasukuma who also occupy part of Tabora Region especially in Nzega, Igunga Districts (Fig. 1). According to Brandstrom (1985) there were no territorial obstacles to Wasukuma moving beyond their border and due to population pressure some Wasukuma particularly those with high cattle numbers have migrated to surrounding areas Some have moved beyond - to Mbeya and Rukwa Regions.

Shinyanga experiences moderate to dry climatic conditions. Most of Shinyanga lies in a zone with rainfall less than 800 mm year^{-1} (Christiansson *et al.*, 1991; Darkoh, 1986; Heemstraa, 1992; Lema, 1990b; Marleyn and Skutch, 1987; Rao and Westley, 1989). In Shinyanga Region annual rainfall totals decrease from West to East (Hankins, 1974; Larsen, 1971) but the pattern is unimodal over the whole Region (Fig. 2). There is only one synoptic meteorological station close to the study area, at Shinyanga town, but gradients across the area are revealed when stations beyond it are taken into account (Fig. 3).

In Shinyanga the rainy season starts mid-November and ends in the April/May period. Over the rest of the year there is hardly any rain and soils become quite dry. Sometimes dry conditions persist beyond mid-November, as in 1993/94 when the rains started two months late.

According to Hankins (1974) and Larsen (1974) local variations in climate from area to area within the region are pronounced. Thus, in any year, one area may suffer a poor crop harvest while an area only 20-30 km away receives adequate rainfall. Severe droughts occur at intervals of 5-9 years (Hankins, 1974).

Terrain, geology and soils

Much of Sukumaland is a flat plain dissected by seasonal rivers and streams. The area extends from south of Shinyanga (Nzega and Igunga Districts, Tabora Region) towards Lake Victoria (Mwanza Region) and parts of Biharamulo and Serengeti Districts in Kagera and Mara Regions respectively. This extensive flat landscape has occasional outcropping hills and rocky areas.

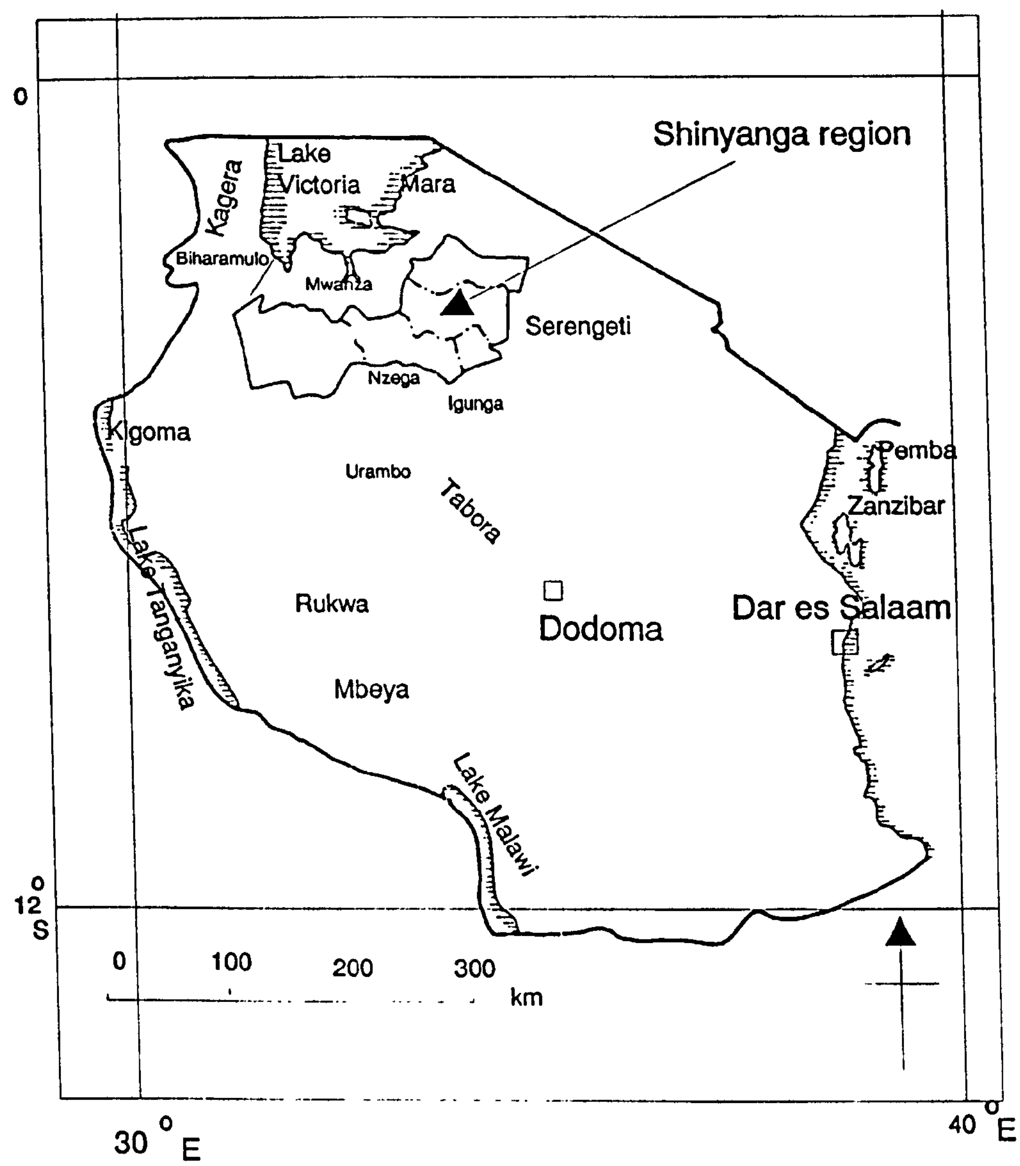

Figure 1: Location of Shinyanga Region and neighbouring areas in Tanzania

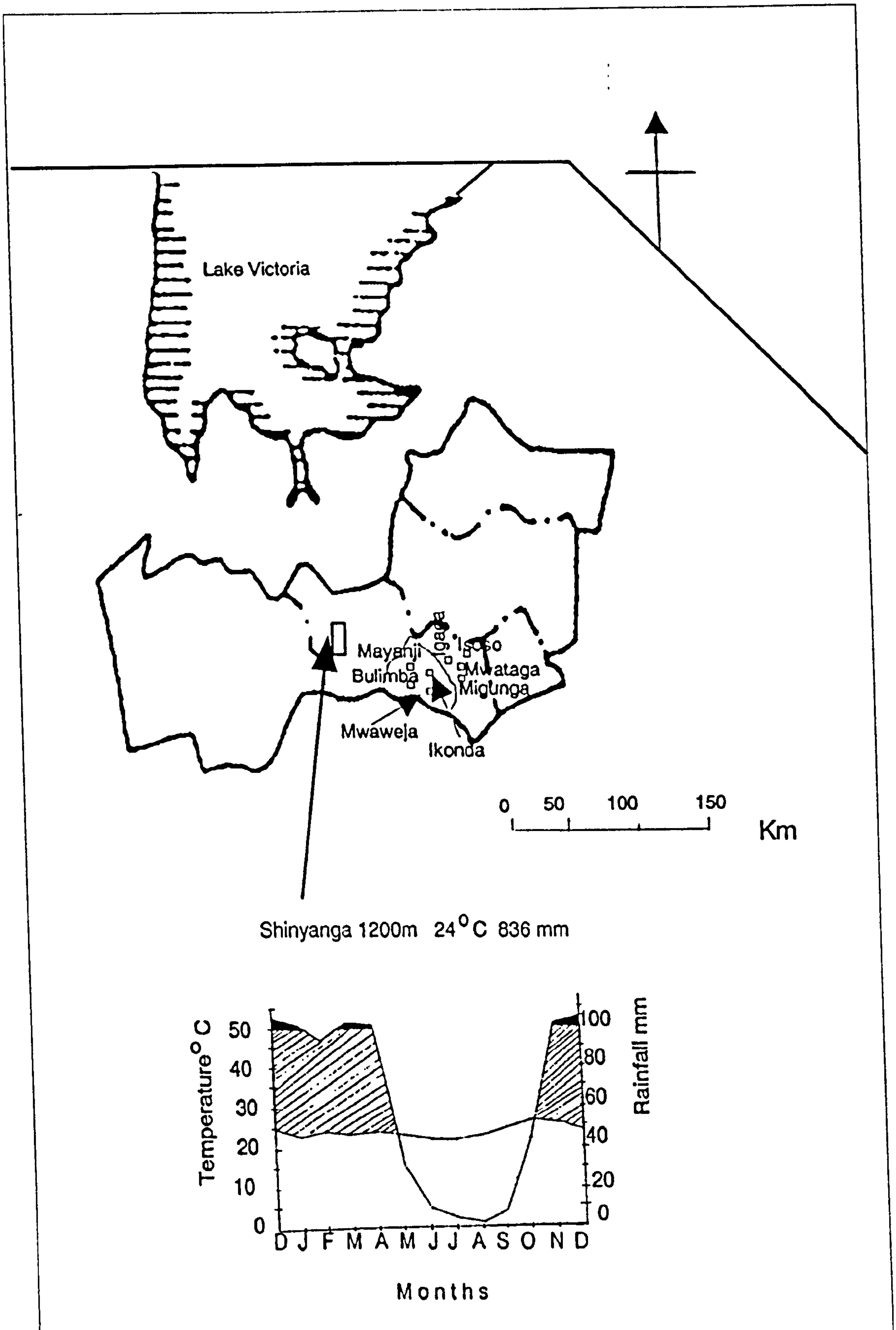

Figure 2: Location of study villages and climatic diagram for Shinyanga, Tanzania

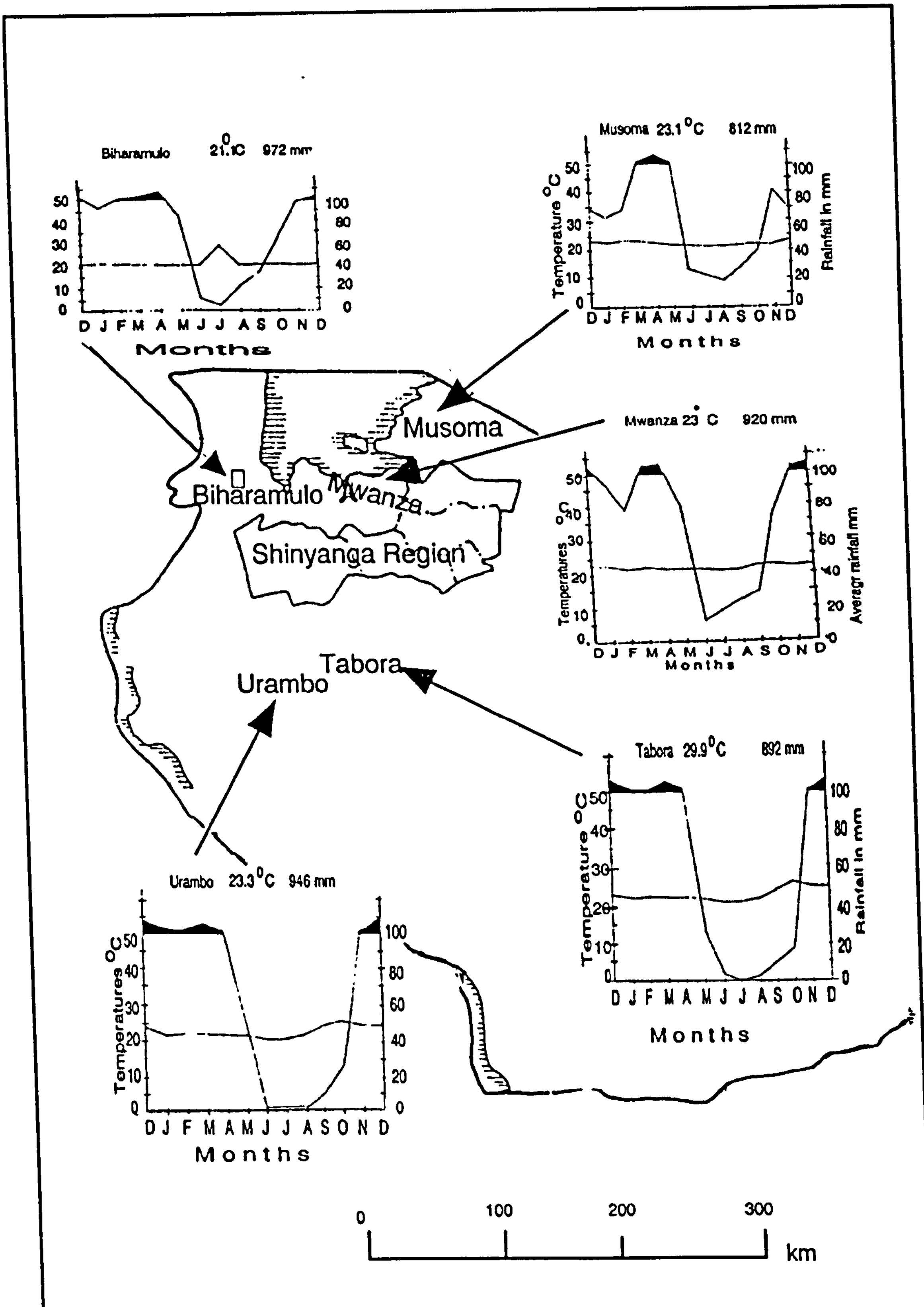

Figure 3: Climatic diagrams for the areas neighbouring Shinyanga Regions, Tanzania.

Geologically Sukumaland is an area of Precambrian basement complex, consisting of granitized early rocks of the Dodomian and basement systems underlying the central plateau (FAO-UNESCO, 1977). The Dodomian system occurs around Urambo (Tabora Region). The basement and the Nyanzanian systems occur in areas around Lake Victoria. According to FAO-UNESCO (1977) these areas consist of a series of slightly to moderately folded metamorphosed sediments. In the basement system there are quartzites and limestone, among others. In the Nyanzanian system there are thick layers of acid and basic volcanic rocks with interbedded sediments.

FAO-UNESCO (1977) places Sukumaland in the complex soil zone of great lakes. Soils present are andosols (associated with recent volcanic activity), humic nitosols, lithosols, and eutric cambisols around the ridges of the Great Rift Valley and vertisols and solonetz in the drier rift floor. Between the rift valley and Lake Victoria are ferrisols and acrisols. In the drier south-east part of Sukumaland, where the study area is situated, the predominant soils are vertisols, calcic cambisols and, locally, rendzinas. Depressions and valley bottoms are dominated by eutric fluvisols. South-east Shinyanga is dominated by vertisols which give rise to 'mbugas' of fine textured soil. The 'mbuga' soils are black and heavy with a high clay content, sticky when wet but developing cracks when dry. Hankins *et al.* (1971) and Malcolm (1953) describe them as difficult to work, especially when wet. According to Ecosystems (1982) vertisols account for 42% of the soil in Shinyanga Region. Most parts of Kishapu and Negezi Divisions were noted to have vertisols in seasonally flooded plains. Calcic cambisols (lacustrine deposits) are present mainly in unflooded flat areas though, in patches, they are water logged. Fluvisols are present mainly in valley bottoms and associated with river banks which receive fresh sediments due to seasonal floods. Seasonal river beds are covered with sand. The remaining parts of the two divisions are either covered by gravel/sandy materials on (hill-tops) or rendzinas - Ibushi (in other areas).

2.2.2 Vegetation and land use

Natural vegetation

The vegetation in Shinyanga Region is divided between the Lake Victoria Regional Mosaic and the Somalia-Masai Regional Centre of Endenism of White (1983). Westwards where rainfall conditions are favourable, the vegetation is evergreen and semi-evergreen bushland and thicket referable to the Lake Victoria region mosaic. However, White (1983) reports that the vegetation has been extensively destroyed. As a result, secondary wooded grassland dominated by *Acacia* and *Euphorbia* *candelabrum* has developed. Eastwards, where conditions are much drier the *Acacia-Commiphora* deciduous bushland and thicket of Somalia-Masai region persist. White (1983) indicates that deciduous bushland is the climax vegetation over the greater part of the region. Characteristically it is dense bush, 3-5 m tall but with scattered emergent trees up to 9 m. The dominant *Acacia* and some *Commiphora* species grow scattered associated with bushes, thickets and undergrowth of grass and herbaceous vegetation. Most of the trees are deciduous. Evergreen species contribute no more than ten percent to the phytomass. In the main canopy are *Acacia bussei, A. mellifera. A. nilotica subsp. subalata, Commiphora africana, C. schimperi* and *C. mollis*. Only a few species have trunks which raise the crown above the main canopy. These large species include *Acacia tortilis, Adansonia digitata, Delonix elata* and *Teminalia spinosa* and they are widely scattered.

Cropping system

The Wasukuma are agro-pastoralists mainly growing sorghum (*Sorghum bicolor*), millet (*Pennisetum typhoides*), maize, (*Zea mays*), rice (*Oryza sativa),* sweet potatoes (*Ipomoea batatas*) and cassava (*Manihot esculenta*) as food crops and cotton (*Gossypium hersutum*) as a cash crop. Farming and cropping patterns in Sukumaland are dictated by soil types and climatic conditions. On vertisols cotton features more than any other crop although sorghum, millet and rice are also cultivated. On calcareous cambisols, sorghum, millet, maize, sweet potatoes and cassava are grown. On fluvisols rice, maize, fruits and vegetables are commonly cultivated.

Ruthenberg (1971) reports that the cropping system involves land holdings of about 2.3 ha per household. Of this 1-1.5 ha are cropped with cotton and 1.5-2 ha carry maize, sorghum, legumes and cassava for personal consumption. Rice and sweet potatoes are cropped separately in valley bottoms. Cotton and food crops are planted in ridges 1.3-1.5 metres apart. Soil is worked mostly with hoe although ox-ploughs are increasingly used.

Cotton cultivation is an important economic activity in Shinyanga region. The role of cotton, its cultivation and effects on Shinyanga's environment have been examined and discussed by various authors (Brown *et al.*, 1992; Collinson, 1963; Goldsmith *et al.*, 1992; Hankins *et al.*, 1971; Hankins, 1974; Hulla, 1971, 1975; Kalma, 1989; Kikula *et al*, 1992; Larsen, 1971; Malima, 1970; Roberts, 1988; Sylor, 1970). Cotton was introduced early this century as a cash crop to the Wasukuma in Shinyanga but it was not until the 1950's that production of cotton increased and became economically important (Hankins, 1974; Kalma, 1989). Despite this trend of development, the majority of farmers in Shinyanga still value livestock more than cotton. Surpluses gained from the sale of cotton are invested in livestock, mainly cattle (Kalma, 1989; Sommy, 1990). McCown *et al.*, (1979) review the history of the local cotton industry based on the cotton introduced to Sukumaland as a cash crop in the 1920's. Production increased slowly but started to pick up in the 1950's. According to Brown *et al.* (1992) government drives for cotton expansion and increased population growth led to clearing of virgin forests to meet the needs.

The Wasukuma evolved a system of cultivating land for a period and then allow it to regenerate under a phase of bush fallow. According to Ruthenberg (1971) Wasukuma had adopted different ways of cropping such as rotating various crops then successively cropping the plant or plant mixture that thrives the best on the particular soils until the yields decline. The last crops to be grown are cassava and millet and then the land goes back to grass and the plot becomes grazing fallow for six to eight years. This system works well at low population densities but fails when the carrying capacity of the resource base is exceeded (Baumer, 1990; FAO, 1989; Whitemore and Burwell, 1986). In Shinyanga Region, land degradation has been noted to be a consequence of deforestation, over-cultivation and overgrazing (Kikula *et al.*, 1991).

Hankins (1974) noted that population growth has been so rapid such that most of Shinyanga is saturated and people are nowadays forced to emigrate to other regions in search of new land to cultivate or use as pasture. Brown *et al.* (1992) observed that in semi-arid (eastern Shinyanga) and arid areas fuelwood collection deters tree growth especially where population density is quite high and natural growth potential of trees/vegetation is rather low. Darkoh reported (1986) that fuelwood demand had reached a crisis point in the semi-arid areas of Maswa and Bariadi in Shinyanga region, and in the Magu area of Mwanza Region. Mushalla, (1980) regarded increasing fuelwood consumption as part of the soil erosion problem affecting many parts of Tanzania. Rapp (1986) examined in detail issues and problems related to soil erosion and sedimentation of water in Sukumaland. Kauzen *et al.* (1986) reviewed soils in Sukumaland with emphasis on conservation practices while Morgan (1979) recommends natural vegetation conservation as a viable approach to deal with soil erosion rates. He further emphasised the application of cow-dung in cropped fields.

People in Shinyanga do not like planting trees (Kerkhof, 1990). This negative attitude towards trees is linked with the belief that trees and forests harbour tsetse flies (*Glossina aethiopica*) which are a threat to the survival of livestock. Therefore, livestock development implies destruction of forests to eliminate tsetse flies (Prinsley, 1990). Interventions to improve land use practices such as the World Bank financed Shinyanga Rural Development Programme (1979-1985) have not achieved their objectives because afforestation was minimal.

Utilisation of resources in rangelands

A good deal of Sukumaland has been cultivated for food and cash crops. To transform the land into cultivated fields the original vegetation was cleared by hand (Skerman, 1968). During the 1920's and 1930's clearing of the natural vegetation in rangeland was organized by the colonial administrators for the purpose of tsetse fly (*Glossina* spp) eradication (Brandstrom, 1985; Hatchell, 1959; Rounce; 1949; Skerman, 1968). According to Brandstrom (1985), Shinyanga Region was selected as the first large-scale experimental area for tsetse reclamation. To extend the accessible grazing land and control ticks clearing of large tracts of woodland and the burning of grasses were necessary (Birley, 1982). Hankins *et al.*, (1971) report that birds destroying millet and sorghum crops as they mature also prompted elimination of trees in Sukumaland because the trees harboured *Quelea aethiopica*. (Disney and Haylock 1955); Skutch, 1983, 1985).

The utilization of grazing areas in Sukumaland varies according to site potential and stocking rates. The value of any grazing land will depend on the amount of available pasture and availability of drinking water. According to Malcolm (1953) and Rounce (1949), the livestock authorities in Sukumaland estimated that an appropriate stocking rate for the semi-arid areas was 2 to 6 hectares per tropical livestock unit (250 kg livestock weight). However, Walker and Scott (1968) suggested a stocking rate of one animal to 0.6 - 1 ha.

Wildstrand, (1975) describes herders in Shinyanga Region as usually rationally managing their herds by attending to their survival and prosperity. According to Brandstrom (1985) herders usually conduct pre-surveys to detect suitable areas for grazing at various seasons of the year. Citing the Barabaig people of Hanang District Arusha Region who reside in similar conditions to the Wasukuma, Lane (1990) observed that "through intimate knowledge of their environment and through intricate mechanisms governing the use of grazing lands which are held as common property resource by communities, the Barabaig have historically maintained the productivity of their lands". In Kishapu and Negezi divisions, due to high stocking rates, availability of stock feed is a challenge to herders. Akong'a *et al.* (1988) observe that "feed availability for existing stocks is imposing a challenge as amount of important grasses have been on the decline". Ivens, (1958) noted that in areas where grass is grazed too heavily, a dense growth of trees may develop but such tree species should be non-palatable to livestock.

2.2.3 The people: waSukuma culture and land tenure

Elements of waSukuma culture have been studied and reported (Barnes *et al.*, 1985; Barrow *et al.*, 1988; Brandstrom, 1985; Disney and Haylock, 1955; Hankins, 1974; Hankins *et al.*, 1971; Larsen, 1974; Schanne-Raab, 1974). Shayo (1986) discussed the role of drought in Sukumaland concluding it was the main cause of food shortage and famine especially in semi-arid and fragile climates like those of Kishapu and Negezi divisions. Local communities in Shinyanga have been conscious of deterioration in their environment and have tried to accommodate this trend through traditional reactions (Barrow *et al.*, 1988; Hankins, 1974; Kalma, 1989; Shao *et al.*, 1990; Sommy 1990). One form of this resilience is the range management system known as "ngitiri". Under 'ngitiri', to reserve sufficient grass for animals to graze at times of critical demand an area is periodically protected from grazing by the community or individual.

Most literature recognises that the value and use of labour within the cultural context of the waSukuma people, has direct impact to community activities. The use of labour on crops and livestock production in Shinyanga is gender-biased (Collinson, 1963; Kerario, 1992). Men are heavily involved in cash earning through livestock and cotton production activities. The majority of the women are involved significantly in agricultural production at household and village levels (Aarnik and Kingma, 1991; Tutwiler, 1990). Women are directly involved in food crop production, processing and storage. Culturally, the Sukuma people value labour sharing and work in groups (Barrow *et al.*, 1988; Hankins, 1974; Schanne-Raab, 1974).

Traditionally women are also committed to firewood collection, cooking and looking after children. Under the Wasukuma culture there is a taboo on men doing cooking and child minding. However, a man can collect and sell firewood the community perceptions is of an income generating activity. Cultural values not only affect peoples' lives but govern their perceptions and determine land-use/ownership styles. Schanne-Raab, (1974) reported that while the Wasukuma people have accepted the idea of cash crops into their economic system, they have resisted attempts to change their attitudes towards cattle and cattle production. According to the Wasukuma culture, cattle are highly valued and controlled by men. Any attempts to change their traditional system of keeping cattle would meet opposition from within the society.

Wasukuma land ownership is based on clan structure under customary law. This is valued for its land ownership security (Conway and Barbier, 1990; Schanne-Raab, 1974; Shayo, 1986). Land tenure categories in Shinyanga Region are as follows: private land, (individually managed and controlled land), communal land (this is the land which is owned, managed and used communally and public land which is outside the village boundary and no village claims ownership. In communal land no individual has more rights than others. Every member of the village is treated equally). Public land is also regarded as no man's land but the regional government and the Prime Minister's Office have authority over such land. Private land is organised into near cropped fields (within 1.5 km of the homestead) and crop fields which are further away. Following the 1970's villagization programme, village communal lands are of two types: communal cropped fields and communal grazing areas. These areas are controlled by the village government. Villagers contribute labour to village communal crop field (mfuma). Products are normally sold to generate village funds. In communal grazing areas direct labour contributions are rare nowadays. In the past men were required to cut trees in grazing areas. Compared with the past, today's population of natural trees is greatly diminished.

In practice, private land is used and controlled by the household under usufruct rights, with customary occupancy but no documented legal rights. Due to population pressure more land-use conflicts (mainly related to farming. grazing and conservation needs) are arising than in the past. In the absence of external influences each village in Shinyanga region, in accordance with traditional norms, had its own authority for dealing with land disputes arising in the course of utilising existing resources. For example, Hurtley (1938) reported that village boundaries were settled by the chief and his advisers. Minor disputes between villages or within a village were settled by 'Wanangwa' (village headmen), 'Basumba Ntale' (youth leaders) and 'Banamhala' (the village elders). This system worked until the 'Arusha declaration' of 1967 when all land was declared a national asset. This conflicts with the control over communal cropped fields to which many farmers are reluctant to contribute labour.

Traditionally, to solve problems arising the Wasukuma had established recognized channels of communication to follow in the village (Hankins, 1994). It was the village headman's responsibility to see that the system worked well. Interactions began at neighbourhood (Kitongoji) level. Villagers were categorized into appropriate groups and each group selected its own leader. In all, five groups were recognised: pumburu (women council); basumba ntale (senior youths, 25 to 40 years); bayanda (junior youths, less than 25 years); banamhala (elders) and banangh'ongh'o (the elders council). The banangh'ongh'o was a small group of five to ten village elders who had the special role of advising the chief and an impact on village decision making. Interactions within and between groups were effected by group leaders and the village headmen during village annual meetings.

CHAPTER 3: DATA ACQUISITION AND ORGANISATION

In this chapter details of methodological procedures followed during the field work (data collection and knowledge acquisition) are discussed. There are three main sections to this chapter dealing with data collection rationale (3.1), data collection procedure (3.2) and data processing (3.3). The first section is subdivided with the character of the data explained in Subsection 3.1.1 and the identification of sources in 3.1.2. In Sections 3.2 and 3.3 structured interview procedures (3.2.1; 3.3.1) are separated from unstructured interview procedures (3.2.2; 3.3.2) and the validation/verification exercise (3.2.3; 3.3.3).

3.1 Organisation of data collection

3.1.1 Derivation of data

Data were gathered from both primary and secondary sources. Quantitative and qualitative primary data were obtained from informants (Plate 3.1) through structured and unstructured interviews. These were supplemented with participation observation and informal discussions with farmers.

Regional background information was extracted from existing records at the University College of North Wales Library, Bangor, UK, and from the Institute of Resources Assessment and the Economic Research Bureau at the University of Dar-es-Salaam. Climatic data were extracted from the archives of the Meteorological Department, Dar-es-Salaam. These were updated with more recent information held in the Regional Offices in Shinyanga involving the Agriculture, Livestock Development, Natural Resources, Shinyanga Region Co-operative Union (SHIRECU) and HASHI Offices. Further data were obtained from maps (1: 250 000) acquired from the Surveys and Mapping Department Office, Dar-es-Salaam.

Information regarding current levels and trends in agriculture, livestock, forestry and land-use activities for Kishapu and Negezi Divisions were obtained from the respective Divisional Offices. Information on study village biodata was obtained from the village offices.

The information collected was both quantitative and qualitative. The former provided a basis for understanding existing resources and for describing the agricultural systems systematically and scientifically. The latter, was needed to establish specifically what

Plate 3.1 Informants were the main source of primary data Mzee Mino (above) from Isoso village (Kishapu) during the interview. Interviews were held under tree shade (below) and sometimes members of the family gathered around.

farmers know about ecological and environmental aspects within their farming and grazing areas.

3.1.2 The village context

Identification of sample villages

Background information assembled about Shinyanga Region and specifically about the villages provided a framework for the execution of the detailed study to obtain information from the primary sources (informants).

Preliminary surveys and selection of study villages

In selecting the village to serve as main study areas, the following process was adopted:

- a list (Appendix 3.1) of all settlements for both Kishapu and Negezi divisions was compiled by extracting these from the 1: 250 000 map.

- a list (Appendix 3.2) of all registered official villages was obtained from each Divisional Office.

- the two lists of villages were compared. It was noted that the official list had more villages than those on the list extracted from the map.

a rapid preliminary survey in Kishapu and Negezi Divisions was carried out to confirm accessibility of potential study villages. Because of transport difficulties it was not possible to visit all villages in the Divisions but in Kishapu 20 (out of 39) and in Negezi 15 (out of 35) villages were covered (Appendix 3.3).

using the official list of villages and augmented with information obtained during the preliminary survey, a series of seven preference villages were chosen by elimination to form a basis for the selection of the main study villages. For a village to qualify as a main study centre, the following conditions applied in order to avoid urban influence and generate information being sought.

the village had to be more than 20 km from Shinyanga town.

the village had to have 200 or more households.
at least 50 per cent of the households had to keep livestock.

Having gone through this procedure two villages from each division were randomly selected from those in each division which qualified. These were: Migunga and Sanjo in Kishapu and Bulimba and Mayanji in Negezi (Fig. 2). Two other villages from each division (Isoso and Igaga) in Kishapu and (Ikonda and Mwamashele) in Negezi (Appendix 3.4) were taken as potential reserves in the event of such need arising. Because of transport problems and lack of accommodation it was not possible to collect information from Sanjo village as it was 72 km from Shinyanga town and about 22 km from Mhunze (Kishapu Divisional Headquarters) where accommodation was easily available. Isoso village was taken instead.

Following a similar procedure two villages for use in the information verification exercise were identified. In principle, reserved villages were considered appropriate for this exercise if not involved in the initial study. In Kishapu Division, it turned out that one of the reserved villages (Isoso) was engaged in the initial study and could not be used in the verification phase. Thus Isoso was replaced by Mwataga village. In Negezi Division, the reserved villages were not used as study areas during the first phase, but Mwamashele village could not be used for verifying information due to difficulty of access and Mwaweja village was used instead. Both Mwataga and Mwaweja villages met the conditions imposed when the villages used in the first phase were identified.

The approach and entry to each village community was through the village leadership, mainly the Chairman and Executive Secretary, by presenting an introductory letter from the Divisional Office. The former ensures national political guidelines are followed and maintains order and peace. The latter is more concerned with the administration and running of day-to-day village affairs. These leaders assisted in explaining to other leaders and to villagers the importance and relevance of the study. All leaders were very co-operative and proved most effective as a link with other members of their villages.

3.2 Data collection procedures

In each village two research assistants (one male and one female) were recruited to assist in interviews. Since informants preferred to express themselves in 'kisukuma' having assistants was mandatory. These assistants were selected on the basis of fluency in "Kiswahili" and "Kisukuma". Being fluent in English was an added advantage. It was a requirement that they be from the study areas (i.e. grew up no more than 10 km from the study villages), understood the local conditions quite well and were acceptable to the villagers. All assistants had completed primary education. No forestry training background was demanded.

In order to ensure some degree of consistency in the information collected the assistants were given a short training on the conduct of interviews, particularly with regard to the manner in which questions should be asked. It was stressed that informants should not be pressurised into their responses and that direct questions should be avoided so that responses were not reduced to yes/no status. Most of the time discussions were conducted in "Kisukuma" and interviews were taped. After each day's interviews, the assistants and the researcher reviewed what was said by the informants to make preliminary identification of the main issues raised, pending translation of the full taped talk. This facilitated monitoring of progress and the extent to which the information sought was being generated. The tapes also indicated if the research assistants were asking questions appropriately. The joint review was further used to brief the assistants on refined interviewing by illustrating how questions should be asked and how to put informants fully at ease.

3.2.1 Structured interviews: household surveys

Questionnaire

The data set generated through this survey was in the form of structured questionnaire responses. The questionnaire (Appendix 3.5) contained questions in two specific categories: questions concerning the socio-economic setting and questions securing data on the agricultural base.

Questions on the socio-economic setting were specifically concerned with informants marital status, occupation, household structure and division of labour (5 questions).

The agricultural base contained questions in seven categories:

(i) Questions concerned with land holding sizes, means of land acquisition, type of cropped fields, crops and cropping systems (6 questions)

(ii) Questions related to livestock ownership (numbers per category), stocking rates and resource utilisation, informants' perceptions of the livestock resources, problems related to livestock keeping and farmers aspirations on livestock (4 questions)

(iii) Questions concerned with grazing land and herding responsibilities (2 questions)

(iv) Questions related to tree growing for various uses (4 questions)

(v) Questions concerned with the non-browsing role of woody plants - specifically on the availability of wood for fuel, poles and timber, and trees for fruits and medicine (4 questions)

(vi) Questions related to farmers' perceptions of trees in different situations: extent of use in cropped fields, choice of sites and species, extent of tree planting and its consequences (4 questions)

(vii) Questions concerned with the role of browse plants: specifically which species were browsed by cattle and by goats/sheep (1 question)

Pre-testing

To improve the accuracy and relevance of the information being sought the questionnaire was first pre-tested using a relatively small sample (two households) in each village visited during the preliminary surveys.

On re-consideration after this trial the questionnaire it was modified by splitting the 1-18 years age group into two; 1-10 years and 11-18 years. It had been noted that there was a distinction between the two and that they played different roles within the household. Questions to find out about field crops near and far from the households and the types of crops grown in each category were added. To improve the flow of information by enabling the informants to express views without unease, questions on livestock ownership and numbers were the last to be asked. In the case of notable discrepancies in the figures the informants were requested to clarify further.

Sample households

In each of the four villages, sixty households, representing about 28% of those in the village were involved in the study. The 60 households were sampled according to a cluster sampling technique. This method was used because it provides fair and unbiased results. Furthermore, all the households in the villages were observed to have same conditions in terms of structure and social setting. In each village a cluster comprised approximately ten households. On average, each village had about 20 clusters. From each cluster three households were selected for interview following a random sampling technique. Men or women aged over 18 years were considered eligible interviewees, depending on who was present and willing to speak at the time of the visit. From each household one informant was interviewed. When there was no one present for interview, at the selected household, the nearest neighbouring household was taken as a replacement.

Interview location

The sixty households were visited by a team composed of the researcher and two assistants (a male and a female). The interviews took place at the selected household premises, mostly under tree shade (Plate 3.1). Each informant was made aware of the objectives of the study. The questionnaire was written in 'Kiswahili'. All interviews were conducted in 'Kisukuma' but responses were translated and recorded in 'Kiswahili'. Male informants were interviewed by the male assistant, female informants by the female assistant. This respected local customs and traditions.

3.2.2 Unstructured interviews

Unstructured interviews were used to elicit knowledge from farmers (qualitative information) about the environment they live in and what they practise in real life.

Sampling procedure

Selection of informants followed a two stage sampling technique involving specification and formalization stages.

Plate 3.2: Old informants were resourceful particularly regarding to past environmental situations. Above - Mzee Mhunze (100+ years old) - Isoso village (Kishapu) being interviewed. Below Mzee Shija Nkinga (70) and his wife - Migunga Village (Kishapu) after interview.

The specification stage

From each village ten key informants mainly elders and influential people (Plate 3.2) including the village chairman were selected for the first stage of interviews. These key informants were identified from the information gathered during the structured interviews and partly in informal talks as well as in consultations with village elders. Village leaders were consulted specifically about individuals with unique knowledge. Experienced villagers well versed in local culture and traditions in relation to the land-use practices were included in the sample.

The formalization stage

This formed the second stage of interview. In each village 30 informants were interviewed in addition to the 10 key informants. Selection of these followed a stratified random sampling technique based on gender and age. Education and wealth were not used for selecting individuals because it was found that not many adults over 18 years had attended school and there was great uniformity among households as far as the standard of living was concerned. The community was stratified into three age groups: 19 - 30 years; 31 - 60 years and 61 years and above. From each age group five men and five women were interviewed making a total of 30 informants per village. The informants' willingness to speak and permit taping of the discussion was an important condition for the interview to take place. Some informants were interviewed once and others as many as four or five times. The first interview followed an unscheduled visit, but subsequent interviews to the same informant were with prior arrangement to ensure their availability. Informants were thus able to proceed with regular activities with minimal interference.

Interview locations

Interviews mostly took place sitting in tree shade beside the informant's premises During a first visit to the informant, an explanation of the purpose of the study was given, stating clearly that the intention was solely to learn of their knowledge of the environment they lived in. This explanation was made as a precaution to eliminate any suspicion or fear. Having made clear why the study was needed, and having secured informant rapport, interviewing proceeded. Informants were first requested to give a brief account how long they had been lived in the village and past trends of the environment.

During the interviews questions were asked in such a way that informants were able to relate what they knew, or to express their perceptions and opinions, rather than saying "yes" or "no". Such questions as "Do you see having trees on cropped fields or rangeland as good or bad thing?" were avoided. Questions like "please tell us what you think about having trees on cropped fields or rangeland?" were asked. A "gaming" approach with hypothetical situations was used, represented as a series of questions such as "imagine the situation was like this or that. What can you do and what will happen?" Informants were thus given an opportunity to explain what they knew or thought was good or bad for them and why. Follow-up interviews on what had been said were used to establish consistency and validity and avoid ambiguity in the information gathered. All unstructured interviews were fully taped if the informant was willing and happy to be recorded. In most cases permission was granted. Only on two occasions when two women became shy and could not speak and therefore no interviews were conducted.

Interview time ranged from about 45 minutes to about 2 hours. A single informant was usually involved but occasionally some informants were joined by members of the family (see Plate 3.1). Two group interviews were undertaken and recorded. One involved 12 women and the other 13 men.

At each household where an interview took place, an inventory of the planted trees and others and their locations was undertaken (using structured questionnaires) to supplement the information collected. This was done by walking around the homestead guided by the informant. Tree species were identified by their names and their positions and an explanation was provided by the informant in terms of preference for the species and positioning. For the planted tree species an explanation of when they were planted, number planted reason for planting and how many were surviving by the time of our visit was provided by the informant.

Participation observation

To obtain reliable information, it was important to have community acceptance and guarantees of farmers' receptiveness and willingness to communicate with the researcher. Farmers' confidence was therefore gained by the researcher residing as close to the study villages as possible and participating with the people in various activities. Regular visits to informants' homesteads and frankness during discussions ensured good interaction with the community. Active participation in funeral, wedding and religious festivals and attending regular Sunday services re-inforced this integration. At such events further informal discussions with the people took place, helping to generate a useful framework for further probing. Field observations were made regularly and written notes taken as a basis for later discussions with informants on why certain actions or decisions were undertaken. Samples of tree and grass species were regularly collected from the field and people requested to explain what they knew about them. Occasionally informal discussions were held with people in the village office or at community gatherings (markets, local "pombe"* shop and at traditional dance festivals). Visits to households, especially during the evenings when people were sitting around the fire (hakikome), were sometimes made.

3.2.3 Information validation/verification exercise

This exercise was conducted in Kishapu and Negezi six months after the first study. This timing took account of two factors: (i) analysis and processing of the information collected earlier had to be completed prior to validation/verification; (ii) a choice of matters for verification had to be made. Verification mainly involved information generated through unstructured interviews and was used to create the knowledge base. The exercise entailed testing structured knowledge bases and assessing the representativeness of the information.

Sampling

Four villages were involved: Mwataga and Igaga from Kishapu Division and Ikonda and Mwaweja from Negezi Division. From each village sixty informants (30 of each gender) were interviewed. Selection of interviewees followed a procedure already outlined (3.2.2).

Interview locations

Interviews were mostly conducted at the informant's house. Since the study villages had experienced drought effects for three consecutive seasons (1991/92, 1992/93, 1993/94), and because the 1993/94 rainy season started in January 1994 (two months late), conditions were already beyond tolerable levels. Many families were suffering food shortages and cattle losses because of the drought. To obtain informants' responses was not easy and much patience was needed. Occasionally informants refused to continue with interviews with a feeling that issues sought from them were known to the study team. However, it was explained that their views were essential

* pombe: beer or local brew.

and that what the researcher knew might differ from what they knew. Interviews were conducted on the principle of an informant's willingness to speak freely. Where a lack of co-operation and reluctance to talk were encountered, replacement by a more informative neighbour was sought.

A questionnaire was used, administered following a semi-structured interview approach. Two knowledge bases were involved: the 'ngitiri' system and the rangeland-tree knowledge. Statements to be verified were categorised into specific topics and underlying sets of questions were put to the informant. Information verification had two objectives:

to cross-check the understanding deduced for informants during the initial study.

to look at the consistency of knowledge distribution within the community.

Statements verified

Statements of facts related to farmers' perceptions of the 'ngitiri' system and rangeland-tree resources were verified. Selection of what statement to verify ensured that the four identified categories (management practices, biological aspects, interactions and resource utilization) were covered. In addition, the following were considered: statements mentioned by few informants (e.g. 'miyuguyu' grow scattered) statements with conflicting perceptions (e.g. timing of 'ngitiri' closure). Because of time and resource limitations, it was not feasible to verify many statements 24 out of 70 statements (for the 'ngitiri' system) and 48 out of the 272 statements (for the rangeland-tree resource base) were identified and used (see Appendices 3.6 and 3.7 respectively).

The statements about the 'ngitiri' system were in three categories:

(i) Statements related to management practices (9 statements)

(ii) Statements on biological processes occurring in 'ngitiri' areas (7 statements)

(iii) Statements on components interactions taking place above and below the ground in 'ngitiri' areas (8 statements).

Statements about the rangeland-tree system were in four categories:

(i) Statements related to management practices (6 statements)

(ii) Statements related to resource utilization (12 statements)

(iii) Statements on component interactions (20 statements)

(iv) Statements related to biological processes (10 statements)

3.3 Data summarisation and analysis

3.3.1 Structured interviews

Treatment of questionnaire responses, by question

Questions related to the socio-economic setting (questions 1- 5)

Question 1 - this was for labelling purposes only and aimed at identifying the informant by name, village, division and district.

Questions 2 - 4 these established the gender, education and marital status combination of the informant and the composition of the household in sex and age group terms.

Question 5 - this revealed whether the informant was a farmer or a herder or dealt with both activities. The question was extended to provide for a breakdown on the use of family labour expressed as hours day^{-1} for the season concerned. Seasons were specified as wet and dry seasons. A provision was also made to establish which activities are done by women, men or all members of the household and how they spend their leisure time. The activities were categorised into three main groups: field work, livestock management and household activities. Field work involved such activities as ploughing, planting crops and trees, tending in terms of weeding and bird scaring, adding amendments in the form of chemical fertilisers or cow-dung, harvesting of crops, processing, storage and marketing of produce. Household work was related to such activities as firewood collection, cooking, washing clothes, cleaning the house and compound and constructing/repairing activity. Time spent on these activities was recorded in hours per day, as the approximate time needed to complete the activity as the season when it was carried out.

Questions seeking responses on the agricultural base

Question 6 - **"how big is your land, is it in one location or scattered?"** determined the size of the informant's land holding and whether fragmented or not. Areas were expressed by informants in acres and converted to ha by the researcher on the basis that one ha equals 2.47 acres.

Question 7 - **"how did you acquire this land?"** determined the source of land acquisition whether by inheritance of clan land, through government allocations or by other means (e.g. purchase). Informants were given the three choices but there was provision for additional means to be noted. The intention was to know from the responses given which of these was the most widespread means of land acquisition in the village.

Question 8 - **"how many km is your nearest and farthest cropped field?, what type of crops are grown in each and why?"** determined how distances to cropped fields may affect crop management practices and how farmers make decisions about what to grow and whether or not to apply cow dung onto the fields.

Question 9 - **"what crops do you grow each year? where do you grow them and why?"** determined cropping pattern (crop type, area and yield) and also established what prompts farmers to grow certain crops more than others and in which areas they are grown.

Question 10 - **"do you mix various crops together? if 'yes' please explain"** determined the extent of crop mixing and why. For those not mixing crops and reasons were also sought.

Question 11 - **"do you use fertilisers or cow manure in your cropped fields?"** determined the extent of fertiliser/cow manure application, the amount used and the reasons for application. Those not applying were also requested to explain why not.

Questions seeking informants' views about trees

Question 12 - **"do you have trees on your farm? if 'yes' what type and uses?"** - determined the extent of trees being retained or grown on farms for various needs/uses.

Question 13 - **"do you see mixing crops with trees on your farm as a good or bad thing? please explain."** This determined attitudes about trees on cropped fields.

Question 14 - **"do you consider having trees in your village as a good or bad thing? explain"** determined attitudes to trees at community level. Views could be positive about trees on village lands but negative about trees on an informant's holding or vice versa.

Question 15 - **"if more trees are to be planted in your village how best this could be achieved? please explain".** This aimed at obtaining villagers input as suggestions of the methods/techniques that could be followed to make an afforestation/agroforestry initiative a success.

Question 16 - **"please list five tree species you prefer most and give reasons"** aimed at identifying tree species most preferred by people.

Question 17 - **"how many trees have you planted for the last five years and type/source of these?"** determined the extent of involvement on tree planting initiatives, the sources of planting materials and the type of material used (e.g. seeds, seedlings or cuttings or others). Where trees had been planted was ascertained through the inventories carried out by the research team in collaboration with the informant around the household and fields. No potential sources of planting materials were specified to informants when the question was asked.

Question 18 - **"of the planted trees how many are surviving?"** determined the extent of success. If planted trees had died, opinions on the reasons were requested.

Question 19 - **"do you have fodder trees on your land?"** determined the extent of using trees for livestock production, and which species used and why. Informants were requested to respond separately for each animal category.

Question 20 - **"where do you obtain your wood for cooking, poles and timber from?"** determined the sources of these and how easy or difficult it was to obtain them in terms of distances involved.

Questions 21 - **"What type of tree species you prefer for firewood and why?"** determined the firewood species preferred for cooking food and why.

Question 22 - **"Who is responsible with firewood collection, time spent and how often is the collection?"** determined who in the household was responsible for this, the time spent and the frequency of collection (daily, once or twice a week or monthly).

Question 23 determined the availability, in terms of distances involved, of species for firewood, poles, timber, fruits and medicinal materials. Responses indicated the extent of any supply problem and what people thought about it. Informants were invited to indicate any other plant usage they thought important.

Question 24 - **"do you keep livestock?"** determined whether the practice was followed and if so the numbers by category and the reasons for keeping them.

Question 25 - **if you have an opportunity to increase or decrease your herd size what do you prefer and why?"** determined informants' aspirations about livestock and why they had them

Question 26 - **"how many units of livestock (by category) can one ha of grazing land support on a sustained basis and why you think so?"** determined perceptions of viable stocking rates.

Question 27 **"where do you graze your animals?"** determined the availability of grazing land in terms of ownership, sizes and distance from homestead.

Question 28 - **"what do you think are good or bad effects of livestock?"** established what was considered good or bad about having livestock.

Question 29 - **"Who is responsible for daily herding of cattle, goats, and sheep?"** determined how grazing responsibilities were assigned. The question also enabled comments to be made on whether different types of livestock were grazed together or separately and why they were used. Men, women, boys or girls were all treated as potential herders

Question 30 - "**Name at least five natural tree species you know which are eaten by livestock**" was to identify the principal browse species recognizes in the rangelands, the type of animal feeding on them, when they were eaten (season) and the parts consumed. There was provision for comments on effects on livestock (toxicity or otherwise).

Although certain questions (12, 13 and 14) aimed at obtaining informants' perceptions, responses were recorded as quantitative scores for positive and negative attitudes depending on each informant's responses. If an informant responded positively or the score would be (1). For example, 40 informants out of a sample of 60 considering trees in cropped fields a good thing (positive attitude) would mean 20 informants see trees as a bad thing (negative attitude) in cropped fields. Summary of use of questionnaire data and analysis are indicated in Tables 2 & 3.

Table 2: Summary of use of questionnaire data.

No	statistical method	input to resource base statement	Simple description	not used
1		name, location	identification	X
2		sex, age	do	X
3		marital status	do	
4		education	do	X
5	X	number of hours	if differences exist	
6	X	land holding sizes		
7	X	how people get land		
8		location of crop fields	ranking	
9	X	types of crops grown	no. of ha and yields	
10	X	crop mixing	maize with others	
11		use of fertilizers		X
12		trees on cropped fields	perceptions	
13	X	positive/negative effects	perceptions	
14		do	perceptions	
15		tree planting initiatives	perceptions	
16		species preference	species preferred	
17		trees planted	tree planting efforts	
18		do	trees survived	
19		Tree fodder species	fodder trees planted	
20		wood supply		
21	X	species for firewood		
22		firewood collection	firewood responsibility	X
23	X	distances to collect wood		
24	X	livestock numbers		
25	X	livestock aspirations		
26	X	stocking rates	informants' estimates	
27	X	grazing areas		X
28		problems of livestock		X
29		herding responsibility		X
30		browse		

Table 3: Statistical analysis of questionnaire returns

	Technique					
		Comparisons				
Q. No	descriptive statistics	within village	between villages	association of parameters	ranking	formal analysis
1						
2		X	X			
3		X	X			
4	X					
5		X	X			Anova
6	X	X	X			t -test
7		X	X			G^2-test
8	X	X	X		X	
9	X	X	X	X		t - test
10		X	X			G^2-test
11						G^2-test
12						
13		X	X			ChiSq.
14		X	X			
15		X	X			
16		X	X			
17		X	X			
18		X	X			
19		X	X			
20		X	X			G^2-test
21		X	X			G^2-test
22		X	X			G^2-test
23		X	X			G^2-test
24	X		X			t - test
25		X	X			
26	X	X				t - test
27	X		X	X		G^2
28					X	G^2-test
29						G^2-test
30					X	

3.3.2 Unstructured interviews

From the notebook translations of the taped interviews a mass of information emerged from informants. The first step was to read through informants' responses to obtain a general impression of what was said and how perceptions of ecological factors could be isolated for subsequent analysis and structuring. The second step was to establish categories for appropriately grouping informants' comments relevant to the study (pasture, livestock, tree and human) interactions in terms of usage, management aspects, propagation aspects and ecological aspects. Four main categories were derived:

management practices
biological processes
resource utilisation
component interactions

These categories were applicable both for the 'ngitiri' system (except resource utilization: apart from cattle eating grass which is covered under components interactions, no aspects of resource utilization were identified in the 'ngitiri' system) and the rangeland-tree base. The third step was to go through each interview again, separating out statements according to 'ngitiri' system and rangeland-tree resource base. Sentences were extracted and when complex broken down into simple statements subject to retention of their meaning. The retained information was then listed and organized (depending on the statement meaning and what it was related to) for both 'ngitiri' system and rangeland-tree resource base as:

statements related to management practices
statements related to biological processes
statements related to components interactions
statements related to resource utilisation

Statements which did not fall in any of the above categories were rejected. For the 'ngitiri' system 70 statements of fact were identified. For the rangeland-tree resource base 272 statements were identified. To enhance clarity, and to simplify comparison of indigenous knowledge with scientific knowledge, statements which referred to the cause-effect interactions were represented diagramatically. Such interactions represent about 49% of the statements for the 'ngitiri' system and about 30% of the statements for the rangeland-tree resource base. Once available, the diagrams could be used to identify information gaps and areas complementary between local and scientific knowledge.

Diagrams are hierarchical structures with nodes linked by arrows. 'Nodes' represent objects (e.g. a tree or a root system), processes (e.g. soil erosion or grass growth) or an attribute (e.g. tree crown size or grass growth rate). Arrows denote the cause-effect interactions and are tagged with statements explaining the direction of change in the relevant characteristic of the object, process or attribute concerned. Size of arrows may vary to denote magnitude of influence or what informants consider to be important interactions between components.

Statistical tests were undertaken to check if there were differences between gender groups and age group's knowledge of firewood species and their characteristics, knowledge of medicinal trees (for human and livestock uses), knowledge of livestock management and breeding and perceptions of how environmental conditions were in the past in relation to current situations. Testing for differences assumed as a null hypothesis that men and women and different age groups are all equally knowledgeable. Responses with respect to these aspects were treated as scores and use in statistical analysis for 'knowing' or 'not knowing'. For example, two out of five women aged between 31 and 60 years were knowledgeable on medicinal materials or one out of five men within the same age group was knowledgeable on the same subject. Using these values for sex and age group statistical (G^2 - test) computations were carried out.

3.3.3 Information validation/verification

Information was verified using four other villages which were not involved in the initial study. It was considered advantageous to undertake verification in different study villages. By using a new group of informants a way of obtaining independent views/perceptions was provided. These villages were 6 km away from the original study areas. It would have been preferable to undertake verification using villages more distant (i.e. more than 20 km) from the original samples, in order to prove knowledge distribution and coherence in the area. Unfortunately such a possibility was ruled out as a result of transport difficulties and the financial problems involved.

Twenty-four statements ('ngitiri' system) and forty-eight statements (rangeland-tree knowledge) were used. The first step was to translate the statements from English to

'Kiswahili' and record them on paper. Since the interviewing was done in 'Kisukuma' the second step was to discuss the statements and how verification should be done with research assistants. The people involved in the first phase were recalled for this activity in view of their experience. They were informed of the objective of the exercise as to confirm facts about the 'ngitiri' system and the rangeland-tree resource base and to ascertain that indigenous ecological knowledge was understood and held by a majority of the people. No specific questions were set, but the statements were the focal point. Interviews were conducted and questions asked using statements from each category (management practices, biological aspects, interactions and resource utilization) as a guide. The character of each category in both the 'ngitiri' system and rangeland-tree resource base is:

For the 'ngitiri' system three categories of statements were verified (no specific statements on resource utilization were identified). Number of statements used are:

Category	Management practices	Biological aspects	Component interactions
Number of statements	9	7	8

(i) Statements related to management practices (e.g. "ngitiri areas are closed from grazing in March if area is fertile and rainfall has been above average". and "Grass quantity in ngitiri areas would increase if areas are closed from grazing for a period of 8 months beginning from March"). These were meant to ascertain the consistency of peoples' understanding of the principles followed and the timing of management operations. Also a provision was made to identify informants practising the 'ngitiri' system and why (e.g. is the system linked with cattle keeping or otherwise?)

(ii) statements related to biological processes (e.g. "quantity of grasses in ngitiri areas would increase if they produce adequate seeds or quantity of grasses would increase if soil moisture is adequate"). This was to ascertain the consistency of their understanding of factors leading to increases or decreases in grass quantity and to establish if many people understood and the concepts of the biological processes involved.

(iii) Statements related to components interactions (e.g. "*Acacia nilotica* in ngitiri areas regenerate if goats graze in such areas" is meant to test if many people understand these trees are spread through livestock droppings and "An increase in grass biomass causes a decrease in soil erosion rates") This determines the consistency of their understanding of the relationships between the amount of vegetation cover and the environment.

(iv) No statements on resource utilisation in the 'ngitiri' areas were verified. This is because the resource mainly involve a single user (livestock) thus such aspects were considered under (iii)

The rangeland-tree resource base has four categories. The number of statements verified are:

Category	Management practices	Biological aspects	Components' interactions	Resource utilization
Number of statements	6	12	20	10

(i) Statements related to management practices (e.g. "Density of trees in rangelands is reduced by cutting to allow an increased grass quantity or grazing in vertisols (mbuga) mainly is done during the dry season") The intention was to ascertain the consistency of people's understanding that management practices are related to existing conditions and resources.

(ii) Statements related to resource utilisation (e.g. "good firewood species should burn slowly, producing hot fire or roots of Masagala (*Anisotes dumosus*) are used to treat effects of mashokolo (*Oxygonum sinuatum*) in cattle") These were used to ascertain the consistency of peoples' understanding of the utility of trees found in rangeland in senses additional to browse.

(iii) Statements related to component interactions (e.g. "grass quantity increase if trees in rangelands grow scattered or amount of tree roots in soil increased causes a reduction in grass growth rate") were used to ascertain to what extent farmers understand about interactions taking place in the rangelands.

(iv) Statements related to biological processes (e.g. "insitu conservation results in increased grass quantity or *Balanites aegyptiaca* grow scattered because seeds are not easily covered by soils"). These were used to ascertain the consistency of peoples' understanding of the biological processes that occur within their environment.

If an informant explained unambiguously in a factual way leading to what was being sought they were regarded as knowledgeable (knowing). Aggregate totals (for knowing, and not knowing) from the sixty informants in each village were made according to age groups and gender (Appendix 3.8). To present a comparative account, the scores for knowing and not knowing for each category for the 'ngitiri' system and the rangeland-tree resource base were tabulated according to age and gender (Tables 49, 50).

Testing for association of knowledge distribution across age and sex groups, assumed a null hypothesis of there being no difference in knowledge and informants are equally knowledgeable on management practices, biological aspects and ecological interactions taking place within the 'ngitiri' system. A goodness of fit (G^2) test for the analysis of frequencies (Sokol and Rohlf, 1981) was followed. A similar approach was used for evaluating responses concerning the rangeland-tree knowledge base.

To test for the differences in the 'ngitiri' system practised between villages or divisions a t - test was used. To test whether 'ngitiri' areas and cattle numbers are correlated a regression analysis was followed.

A provision for comparing indigenous ecological knowledge and what scientists know was made. This was considered at two stages. First, to compare issues advocated by field extension workers and what farmers knew and practised. This determined areas of conflicts between scientific field officers and the farming community or similarity of ideas. To do this conversations were held with agricultural and forestry extension staff at the divisional level seeking their clarification on what they recommend to farmers. Secondly, informant's perceptions of livestock-tree-pasture interactions and conventional scientific knowledge as documented in various literature were compared. This determined inconsistency or complementarity of scientific and indigenous ecological knowledge.

CHAPTER 4 : RESULTS

This chapter is organised into two main sections: the results of the structured questionnaire surveys (4.1) and the outcome of the unstructured interviews (4.2). The former is divided into two sub-sections. The first one sets out the socio-economic setting (4.1.1), focusing on sample composition as representative of population (4.1.1.1) and the agricultural base (4.1.1.2). The second sub-section is on responses concerning the resource base (4.1.2), livestock (4.1.2.1), and woody plant resources (4.1.2.2).

The outcome of the unstructured interviews and verification (4.2) is organized into the familiarisation phase (4.2.1) covering the 'ngitiri' system (4.2.1.1) and the rangeland grass and tree resource base (4.2.1.2). This is followed by information validation/verification (4.2.2)

4.1 Structured interviews

4.1.1 Socio-economic setting

This is considered with respect to sample composition and the agricultural base.

4.1.1.1 Sample composition as representative of population

Gender. education and marital status and age of informants (question 2-4)

Table 4 shows informants marital status. Only 7% (five women and twelve men) of the sample is represented by unmarried people. Women represent 22% of married informants. Majority of the married informants (66%) were from the 31 - 60 years age group. Most of the unmarried informants are from Bulimba. Informants age ranged from 19 years to about 80 years. Figure 4 indicate the distribution of male and female informants in Kishapu and Negezi Divisions.

Table 4 : Informants age and marital status

		Age group						
		≥ 19 < 30 years		≥ 31 < 60 years		≥ 60 years		
		male	female	male	female	male	female	total
Migunga	married	5	0	44	0	0	10	59
	single	0	1	0	0	0	0	1
Isoso	married	5	0	37	3	12	0	57
	single	1	1	1	0	0	0	3
Bulimba	married	5	5	20	12	6	2	50
	single	5	2	3	0	0	0	10
Mayanji	married	7	10	15	13	9	1	55
	single	1	2	2	0	0	0	5
	Total	29	21	122	28	27	13	240

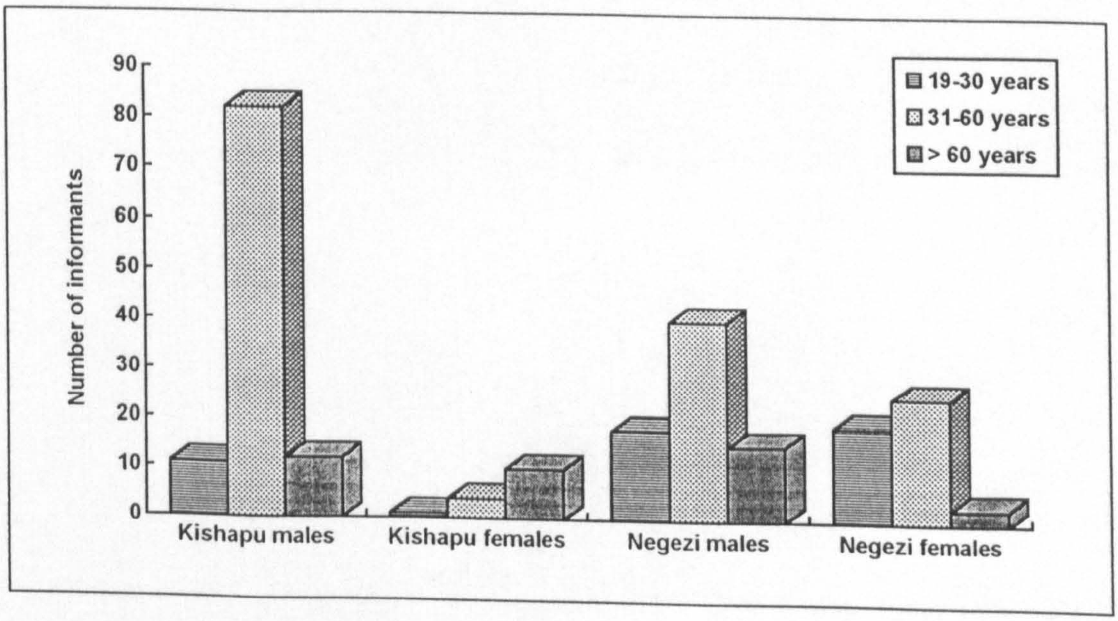

Figure 4 : Distribution of male and female informants by age groups in Kishapu and Negezi Division.

Household size ranged from a minimum of three to a maximum of 35, averaging 9 members (Table 5)

Household size ranged from a minimum of three to a maximum of 35, averaging 9 members (Table 5)

Table 5: Informants' family structures by age and gender.

	Age								
	<10 years		≥10<18 years		≥18<60 years		≥60 years		Total
Village	M	F	M	F	M	F	M	F	
Migunga	111	114	70	51	105	131	9	1	594
Isoso	99	82	52	66	99	83	15	12	508
Bulimba	81	70	67	70	109	105	15	5	523
Mayanji	82	74	79	60	80	97	13	6	491
Total	375	340	268	247	393	416	52	24	2115

M, male; F, female

Education among informants was varied. Some informants had received formal education (which takes into account several years of attending school) and others informal education (where writing and reading skills are acquired through adult education). Illiterate and semi-literate informants account for 56% of the sample whereas those with seven years of primary education accounted for 44% of the sample (Table 6). Women account for only 20% of those who have attended primary education but 30% of those without education.

Table 6: Informants level of education according to age and gender

		Age group								
		≥ 19 < 30 years			≥ 30 < 60 years			≥ 60 years		
		A	B	C	A	B	C	A	B	total
Migunga	male	0	2	5	12	8	23	9	0	59
	female	0	0	0	0	1	0	0	0	1
Isoso	male	0	0	6	4	14	21	8	2	55
	female	0	1	0	2	0	2	0	0	5
Bulimba	male	6	0	3	3	3	21	5	0	41
	female	5	0	1	5	0	8	0	0	19
Mayanji	male	2	0	6	9	0	2	8	0	27
	female	6	0	5	10	0	3	9	0	33
	Total	19	3	26	45	26	80	39	2	240

A, illiterate; B, semi-literate; C, standard seven

Figures (Table 7) indicate that herding alone is rare. The majority of households in Kishapu (Migunga and Isoso villages) combine cropping and livestock keeping. In Negezi (Bulimba and Mayanji villages) about 50% of the informants are either practicing cropping alone or combining cropping and livestock keeping.

Question 7 - Occupation, labour use and time budget

Table 7: Occupation of households.

	Farming	Herding	Farming and Herding
Migunga	1	0	59
Isoso	3	0	57
Bulimba	32	1	27
Mayanji	26	1	33
Total	61	2	176

Some activities (e.g. planting, weeding, and harvesting of crops) are done by all members (Fig. 5). In other respects there is a clear division of labour. Men (Fig. 6), are involved in heavy duties (e.g. ploughing or house construction) and the controlling of household assets and cash income generating activities (e.g. marketing of cotton). Women (Fig. 7) deal exclusively with household work (e.g. firewood collection and cooking) whereas children (Figs. 8, 9) may contribute to either side (e.g. boys caring for livestock; girls helping their mothers; both boys and girls scaring birds and caring for calves).

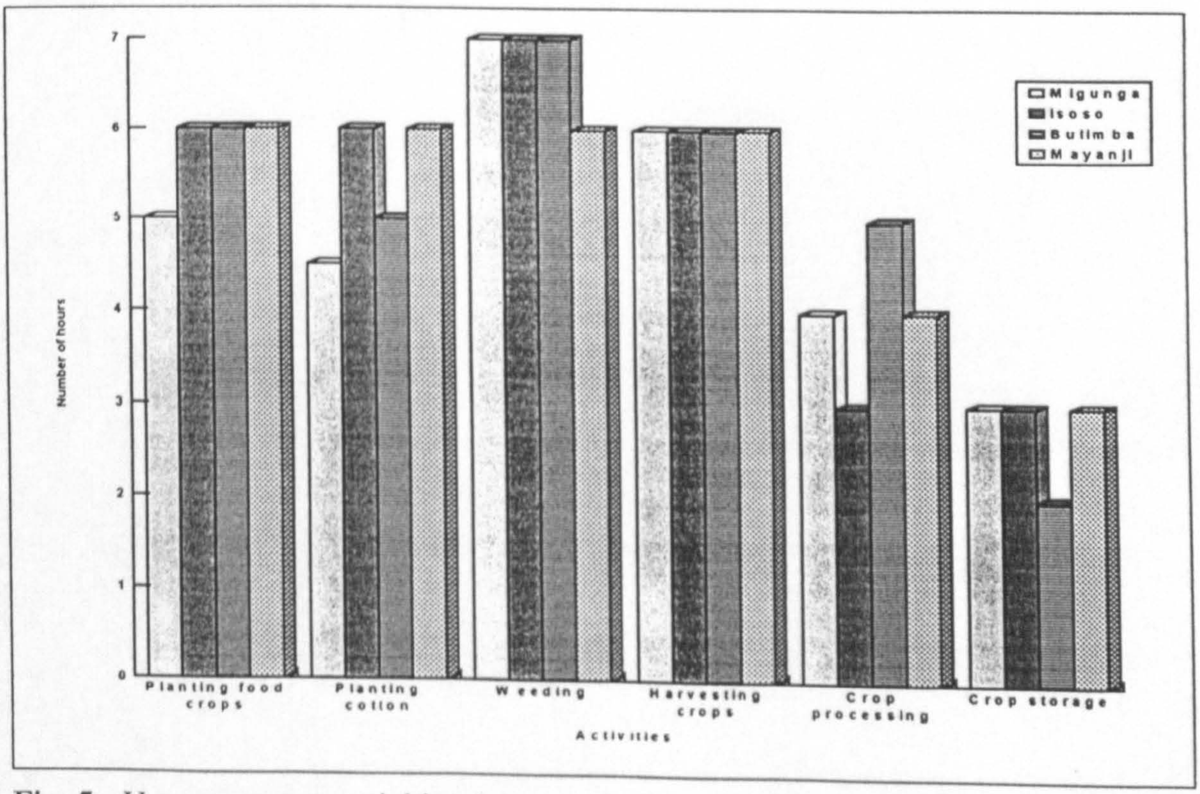

Fig. 5 : Hours spent on activities done per day by all members of the family in Kishapu and Negezi Divisions.

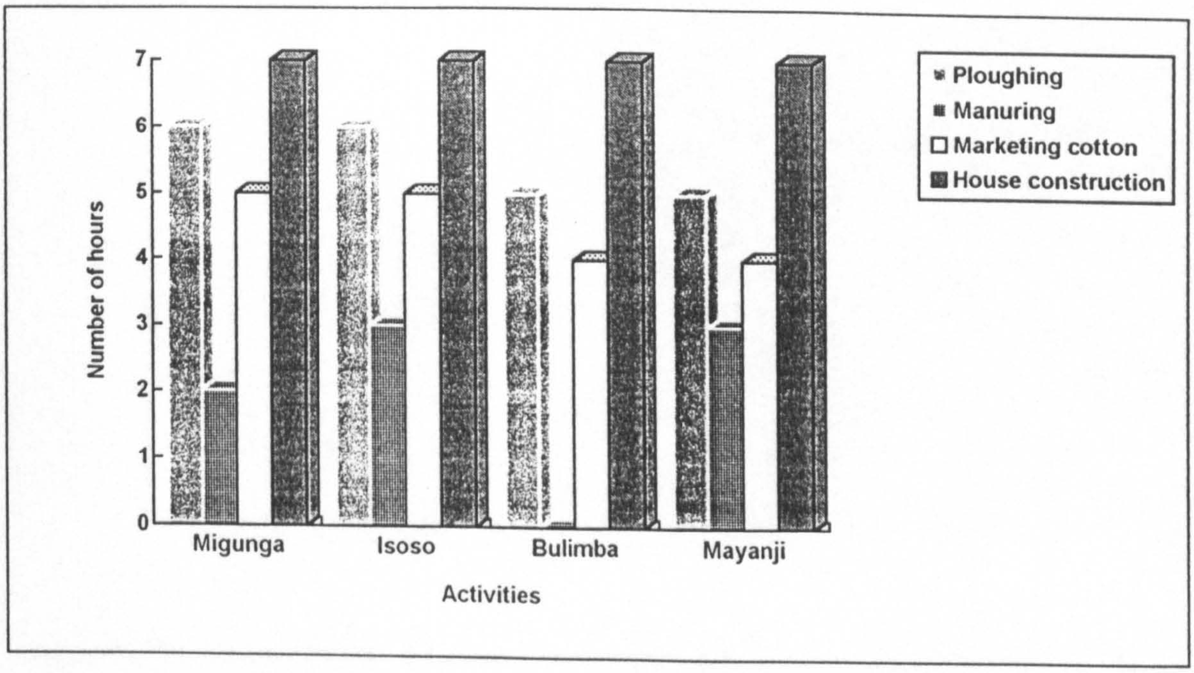

Fig. 6 : Activities done by men and time spent per day in Kishapu and Negezi Divisions.

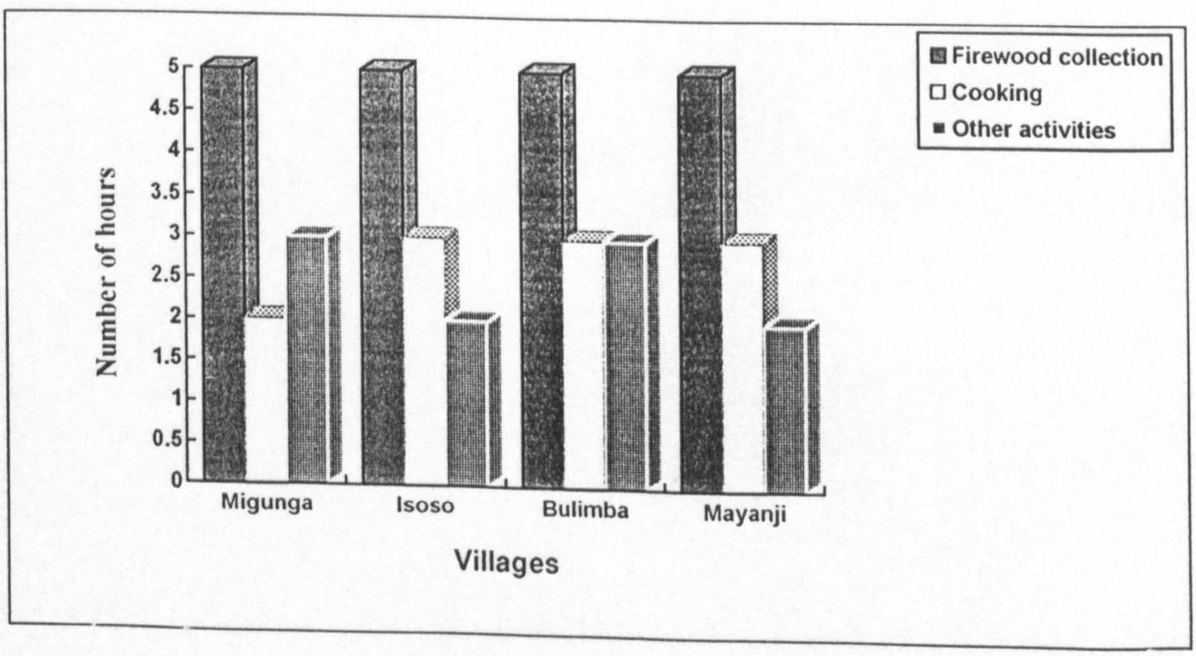

Fig. 7 : Activities done by Women and number of hours spent per day in Kishapu and Negezi Divisions (Shinyanga Region), Tanzania.

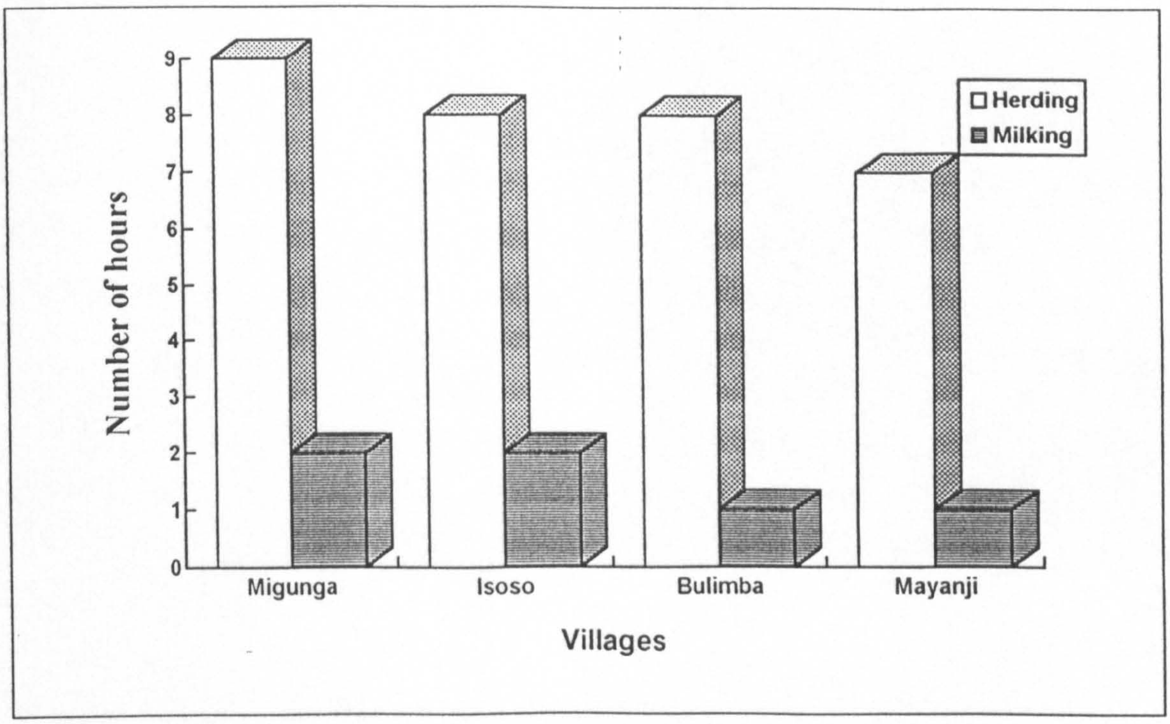

Fig. 8 : Activities done by boys and time spent per day in Kishapu and Negezi Divisions (Shinyanga Region), Tanzania.

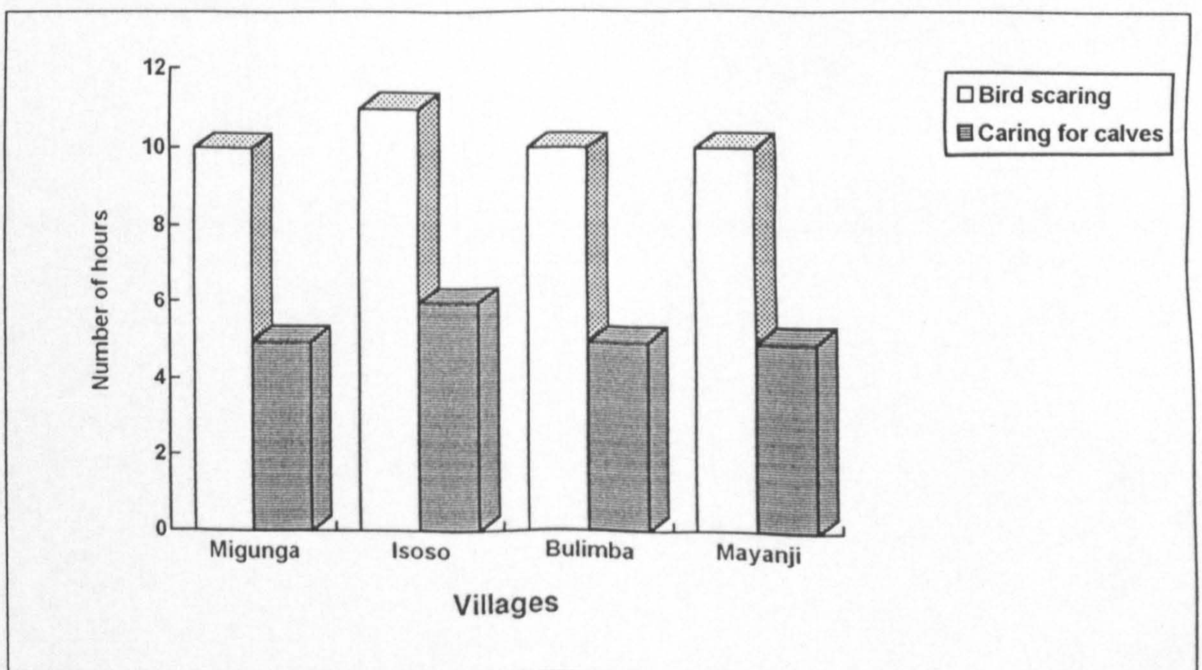

Fig. 9: Activities done by boys and girls and hours per day in Kishapu and Negezi Divisions (Shinyanga Region), Tanzania.

The hours indicated are averages per group (e.g. about 10 hours spent by children on bird scaring) per day. Some activities are completed within a day, or done twice a week, while others are over several days. Thus, marketing of cotton is one day's activity done by men within the cotton marketing season (from July to October). Women spend about 3 hours a day cooking meals. Activities such as ploughing, planting, weeding and harvesting extend over one to four weeks, depending on extent and intensity and availability of labour and/or equipment. During the dry season men concentrate on repairing and constructing houses whereas women spend more time in gathering firewood. Throughout the year the majority of women (75%) collect firewood once each week - a 4 to 5 hour exercise, on average. Statistical analysis for the number of hours spent on various activities group^{-1} day^{-1} indicates no significant differences at village or divisional levels at the 0.05 level.

4.1.1.2 The agricultural base

Land holding size and location (Question 6)

There is a marked difference in land holding among the households in Kishapu and Negezi divisions (Table 8).

Table 8: Land holding household^{-1} (ha).

Village name	Average per household	Minimum	Maximum
Migunga	18.3 (7.6)	8	40
Isoso	8.1 (3.4)	4	24
Kishapu Division	13.2 (8)	4	40
Bulimba	5.8 (2.1)	2.4	12
Mayanji	4.5 (1.9)	2	9.6
Negezi Division	7.0 (2)	2	12

Numbers in parentheses indicate standard deviation

Results of statistical analysis (Table 9) confirm that mean land holdings between villages and at division level significantly differ at the 0.01 level. The variations are probably due to variations in land potential. The fact that Table 6 shows more herding in Kishapu than Negezi and the former being eastwards is an indication that as you move from the west towards the east the quality of land declines and becomes drier.

In that context people in eastern villages (e.g. Migunga and Isoso) may need more land to gain a living. Also location of village matters. Migunga and Isoso villages were noted to be far from neighbouring villages hence more land was availble compared to Bulimba and Mayanji villages

Table 9: Results of t-test (mean land holding sizes) between villages and divisions.

	mean 1	mean 2	pooled SD	df	t-test
Migunga & Isoso	18.3	8.1	0.882	53	* *
Bulimba & Mayanji	5.83	4.49	0.596	53	* *
Kishapu Vs Negezi Divisions	13.2	6.97	0.37	107	* *

. * *, $p < 0.01$ showing that means are significant at the 0.01 level.

Means of land acquisition (Question 7)

According to informants (Table 10) all land is acquired in one of three ways: by inheritance, by allocation and by purchase.

Table 10: Means of land acquisition

	Number of informants		
Village	Inherited from parents	Allocated by village Government	Purchased from others
Migunga	35	22	3
Isoso	36	19	5
Bulimba	34	22	4
Mayanji	33	25	2
Total	138	88	14

More than half of the informants (58%) obtained land through inheritance under the customary land tenure system. No household revealed evidence of acquiring land through more than one means. To test if there is any difference between villages or division in the means of land acquisition by inheritance or by allocation G^2 test was used. Results of G^2 test indicated no significant differences between villages and divisions in means of land acquisition at the 0.05 level.

Question 8 - Location of crop fields: distances in relation to homesteads

All informants had access to crop fields within 1.5 km but most were also raising crops further away, sometimes at a considerable distance (Tables 11, 12). In Migunga village (Kishapu) and Mayanji village (Negezi) most households cultivated land within 0.5 km.

Table 11: Nearest crop fields - distances in km (number of responses)

Village	< 0.5 km	0.5 < 1 km	1 < 1.5 km	1.5 km +
Migunga	45	13	2	0
Isoso	25	24	11	0
Bulimba	14	15	31	0
Mayanji	48	6	6	0
total	132	58	51	0

Some crop fields (Table 12) are beyond 6 km from homesteads, and the majority of these in Bulimba and Mayanji villages, (Negezi). Statistical analysis (Appendix 4.1) indicate differences in responses for cropped fields within and beyond 4 km distances, between Migunga and Isoso villages indicating that majority of the informants in Migunga village having crop fields within 4 km compared to Isoso village (Kishapu) at the 0.05 level. More responses for having crop fields within 4 km are revealed in Kishapu than in Negezi indicating that in the latter division cropping involve a considerable travelling distance.

Table 12: Far crop fields - distances in km from homestead: number of responses

	> 2 < 4 km	4 < 6 km	6 km +
Mugunga	48	8	4
Isoso	37	12	11
Bulimba	29	15	16
Mayanji	26	18	16
Total	140	53	48

Crops and where grown (Question 9)

The Main crops grown are Sorghum (*Sorghum vulgare* and *S. bicolor*), millet (*Pennisetum typhoides*), ground nuts (*Arachis hypogaea*) and Maize (*Zea mays*) mainly for food, but cotton (*Gossypium hirsutum*) and any surplus from food crops is for cash.

The main crops grown in near fields are maize, millet, sorghum, groundnuts and paddy (Table 13).

Table 13: Crops grown in the nearest crop fields: number of responses

	Maize	Millet	Sorghum	Groundnut	Paddy
Migunga	41	28	20	12	14
Isoso	49	44	29	27	8
Bulimba	19	34	15	9	2
Mayanji	19	37	20	8	4
Total	128	143	84	56	28

Cotton (Plate 4.1) is the crop grown by about 64% of households (Table 14) in far fields. This is followed by sorghum (57%), millet (45%), maize (34%) and groundnuts (14%).

Table 14: Crops grown far from the homestead: number of responses

Village	Cotton	Sorghum	Millet	Maize	Groundnut
Migunga	56	50	33	30	21
Isoso	48	46	34	32	12
Bulimba	31	26	18	9	0
Mayanji	20	21	23	12	0
Total	155	143	108	83	33

Furthermore, both crop areas (ha) and crop yields (KGs dry weight ha^{-1}) are low (Tables 15, 17).

Table 15: Main crops acreage (ha) mean values $household^{-1}$

Village	Migunga	Isoso	Bulimba	Mayanji
Crop	ha (mean)	ha (mean)	ha (mean)	ha (mean)
Maize	2.4 (0.8)	2.1 (0.7)	1.5 (0.6)	1.2 (0.4)
Paddy	1.2 (0.5)	1.5 (0.5)	0.9 (0.3)	1.0 (0.3)
Sorghum	2.3 (0.9)	2.2 (0.9)	1.1 (0.3)	1.1 (0.3)
Millet	1.9 (0.8)	1.8 (0.8)	1.8 (0.6)	1.6 (0.5)
Cotton	2.6 (0.9)	2.2 (0.8)	1.1 (0.4)	1.5 (0.4)

Numbers in parentheses indicate standard deviation.

Statistical analysis (ANOVA) using mean values of the size of cultivated areas indicated no significant difference between villages but a significant difference between divisions (Table 16). This is because there are more households in Kishapu engaged in sorghum and cotton cultivation than in Negezi.

Plate 4.1: Cotton - the main cash crop. Above - a farmer inspecting the crop for pest attack. Below - an ox-cart loaded with seed cotton ready for marketing (Mhunze village primary society, Kishapu Division)

Table 16 : Results of ANOVA test for the differences in cropping areas between Kishapu and Negezi Divisions.

Source of variation	SS	df	MS	F	Pvalue	Fcrit
Between Divisions	2.738	1	2.738	20.2648	* *	4.4138
Within Division	2.432	18	0.13511			
Total	5.17	19				

* *, (p<0.01)

Although differences in crop yields ha^{-1} are observed, statistically no significant differences between villages and divisions occurs at the 0.05 level. This indicates that conditions of soils and field fertility levels are almost the same.

Table 17: Crop yields (kg) dry weight ha^{-1}.

Village	Migunga	Isoso	Bulimba	Mayanji
Crop	yields kg (dry weight)			
Maize	749 (278)	639 (285)	535 (231)	415 (179)
Paddy	1348 (843)	1062 (332)	917 (500)	800 (522)
Sorghum	854 (361)	774 (361)	607 (258)	527 (207)
Millet	660 (235)	668 (230)	524 (193)	470 (194)
Cotton	452 (153)	435 (135)	498 (135)	477 (152)

Numbers in parentheses indicate standard deviation.

Crop mixing (Question 10)

There are different crop mixtures favoured in different villages (Table 18). Combining groundnuts and maize is, however, widespread. Cowpea and maize are rarely mixed. In Kishapu (Isoso village), mixing of sorghum and maize (Plate 4.2) is popular. In Negezi (Bulimba village), mixing of millet and maize is favoured. A few households in Isoso village were observed to mix cotton with maize. Statistical analysis (G^2 test) to test differences among villages in the frequency of mixing maize with groundnuts and maize with other crops (sorghum, cowpea and millet) indicates no significant differences between Migunga and Isoso villages (Kishapu), but slightly significance between Bulimba and Mayanji villages (Negezi) and between divisions at the 0.05 (Appendix 4.2), but not when G^2 is adjusted.

Table 18: Crop mixing practices in Kishapu and Negezi divisions: number practising

	Groundnuts & maize	Sorghum & maize	Cowpea & maize	Millet & maize
Migunga	44	12	2	2
Isoso	35	20	4	1
Bulimba	42	3	1	14
Mayanji	51	5	2	2
Total	172	40	9	19

Reasons why farmers practise crop mixing are summarized (Table 19).

Table 19: Reasons for crop mixing and proportions practising

Reason	Practice	Proportion practising	Comment
1. To reduce groundnuts visibility to birds	Groundnuts mixed with maize or millet	72%	maize/millet provide cover to groundnuts
2. Variations in soil conditions	millet & maize or sorghum & maize or cowpea & maize	25%	crops respond differently in various soil types and conditions
3. Unreliable rainfall	maize & sorghum or maize & millet	63%	in case rainfall is not good farmers obtain some produce from drought resistant crops
4. Land shortage	sorghum & maize or millet & maize	36%	optimise production from relatively small area by combining crops
5. Minimise labour requirement	sorghum & maize, millet & maize or groundnuts & maize	33%	energy is saved on ploughing, planting, weeding or bird scaring when crops are mixed than in monocropping

Plate 4.2: Crop mixing practices. Above - maize mixed with sorghum. Below - cotton mixed with maize (Isoso village, Kishapu Division), Shinyanga Region, Tanzania.

Use of chemical fertilisers and cow-dung (Question 11)

No chemical fertilisers are used but some farmers (about 39%) apply cow manure, with Isoso village having more users than the other villages although Migunga and Mayanji have almost the same number of farmers using cow dung (35% and 34% respectively) and Bulimba has only 26%.. These are the villages with the most livestock (Table 21). The reasons for not using fertilisers are varied (Table 20) but about 33% of the informants claimed that their crop fields were fertile.

Table 20: Numbers of households using and not using fertilizers

	Amendment		Reasons for not using		
	(Total) Cow-dung	Not using (total)	Land is fertile	Fields too far	Never thought
Migunga	21	39	20	10	9
Isoso	27	33	9	20	4
Bulimba	16	44	12	22	10
Mayanji	20	40	11	25	4
Total	84	156	52	77	27

Although there are some differences in responses for cowdung application, but statistically there are no significant differences at village and divisional level.

4.1.2 Responses concerning the resource base

4.1.2.1 Livestock

The livestock resource (Questions 24, 26)

Livestock numbers (Question 24)

Figures (Table 21) indicate more livestock in Kishapu Division than in Negezi Division. Statistical test (mean values) indicates significant differences between the divisions for cattle and goats, but not sheep (Table 22). Within each division the difference in mean livestock numbers of each livestock type between villages was not significant at the 0.05 level

Table 21: Livestock numbers household^{-1}

	Cattle	Goats	Sheep		Cattle
Village	mean	mean	mean	(n)	total
Migunga	38 (14.1)	13 (5.6)	9 (3.3)	48	1814
Isoso	41 (19)	16 (5.3)	11 (6.2)	48	1938
Kishapu Division	39 (16.7)	15 (5.5)	10 (5.0)	96	3752
Bulimba	28 (5.5)	11 (4.6)	9 (3.4)	25	693
Mayanji	27 (9.4)	12 (5.2)	11 (4.2)	25	662
Negezi Division	27 (7.7)	12 (4.9)	10 (4.0)	50	1355

The numbers in parentheses indicate standard deviation

Table 22: Results of t-test (mean livestock numbers) between the Kishapu and Negezi Divisions.

	mean 1	mean 2	pooled SD	df	t -test
Cattle	38	27	3.384	49	* *
Goats	15	12	3.0	29	*

* *, $p < 0.01$; *, $p < 0.05$

Estimates of stocking rates ha^{-1} per category (Question 26)

Informants' estimates of stocking levels are quite high (Table 23). Individual numbers were as high as 10 ha^{-1} for donkeys, 20 ha^{-1} for cattle and 50 ha^{-1} for goats and sheep.

Table 23: Informants' estimates of numbers of livestock ha^{-1} by category

	Cattle (mean)	Goats (mean)	Sheep (mean)
Migunga	3 (4)	7 (9)	11 (6)
Isoso	5 (2)	2 (13)	19 (12)
Bulimba	2 (2)	5 (5)	4 (5)
Mayanji	3 (4)	7 (7)	8 (7)

The numbers in parentheses indicate standard deviation

Statistical analysis for stocking rate (estimates) for cattle indicates no significant differences at village and division levels at the 0.05 level.

Perceptions on the livestock resource (Questions 25, 28)

Farmers' aspirations on livestock (Question 25)

Informants attitudes were also tested to see whether they intend to increase or decrease their stock numbers. No informant expressed any support for reducing numbers of livestock but many were interested in keeping more. Even those without any at the moment expressed interest in keeping some animals for the reasons suggested (Table 24). Furthermore, thirteen households in Migunga and two in Isoso villages responded for keeping donkeys. Currently only two households have a donkey each and none were detected in the rest of the study villages.

Table 24: The role of livestock: reasons for keeping and number of responses

	Draught power	Milk	Meat	Manure	Security	Dowry
Migunga	59	59	59	14	50	50
Isoso	56	56	53	40	52	42
Bulimba	60	59	58	19	48	37
Mayanji	55	56	51	22	49	35
Total	230	230	221	95	199	127

In total six reasons were offered for keeping livestock (Table 24) and informants offered more than one reason. Although Kishapu Division has more livestock numbers household^{-1} than Negezi Division, reasons for keeping the animals appear to be the same. Within each division evidence for significant differences in reasons for keeping livestock were sought between villages but none was detected.

Good or bad effects of livestock (Question 28)

Informants identified three problems associated with keeping livestock (Table 25) Statistical test basing on responses on soil erosion and destruction of crops (Appendix 4.3) indicate significant difference between divisions at the 0.05 level but not between the villages.

Table 25: Problems related to keeping livestock number of responses

	Soil erosion	Destroy crops	Hard work
Migunga	25	28	7
Isoso	24	22	14
Bulimba	8	28	24
Mayanji	11	19	30
Total	68	97	75

Soil erosion by cattle is visualised as a problem minor in Bulimba and Mayanji villages (Negezi Division) however, more of a problem in Isoso and Migunga villages (Kishapu Division). This is perhaps because the latter villages have more livestock than the former (Table 21). Destruction of peoples' crops during the cropping season is a problem in all villages though Isoso has more scores (33%) followed by Migunga (25%) both in Kishapu. Bulimba and Mayanji of Negezi have almost equal scores of about 20%.

Grazing is recognised as hard work mostly in Mayanji (44%) and Bulimba (29%) villages (Negezi division). However, in Migunga and Isoso villages (Kishapu) it is not visualised as a serious problem (9% and 19% respectively).

Organisation of livestock husbandry (Questions 27, 29)

Grazing land and distances involved (Question 27)

Table 26 shows the average area (ha) available as grazing for individual holdings and the accessible areas in on communal and public land.

The figures indicate that not many households have enough land for grazing and there is uneven distribution of grazing lands owned individually particularly in Isoso village. It appears that livestock keepers rely more on communal and public lands for feeding their stocks than their own lands.

Table 26: Average available and accessible grazing lands (ha)

Village	sample	Own land	Communal land	Public land
Migunga	50	12.6 (4.2)	111 (73)	826 (411)
Isoso	50	11.6 (3.9)	161 (105)	950 (580)
Bulimba	22	2.5 (0.9)	157 (85)	964 (663)
Mayanji	22	1.9 (0.7)	134 (36)	981 (502)
Kishapu Division	100	12.1 (4)		
Negezi Division	44	2.2 (0.9)		

Numbers in parentheses indicate standard deviation

Infornants estimated the size of communal and public grazing areas as their exact sizes are not known to them.

Statistical analysis (regression) for grazing areas (independent variable) against cattle numbers (responding variable) showed a weak relationship in all the study villages. (Table 27).

Table 27 : Results of the regression analysis (cattle numbers against grazing areas)

	Migunga	Isoso	Bulimba	Mayanji
	R^2 Values			
Individual grazing areas	0.0223 ($p>0.05$)	0.03278 ($p>0.05$)	0.000134 ($p>0.05$)	0.0145 ($p>0.05$)

Further statistical analysis (t-test) for individually owned grazing areas indicate a significant difference between Bulimba and Mayanji villages (Negezi) at the 0.05 level but not significant between Migunga and Isoso villages (Kishapu). This indicates that Bulimba has more people with their own grazing areas than Mayanji For the divisions the differences are quite significant at the 0.01 level (Table 28). Farmers in Bulimba and Isoso villages have relatively small land for grazing their stocks but the situation is critical in Mayanji compared to Bulimba. On average the situation is relatively better in Kishapu Division than in Negezi.

Table 28: Results of t-test (mean individual grazing areas)

source of variation	mean 1	mean 2	pooled SD	df	t-test
Bulimba & Mayanji	2.5	1.9	0.4107	21	*
Kishapu & Negezi	12.1	2.2	0.6656	43	* *

*, $p < 0.05$; * *, $p < 0.01$

Table 29: Distances to grazing lands from homesteads: number of households keeping livestock.

	Own land km			Communal land km			Public land km		
Village	< 2	≥2<5	≥5	< 2	≥2<5	≥5	< 2	≥2<5	≥5
Migunga	46	5	9	9	38	13	0	23	36
Isoso	55	3	2	4	51	5	0	11	49
Bulima	57	2	1	8	44	8	0	16	44
Mayanji	55	5	0	9	48	3	0	0	60

The number of responses (Table 29) indicate that most of private and communal grazing areas fall within 5 km from the homesteads however, for the public lands herding involves a considerable distances.

Herding responsibility (Question 29)

Herding mostly involves boys (Table 30) but there is also female participation. More women/girls in Negezi Division are involved in livestock herding than in Kishapu Division. Significant differences in herding responsibility (Appendix 4.4) are observed between Migunga and Isoso village but not between Bulimba and Mayanji. Also differences between divisions were significant at the 0.05 level for G^2 adjusted.

Table 30: Herding responsibility

Village	Cattle			Goats		
	Men	Boys	Women/Girls	Men	Boys	Women/girls
Migunga	9	41	2	0	30	5
Isoso	1	49	0	0	29	3
Bulimba	4	20	3	0	17	6
Mayanji	3	22	4	0	13	9
Total	17	132	9	0	89	23

4.1.2.2 Woody plant resources

The woody plant resource base (Questions 20, 21, 22, 23)

Distances travelled for collecting firewood , poles and timber)Questions 20, 22).

The vast majority (92%) of households reported firewood to be available within 5 km of the homestead (Table 31). However, the fact that that only 46% obtain wood for firewood within 2 km is an indication that availability of wood for firewood is increasingly becoming a problem. This explains the average number of hours (4-5 day^{-1}) spent by women on firewood collection.

Statistical analysis (G^2 test) for the responses on availability of firewood within and beyond two kilometres indicates significant differences between villages and between divisions at the 0.01 level (Appendix 4.5). This means that some villages can obtain firewood with 2 km (Isoso in Kishapu and Bulimba in Negezi) while the remaining involve a considerable distance for firewood collection.

Table 31: Number of responses on distances involved in obtaining wood for firewood.

Village	Near <2 km	Far 2-5 km	Very far >5 km	Difficult to obtain
Migunga	6	52	2	0
Isoso	35	21	1	3
Bulimba	50	10	0	0
Mayanji	20	27	13	0
Total	111	110	16	3

Responses on wood availability for poles and timber (Table 32) indicate that poles and timbers tree species are very difficult to obtain and in Mayanji village all informants felt it is difficulty to obtain timber. Responses on availability of poles within and beyond 5 km indicates no significant difference between Migunga and Isoso villages (Kishapu) at the 0.05 level but significant between Bulimba and Mayanji villages (Negezi) and between divisions (Appendix 4.6). In both divisions informants felt that poles are available but a considerable distance greater than 5 km is involved.

Table 32: Availability of wood for poles and timber.

	Poles				Timber		
Village	< 2km	< 5km	> 5km	Difficult to obtain	< 5km	> 5km	Difficult to obtain
Migunga	1	5	53	1	0	8	52
Isoso	4	8	43	5	0	1	59
Bulimba	2	6	51	1	0	12	48
Mayanji	1	22	25	12	0	0	60
Total	8	41	172	19	0	21	219

Fruits and medicinal material

Question 23 - other woody products : fruits and medicinal materials

Table 33: Availability of trees for fruits and medicine: number of responses

	Fruits				Medicine		
Village	< 2 km	< 5km	> 5km	Difficult to obtain	<5km	> 5km	Difficult to obtain
Migunga	16	28	16	0	55	4	1
Isoso	4	55	1	0	46	6	8
Bulimba	1	11	9	39	22	4	34
Mayanji	8	47	5	0	60	0	0
Total	29	141	31	39	183	14	43

Responses (Table 33) indicate that about 75% of people in the study villages are able to obtain both fruits and medicinal materials within 5 km from homesteads, the exception being Bulimba where only a small proportion is able to obtain fruits and medicinal materials within 5 km. Responses on availability of natural fruits within and beyond 5 km from homesteads indicate significant differences between all villages and divisions at the 0.05 level (Appendix 4.7) For the availability of medicinal materials there is a significant difference between Migunga and Isoso villages (Kishapu) at the 0.05 level (Appendix 4.8). In both villages the majority of informants feel that medicinal materials are still available within 5 km. In the case of Bulimba and Mayanji villages (Negezi) responses also differ significantly at the same level. In Mayanji village all informants claim to be able to obtain medicinal materials within 5 km. In Bulimba only 37% of informants claim to obtain them within 5 km while the majority feel it involves a considerable distance.

Perceptions of trees in different situations (Questions 12, 13, 14, 15)

Figures in Table 34 indicate that the majority of informants (78% of the sample) feel that having trees on crop fields is a bad thing and the majority in Bulimba village felt trees in cropped fields would increase population of birds. In most cases informants gave one reason although a combination of reasons could have been given.

Table 34: Farmers' attitude to trees in cropped fields:.number of responses

Village	Positive effects			Negative effects		
Village	SF	WB	SD	IB	DSW	SC
Migunga	14	6	4	26	4	6
Isoso	12	5	2	23	8	10
Bulimba	4	1	0	50	1	4
Mayanji	1	2	1	28	9	19
Total	31	14	7	127	22	40

Key: SF, increase soil fertility; WB, Windbreakers; SD, Resting shade; IB, increase birds; DSW, Decrease soil water; SC, suppress crops (shade)

Tree planting initiatives (Questions 16,)

The majority of the informants (89%) favour trees being located around their homesteads (Table 35).

Table 35: Responses on areas most preferred for growing trees

Village	Near homestead	Cropped fields	Degraded areas
Migunga	46	8	6
Isoso	57	3	0
Bulimba	55	4	1
Mayanji	57	3	0
Total	215	18	7

Only about 8% of informants favoured trees on cropped fields. Only 3% of the sample felt that trees should be planted in degraded areas and the majority within this small group were from Miganga village (Kishapu division) where more degraded than in the other study villages.

Most species identified as appealing are for multiple uses (Table 36) *Acacia nilotica, A. tortilis, Eucalyptus* spp and *Leucaena leucocephala,* were specified. Also preference on species are varied amongst the households but Isoso village (Kishapu) and Bulimba village (Negezi) indicate more varied preferences.

Table 36: Responses for type of tree species most preferred for planting

Species name	Migunga	Isoso	Bulimba	Mayanji	Total
Acacia nilotica	45	9	31	16	101
Leucaena. leucocephala	36	18	21	20	95
Eucalyptus spp	22	27	12	13	74
Acacia tortilis	18	6	17	10	51
Psidium guajava	3	19	9	1	32
Citrus sinensis	2	16	10	1	29
Carica papaya	5	8	7	1	21
Tamarindus indica	1	2	1	1	5

Table 37 indicates informants' responses why some trees planted do not survive. Drought is most common in Migunga village followed by termite attack. In Isoso village browsing problem is observed whereas in Bulimba and Mayanji villages termite attack is felt most.

Table 37 : Reasons for the planted trees not to survive: number of responses for each reason

Village/Reason	Drought	Termites attack	Browsed by livestock
Migunga	20	15	1
Isoso	8	6	12
Bulimba	2	7	3
Mayanji	1	4	1
Total	31	32	17

Low survival rates were attributed particularly to drought and termites in Migunga village and to browsing in Isoso (Table 37).

Numbers of trees planted and survival rates for the past five years, (Questions 17, 18, 19)

Figures 10 to 13 indicate average number of trees planted and survival rates for 1989 to 1992.

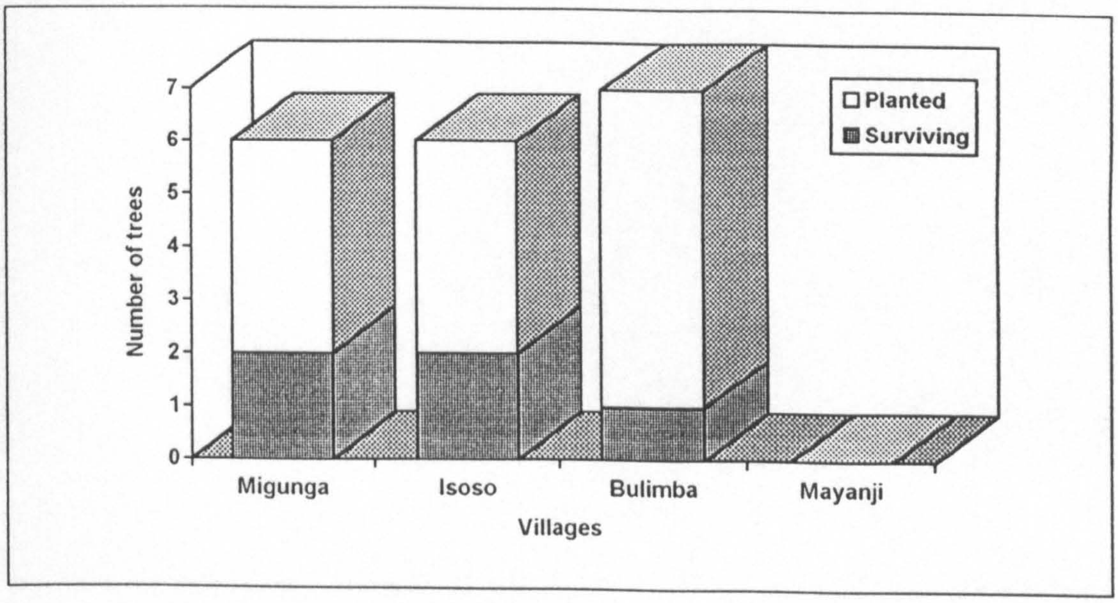

Fig. 10: Average number of trees planted and survived household^{-1} for 1989 in the study villages in Kishapu and Negezi Divisions.

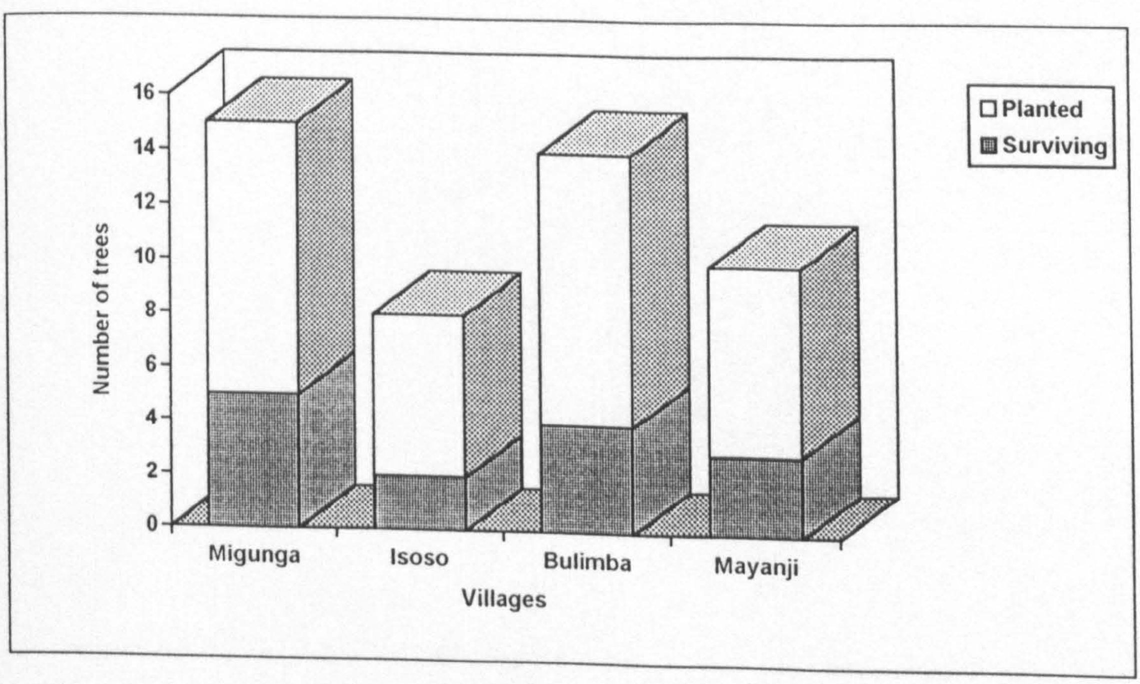

Fig. 11: Average number of trees planted and surviving household^{-1} for 1990 in the study villages in Kishapu and Negezi Divisions.

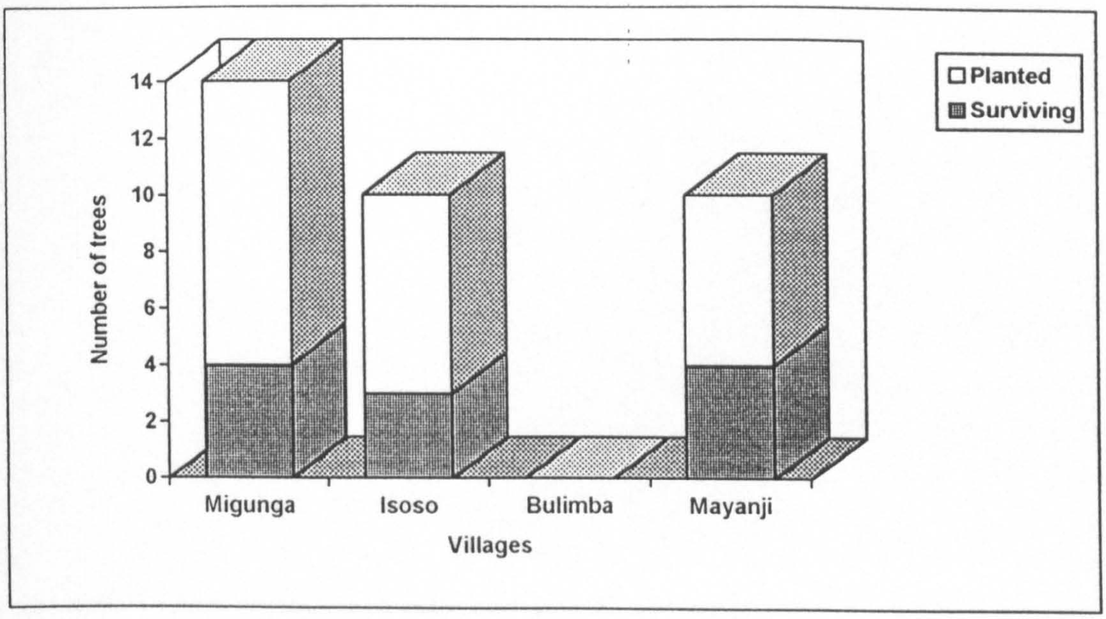

Fig. 12: Average number of tree planted and survived household^{-1} for 1991 in the study villages in Kishapu and Negezi Divisions.

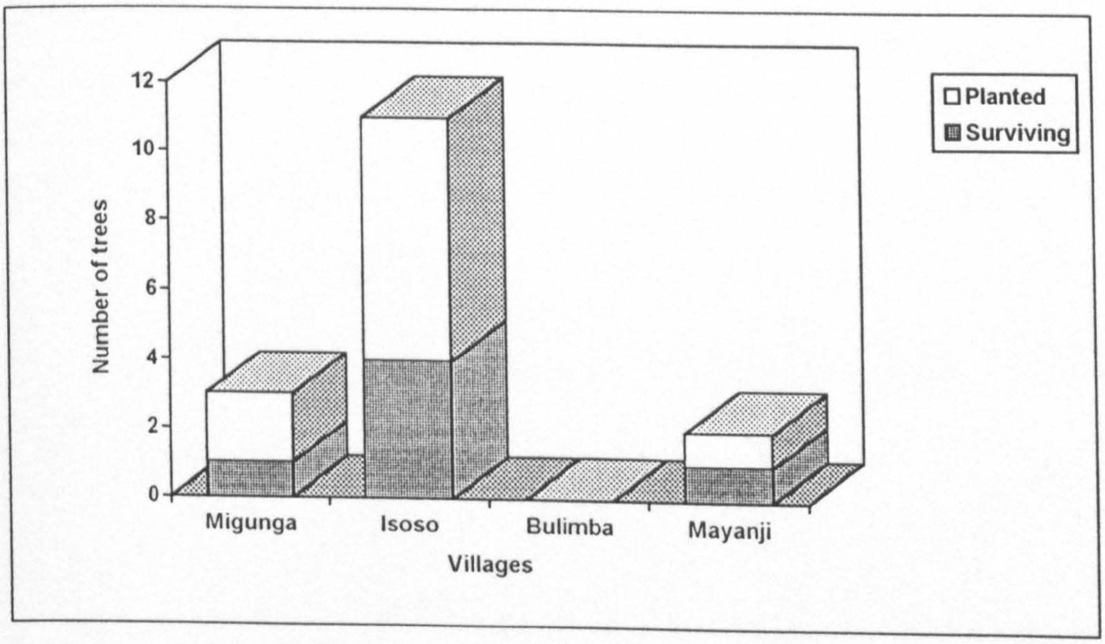

Fig 13 : Number of trees planted and survived household^{-1} (1992) in the study villages in Kishapu and Negezi Divisions.

Figures 14 - 18 indicate average number of tree species (by name) in 1990 and 1991 village^{-1} and their survival rates. *Carica papaya* and *Psidium guajava* are the most planted fruit trees. In most cases a survival rate of less than 50% has been achieved.

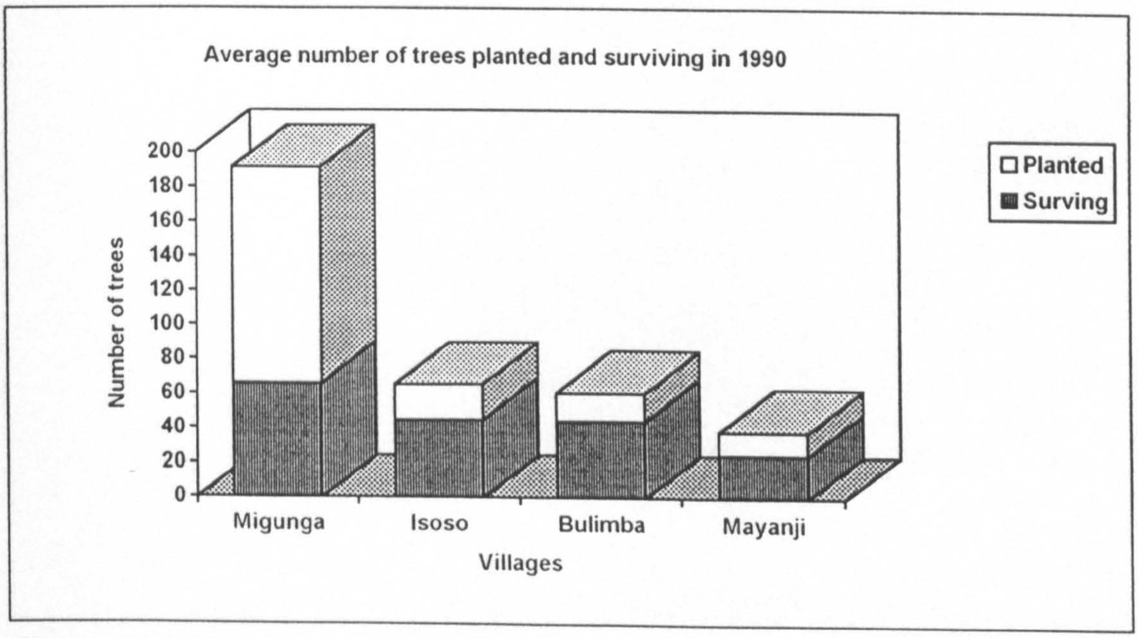

Figure 14 : *Acacia nilotica* (mihale) number of trees planted and survived village^{-1} (1990) in Kishapu and Negezi Divisions.

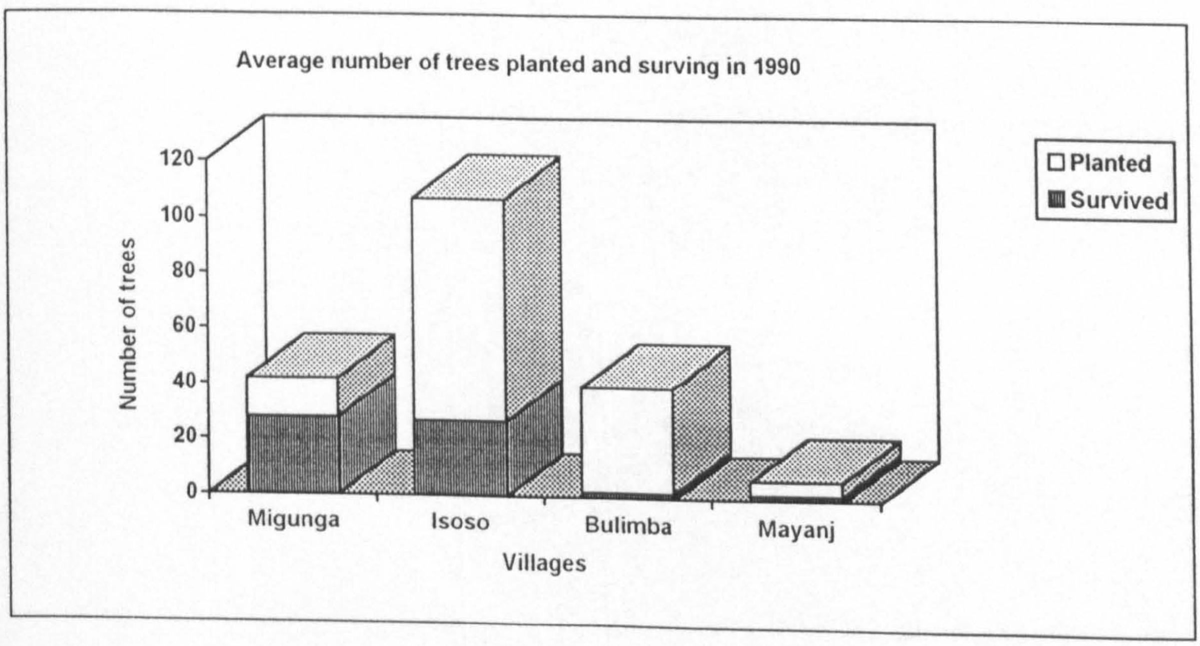

Figure 15 : *Leucaena leucocephala* (milusina) number of trees planted and surviving village^{-1} in Kishapu and Negezi Divisions.

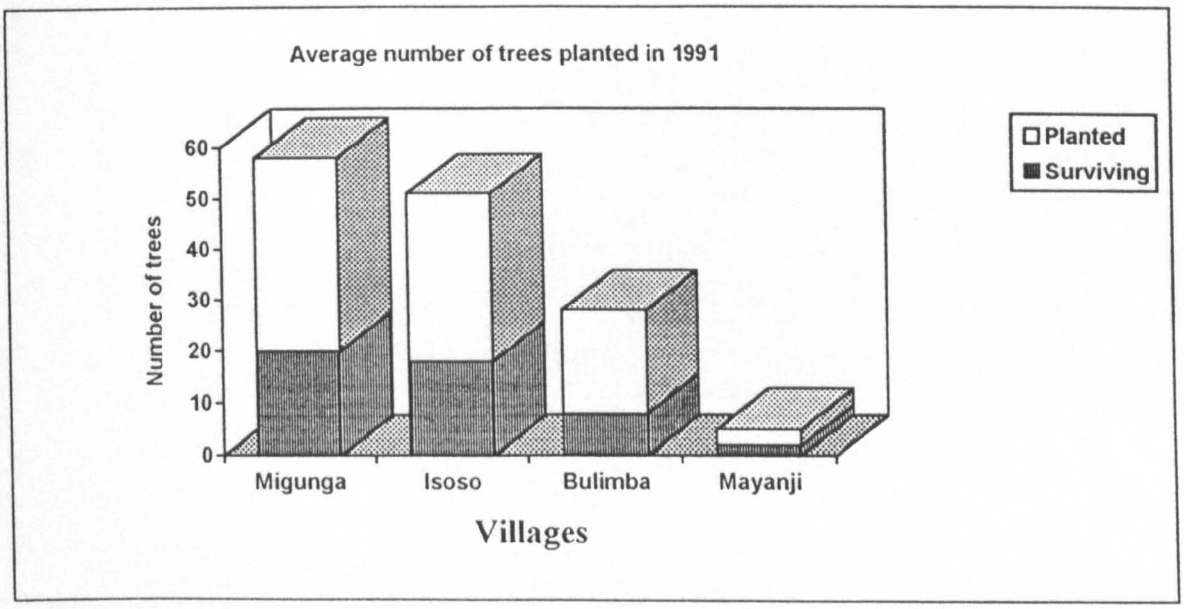

Figure 16 : *Senna siamea* (misongoma) number of trees planted and surviving village^{-1} in Kishapu and Negezi Divisions.

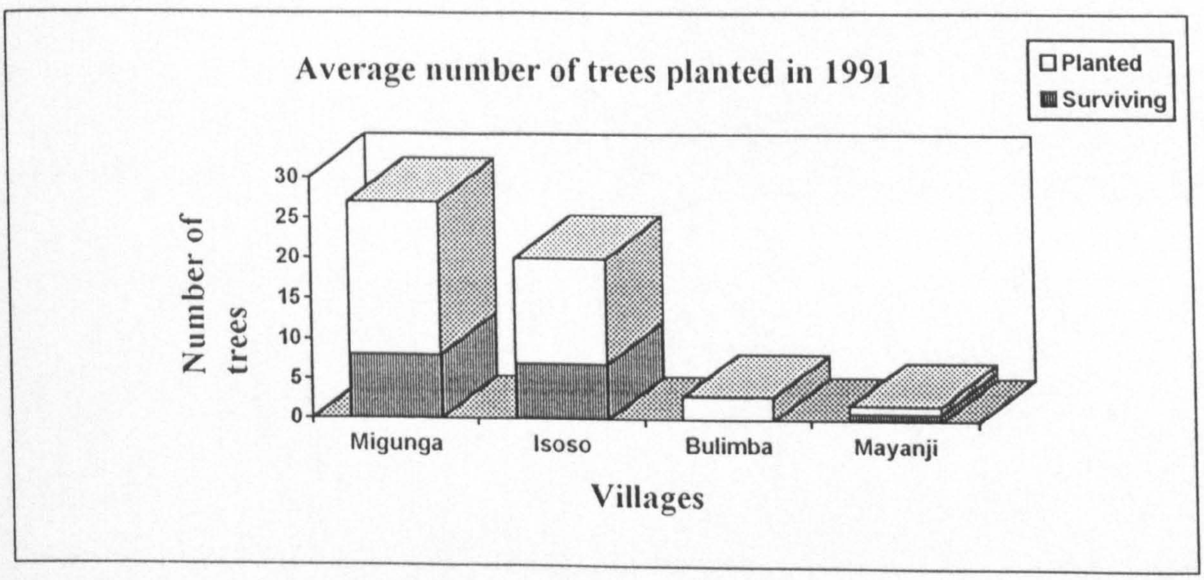

Figure 17 : *Carica papaya* (mpapai) number of trees planted and surviving village^{-1} in Kishapu and Negezi Divisions.

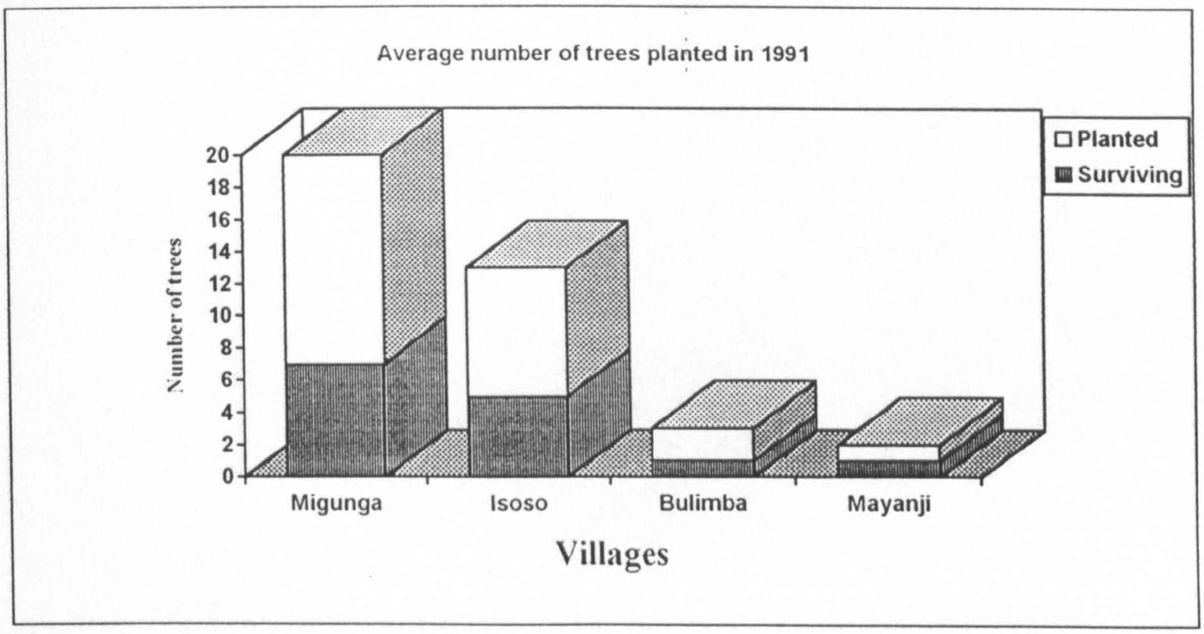

Figure 18 : *Psidium guajava* (mipera) number of trees planted village^{-1} in Kishapu and Negezi Divisions.

Informants perceived browsing as more damaging to planted trees in Isoso village than elsewhere. In Isoso, it was, in fact, the main cause of mortality suggested. On average *Acacia nilotica* shows better survival rates than other trees (Fig. 14) which suggests that the species can withstand drought and browsing pressure. It is followed by *Senna siamea* (Fig. 16). Initiatives for planting trees for fodder production were investigated but no informant responded for such initiatives.

Browse species (Question 30)

Table 38 indicates tree species informants reported were browsed by cattle.

Table 38: Tree species browsed by cattle: number of responses per village.

Village	Migunga		Isoso		Bulimba		Mayanji	
Species name	Le	Le&Po	Le	Le&Po	Le	Le&Po	Le	Le&Po
Acacia nilotica	28		27		5	8		
Lannea humilis	42		35		4	5		9
Leucaena leucocephala		17	2	4	4	1		17
Adansonia digitata	27		2	13	15			
Dichrostachys cinerea		10	4					
Calotropis procera	3							
Boscia angustifolia	2		1					
Anisotes dumosus	29			6		1		
Thylachium africanum	26		8				-	
Tamarindus indica	1							
Balanites aegyptiaca	1		4		3		2	
Lonchocarpus bussei	1		10					
Acacia tortilis	5		11			12	3	
Grewia bicolor	6						11	
Combretum orbovatum	15		13					
Azma tetracantha	1		11		12			

Le, leaves; Le & Po, leaves and pods.

Lannea humilis, Acacia nilotica, Adansonia digitata, Leucaena leucocephala, Cadaba adenotricha, Anisotes dumosus, Thulachium africanum and *Acacia tortilis* are perceived as the most readily available browse tree species of importance to cattle (Table 38). With the exception of *Leucaena leucocephala* and *Acacia nilotica* of which they eat both leaves and pods, it is the leaves and twigs that are eaten.

Table 39 shows tree species perceived as important browse for goats and sheep. Informants emphasized, however, that sheep prefer grazing to browsing while goats are preferential browsers and only graze when there are no trees or shrubs.

Table 39: Trees species browsed by goats: number of responses

Village	Migunga		Isoso		Bulimba		Mayanji	
Species name	Le	Le&Po	Le	Le&Po	Le	Le&Po	Le	Le&Po
Acacia nilotica	36	24		27		11		8
Leucaena leucocephala		16		8		5		9
Anisotes dumosus	27		4				2	
Dichrostachys cinerea	1	8	2	13	2	5	1	21
Adansonia digitata	14		11		1			
Cadaba adenotricha	18				1			
Calotropis procera	2		3					
Boscia angustifolia	1							
Senna siamea	4		2		5		2	
Thylachium afrinum	20							
Tamarindus indica	1		1					
Lonchocarpus bussei	1		9					
Acacia tortilis	16		14			10	27	
Grewia bicolor			6		4		1	
Combretum orbovatum	2		1		6		8	
Azma tetracantha			1					
Acacia drepanolobium		2		10	10		5	
Ormocarpum trichocarpum	6		8				3	
Euphorbia tirucalli	4		4		1		2	
Acacia polyacantha	1		5		6			
Acacia mellifera	2		4		2			
Combretum fischeri	1						3	
Caparis tomentosa			3		1			
Acacia benthamii			4					
Acacia fischeri			4		2		3	
Grewia similis			1					

Le, leaves; Le & Po, Leaves and pods.

The fact that goats prefer tree forage to grass is supported (Table 39) by the larger list of browse species (26 species) than that for cattle (16 species). These responses indicate that goats eat both leaves/twigs and pods of *Acacia nilotica*, *Leucaena leucocephala*, *A. drepanolobium*, *Dichrostachys cinerarea* and *A. tortilis*. Leaves and twigs are available during the wet season for most of *Acacia species* and *Adansonia digitata*. Some trees, such as *Lannea humilis* or *Acacia nilotica*, become quite green during the dry season when livestock see them easily and browse them.

Figures (Table 39) show fair distribution of informants' understanding of which species are browsed by goats, although more responses are observed in Migunga and Isoso villages (Kishapu) than Bulimba and Mayanji villages (Negezi).

4.2 Unstructured interviews

4.2.1 Familiarisation phase

Two indigenous knowledge bases were compiled as a result of the unstructured interviews. The first covered the 'ngitiri' system and the second the rangeland-trees knowledge.

4.2.1.1 The 'Ngitiri' system

There are two types of 'ngitiri' system: individual units and communal. Individual 'ngitiri' areas are located close to household units and have an average area of 18 ha (Table 52). Village communal 'ngitiri' have an average area of 200 ha and are usually located 3 - 5 km from the village centre. 'Ngitiri' areas are usually closed annually to grazing for a period of about eight months starting in March. There are three arbitrary aspects of local knowledge about the 'ngitiri' system:

- practical experience
- management practice
- underlying perceptions.

Practical experience

Practical experience enables farmers to acquire relevant knowledge through practice and usage. In the 'ngitiri' system they learn to identify suitable areas and to distinguish valuable pasture species in terms of quality and quantity.

Most key informants revealed that the location of suitable areas for the 'ngitiri' system was specifically decided by men according to perceived site ecological conditions and relative distances from the homesteads (private 'ngitiri') or village centre (communal 'ngitiri'). Village leaders and a council of male elders mutually agree on where communal 'ngitiri' should be located. The decision is normally relayed to villagers through village meetings. Informants further emphasized that for an area to qualify as an 'ngitiri' site, soil characteristics (mainly texture and fertility levels) are important considerations. Soils which retain water for two or more months after the rainy season ends and are dominated by *Setaria verticillata* (malamata), *Pennisetum purpureum* (lugubi) or *Hyparrhenia rufa* (ntelenghu) qualify as good sites for practising 'ngitiri'. Areas dominated by 'mbuga' soils are commonly reserved for 'ngitiri'. 'Mbuga' soils are essentially vertisols and retain water longer than other types of soils in Kishapu and Negezi Divisions. Furthermore, 'mbugas' are understood to be fairly fertile (a factor also regarded essential for optimum grass growth and biomass accumulation).

Distances from the homestead, particularly to private 'ngitiri' areas, are crucial for two reasons. The first is so that management and control measures are effected and unauthorised grazing easily detected. The second reason is so that old and sick cows and calves are easily tended when they are grazing. Private 'ngitiri' areas are therefore often located within 1 km of the homestead. For communal 'ngitiris', location depends on suitable sites available within communal land under village control.

Farmers determine the quality of grass by first observing its condition and appearance. Colour (greenness), vigour and the stage of growth are indicators. Secondly, if cattle concentrate their feeding on certain grasses the effects these produce in the animal becomes an indicator.

Characteristics of good quality grass recognized by the farmer are:

- palatability (animal clearly attracted to it)
- very nutritious and easily digested
- freshness (green and wet)
- cause an increase in milk production
- lead to a notable gain in live weight and improved health conditions
- dung becomes soft and easy to drop.

Examples of good quality grasses were often mentioned by informants. Included were *Imperata cylindrica* (supyu), *Glycine wightii* (bupuna), *Dactyloctenium aegyptium* (bugimbi), *Digitaria scalarum* (ngobi), *Pennisetum pupureum* (lugubi), *Heteropogon contortus* (ndasa), *Setaria verticillata* (malamata) or *Hyparrhenia rufa* (ntelenghu). The stage of grass growth is recognized as an important parameter for diet quality. Young grasses are regarded as best and informants reported that their cattle can easily bite and chew them. Animals so fed produce soft dung. An increase in milk production (from half a litre to two litres) and gain in animal weight are noticed.

Bad quality grasses are recognized for producing the following effects:

- decreased milk production noticed (when lactating cows feed on them)
- no live weight gain and deteriorating cattle health

- toxic effects to cattle which may lead to death if no immediate attention is provided.

Grasses and forbs reported to have undesirable effects are *Panicum coloratum* (huluda) which is believed to reduce milk yield, *Oxygonum simuatum* (mashokolo) recognised as toxic to cattle especially when flowering. Herders therefore avoid grazing cattle in areas where *Oxygonum simuatum* is growing and already flowering and avoid grazing lactating cows in areas where *Panicum coloratum* is found if other alternatives are available.

The amount of grass available in the 'ngitiri' areas is important because it determines if stock feed is sufficient. According to informants grass growth rates, and hence grass quantity, in Kishapu and Negezi Divisions are affected by four factors: climate, tree density, stocking rate and human activities.

Climate affects grass quantity in a number of ways. Most informants (82%) indicated that rainfall was the major determinant of production. The amount of rain falling on each rainy day during the wet season (November to May) and the extent of its distribution (which informants expressed as constraints in the related numbers of rainy and rainless days per week) is recognized as an important fact for increased grass biomass. It was reported that if moderate rainfall was received three times a week, lasting for about three hours on each occasion, conditions would be conducive for optimum grass growth rates. Low rainfall resulted in poor grass growth rates and substantially reduced grass quantity. Fifteen informants considered sunshine equally important. They felt that with inadequate sunshine during the rainy season, grass growth rates would be adversely affected and a shortage of grass would arise. Some informants mentioned wind as another factor affecting grass quantity in rangelands. Strong winds are believed to blow away some grass flowers which could have supplied seed for increased grass regeneration in their 'ngitiri' areas. Soil factors were noted to be crucial for increased grass quantity. According to informants soils differ in fertility rates and ability to allow rain water to penetrate and be retained for a long time. For instance, it was reported that 'ibambasi' (cambisols) are quite hard and do not allow water to penetrate easily. 'Mbuga' (vertisols) are known to retain water for a long time and are fairly fertile. Thus informants classify soils through their variability in texture and fertility recognizing that these determine the types of grasses that grow there.

In summary, informants' perceptions are that the amount of grass biomass in the 'ngitiri' areas and the rangeland will increase or decrease depending on:

- amount and distribution over time of rainfall
- date of onset and duration of rainy season
- soil fertility rates and moisture-holding capacity
- grazing pressure (animals ha^{-1})
- area available
- how grazing is controlled (for example grazing in areas dominated by cambisols is during rainy days while those dominated by vertisols are reserved for dry season grazing)
- type of grass species
- amount of grass seeds produced and available on site
- density and composition of tree cover.

Management practices

Management of 'ngitiri' systems is exclusively by men, and aimed at accumulating grass quantity in accordance with five basic principles:

- location of the area to permit optimum control, particularly regarding unauthorised grazing
- timing closure phases to allow optimum grass production
- systematic grazing as part of grass management strategy (area divided into sections and grazed one at a time)
- regulation and control (by 'sungusungu') of communal 'ngitiri' usage. 'Sungusungu' is the authority maintaining order and peace in the village
- removal of trees considered detrimental to grass growth.

Supplementary measures taken include establishing well-marked boundaries. Farmers effect this in three ways:

- heaping soil (maseso) at intervals of about 250 m

- creating a line barrier by placing thorny branches (masanzu) mainly of *Acacia*, close to each other. 'Masanzu' are dead branches, trees used as barriers to separate animals from crops.

- creating live fences of sisal (*Agave sisalana*) or manala (*Euphorbia tirucalli*).

Soil heaping and the planting of sisal are common practice in communal 'ngitiri'. Use of 'masanzu' and planting of *Euphorbia tirucalli* is more common in private 'ngitiris'. Once such boundaries are created, members of the community respect them. In addition, trees browsed by livestock or medicinally valuable such as 'miyuguyu' (*Balanites aegyptiaca)* are retained on 'ngitiri' areas and protected from animal damage with 'masanzu' until they are two metres high.

Responses to inquiries on the use of fire as a management tool indicate that fire was used in the past (about 40 years ago), when there were few animals, for two reasons:

- to create new and fresh pasture. Since animals were few they did not exhaust the grass but its nutritional value declined in the dry season. As the rainy season approached grasses were set on fire to allow new growth.

- grasses were associated with populations of ticks. As grass biomass increased more ticks were observed and to reduce their numbers grass was set on fire.

Nowadays the situation is different. Fire is not used as a management tool. Because of high population pressure grass biomass has been greatly reduced and animals are short of feed. It was thought that ticks are no longer a threat because animals are sprayed or dipped regularly using acaricidal chemicals. Since grass biomass has been reduced, the tick population has also declined.

Usage is organised such that during the wet season (February or March) 'ngitiri' are closed to grazing to permit the accumulation of grass biomass. According to informants they are closed from February if soil fertility levels are low and/or the amount of rainfall and its distribution is below average. Where fertility levels are high and rainfall is normally distributed closure is effected from March. Re-opening is in either September or October. Villagers are informed of opening and closing times through village meetings. Enforcement is mainly through 'sungusungu' and village elders. Two factors govern when 'ngitiri' areas can be opened to grazing: available grass quantity and the size of each 'ngitiri' area. According to informants, provided rainfall is well distributed over the rainy season and its intensity high, other grazing areas have sufficient grass to suffice for a longer time and 'ngitiri' areas are used from October. Under moisture stress conditions use starts from September. The area of 'ngitiri' also affects the timing of opening: large areas are opened in September, small ones in October.

Informants considered private 'ngitiri' small relative to needs. Farmers therefore give priority to the use of private 'ngitiri' for grazing old and sick cows and calves while other animals are grazed in communal areas or taken to distant grazing places. Two other problems were mentioned regarding private 'ngitiris'. First, declining rainfall regimes over the years have affected the availability of sufficient grass quantity. Because adjacent areas are cultivated, 'ngitiri' areas are over-used and the grasses in them are grazed to the root collar, lowering future regeneration potential under moisture stress situations. Secondly, it was reported that some aggressive cattle owners graze their animals in neighbours' 'ngitiri' areas without permission. Sometimes people graze their animals in communal 'ngitiri areas before they are re-opened for usage. Detection of such illegal grazing is through routine inspection in the case of communal 'ngitiri' areas. For private 'ngitiri' areas, location close to homes enables owners (family members) to detect unauthorised grazing. When such situations arise there may be fighting. Such disputes are settled in two ways: using the formal village government authority or using traditional (informal) institutions (e.g. village elders). The latter is more popular for settling disputes than the former because people trust and respect decisions made. This is because decisions are effective and based on existing community culture and traditions. Usually the offender is warned once and a second offence leads to a fine of one or two goats or a cow. If this does not work the offender may be cut-off from the rest of the community or even expelled from the village.

Underlying perceptions

Many informants appreciate the significance of 'ngitiri' (private or communal) supplying the grass needed during the critical times of the dry season. Grasses accumulate as a result of area closure. Closure is an action they are able to influence and control. Informants felt a need to have more areas reserved and operated as private 'ngitiri' areas. For two reasons, however, they questioned the feasibility of this:

- the sharp rise in population was causing more land to be used for cropping and settlements

- restrictions and influences from government have made it impossible to designate sufficient areas exclusively for livestock production.

Readily accessible water is also perceived as desirable for increasing animal production. Additional water points need to be created but resources to do this are lacking. Most informants felt that if part of the rain water could be diverted into reservoirs problems related to water shortage during the dry season would be reduced. Some informants also felt that transhumance to distant districts and regions for alternative pasture lands was an undesirable situation and a consequence of too much grazing land being put to other use or becoming degraded. These informants sought a system (see Fig. 31) enabling them to sustain their animals within their traditional areas. They envisaged an efficient system meeting their needs for livestock production and sustainable in terms of better land use practices and effective government support. The Government support they desired related specifically to veterinary services and the integration of services of Agriculture, Forestry, Livestock, Community Development, Water and Land-use Planning sectors. Farmers concern with such a system is for the accommodation of a further increase in cattle numbers but with confidence that the required feed would be available, especially during the dry season. Increased feed resources are visualized in terms of grasses and tree fodder and expected to lead to improved animal health and increased animal products.

Informants were asked to elaborate further as to why the system suggested was essentially a top-down government involvement. None offered any idea how an indigenous alternative could work effectively under the current governance and political system. The majority felt that indigenous systems had worked well before the abolition of chiefdomships in the early 1960's. Nowadays traditional rights and indigenous institutions can no longer operate well. Many informants believed it difficult for villagers to challenge the government system.

Indigenous institutions (power) were abolished some years ago and chances of their revival are negligible. Informants were therefore asked to suggest a system considered appropriate for solving village problems including the use and control of natural resources in their areas without heavy reliance on government initiatives. Informants considered how things operated before independence in 1961, when problems arising were addressed by all members of the village under the co-ordination of the village headman (mwanangwa). In the procedure informants outlined (see Fig. 32) whereby all members of the village participate, existing infrastructure provides the channels of communication. Each group leader submits a group consensus view to the 'mwanangwa' for decision making. Suggestions received by the 'mwanangwa' are discussed by the villagers' meeting. The decisions reached at the meeting go forward to the 'lutala' (a highly respected elder in the village who is elected by fellow elders to chair the elders council meeting) for the elders council (bananghongho) to endorse and communicate to all villagers for implementation. Each year the village council would meet twice or thrice depending on issues for discussion. Decisions made would be popularised to all villagers through traditional songs and dances, a process regarded as 'mhola' which means "togetherness" and "for all". Composing songs is a joint effort between members of the choir/dancing troupe and the leaders. If villagers violated village decisions fines (ralida) were imposed (in the form of goats or cattle) and the meat would be shared by all. Failure to pay the fine would lead to isolation (no social communication with fellow villagers) for about three months (kutulija) and within that period a reconciliation had to be achieved. Failing even this, an offender would be expelled from the village as an outcast. Informants favoured such a system because it ensured discipline among the villagers. However, it needed support from the regional government. If natural resources were to be managed by the villagers themselves then the role of state organs should remain at advisory level. A few informants saw no chance of such a system proving effective in regulating the management and usage of natural resources to avoid further land degradation.

4.2.1.2 The rangeland grass and tree resource base

Rangeland grass resources

There are three arbitrary aspects of local knowledge about the rangeland-grass and tree resource base:

Practical experience
Management practices
Underlying perceptions.

Practical experience

Rangelands are seen as extensive areas for grazing and livestock is managed extensively. Animals are taken out to graze during the day by boys or men. In the wet season the grazing period on the rangelands is from 10 am to 6 pm. In the dry season when feed is scarce, herding starts earlier (7 - 8 am) and continues until late evening (7 pm).

According to informants suitable grazing areas are detected through pre-surveys, particularly during the dry season. Also, while herding, areas that can be used during the coming days are identified. Some fifty years ago, pre-surveys were meant for determining areas free of wild animals and tsetse flies. Today suitable areas are determined by the grasses available and the presence of water points. Distances to such places range between five and twenty kilometres from the village. Sometimes, in October, farmers with more than 150 cattle temporarily migrate to villages where grazing is more readily available, a process known as 'lugundiga' or 'lubaga'.

During the wet season grass biomass builds up from December normally and temporary migrants return at this time. Also during the wet season grazing distances become short: animals graze in uncropped fields scattered around the village. Through herding activity herders gain knowledge of ecological factors leading to desirable pastures and increased grass quantity.

The effects of trees on grass (pasture) are recognized by informants mainly through above ground interactions. Trees are widely believed to suppress grass growth rates and cause decreased grass quantity, mainly through shading effects. According to informants the extent and intensity of tree shade is characterised by the following:

- tree crown size and shape
- the size and amount of the tree leaves
- tree density.

Both male and female informants recognize that trees with large, laterally spreading branches are more detrimental to grass growth rates and depress grass quantity more than straight trees and narrow crowns (an upward pointing canopy). Most women informants and a few men associated the large size of old trees with large crowns. Trees with large crowns are also considered to root deeply and over a wide area. When asked to explain why they link root spread and size of trees, women explained that when they cultivate around a large tree they strike its roots at a considerable distance (10 - 20 metres) from the bole. Tree species specifically mentioned in this context include *Acacia nilotica* (mihale), *Ficus glumosa* (mikuyu) *Boscia angustifolia* (misingisa), *Afrormosia angolensis* (mibanga) *Ficus nigropunctata* (migumo) and *Lonchocarpus capassa* (nkubankubi). Most women informants reported that *Acacia* *fischeri* (mahushi) grew from root suckers and became a thick bush (Plate 4.3) which severely depressed grass quantity.

According to informants most of the trees in Kishapu and Negezi Divisions shed their leaves during the dry season (Plate 4.4) but are heavily loaded with leaves during the wet season. During the dry season there is an apparent decrease in soil moisture and people understand that trees shed their leaves as a response. When asked to explain further what exactly makes them link shading of leaves as a response to moisture stress 15% of informants reported that they normally see these trees loaded with leaves during the rainy season and none during the dry season. When asked to comment about trees known to retain leaves during the dry season most informants suggested that trees such as *Acacia nilotica* had long roots. When requested to explain how long roots assisted the tree to get water in rainless seasons and in dry soils only two informants indicated awareness that there was some water in the soil at depth (more than 10 metres) and that a tree with long roots could tap reach it. They had noted such rooting when digging wells.

The density of trees on rangelands also affects grass growth and available quantity. High tree density is negatively correlated with grass growth and quantity. Informants felt that where there are too many trees in rangelands, perhaps even having crowns touching each other and branches within 1 m of the ground the deep shade produced inhibits undergrowth including grass. The thicket-forming *Dichrostachys cinerea* (matunduru) and *Acacia drepanolobium* (malula) were often cited as examples of this phenomenon (Plate 4.5).

Trees are recognized to increase soil fertility through litter fall and through their crowns improve infiltration rates of rain water into the soil; thus increasing grass growth rates and quantity. Most informants recognized that sunlight (solar radiation) is necessary for increased grass growth and that trees on rangelands intercept light. The extent and intensity of tree shade are attributes recognized as detrimental to grass growth. Two types of tree shade are recognised: dense and light shade.

Plate 4.3: *Acacia fischeri* (mahushi), Igaga village (Kishapu Division). The species is known to regenerate through root suckers and grow dense thus considered detrimental to grass growth in rangelands

Plate 4.4: Above - *Adansonia digitata* (miandu) without leaves during the dry season. Below - the tree is loaded with leaves which appear around October and by November cattle obtain feed

Plate 4.5: Trees in rangelands are considered detrimental to grass growth in terms of their size e.g. *Acacia nilotica* (above) - which cause dense shade. Some trees grow with branches near the ground e.g. *Dichrostachys cinerea* (below) and suppress grass growth.

Heavy tree shade is acknowledged to greatly affect grass growth. Informants recognize that the extent of grass suppression by the tree canopy depends on the intensity of shade and that this varies from heavy below the crown centre to lighter below the periphery. The heavier the shade the more grass suppression due to insufficient light penetration. The understorey (grass layer) micro-climate is also affected. Around the tree centre conditions are less warm and more damp than further from the base of the trunk. *Boscia angustifolia* (misingisa) was mentioned by one-hundred and thirteen out of one-hundred and sixty informants as an example of a tree casting heavy shade.

Light shade is recognised as less detrimental to grass growth because of the greater light which penetrates to the ground, allowing some grass to grow. However, informants still emphasized that too many trees even with light shade was not desirable. Three attributes determining if a tree cast heavy or light shade were identified.

- leaf disposition (size, shape and quantity of leaves and number of branches)
- tree architecture (branching extent and habit)
- tree maturity (age and size).

Farmers recognize that because of their large sizes, trees tend to have many large and widely spreading roots as compared to grasses. It is further recognized that certain tree species take up more water and soil nutrients than others and are more detrimental to grass growth nearby. For example *Acacia nilotica* (mihale) was mentioned as being more detrimental as an associate than *Acacia tortilis* (magunga) because it pumps more water and nutrients from the soil. *Acacia fischeri* (mahushi) is noted to suppress grasses because (see p 92) it is quite dense. Women also mentioned *Adansonia digitata* (miandu) as requiring copious water and, due to its frequent large size, as having roots spreading to obtain it. There is unanimity among the farmers in the view that the amount of water taken up by trees is greater than that taken up by grasses. However, forty-one out of sixty women informants provided some perceptive comment on tree-grass root competion as compared with only seventeen out of sixty men which indicates significant difference at the 0.05 level (Table 40). This is probably because their social and gender roles involve women in spending so much time in crop fields. Thus they have firm views on which tree species affect crops most and can relate the identity with size, amount of roots and spreading habits (Plate 4.6).

Table 40: Output of the G^2 test on informants' perceptions of the above and below ground interactions between trees and grass

	Women	Men				
knowledgeable	41	17	df	G^2	G^2adj.	P
not knowledgeable	19	43	1	19.795	18.137	*
Total	60	60	1			

*, $p < 0.05$

Management practices

Farmers in Kishapu and Negezi Divisions desire optimum grass production in rangeland. No systematic methods and principles being followed to manage the rangeland-grass resources were identified. It was mentioned that some people while herding manipulate the extent and intensity of tree shade by lopping branches and regulating the number of trees in grazing areas by cutting. This was the routine practice some 50 years ago when tree density was high. Nowadays tree density is low due to increased grazing pressure and lopping of branches is done to selected species (e.g. *Adansonia digitata*) for cattle feeding during the dry season. Trees are cut for usage (e.g. poles or fuel) but not to permit optimum grass production. Thus grass production in communal and public grazing areas follow a natural process.

Underlying perceptions

Apart from their negative effects, some informants felt trees could benefit grass growth by improving soil fertility because of the accumulation of dead leaves and twigs beneath them. Informants recognise that when tree leaves fall down they eventually decompose and thus increase soil fertility. They also understand that rates of decomposition differ from species to species. Ninety-six out of one hundred and sixty informants mentioned that leaves of *Acacia tortilis, Diospyros fischeri.* and *Senna siamea* decomposed faster than leaves of *Grewia bicolor* (mikoma) and *Borassus aethiopum* (mihama). Informants also recognized tree crowns as useful in obstructing rain drops and reducing their adverse impact on the soil. Their experience had shown that areas with trees or shrubs and those without them behaved differently. During rainfall the latter have more surface run-off than the former and soil erosion is much more noticeable, less water sinks into the soils, soil fertility declines and grass growth is reduced.

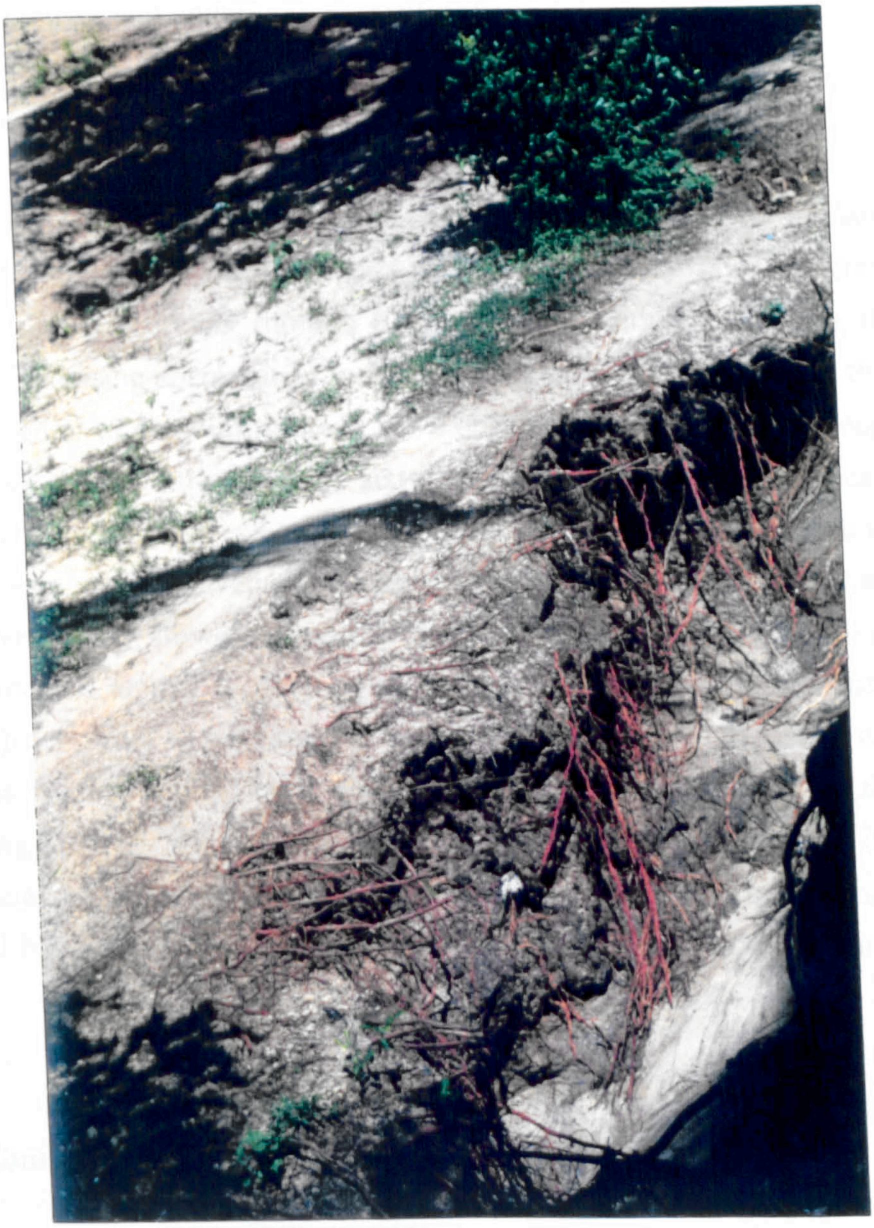

Plate 4.6 Root density and spreading characteristics are some of the attributes considered to intensify below ground competion between trees and grass in Kishapu and Negezi Divisions.

Rangeland-tree resources

Local knowledge of this is also considered in terms of practical experience, management practises and underlying perceptions.

Practical experience

Trees are recognized for use to livestock as a source of browsing particularly during the dry season. However, most informants were aware that cattle prefer grass to tree forage but during the critical months (October to December) feed on the latter. Knowledge of browsing species held varies between men and women. On this subject men (thirty-one out of sixty informants) were observed to be more knowledgeable on browse species than women (ten of sixty women informants). Statistical analysis indicates significant differences between the sexes (Table 41). Perhaps this is because traditionally men are involved in herding and livestock management more than women. Leaves, twigs, flowers or pods/fruits are eaten dry or wet (green) depending on species and the animal feeding on it. Informants recognize *Calotropis procera* (mapumbula) dry fruits to be eaten by goats, for example, while cattle eat the dry leaves. While grazing herders lop branches either by reaching them from the ground or by climbing the tree. When the branches fall the animals eat the foliage (Plate 4.7). Browse species are listed in Table 38 (for cattle) and Table 39 (for goats/sheep). In Kishapu and Negezi people are not used to cut and carry practices and animals feed on site.

Table 41: Output of G^2 test on perceptions of browse species.

	Women	Men	df	G^2	G^2adj.	P
knowledgeable	10	31				
not knowledgeable	50	29	1	16.934	15.306	*
Total	60	60	1			

*, $p < 0.05$

Plate 4.7 Livestock feeding on leaves of *Acacia nilotica.* Herders cut branches and when they fall on ground animals eat the leaves and/or pods (Isoso village) Kishapu Division.

The majority of the informants singled out *Adansonia digitata* as of vital importance to cattle from October to December when grass was particularly scarce and nutritionally poor. In October, *Adansonia digitata* starts flowering and livestock then feed on the fallen flowers. On the branches new leaves are then produced. By November the trees have their full complement of foliage and herders then lop branches and bring them to the ground for the animals to eat the leaves. The tree was particularly appreciated in the 1949 drought in the study area which left many cattle dead and at that time *Adansonia digitata* helped save some. It is nevertheless understood that if these trees are continuously lopped they lose their regeneration potential (Plate 4.8). Livestock are attracted to the young leaves/twigs because they are palatable, soft and easy to chew and digest, and produce an attractive aroma. Farmers have three broad perceptions of browse:

- good browse produces livestock weight gain and increased milk production
- tree leaves which are quite green attract cattle most and are highly palatable which is believed to reflect high amounts of sugars and salts
- for browse to produce the desired benefits it must be highly digestible and very nutritious.

Men were more knowledgeable on aspects of livestock breeding and management compared to women. They have four broad perceptions of cattle breeding:

- produce more milk and ghee
- smooth skin and resistant to disease
- fast growth with large health body
- non-aggressive, produce small horns and hooves do not grow long because cattle movement is obstructed especially when soils become soft and muddy.

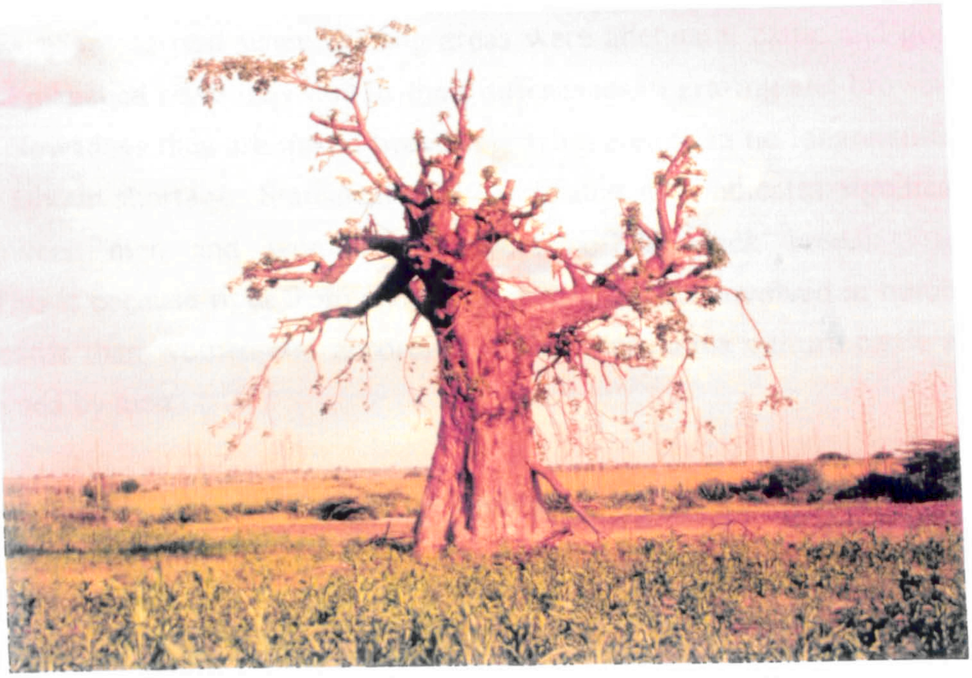

Plate 4.8: Above - *Adansonia digitata* lopped for cattle feed. Below - when the tree is frequently lopped its ability to regenerate decline. But age of the tree is another factor to reckon.

It was reported that in the past when grazing areas were adequate, cattle and goats were grazed and managed separately due to their differences in grazing and browsing characteristics. Nowadays they are mixed because grazing areas can no longer suffice and there is a labour shortage. Statistical analysis (Table 42) indicates significant differences between men and women on aspects of livestock breeding and management. This is because right from childhood men are more involved in herding and caring of cattle than women and according to the Wasukuma culture cattle are manned and owned by men.

Table 42: Output of G^2 test on informants' knowledge on livestock breeding and management

	Women	Men	df	G^2	G^2adj.	P
knowledgeable	8	37	df	G^2	G^2adj.	P
not knowledgeable	52	23	1	31.78	29.486	*
Total	60	60	1			

*, $p < 0.05$

Examples of browse tree species frequently mentioned by informants and parts eaten are indicated in Table 43:

Table 43 : Browse species often mentioned by informants

Species	parts eaten	Comments
Acacia nilotica	leaves, pods	pods mostly liked by goats and they are noted to gain weight as they feed on them. Also seeds regenerate through animal droppings
Acacia tortilis	leaves, twigs, pods	seeds regenerate through animal dung
Acacia drepanolobium	leaves, flowers	spread through animal droppings
Adansonia digitata	leaves, flowers	increased milk production observed in lactating cows
Balanites aegyptiaca	leaves, twigs, fruit	
Dichrostachys cinerea	leaves, twigs, pods	

Management practices

The majority of informants (one-hundred and thirty-six out of one-hundred and sixty) were quite concerned that both browse and useful non-browse tree species within five km of homesteads or beyond were not easily available compared with past situations. Tree populations for firewood and browse have been declining due to over-cutting, conversion of rangelands to other usage and overgrazing. During interviews the majority of informants acknowledged grasses to be more important to cattle than tree forage (browse). Thus informants have been using this understanding to carry out some rangeland management practices leading to increased grass quantity by:

- removing all trees which characteristically cast dense shade

- regulating overall tree density through periodic cutting.

It was mentioned that 40-50 years ago fire was used to regulate undergrowth, create new grasses and kill ticks. However, this technique is no longer used for this purpose because the density of vegetation in Kishapu and Negezi Divisions has been much reduced. No deliberate efforts were reported to be used to manage rangelands for increased production of browse tree species or other tree products (e.g. fuelwood, fruits, medicines). Populations of browse species known to informants and used by livestock regenerate only by spontaneous processes.

Underlying perceptions

Only with the HASHI programme of introducing *Leucaena leucocephala* have browse species been planted in the region. Now fodder propagation is mentioned as an important need. Cattle were seen to be attracted to the leaves of *Leucaena leucocephala* (milusina) even during the wet season when grass is in abundance. Informants described this as a "sweet food" for livestock. Previously, there was no planting of trees as fodder crops. Browse species were regarded as a gift of nature (endowed resources) not needing to be propagated through artificial means.

Farmers recognize ecological linkages between cattle and grass in the sense that cattle depend on grass for their survival. They also recognize that cattle affect grass in two negative ways:

- by overgrazing: as cattle numbers have increased grass has been increasingly heavily utilized, grass regeneration potential is suppressed and, over time, grass quantity decreases

- by trampling while grazing: cattle have a negative effect on the grass cover (inaathiri nyasi) particularly where permanent cattle paths are created. As a consequence, soils become loose or compact (depending on type) and soil erosion may follow.

All informants are aware that the human population has greatly increased and that this has decreased grass growth and quantity through expansion of crop fields and settlements and keeping of more cattle. Although the majority of the informants recognize that the density of trees in rangeland has greatly decreased, they also perceived a number of benefits attributable to natural trees.

Poles

Acacia mellifera (malugala) and *Dichrostachys cinerea* (matunduru) are recognised as good for fencing posts. These species are known to have quite hard wood not attacked by termites or fungi. Apart from poles 'masanzu' are used to make a barrier. In the case of 'masanzu' both *Acacia mellifera* and *Acacia drepanolobium* are valued because they share two characteristics:

- they have many branches which become thick
- they have quite conspicuous thorns.

These characteristics make their branches particularly suitable for 'masanzu' and when closely placed they form a strong barrier preventing both human and livestock trespass on crop fields.

Firewood species

Women informants were very articulate in providing information about rangeland tree species valued for firewood (Table 45). Responses indicate fifty-six out of sixty female informants to have views about firewood aspects compared to fourteen out of sixty male informants. Statistical analysis (Table 44) indicates significant differences between gender.

Table 44: Results of G^2 test on perceptions of good firewood species between women and men

	Women	Men	df	G^2	G^2adj.	P
knowledgeable	56	14				
not knowledgeable	4	46	1	68.425	63.977	*
Total	60	60	1			

*, $p < 0.05$

There were three perceptions of women on the characteristics of good firewood species:

- the wood should burn slowly while producing a hot fire with little ash

- the wood should be easy to split and should dry in 2 to 5 days when kept in a sunny place

- the wood should produce little smoke and this should be non-irritant to the eyes and without a bad smell.

Examples of such good tree species which were frequently mentioned are in Table 45.

Table 45: Tree species report suitable and unsuitable for firewood

Considered as good firewood species	Comments
Acacia mellifera	wood hard to split but burns slowly releasing a substantial amount of heat and does not require constant attention
Acacia nilotica	wood burns well and is easy to split and dries quickly
Dichrostachys cinerea	do
Acacia drepanolobium	do
Acacia kirkii	do
Considered bad firewood species	
Euphorbia tirucalli	wood produces lots of smoke which irritates the eyes
Calotropis procera	wood produces a low fire and becomes smoky
Diospyros fischeri	too smoky
Anisotes dumosus	is good firewood but should be quite dry or is too smoky
Lannea humilis	wood burns quickly demanding constant attention

Food benefits

Rangelands are sources of food. Women informants proved to be more knowledgeable on this than men. Fruits are obtained from various trees and herbs (Table 46)

Table 46: Reported natural fruit tree species

Fruit tree species	parts eaten	Comments
Adansonia digitata	fruit pulp soaked in water and solution added to porridge or eaten directly	fruits are ready beginning March. Also women informed that seeds could be powdered to make porridge and this was used during the 1949 drought.
Balanites aegyptiaca	the fruit is sweet	fruits are ready in April. Also women mentioned that seeds contain edible oil but their shell is too hard to break
Tamarindus indica	fruit pulp mixed with porridge or eaten directly	available from April
Crosspteryx febrifuga	fruit is sweet but not as much as that of *Balanites aegyptiaca*	available beginning February
Herbaceous vegetables		
Amaranthus spp (mwogawagole)	leaves. Before cooking they are spread in sun to eliminate pests	can be prepared fresh or dried using sun heat
Cucurbita moschata (limbe)	leaves, twigs	leaves eaten fresh or boiled and sun dried
Manihot spp (kayeba)	leaves, twigs	do

Natural trees and herbs for medicines

Trees with significance medicinal values (Table 47) were often mentioned by both male and female informants. Responses indicate that twenty-six out of sixty women informants were knowledgeable about aspects of medicinal plants compared to thirty-three out of sixty men. Statistical analysis (G^2) indicate no significant difference (at the 0.05 level) between the knowledge of women and men about traditional medicine materials.

Plant species of medicinal values which were mentioned by informants are indicated (Table 47).

Table 47: Natural trees and herbs of medicinal value

Species name	Disease cured	Comments
Balanites aegyptiaca	a variety of diseases are cured e.g. stomach troubles.	every part of this tree is valued for medicine. (Plate 4.9) It was mentioned by both male and female informants
Anisotes dumosus	roots and leaves are used	mostly for treating livestock. Mentioned by eighteen out of sixty males and six out of sixty female informants
Solanum nigram	used to treat lactating cows in case they do not like to feed calves	only fruits are used mentioned by twelve out of sixty male informants. No responses from women.
Albizia anthelmintica	mainly roots are used cattle with swollen stomach.	mentioned by eighteen out of sixty male informants.
Tamarindus indica	leaves are used	leaves mixed with barks of *Acacia nilotica* are used to treat aenemia
Acacia nilotica	bark used	these trees are often debarked for medicinal needs
Azadirachta indica	leaves and barks are used	can treat a variety of diseases but mostly used for malaria
Rothmannia spp	dry leaves are used	leaves are burnt and ash slowly swallowed to help throat sores

Plate 4.9: *Balanites aegyptiaca* (miyuguyu) valued for medicine, fruits and browse. Above - a young tree and below- a mature tree in a reserved area (Migunga village) Kishapu Division.

Some trees are debarked for medicine, most of the material being taken for sale in urban centres (Plate 4.10).

Symbolic and ritual roles of rangeland trees

Acacia mellifera (malugala) has a significant cultural value in livestock bomas. Two posts of *Acacia mellifera* are normally placed at the entrance of the boma and at the time of fixing these posts, a ritual ceremony takes place involving the head of the household, elder son and the traditional medicine man. This action is believed to ensure that the boma is closed to outsiders who cannot tamper or cause any harm to cattle.

Other uses

Apart from browse, firewood, fruits and medicinal benefits obtainable form rangeland trees, some informants mentioned other uses (Table 48)

Table 48: Species of other uses

Species name	Type of use	Comments
Acacia polyacantha	considered useful for timber, poles, draught animal bars, hoe handles	grows fast, wood light but not easily broken
Anisotes dumosus	good for construction of traditional granaries (mabelele)	produces good small sized branches which are not easily broken on bending and can last long
Calotropis procera	do	do
Acacia mellifera	makes good poles for maize storage (crossed bars)	wood is not easily attacked by termites. Also the tree has symbolic and ritual value.

The use of *Anisotes dumosus* and *Calotropis procera* for granary construction is important in the study villages. They are not usually attacked by termites or borers and they bend easily without splitting. The granaries are strengthened by a plaster of wet cow dung (ukolongo) which prolongs usage and prevents stored grains (especially those of sorghum and millet) leaking. Maize is stored in open, airy, spaces with some sheath retained and tied on erected posts of *Acacia mellifera* supporting a trellis woven of *Anisotes dumosus* or *Calotropis procera*. Maize cobs are hung (Plate 4.11) on these trellises, allowing easy shedding of rain water and ventilation.

Plate 4.10: Above - *Acacia nilotica* debarked for obtaining medicinal material. Below traditional medicine materials for sale in Shinyanga town, Tanzania..

Plate 4.11: Above: a traditional granary (mabelele) constructed using *Anisotes dumosus* (masagala), Mwataga village (Kishapu). Below - maize corbs stored on *Acacia mellifera* poles, Bulimba village (Negezi), Shinyanga Region, Tanzania.

4.2.2 Information verification

Verification of information covered the 'ngitiri' system and rangeland-tree knowledge bases.

4.2.2.1 The 'Ngitiri' system knowledge base

Table 49 indicates for the whole sample the number of responses by category for the informants - knowing and not knowing various aspects of 'ngitiri' management practices, biological aspects and component interactions.

Table 49: 'Ngitiri' knowledge base : numbers of responses for the whole sample for knowing and not knowing

	Knowing		Not knowing		
Aspects of the 'ngitiri' knowledge	Women	Men	Women	Men	Total
Management practices	75	81	45	39	240
Biological aspects	101	105	19	15	240
Component interactions	108	110	12	10	240
Total	284	296	76	64	720

The figures indicate that a large proportion of the informants are knowledgeable about the 'ngitiri' system and its underlying management and usage practices compared to 19% not knowing. No significant differences were detected between men and women at the 0.05 level but significant differences were observed between those knowing and not knowing (Table 51).

4.2.2.2 Rangeland-tree knowledge base

Table 50 indicates the results for the whole sample's responses for knowing and not knowing various aspects of this knowledge base.

Table 50: Rangeland-tree knowledge : numbers for knowing and not knowing

	Knowing		Not knowing		
Aspects of knowledge base	Women	Men	Women	Men	Total
Management practices	104	106	16	14	240
Resource utilization	86	92	34	28	240
Biological aspects	88	86	32	34	240
Components interactions	105	103	15	17	240
Total	383	387	97	93	960

Figures in Table 50 indicate a large proportion of informants (80%) possesses knowledge related to rangeland-tree resource base and utilisation.

Statistical analysis using Chi-squared tests on responses for knowing and not knowing management practices, resource utilization, biological aspects and components interactions for both knowledge bases showed no significant differences between sexes in the villages and divisions. This means that levels of knowledge are the same regardless of gender and location. Significant differences are indicated (Table 51) between those knowing and not knowing.

Table 51: Results of chi square tests between informants knowing and not knowing aspects of the 'ngitiri' system and the rangeland-tree resource base.

	knowing	not knowing	df	chi square	p value
'Ngitiri' system	580	140	2	57.529	* *
Rangeland-tree	770	190	3	28.846	* *

* *, $p < 0.01$

'Ngitiri' system : number of household practising

Informants responses on 'ngitiri' practices (Table 52) indicate variations in practising the system and size of areas owned among the study villages and households.

Table 52: Number of households practising private 'ngitiri'

village	sample size	number practising	area (ha) mean	cattle mean
Mwataga	60	31	18 (8.6)	35 (18)
Igaga	60	30	14 (6.0)	29 (16)
Ikonda	60	14	17 (8.0)	26 (12)
Mwaweja	60	13	22 (14)	20 (15)
Kishapu Division	120	61	16 (7.5)	32 (17)
Negezi Division	120	27	19 (11.2)	23 (14)

Numbers in brackets indicate standard deviation.

The figures (Table 52) indicate that 52% of the sample in Kishapu Division practice 'ngitiri' system compared to only 23% in Negezi Division. This further indicates that not many households in Negezi Division own cattle which compares well with results in Tables 21. The 'ngitiri' areas are used for grazing between September and December. Statistical analysis (t-test) using means for both area and cattle numbers indicate no significant differences between villages. At division level the test indicate significant differences for cattle numbers using the 'ngitiri' areas at the 0.05 level (Table 53) but not significant for the 'ngitiri' sizes between the divisions.

Table 53: Differences in cattle numbers using 'ngitiri' areas between Kishapu and Negezi Divisions.

Source of variation	mean 1	mean 2	pooled SD	df	t-test
Kishapu & Negezi	35	23	5.5	30	*

*, $p < 0.05$ indicating that means are significant at the 0.05 level i.e. $t > t_{0.05}$ (30).

Furthermore, results of regression analysis (Table 54) indicate a weak relationship between cattle numbers and 'ngitiri' sizes. This means that cattle number are not correlated with size of grazing areas.

Table 54: Results of regression analysis 'ngitiri' areas against number of cattle

Village	Mwataga	Igaga	Ikonda	Mwaweja
R^2 values	0.147 ($p<0.05$)	0.049 ($p>0.05$)	0.063 ($p>0.05$)	0.002 ($p>0.05$)

CHAPTER 5: ANALYSIS AND EVALUATION

This chapter focuses on the evaluation of the results produced during this study. In Section 5.1 analysis of the farmers' perceptions with reference to the 'ngitiri' systen (5.5.1.) and the rangeland-tree resourse base (5.1.2) is provided. The procedures of indigenous knowledge structuring and presentation are considered in Section 5.2, and those of verification in Section 5.3. In the final Section (5.4), indigenous ecological knowledge and scientific knowledge are compared.

5.1 Analysis of the farmers' perceptions of the 'ngitiri' system and the rangeland-tree resource base

5.1.1 The 'ngitiri' system

Farmers have been using ecological knowledge to their advantage and adopt different approaches to various ecological conditions. There is recognition of good quality grass enabling optimal economic gain from cattle. Efforts have been made to sustain their cattle by establishing pasture reserves (ngitiri). Cattle grazing practices are differentiated according to the seasons (dry and wet) so that the ability of grass to regenerate itself is maintained. However, most farmers regarded fresh grasses (wet) to be most desirable for animal growth and production. The effects grasses produce to animals are illustrated and it is observed (Fig. 19) that both direct and indirect effects are perceived by the farmers. Direct effects are related to grass attributes that lead to an increase in stock feeds' palatability and digestibility rates. These were better explained by the informants than indirect ones. Grass greenness and grass wetness which are both related to amount of moisture content were viewed as essential attributes desirable to enable animals feed on them with ease. As the grass greenness and wetness increase, leads to more grasses being consumed by the animals and hence more milk production (Fig. 20).

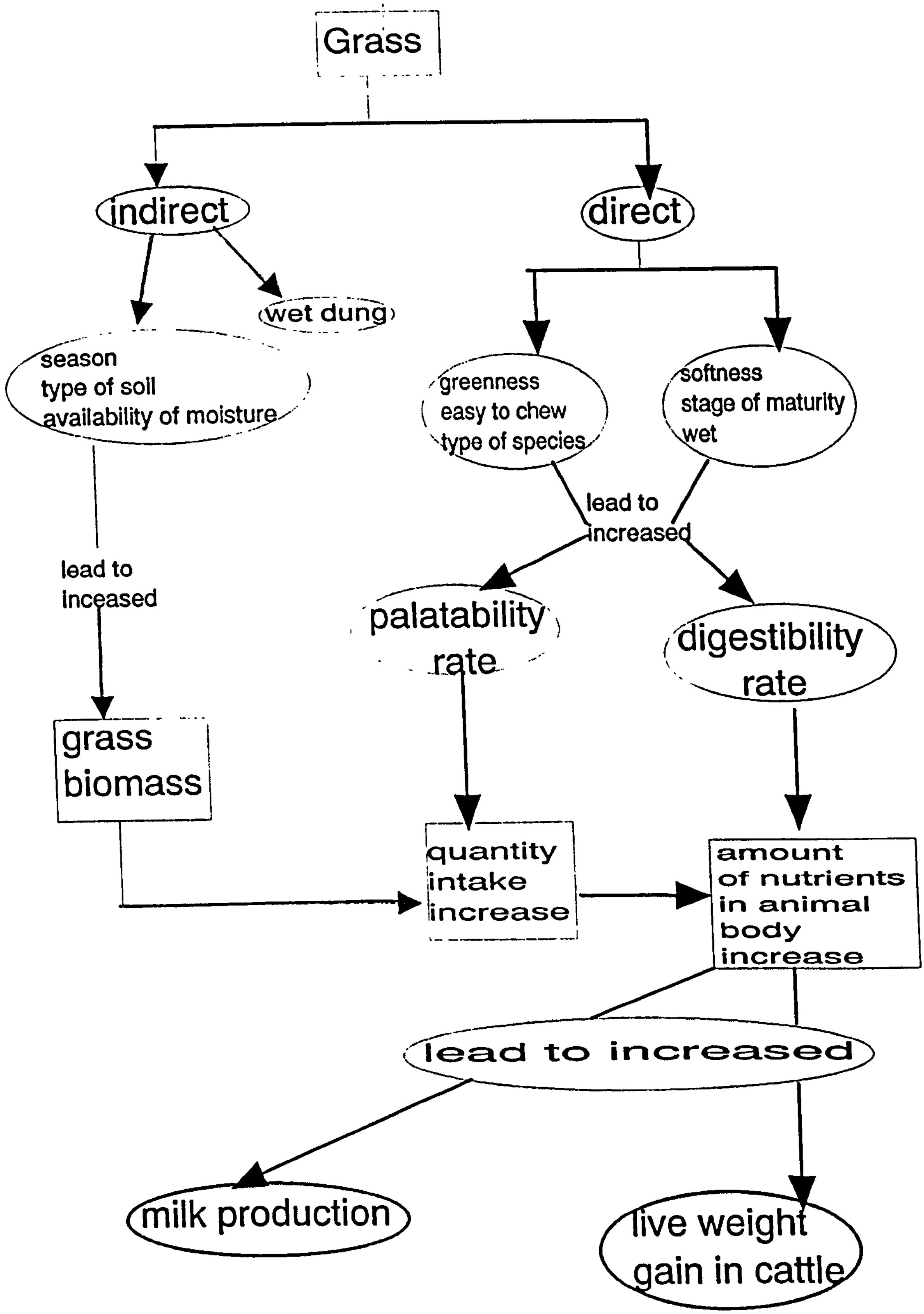

Figure 19: Farmers' perceptions of the positive links between environment and grass quantity that indicate a good 'ngitirii' in Kishapu and Negezi Divisions.

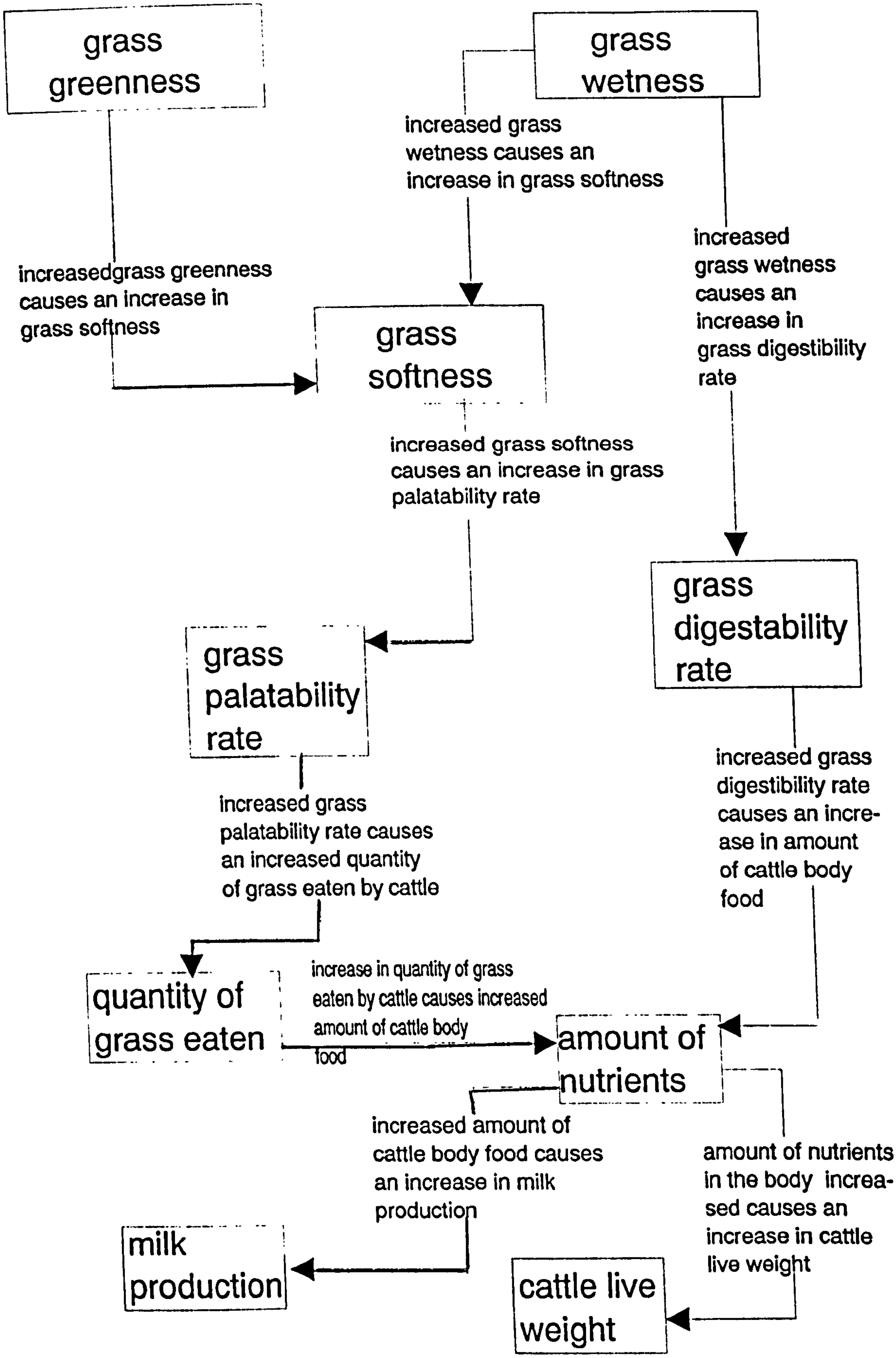

Figure 20: Effects of grass values to cattle as perceived by informants in Kishapu and Negezi Divisions.

Four main factors were identified to affect grass growth rates and quantity in the study villages. The interrelationship of these factors is summarised in Fig. 21. However, informants reported climate to have more impact on grass growth and quantity than the other factors. Details of how climate affects grass growth rates and quantity according to informants' perceptions presented in Fig. 22.

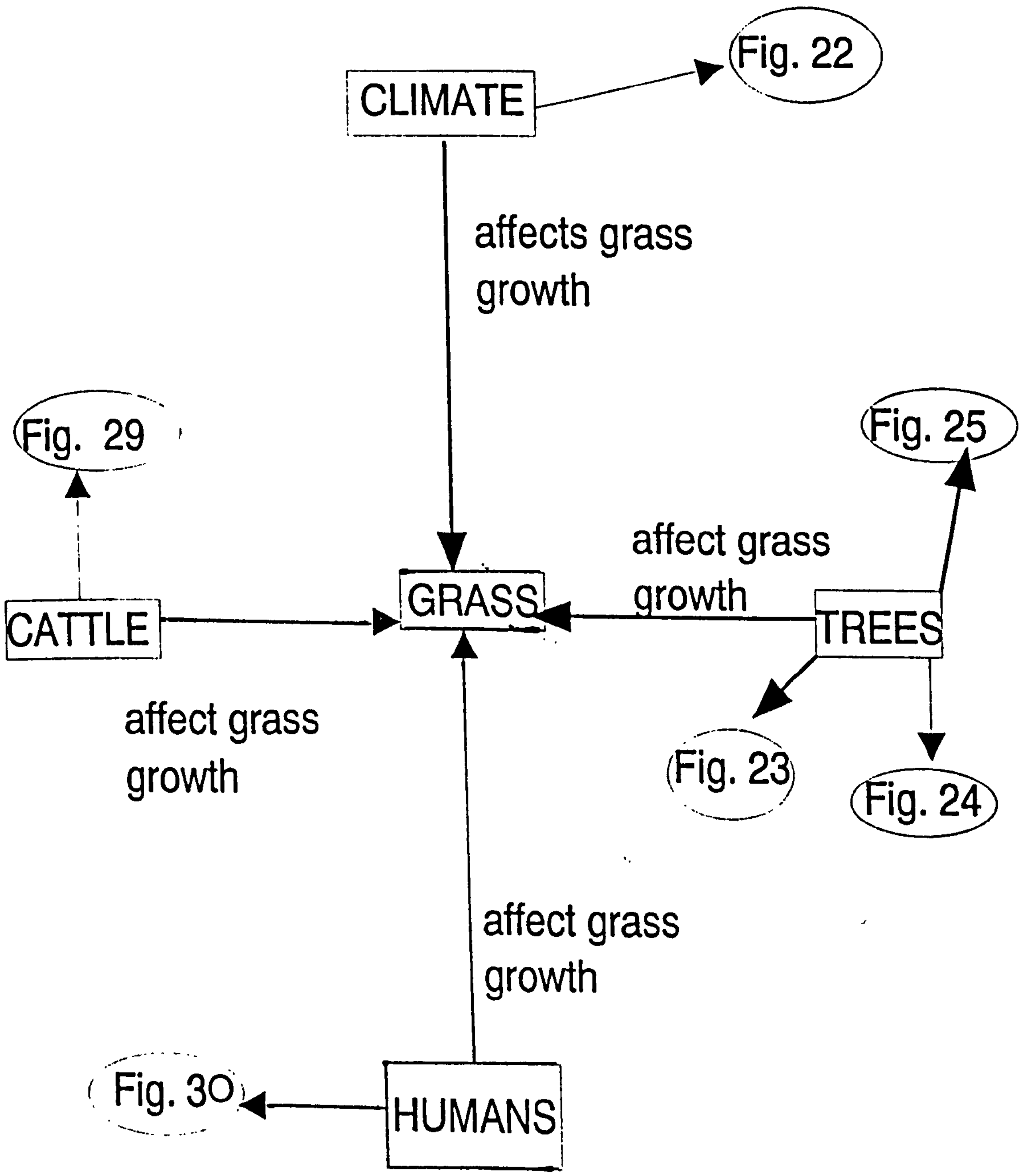

Figure 21: Factors affecting grass growth in the rangelands of Kishapu and Negezi Divisions.

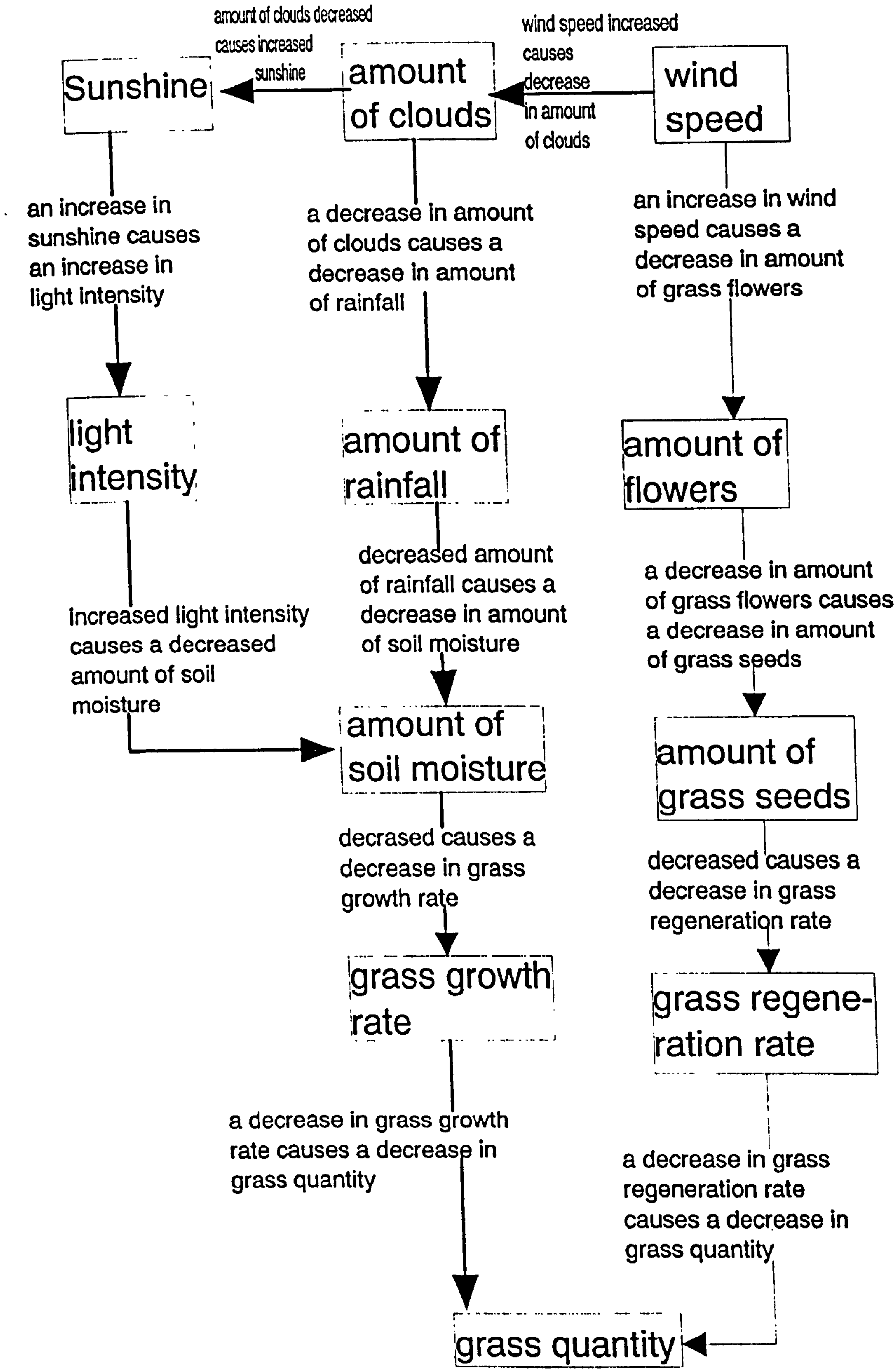

Figure 22: Climatic factors affecting grass growth rates and quantity in Kishapu and Negezi Divisions.

5.1.2 The rangeland-tree resource base

Ecological interactions occurring in the rangeland and observed by the farmers are the same as those noted under the 'ngitiri' system. The only difference between the 'ngitiri' system and the rangeland-tree resources is that the former is limited to single usage (e.g. as a source of animal feed) whereas the latter is of multiple usage (see 4.2.1.2). According to informants the tree component affects grass growth rates both positively or negatively as illustrated (Figs 23, 24 and 25). Positive effects (Fig. 23) were linked with the amount of leaves falling on the ground and later decompose to release nutrients in the soils. These are taken up by grass thereby effecting their growth rates. Accordingly, the amount of leaves on ground will depend on the size of the tree crown. The larger the crown the more leaves are likely to be available on the ground. Apart from this influence, tree crowns were linked with reduction of surface run-off. and therefore, increased rain water infiltration rate so that more soil moisture would be available for grass growth (Fig. 23). Furthermore, tree crown size is a function of tree age, size, number of branches and quantity of leaves. A combination of these attributes lead to a decreased grass growth rate through an increased above ground (dense tree shade) and below ground (root density and spread) interactions. These produce negative effect through dense tree shade inhibiting solar radiation from reaching the ground (Fig. 24) and increased root competion for nutrients and water (Fig. 25) in turn rates of water uptake from the soil is increased thereby affecting grass growth rates and biomass.

A summary of the farmers' perceptions of the effects of dense tree shade and root competition on grass growth rates in Kishapu and Negezi Divisions are presented (Fig. 26).

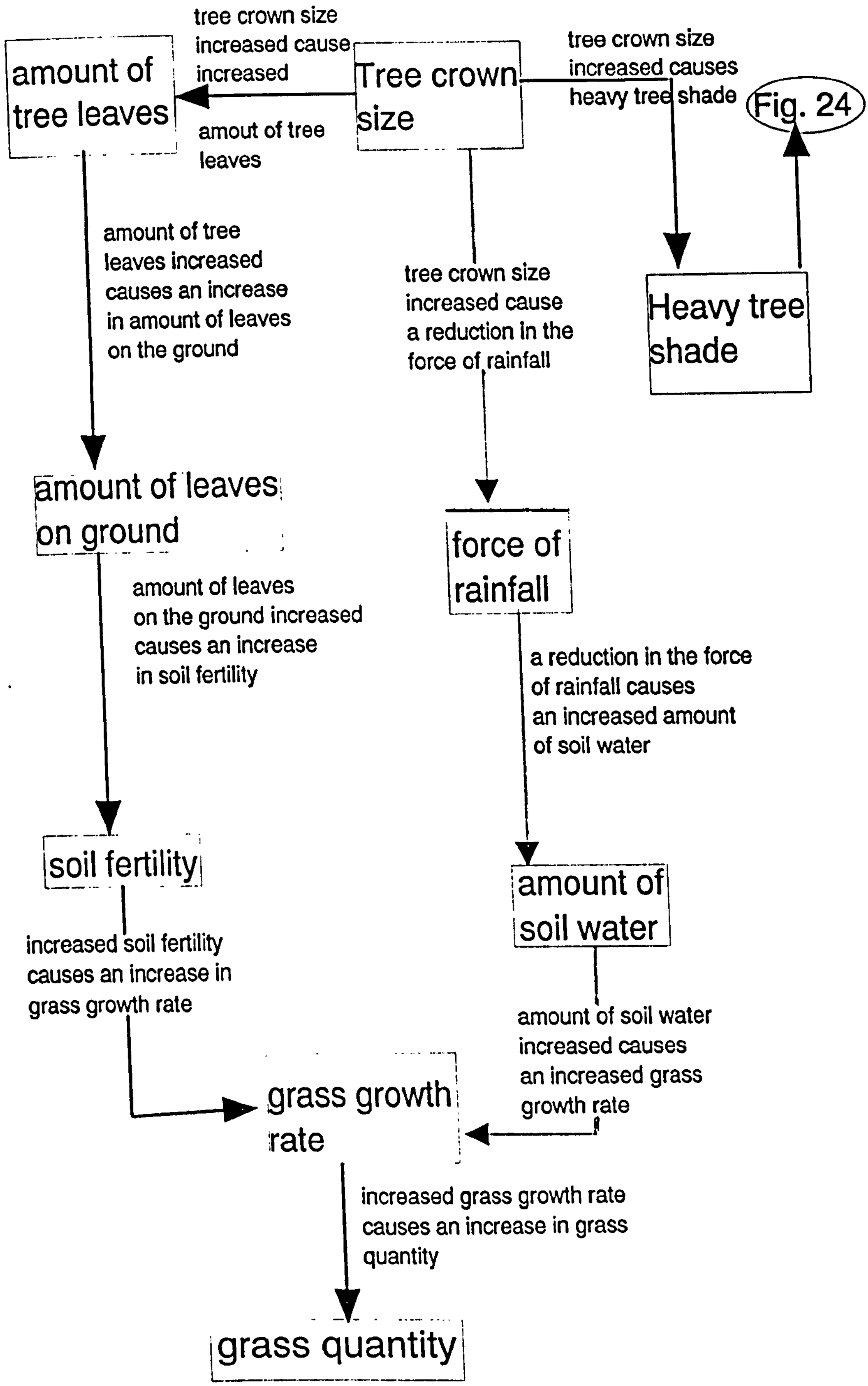

Figure 23: Effects of tree crown size on grass quantity according to informants' perceptions in Kishapu and Negezi Divisions.

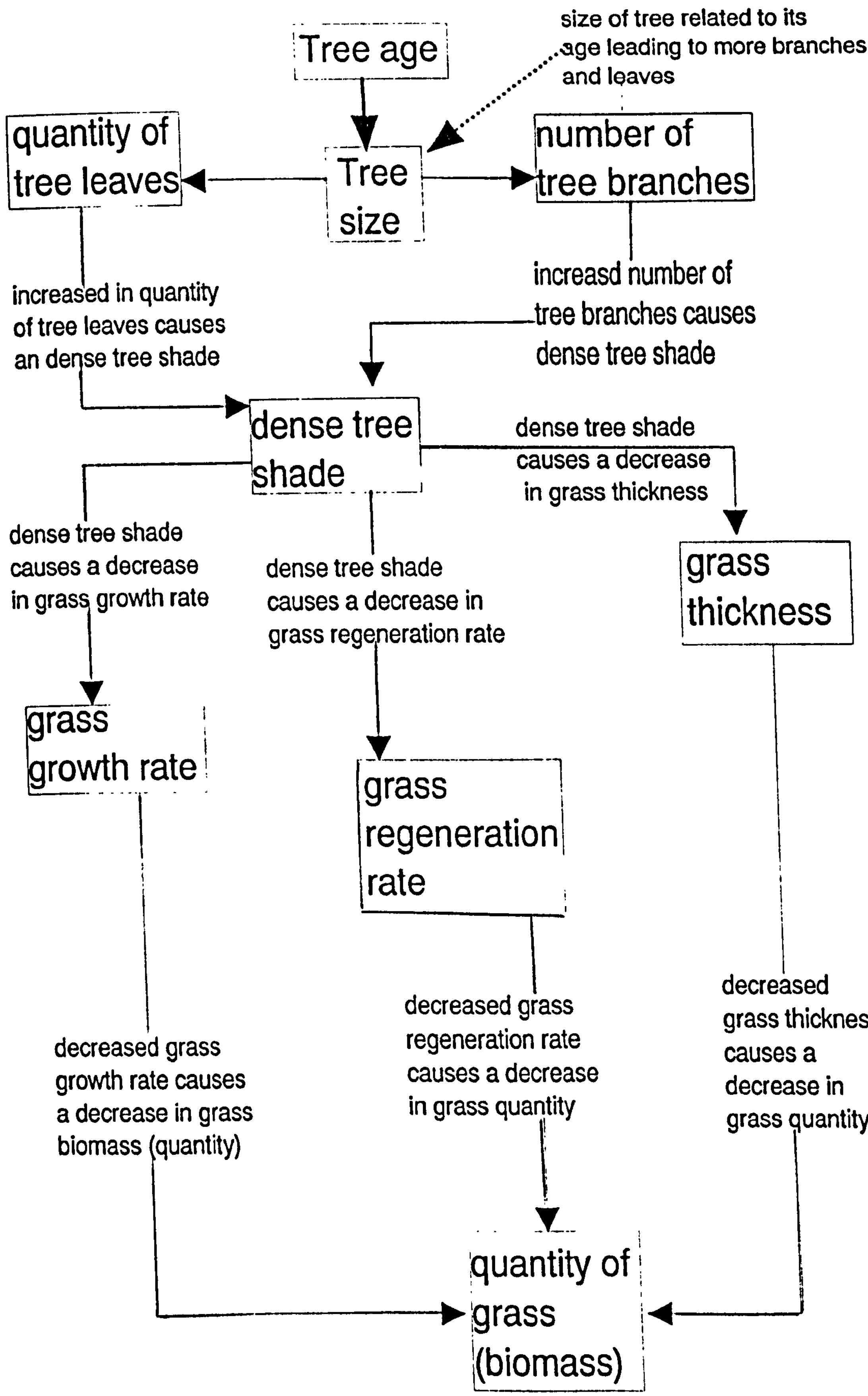

Figure 24: Effects of dense tree shade on grass growth rates and quantity in Kishapu and Negezi Divisions.

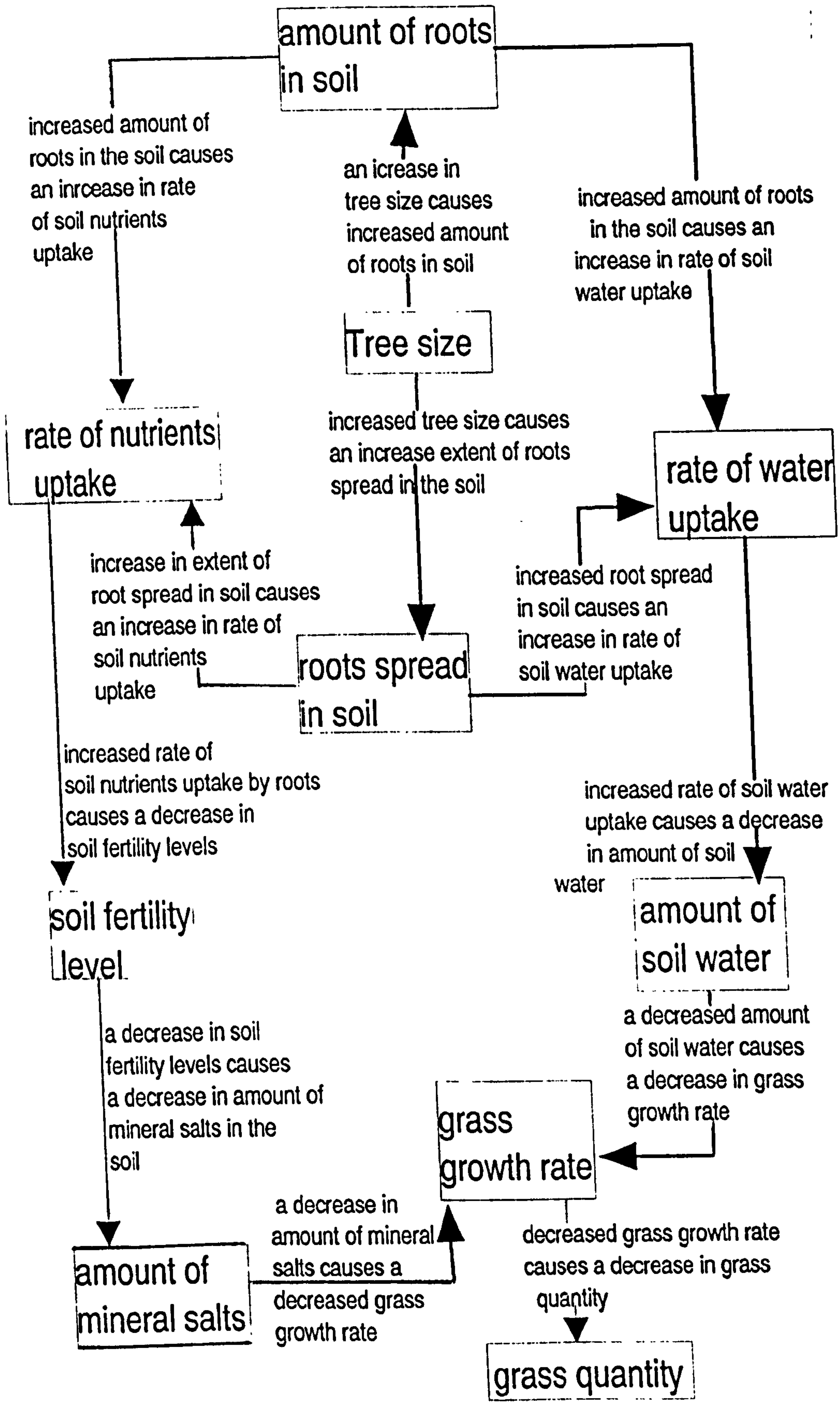

Figure 25: Effects of tree size and root density on grass growth rates and quantity as perceived by farmers in Kishapu and Negezi Division.

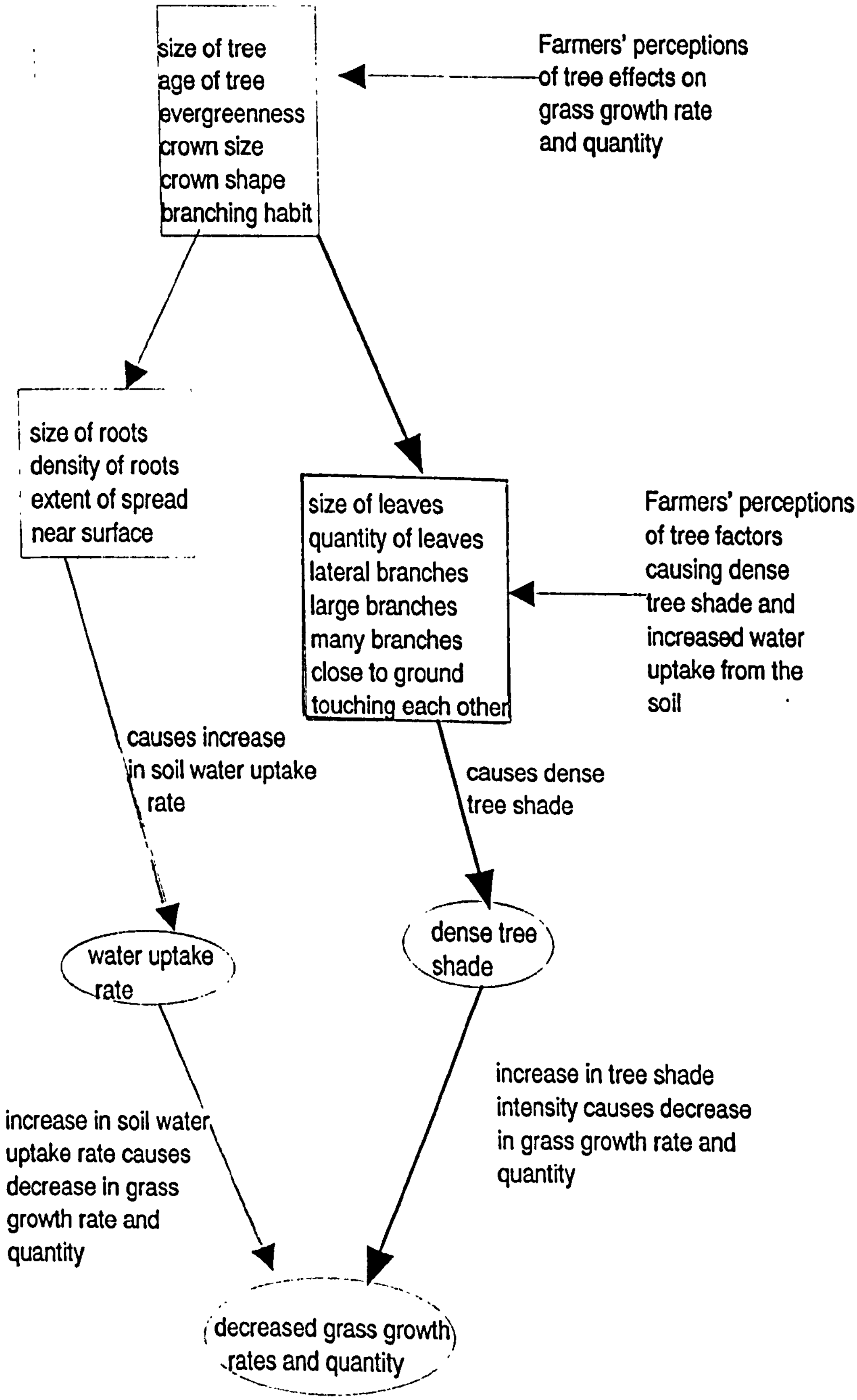

Figure 26: Summary of the farmers' perceptions of the effect of dense tree shade and root competition on grass growth rates in Kishapu and Negezi Division.

Trees are also recognized to benefit livestock through browsing and as a source of fodder. The effects on the animals will depend on the type of browse or fodder species. Farmers' perceptions of browse and fodder trees and their effects to animals are illustrated in Figs 27 and 28. The latter indicates what informants considered to be good for their animals. If tree leaves are green with a considerable amount of moisture content they would be soft for the animals to chew (palatability and digestibility rates) would increase and therefore the animals would be better nourished and produce more milk.

Farmers' perceptions of the effects of browse or fodder species involve direct and indirect observable effects. Direct effects are linked with palatability and digestibility rates and these are well perceived by the farmers. For the indirect effects tree forage that makes animals produce wet dung are regarded as desirable (Fig. 28).

Farmers' perceptions of the effects of livestock on the environment are illustrated (Fig. 29). Through trampling animals cause soil compaction and erosion and such processes lead to decreased grass growth rates and quantity.

The effect of increased human population on the environment are recognized. Through wood shortages and shrinking grazing areas, farmers in Kishapu and Negezi Divisions have realised the effect of increased population on grass growth and quantity as summarised in Fig. 30.

Informants suggested an integrated Government action (Fig. 31) with a perception that environmental degradation processes in Kishapu and Negezi Divisions would be contained and provide conducive conditions for increased grass growth rates. Furthermore, an indigenous institution (Fig. 32) was also considered. Such a system worked well in the past but still could provide a mechanism that can help to solve problems related to environmental degradation at the village level without too much Government involvement.

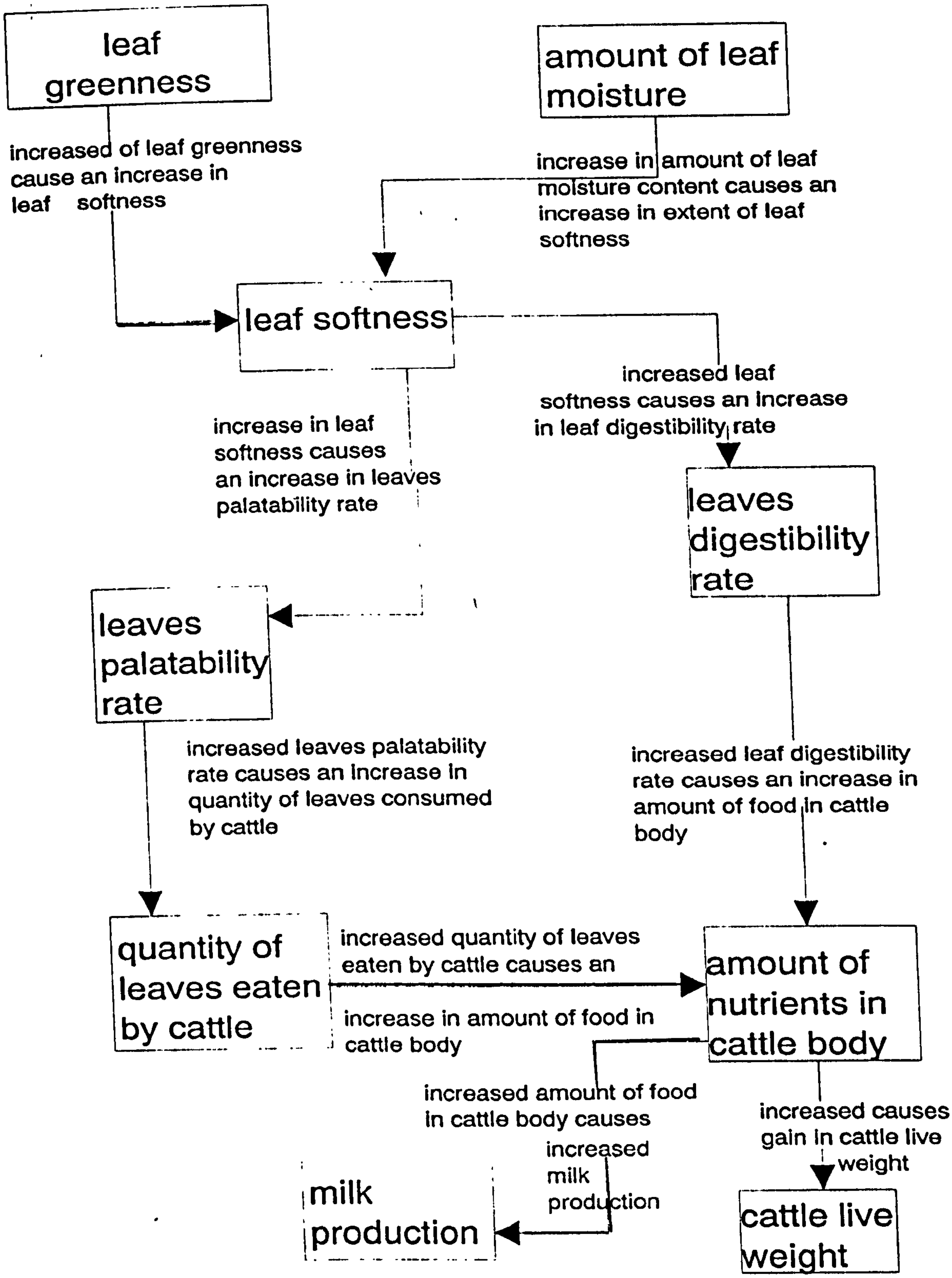

Figure 27: Effects of tree forage to cattle according to farmers' perceptions in Kishapu and Negezi Divisions.

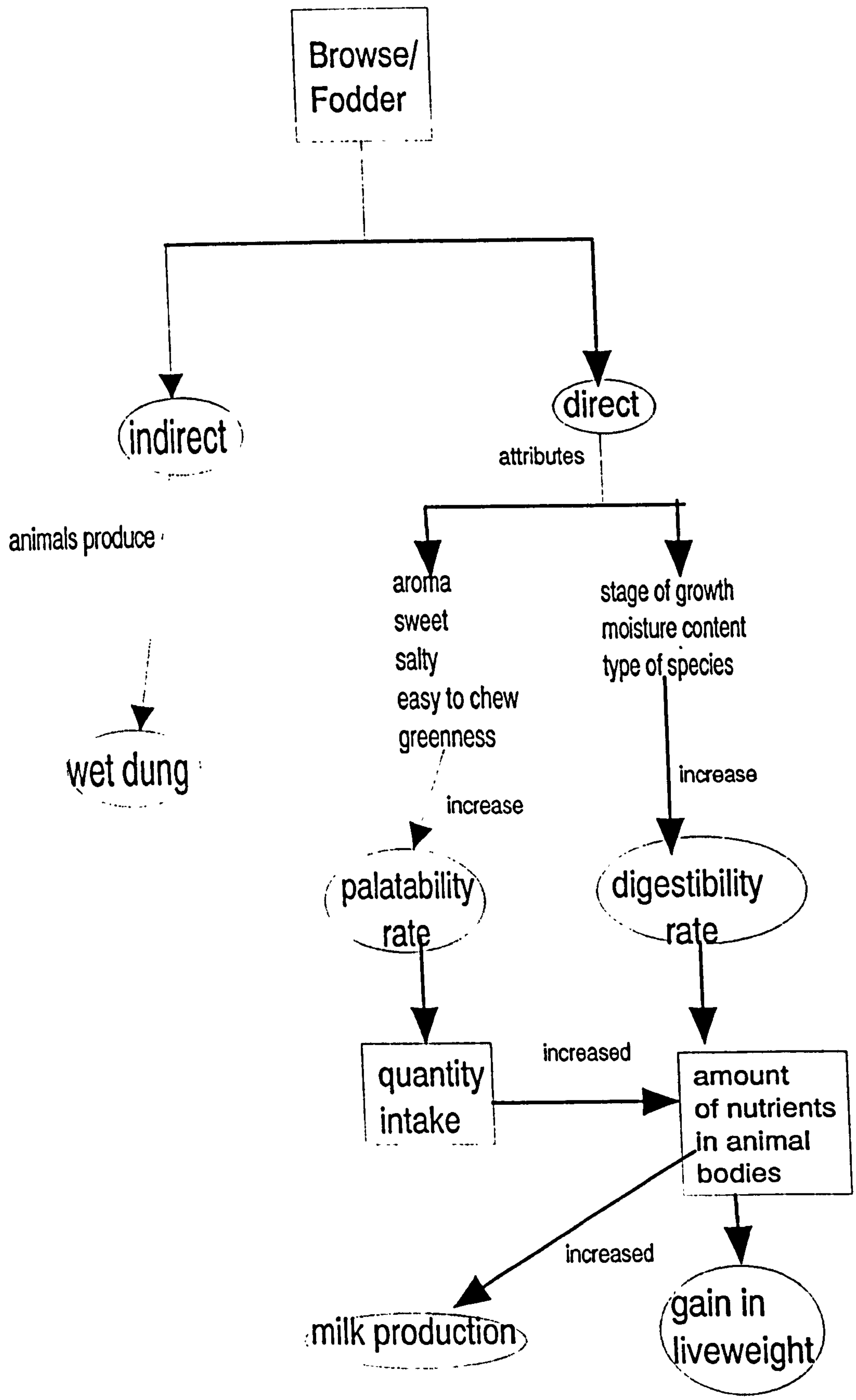

Figure 28: Farmers' perceptions of the positive links between tree forage and animal production in Kishapu and Negezi Divisions.

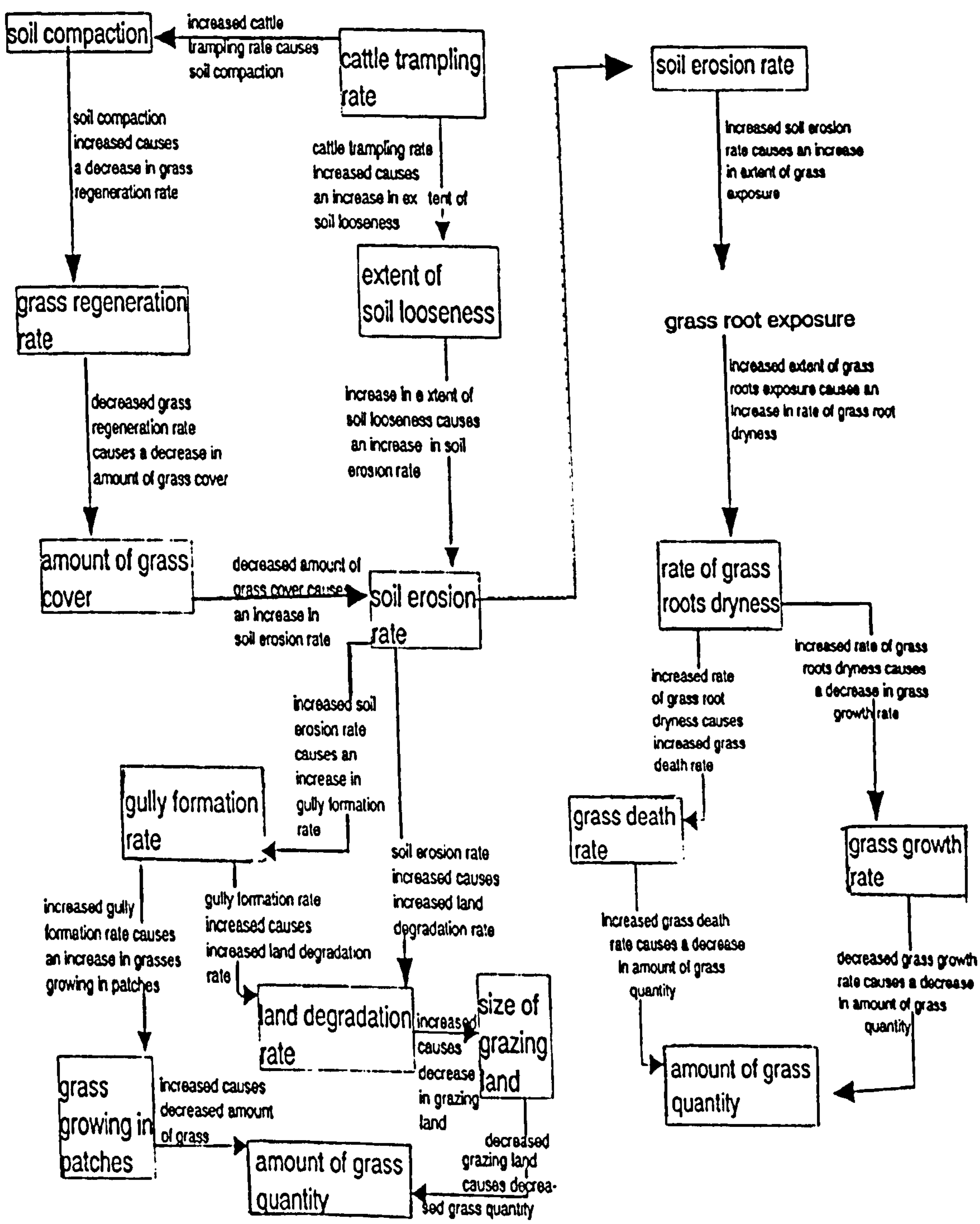

Figure 29: Effects of cattle to soil and grass quantity according to farmers' perceptions in Kishapu and Negezi Divisions.

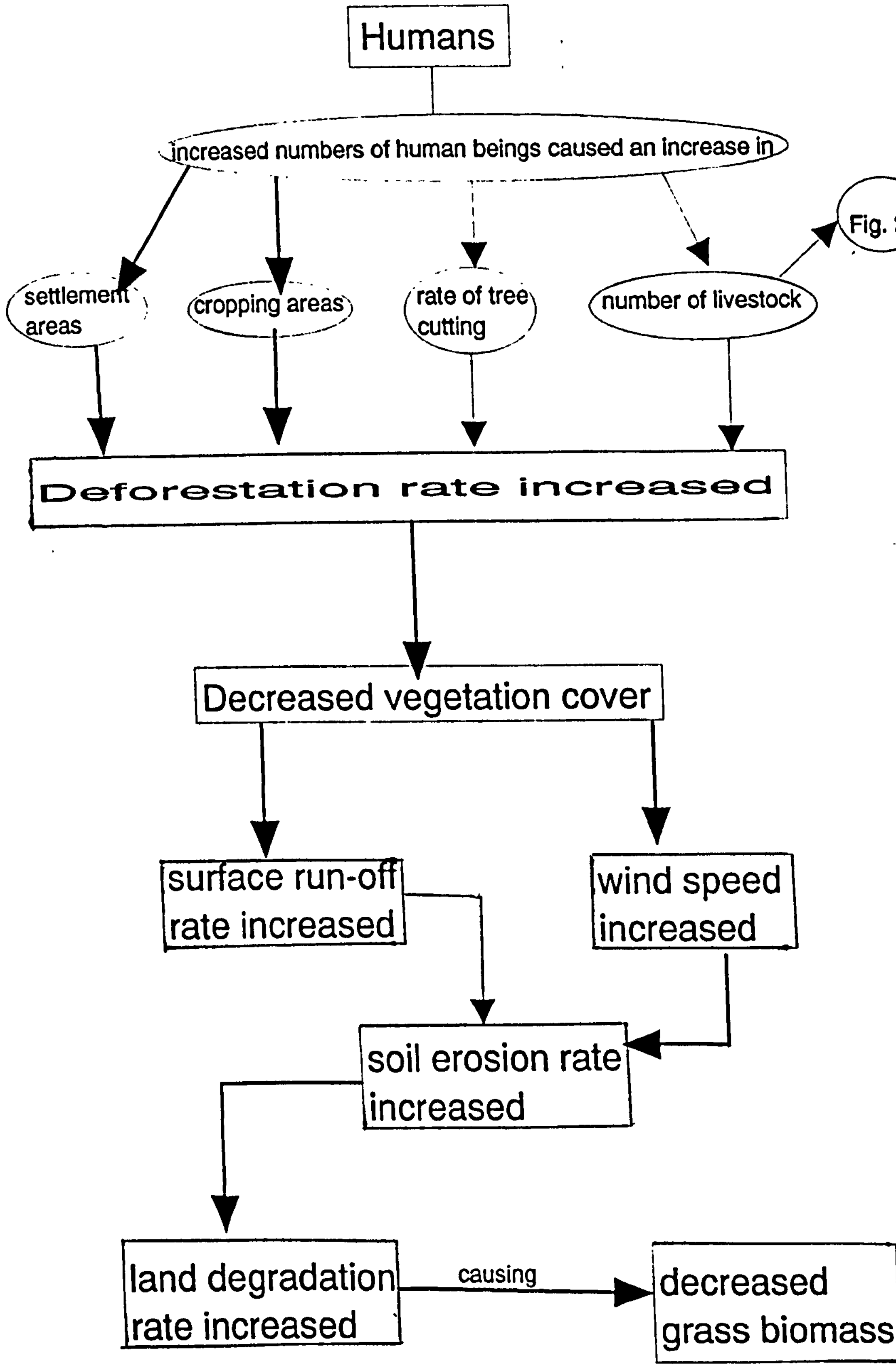

Figure 30: Effects of human-beings on the environment and grass biomass in Kishapu and Negezi Divisions.

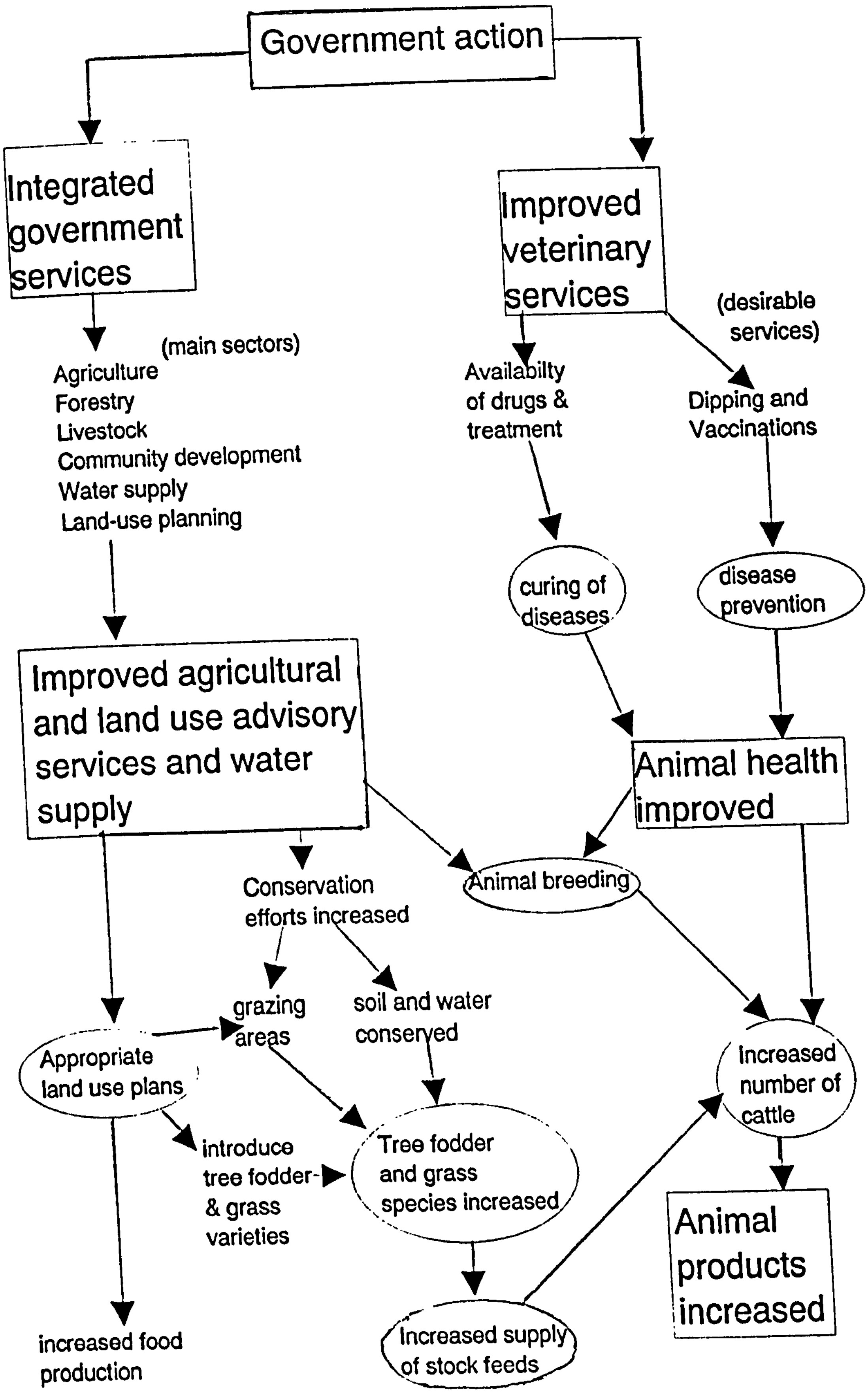

Figure 31: Informants' perceptions of an efficient system for the well-being of livestock in Kishapu and Negezi Divisions.

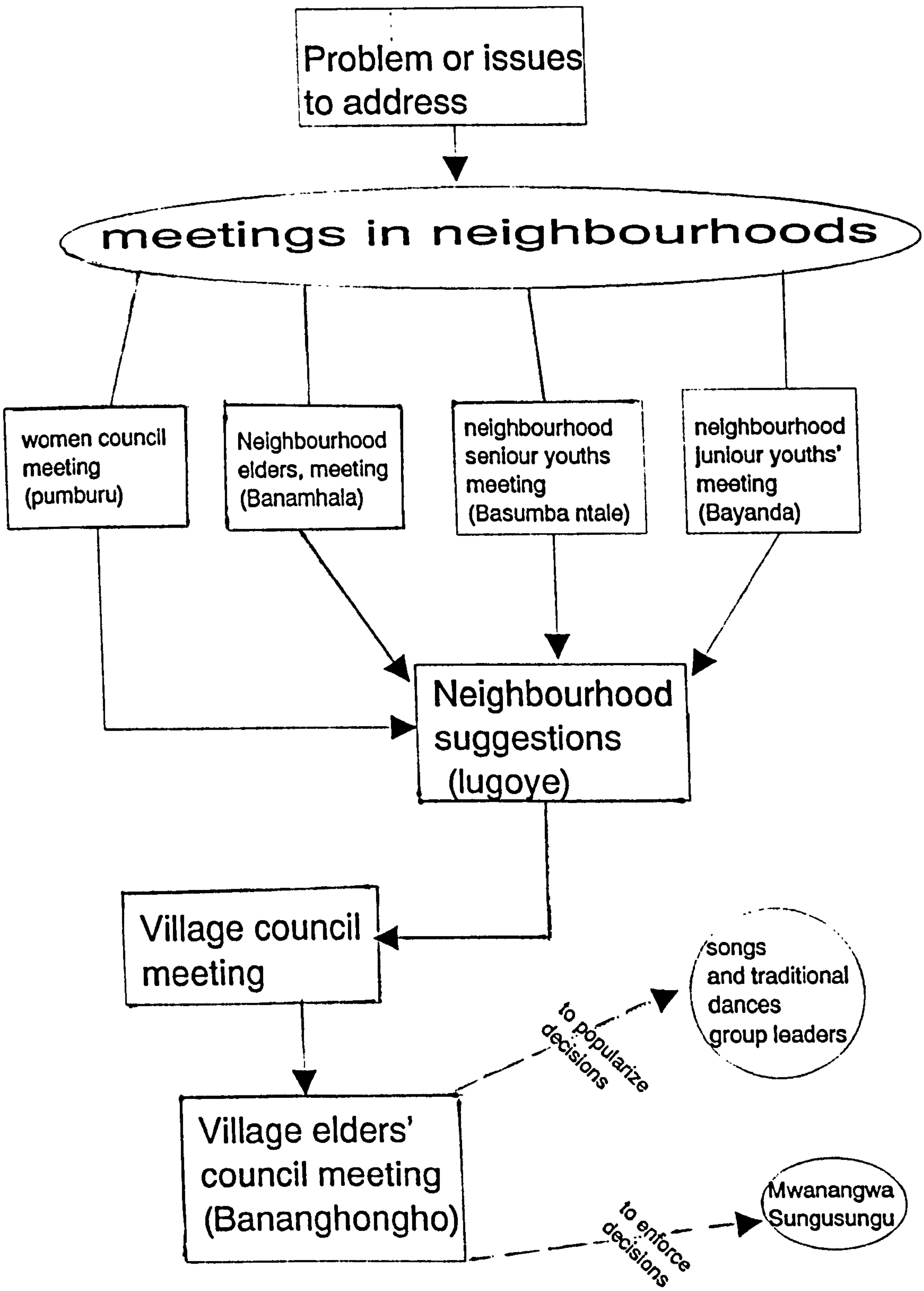

Figure 32: Traditional system for village decision making and enforcement which operated in the past in Kishapu and Negezi Divisions

5.2 Indigenous knowledge structuring and presentation

The information given by the farmers in Kishapu and Negezi Divisions, Shinyanga Region, reflects the knowledge they have acquired over a long period of time, through observations and their interaction with various components of the environment. This is reflected in their cropping and livestock keeping practices. Extensive bodies of knowledge held by the farmers in the study villages may be attributed to each of two main areas: the traditional system of pasture management ('ngitiri'), and rangeland tree livestock resources. These knowledge bases are inter-linked with aspects of both the soil and climate.

Sources of differences in knowledge levels

Levels of knowledge vary amongst the people, and no single person possesses the entire knowledge base. Thus the information collected results from a variety of sources. As groups, men and women, whether young or old, all possess at varying levels, segments of the knowledge in their locality. Due to Wasukuma customs, habits and cultural values, certain members of the society are more knowledgeable about certain aspects when compared with others. Women have more skills/talents in the utilisation of rangelands for natural food (vegetables, fruits and nuts) and also firewood when compared to men. Specialised knowledge such as in traditional medicine, is held by few members of the society. Not even all members of a traditional doctor's family share the relevant knowledge. Skills are usually passed on to one chosen member of the family, and the successor is bound to abide by the customs and cultural values related to the practice.

Men were very knowledgeable on issues related to livestock and herding activities. These skills are developed from an early age, as boys take on the custodianship of cattle. (Fig. 8). Roles are changing, however, and women and girls are becoming increasingly involved in herding (Plate 5.1); provided that grazing is near and the numbers of animals is limited.

The majority of people in the Kishapu and Negezi Divisions clearly recognize that land degradation is accelerated by high stock numbers. When asked what they thought would be the best approach to securing a balanced use of available land resources within their environment, informants offered no responses. Thus knowing something is one thing, but adjusting practices to take it into account is another; especially when resources are used communally. Therefore, sound ecological practices are not followed not because people lack the understanding of the underlying factors but due to some social, cultural, political and economic factors. Lack of conducive land tenure policy and ownership; belief that trees increase population of birds, which attack crops such as sorghum, millet and rice; and belief that trees suppress crop and grass growth rates are some of the factors. Also, as a result of unreliable rainfall and periodically severe droughts, farmers are vulnerable to losses of production and in desperation may act contrary to the best of their knowledge by keeping cattle numbers in excess of carrying capacity or some farmers cutting trees in reserved areas (Plate 5.2) to meet short term needs. These problems should be addressed jointly by policy/decision makers, researchers and extension workers to ensure that the environment in the Shinyanga Region is maintained.

The problem in relation to common property is how the resource should be managed. People consider only their own needs: for one to reduce or increase cattle numbers does not affect the statutory rights of other users. The tendency is to increase numbers regardless of what happens to the resource base. This is confirmed by the regression analysis (see pp.68 & 115) which demonstrates a weak correlation between cattle numbers and the size of grazing areas.

Before government reorganisation, communities followed their own indigenous institutions and regulations (see Fig. 32). However, with reorganisation, indigenous capacities were weakened. When rangeland was used before land was declared a national asset (in 1967) there was a common approach to resource usage, and grazing pressure was evenly distributed. With the introduction of the 1967 "Arusha declaration" followed by the villagisation programme during the 1970's, animals started to be confined to one particular location. As a result indigenous strategies for the management and utilization of natural resources on a sustainable basis (i.e. through transhumance, particularly during the dry season) became ineffective. Furthermore, the people are now confined to villages where they compete for resources, and environmental degradation often occurs as a result. This leads to serious weaknesses in the stability of the community as far as environmental conservation issues are concerned. The land degradation in Shinyanga Region was largely associated with this weakness by the majority of informants.

A factor of equal significance is population pressure. Increased population has caused the progressive removal of trees from rangelands through the expansion of crop fields and settlements.

Plate 5.1: Nowadays women are increasingly involved in herding. Above - a girl leading livestock to a grazing area (Bulimba village, Negezi). Below - a woman herding cattle. (Isoso village, Kishapu Division.), Shinyanga Region, Tanzania.

Plate 5.2: Above - a stump of a tree which has been cut. Below - stacked wood ready for making charcoal which is sold in peri-urban and urban centres.

As a result, problems caused by population pressure are increasingly becoming apparent. Unfortunately, however, people as individuals tend to ignore these.

5.3 Information verification

The verification of information was an integral part of the study of indigenous ecological knowledge, and was based on interviews yielding conversational information. The original sample of 40 informants per village used in the unstructured interviews was considered a relatively small sample, and thus most of the information was qualitative. Furthermore, statements of facts were extracted from the text of interviews, and therefore, there were possibilities for making errors. In this context verification was necessary.

There are two major advantages in verifying qualitative information using different sample areas:

it provides good opportunities for obtaining independent informants' views/perceptions, and thus is a way of confirming statements extracted from previous interview texts

knowledge distribution is confirmed by involving a wider coverage in terms of distances and sample size.

Disadvantages are considered to be that:

the approach involves taking a further sample and in a new area; so that it requires considerable additional time (for winning confidence)

verification cannot be done until the analysis and processing of the information collected in an earlier phase is well advanced, and preferably completed (issues are inevitably even more complicated where cultural differences and language problems are involved).

5.4 Indigenous ecological knowledge as compared to scientific knowledge.

Comparisons were made at two levels between indigenous ecological knowledge and scientific knowledge. First, information gathered from agricultural and forestry field officers at the Divisional level was compared with informants' perceptions. Secondly, informants' ecological knowledge was compared with conventional published scientific knowledge.

Conversations with agricultural field staff focused on ecological aspects and what these staff thought farmers should do in order to maintain a sound ecological environment. The Divisional Agricultural Field Officers stressed four points:

> early planting and weeding are essential to take advantage of the first rains for crop germination and thereby ensure a long good period of growth. Through weeding, competion for water and nutrients is avoided
>
> improved seeds should be used for higher yields and for drought and disease tolerance
>
> planting should be carried out at recommended distances (i.e. 90 cm between rows and 30 cm between plants for maize; and 45 cm between rows by 15 cm between plants for sorghum and millet)
>
> manure should be intensively used because crop fields are of low fertility.

It was emphasized that if farmers in the study villages followed the above points, crop yields would be improved from, for example, an average of 600 kg to 1500 kg ha^{-1} (dry weight) for maize, and an average of 700 kg to 2500 kg ha^{-1} (dry weight) for sorghum and millet. This would mean that a smaller area - from an average of six ha to two ha - would need to be cultivated rather than the present level, and thus the environment could be preserved as a result of its less extensive use. In Tanzania, an average yield of 900 kg ha^{-1} for sorghum is reported (Wall and Ross, 1970). For millet, Tanzania's yield is reported to be higher than Africa's average of 564 kg ha^{-1} (de Milliano, 1992; Warder and Manzo, 1992). However, Banyikwa, (1991) reported a decline in yields ha^{-1} for both export and food crops in Tanzania, which is attributed to low rainfall and declining soil fertility.

Informants' views support the first point, and they have perceived that given the unreliability of rainy days, the earlier one plants the better. Timely weeding is also recognised as important because weeds are known to suppress crop growth and therefore reduce yields. Thus on these points agricultural extension and informants views agree. However, the views of farmers conflict with the other three points. Thus the use of seeds of improved crop varieties is unpopular. According to the farmers, food produced from these varieties does not taste as good, and does not store as well as the traditional varieties. The improved varieties are perceived as being easily attacked by grain borers unless pesticides are applied. The use of seed chemicals in crop storage does not appeal to them because care in application is needed, and they are expensive and require careful storage. Local crop varieties are palatable and store well in traditional granaries without experiencing serious loses caused by pests.

Farmers do not follow recommended spacement for two reasons:

it is considered too labour intensive

land has to be tilled before planting to allow water penetration and easy seed germination.

Alternatively, they follow the traditional practice whereby the planting and tilling of the land is carried out concurrently. During the dry season, the soil becomes dry and hard, but softens within a week of the beginning of the wet season. Once the soil has accumulated some moisture, tilling and planting proceed together: Seed is broadcast and tilling follows. The practice takes less time and labour to finish than the measures advocated by extension staff. In a moisture stress environment, it may be sensible for the farmers not to follow recommended crop spacings which are used in areas with high potential. Ideally, recommended spacing is meant to produce more plants ha^{-1} when compared to traditional practices. More plants however, mean increased competition for available soil moisture. In moisture stress areas farmers thus avoid this problem through the use of wide spacing and inter-cropping; taking advantage of variations in soil conditions, and the different amounts of water required by different crops. These are some of the observable factors for which interventions, which are relevant to local conditions should be designed.

The application of cow manure is not popular because it must be transported to crop fields and labour is needed for spreading it. Chemical fertilisers are not applied. It was reported that they are only effective if there are good rains and also that they are expensive. Farmers believe that chemical fertilizers burn crop roots if the rainfall is not enough to ensure they dissolve.

Foresters emphasize both the planting of new trees, and the conservation of existing ones as a means preserving the environment and providing farmers with required woody materials. However, the farmers' views conflict with those of the foresters. Firstly, farmers consider that trees harbour birds detrimental to sorghum and millet. Furthermore, trees are seen to take up space and to suppress crops and grass through above - and below - ground interactions. Some species (e.g. *Acacia nilotica)* are even reported to degrade land even though they are promoted by the foresters. Thus farmers will not accept trees with such reputations in cropping areas, although they may plant them around their homesteads to provide resting shade and firewood. This indicates a degree of acceptance, at least, as well as helping to implement the policy that more trees should be planted in rural areas.

Livestock field officers advocate reduced cattle numbers and suggest that only small herds of improved stock should be kept; which will provide more milk day^{-1} (i.e. from one/two to about six litres day^{-1} for each lactating cow). The farmers disagree and reported that milk from improved cows is watery and does not produce much ghee. The local breeds produce milk which is sweet, with a good taste and ghee yields are high. Ghee is an important food: it is used in conjunction with natural green vegetables or directly with stiff porridge (ugali). The traditional representation of wealth as cattle numbers also means there is a sharp divergence of views between the farmer and the livestock officer over what is desirable.

Farmers' perceptions elicited through the unstructured interviews can also be compared with documented scientific knowledge. In the case of the 'ngitiri' system, management practices are based on understanding those site ecological factors which match with scientific principles. However, farmers' knowledge is less developed and changes more slowly. In science, efforts are always being made to learn more, by research, about the interactions taking place above and below the ground between the various components of the ecosystem. Farmers efforts are essentially limited to opportunistic observations and practical experiences (visualized outcomes). They lack the relevant technology and analytical tools to do otherwise and see no need for the acquisition of more knowledge. An important difference between the farmers and scientists is that the latter work continuously for solutions to these questions. This is clear where aspects such as soil moisture, fertility levels, texture, light and tree shade, or rooting habits are considered. In cause-effect interactions it may be easy for the farmers to notice the link (e.g. vertisols linked with ability to retain water longer than cambisols) but difficult to explain why. Continuous work done by scientists has provided explanations for such links. An example is: the effects of trees on crops or grass (Fujisaka *et al.*, 1994; Khan and Ehreinreigh, 1994). Farmers may perceive underlying causation but lack details. For instance, informants were asked to explain how they perceive certain soil types (e.g. vertisols) in terms of their ability to retain water longer than other types however they were unable to provide detailed explanations. In scientific studies soils have been analysed in detail thus determining particle sizes, the organic matter content, and the relative proportions of clay or sand.: All of these factors affect the chemical and physical properties of the soil such as its ability to retain or lose water at varying rates. Thus, for instance, soils with a large proportion of sand (lusanga) lose water faster than soils with a higher clay (vertisols), or organic matter content.

Informants reported certain tree species (e.g. *Acacia tortilis*) as improving soil fertility. For example, the amount of tree leaves on the ground where such trees grow is associated with an increase in soil fertility (see Fig. 23), leading to an increased rate of the growth of grass. The informants understand that fertility levels would increase only if leaves rot, but could not explain the underlying biological processes leading to leaf decomposition (i.e. the activity of micro-organisms). They also realise that leaves of *Acacia tortilis* decompose faster than others e.g. *Combretum obovatum* (magobeko). However, they were not able to provide details to relate leaf structure, its chemical composition and environmental conditions as factors leading to faster decomposition. Whereas it is more important to know the link than to explain it, it would benefit the farmers more if a clear and understandable basis could be provided for the explanation of underlying processes. This indicates an area where scientific and indigenous knowledge could interact through extension and research outlets.

Despite the farmers' lack of analytical tools and relevant technologies, they perceive some of these factors well and recognize that high quality grasses and tree forage are essential for increased milk production and livestock live-weight gain. This demonstrates that indigenous ecological knowledge and formal scientific knowledge have considerable potential to complement each other. If the two could be combined and appropriately used, this would enhance rural development and technological transfer, and ensure sustainability in the farming systems, rather than just by relying on scientific knowledge alone.

The study has demonstrated that the field scientists working with the farmers in Kishapu and Negezi Divisions have not recognized two aspects:

Local taste and preferences: failure to understand these results in inappropriate action by the extension services. Emphasis on high yielding varieties or the introduction of trees in cropped fields needs close consultation with the target groups and their beneficiaries

Variations in local climatic conditions, especially the amount and distribution of rainfall over the rainy season: the understanding of this could help to minimize problems arising from the application of chemical fertilizers when soil moisture is low. This would allow the formulation of sound extension advice.

Extension workers are trained in national institutions and recommendations to farmers are universally made throughout the country, nevertheless there is a weakness in not taking into account variations in ecological and environmental conditions. Bearing in mind regional climatic variations, and the fact that most of the extensionist's work is in localities of unfamiliar ecological conditions, there is a need to decentralise the training of extension workers if better services are to be provided for the farmers through an increased understanding of local conditions in terms of semi-arid, medium, and high potential environments. Furthermore, research and training should be carried out in co-operation with the farmers, particularly in semi-arid areas in order to capitalise on knowledge of the local conditions and thus use such knowledge in training extension workers.

CHAPTER 6: DISCUSSION

Environmental degradation in Shinyanga Region, Tanzania, poses a threat to both the human and livestock population. This study of the indigenous ecological knowledge of the trees and agroforestry practices in the rangeland of Shinyanga has involved assembling and documenting what people know and have been practising, thus providing a basis for addressing the environmental problems which face the region. Strategies to combat land degradation processes are likely to fail if the ecological knowledge of the farmers is neglected. Systematic understanding of what inspires farmers to decide, and take certain actions (e.g. keeping high cattle numbers, not planting trees and not amending crop fields) is a crucial aspect of the context of environmental degradation in the region. In this discussion, the perceptions and views of the farmers and the possibilities in terms of government initiatives to fight further environmental degradation are addressed.

There is (see Table 8) considerable variation in land ownership in the region although there is no official record of the exact size of each village area including its communal and public grazing lands. Informants' responses on this aspect reflect this vagueness. For communal and public grazing areas consistent responses were expected (i.e. estimates of the extent of the grazing area). Instead, informants responses differed because the size of these areas has not been determined. This is a serious weakness in planning resource usage. If the exact size of a grazing area is not known, a farmer may assume there is enough land for keeping more cattle when it is not actually available. Responses provided (Table 26) may have over - or under- estimated the areas. Varying stocking rates suggested by informants (Table 23), partly arise from this problem. Available information indicates stocking rates of 2-6 ha per livestock unit (Malcolm, 1953) although Walker and Scott (1968) suggest one livestock unit ha^{-1} of grazing land. Informants suggested higher rates. Perhaps this results from a lack of experience of not keeping animals in paddocks. Livestock keepers in Shinyanga Region are used to taking the animals out early and grazing them freely from place to place. Thus, informants have no basis for suggesting few livestock units ha^{-1} $year^{-1}$.

Recommended agricultural practices (e.g. pre-set crop spacing) are not followed, and there are unplanted gaps in crop fields, reducing productivity (Plate 6.1). Soil is frequently exhausted (Plate 6.2) because so few households use cow manure to fertilise cropped fields (Tables 17 and 20) and most crop residues are grazed

Plate 6.1: Seed broadcasting is widely used. Sorghum (above) and cotton (below) in Mwataga village, Kishapu Division. Note the gaps: Farmers offset these by planting large areas.

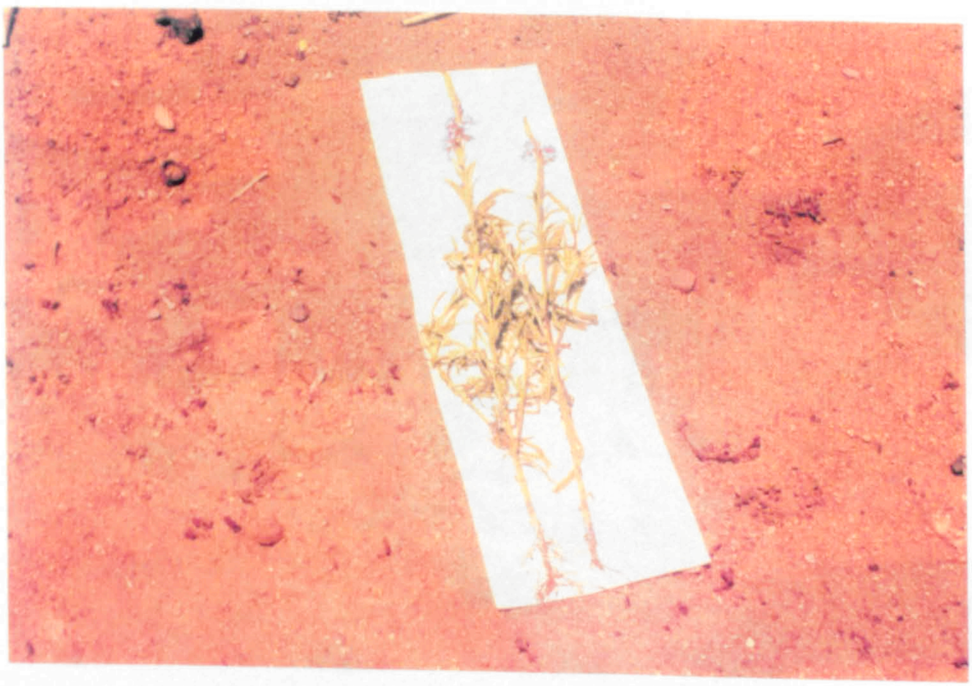

Plate 6.2: Above - stunted cotton due to low fertility levels and, below, the 'maduha' (*Striga* spp) plant which indicates loss of soil fertility in fields which are regularly cropped without manuring (Bulimba village, Negezi Division).

Plate 6.3: Cattle grazing in cropped fields near homesteads. Their droppings improve soil fertility (Mhunze village, Kishapu Division).

during the dry season (Plate 6.3). Other residues are collected for domestic fuel because firewood is no longer readily available close at hand. Biological deterioration has resulted as a consequence of this. The application of cow manure to cropped fields is done by few farmers (see Table 20) This situation arises not because farmers do not realise the benefits behind its application, but is a result of social and economic factors. Social causes include the fact that cattle kraals (bomas) were formerly used as burial places for heads of the households. Such areas are special places and not easily accessible to people. Also, entry into cattle bomas was restricted for fear of witches who could cause cattle death. Economic factors include a shortage of labour and lack of resources (e.g. transportation facilities). Since some crop fields are at a considerable distance from kralls, it becomes difficult to apply cow dung because of the amount of travelling involved. Most farmers are not interested in applying chemical fertilizers on two accounts: primarily a considerable amount of moisture is needed to dissolve them and secondly they are expensive and often not readily available.

There is a need to emphasize the use of animal dung to amend cropped fields. Cow dung is available in the study villages and is more advantageous to use, in order to enhance the fertility and biological processes within the soils, compared to the use of chemical fertilisers, in drought-prone areas. Kabaara (1964) reports that animal dung is balanced with respect to nitrogen and phosphorus, thus producing better growth effects in crops. Policy changes designed to motivate farmers to invest part of their time and labour on amending crop fields to sustain production would be a welcome development. This could be in the form of changes to land tenure systems where homesteads would be close to cropping fields (the distance which farmers have to travel for cropping should be an important consideration) and be granted with rights of occupancy. Also, there should be encouragement of the production and supply of cheap ox-carts and other farm implements (e.g. wheel barrows) to encourage the use of cow dung in cropped fields as a long term solution to declining soil fertility.

The average household size in the study villages was found to be nine members, (the national average is six). This suggests that there are more people to feed in the study area than other parts of the country. To sustain more people and at the same time conserve the environment, necessitates raising crop field productivity through regular amendments. Farmers attitudes to the use of cow manure in their crop fields must change, but this needs concerted efforts from the policy makers and extension personnel if it is to be achieved.

Plate 6.4: Above - cattle grazing but with little grass to feed on (Isoso village, Kishapu). Below - the 'ngitiri' reserve (Bulimba village, Negezi), Shinyanga Region, Tanzania.

Communal and public grazing areas could be used more effectively if village authorities exercised more control (Plate 6.4). The same goes for areas designated for conservation and afforestation purposes. When these areas are controlled by

government workers (i.e. foresters), villagers regard them as government property resulting in conflict with government workers. Such impositions and control by the government on village resources lack incentives for the villagers, resulting in the loss of their support. Villages with a perceived need should be technically supported and encouraged to use indigenous institutions and regulations in order to manage and control their resource usage. It is important that policing and control measures should emerge from the users themselves.

It has been reported (Kerkhof, 1990) that "the people of Shinyanga Region do not like tree planting." To consider this suggestion further, farmers' attitudes and perceptions of trees were sought. For instance, an aged woman in Bulimba village (Negezi) made this comment "if you have several large trees in one hectare, it means that the net area for cropping is reduced. Also ploughing using draught animals becomes difficult because you are forced to go around the trees and some trees have roots near the surface which obstruct ploughing as well". Such a comment clearly demonstrates that the farmer's feelings about having trees in cropped fields are dominated by the problems they create as opposed to their tangible benefits e.g. firewood, poles or fodder. The majority of informants preferred having trees near their homesteads and not where their crops grew. This attitude is a result of long standing traditional practices, and is partly an acceptance of forestry extension ideas.

To what extent do farmers implement government initiatives on tree planting? Government policy aims at achieving tree planting of about 20 trees person^{-1} year^{-1} as a basis for striking a balance between wood consumption and supply (Kaale and Gullinsson, 1985). This study indicates the level achieved has been about 3 trees year^{-1} in Migunga and Isoso villages (Kishapu) and about 2 trees year^{-1} in Bulimba and Mayanji villages (Negezi). Throughout the study *A. nilotica* was mentioned as bad because it leads to land degradation. Where *Acacia nilotica* grows, grasses generally do not, according to informants. Yet *A. nilotica* is publicised as a multipurpose tree with a range of benefits to the farmers including nitrogen fixation and fodder (Bosak and Goyal, 1982; Hogberg, 1992; Jambulingan and Fernandes, 1986; Sharma, 1992; Thormas, 1988). In the field livestock, especially goats, are frequently observed grazing under the tree (see Plate 4.7). They graze heavily on the pods and can be seen to seek out the nearest *A. nilotica* to find these.

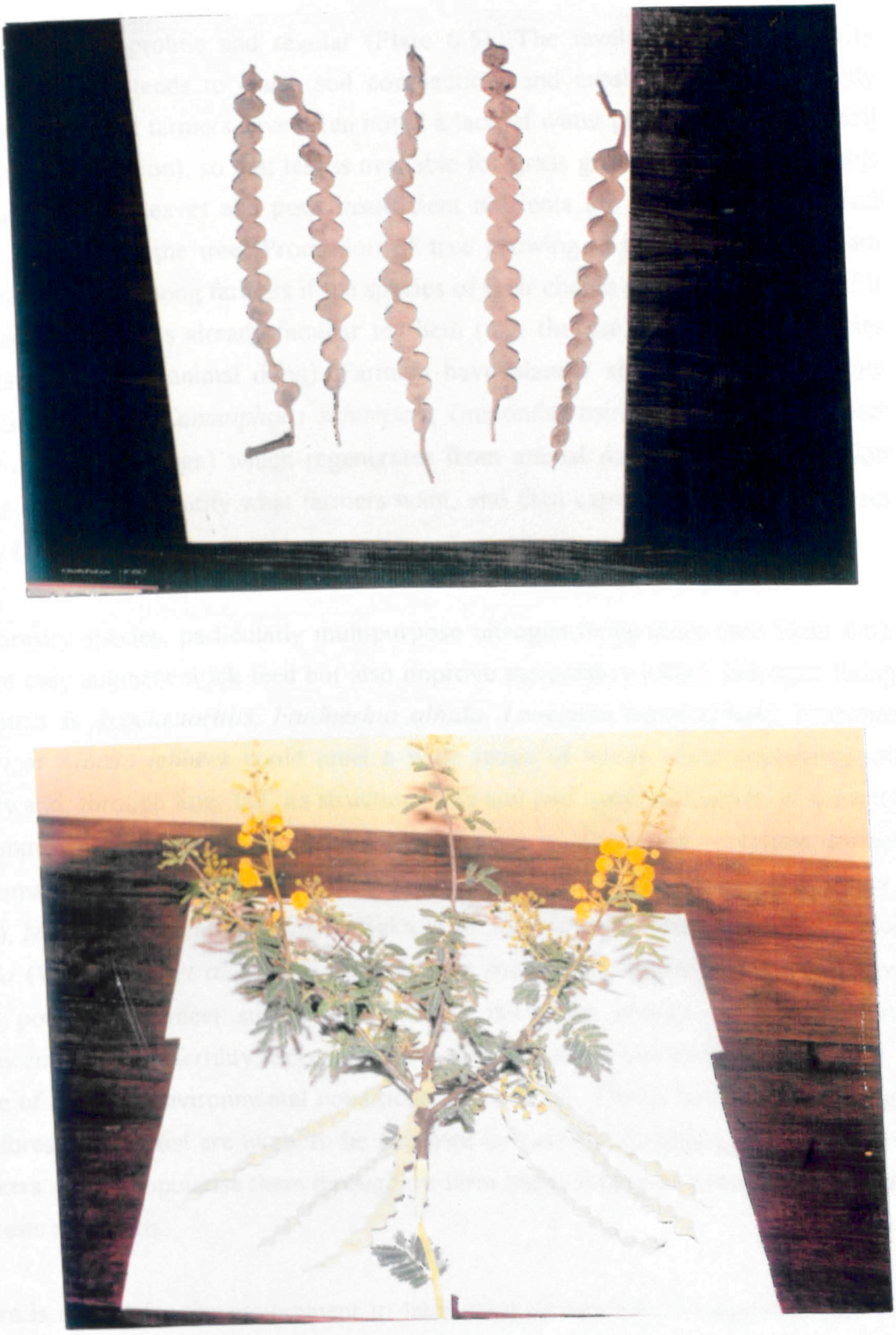

Plate 6.5: Above - Mature pods of *Acacia nilotica.* Below - a branch of A. nilotica with pods which are not mature and flowering in stages.

Pod production is prolific and regular (Plate 6.5). The level of livestock activity around these trees tends to cause soil compaction, and erosion may subsequently occur. In this respect farmers have often noted a lack of water percolating into the soil (because of compaction), so that less is available for grass growth. While the animals feed heavily on the leaves and pods insufficient nutrients are returned into the soil through litter fall at the tree. Promotion of tree growing is likely to meet a more receptive audience among farmers if the species of their choice are considered and if it capitalizes on methods already familiar to them (e.g. the use of cuttings or species regenerating through animal dung). Farmers have planted species like *Combretum* spp, (mitangale), or *Commiphora schimperi*, (miponda) using cuttings and protect *Acacia tortilis* (magunga) which regenerates from animal dung. Forestry extension services should aim identify what farmers want, and then capitalize on the techniques already familiar to them.

Agroforestry species, particularly multipurpose nitrogen-fixing trees (see Plate 6.6), will not only augment stock feed but also improve marginalized sites. Nitrogen fixing trees such as *Acacia tortilis, Faidherbia albida, Leucaena leucocephala, Sesbania sesban* or *Albizia lebbeck* could meet a wide range of needs while improving soil fertility and, through litter fall, its structure. Site soil and water conservation capacity will improve in consequence. Studies elsewhere e.g. Cameroon - *Acacia tortilis* (Duguma and Tonye, 1994), Tumbi Tanzania - *Sesbania* species (Karachi *et al.*, 1994), Malawi - *Faidherbia albida* (Saka *et al.*, 1994) and Zimbabwe - *Faidherbia albida* (Wanyancha *et al.*, 1994) indicate that such multipurpose tree species have great potential to meet smallholder farmer's needs for energy, stock feeds and enhancement of soil fertility. Species like *Faidherbia albida* can perform well under a range of different environmental conditions (Saka *et al.*, 1994). Such species of high agroforestry potential are likely to be accepted by farmers. Foresters and agricultural workers should popularise them through on-farm trials, aiming at meeting the farmer's interests and needs.

There is a need for the government to harmonise its services as suggested (see Fig. 31) in order to develop implementable ideas for the benefits of farmers. Services should be rendered to farmers jointly by extension workers and should be guided by local interests. What is needed are desirable practical services for farmers (Mgeni, 1991). When local interests are ignored, interventions may run into conflict with local communities (Panos, 1991; Repetto, 1988). In the opinion of informants, desirable technical services include how to plant trees, how to prune them, when and how to thin woodlots to obtain good poles, and the introduction of suitable species for the

Plate 6.6: *Leucaena leucocephala* (above) and *Sesbania sesban* (below) planted in cropped fields near the homesteads (Mhunze village, Kishapu Division). Note the use of dead branches of *Acacia* (below) to protect crops from animal damage.

production of these. *Eucalyptus* trees were often mentioned as suitable for the production of poles and timber, which the majority of informants find difficult to obtain (Table 32). Although *Eucalyptus* species have been reported as degrading land (FAO, 1986) and are particularly associated with greater consumption of soil water (Poore and Fries, 1985), the trees grow more rapidly to produce much needed wood; especially in deficit areas. Although the planting of *Eucalyptus* species in some regions (e.g. Singida) has been critisized by politicians in Tanzania, the Wasukuma like them due to there being a critical shortage of building poles and fuel. There are no universal approaches favouring or disfavouring the planting of *Eucalyptus* species. Furthermore, not all trees are good for planting on farm land (Opeke, 1982), or possess all the desirable characteristics (Duguma and Tonye, 1994; FAO, 1988), but with careful selection and identifying favourable sites for tree growing, shortage of wood in Shinyanga could be alleviated. Lobot and Ranaivoson (1994) report successful planting of *Eucalyptus* species to meet local need for domestic energy and timber in Madagascar. Furthermore, growing and selling of Eucalypts is reported to be a profitable activity for small farmers in Gujarat (Conroy, 1993). Thus species like *Eucalyptus camaldulensis* and *E. tereticornis* could be planted in Shinyanga to benefit the farmers. An anticipated problem would be termite attack, but since men like the trees they may protect them from animal damage. On the other hand, the introduction of exotic species should be balanced with local species e.g. *Acacia senegal* (magwata) or *A. polyacantha* var. *campylacantha* (migu) which are adapted to the environment, and could be cheaper to propagate than exotic species (Mnzava, 1985).

The importance of the 'ngitiri' system in the Sukumaland cannot be over-emphasised. It creates a "bank" for pasture used in times of need. Most informants practise the 'ngitiri' system because they own cattle. However, it was learned that a few people practise the system without owning cattle - by renting 'ngitiri' areas to those with cattle when other areas possess no more cattle feed. Thus, practising the 'ngitiri' system could be promoted as a cash earning mechanism.

The most important aspect of the 'ngitiri' system is how its management principles are applied. Normally management manipulations determine the quality and amount of grass. The study has established that farmers have developed 'ngitiri' knowledge and underlying management principles as a result of routine practices and observations. There are no deliberate technical treatments and there has been no introduction of highly nutritive grass legumes to improve productivity. Since 'ngitiri' areas are relatively small in sizes compared to high stocking rates, such technical refinements as introducing improved forage varieties might not produce the desirable changes unless deliberate efforts were made to balance resources and their use. Such a balance would perhaps optimise production in terms of grasses and animal products. Rangeland extension expertise needs to focus on this. Rangelands are the mainstay for the livestock industry in Shinyanga. The study has given insight into what people know in terms of rangeland management and usage. Farmers recognise that the sustainability of rangeland resources varies according to the extent and intensity of grazing and browsing pressure. Nevertheless, the attitude is to increase livestock numbers, especially the numbers of cattle. Perceptions of cattle numbers are problematical because of the socio-economic values attached and the interventions leading to reduction without support from the owners would fail.

In the study area moisture is a limiting factor and according to Rugumamu (1991) it has become an impediment to the development of the livestock industry in Shinyanga Region. The quantity and quality of pasture are influenced by the amount of moisture, and, by site quality. Farmers regard rangeland as an endowment developed naturally through ecological interactions; mainly between grass, trees, climate, soils and livestock. Thus, management practices have been limited to keeping tree density low. There have been no deliberate technical inputs to improve rangeland productivity through raising fodder and/or browse species populations. While the elimination of trees and shrubs encourages grass growth and makes the area more suitable for grazing, a more considered approach to management could be adopted whereby certain tree species which are considered highly nutritive could be managed more effectively. Furthermore, efforts through the seeding and re-seeding of grasses of similar value were not revealed. No such treatments were identified, and instead most of the grazing areas were observed to be degenerating and their ability to support present stock numbers is entirely a natural process. Perhaps this is because the rangelands are common grazing grounds. Usually the management of public and communal grazing areas is negligible (Fries and Heermans, 1992).

Knowledge transfer is another aspect worthy of consideration. In the study villages, no formal system for knowledge transfer (i.e. through documentation) was identified. Knowledge transfer is observed to follow an informal system mainly involving social and cultural outlets. Learning in Sukuma culture starts at childhood and both boys and girls are involved in the process in household activities like farming (see Plate 6.7). The contribution to household activities by children enables them to acquire some knowledge, while at the same time providing a valuable contribution to the work-load. Usually boys and girls are involved in all activities but to varying extents. Thus for instance, girls might be involved in herding (see Plate 5.1) but to a lesser extent

Plate 6.7: Above - a group of boys preparing a field for growing crops. Below - a boy looking after goats as they feed, Bulimba village, Shinyanga Region, Tanzania..

than boys. Likewise, boys might collect and fetch water, but girls receive more encouragement to be involved in this activity than do boys. The base of knowledge needed to manage resources well takes time to build up, particularly in view of pastoral expertise is concerned (Gudrun, 1991). Nowadays, many youngsters spend extended periods away from herding or farming activities (e.g. in attending school or looking for jobs in urban centres), and their chances of gaining local knowledge and skills are gone. Knowledge transfer from parent to child becomes less effective as interactions become less common and the Wasukuma were responding to such external forces by discouraging schooling. However, indigenous knowledge could be upheld and made available to future generations if deliberate efforts are made by scientists to document farmer's knowledge. According to the informants much information about culture and society norms, and what is expected of children when they mature, is told through stories in the evenings when all members sit around the fire (hakikome). Also, knowledge has been noted to spread through dramatised events (e.g. during seasonal celebrations after harvests) or in regular village meetings and social events. Such traditional communication channels are worth considering when designing extension services to transfer information within the society.

There is great potential for both scientific knowledge, and indigenous ecological knowledge to complement each other, particularly in the development of the livestock industry in Shinyanga. Great efforts should be made to improve stock feeds in terms of quantity and quality. Since farmers possess ecological knowledge, scientists should interact with them, supporting their efforts to manage and sustain rangelands and focusing on what farmers would appreciate by adopting inter-sectoral approaches. Discussions with extensionists in the study area indicate that efforts are directed mainly at farmland and veterinary services. No strategies for improving rangeland productivity apart from the foresters trying to rehabilitate severely degraded areas were identified. This is an area needing concerted efforts and attention.

Halting environmental degradation in the Shinyanga Region is no simple matter. Banking on tree planting using seedlings raised in nurseries (Kaale and Gullinsson, 1985; Jerve, 1989; Mnzava, 1985) as the major means to solve the problem is unlikely to have positive early results. The majority of the farmers are not keen to plant trees and there are excessive stocking rates. There is also an unfavourable climate, and other problems including the scarcity of fuelwood and poles (Barrow *et al.*, 1988; Kaale and Gullinsson, 1985; Kikula and Nilsson, 1987; Jerve, 1987; Nelson, 1988; Nilsson, 1983). Furthermore, the rate of land degradation is alarming (Kikula *et al.*, 1991). Something must be done. Only the farmers of Shinyanga can save their own environment. What they need is support from concerted extension efforts based on their indigenous knowledge (Kilahama, 1994; Rana, 1990). They have insights into in-situ conservation (the 'ngitiri' system), and they have been raising some trees through cuttings and also use seedlings regenerating from animal dung. They also know what they want. Thus extension work should help them, using what they already know as the starting point and not by introducing unfamiliar schemes originating elsewhere or bringing in unfamiliar species.

For the extension work to bear fruit, resources (i.e. funds, transport facilities and infrastructure, especially rural documentation centres) are needed. The importance of having small rural libraries to enhance farmers' literacy skills and knowledge is part of rural empowerment (Baregu, 1972; Gaviria, 1992; Mchombu, 1992). Land tenure and nucleated 'Ujamaa' villages were often mentioned by informants as a cause of land degradation and is a problem also reported from other regions (Ndosi, 1989; Wardell, 1990). Banyikwa (1991) reports that the 1975 'Ujamaa' villages Act contributed significantly to the relative neglect of village natural resources in Tanzania. Management of trees on farmland and/or rangeland can successfully be done if tenural rights are clear and enforced according to regional laws and villages by-laws (Shepherd, 1991), and also if local traditions, practices and the social system are taken into consideration (Raintree, 1986).

The government should address these problems urgently in Shinyanga: Commitments should be made to stop further environmental degradation in the region by controlling soil erosion processes. This could be done by allocating sufficient funds for both research and development work. The Government of Tanzania would need support from donor/aid agencies. The region needs this support mainly for training both farmers and extension workers, to carry out socio-economic aspects of research, to provide literature and to set up small rural libraries to enhance reading and writing skills. The National Environmental Management Council should be given a mandate to co-ordinate and make sure these activities are implemented.

Livestock keepers should be categorized into small (≤ 50 cattle), medium ($> 50 \leq 150$ cattle) and large (> 150 cattle) owners to obtain their views on livestock (overstocking) and land degradation. Research should be carried out according to these groups to determine their perceptions of stocking rates and environmental conservation and how the problem could be solved. Priority should be given to the large owners. Factors leading to people keeping more cattle have been identified but this is not enough. Why are cattle owners reluctant to reduce their numbers? Should environmental degradation in Shinyanga Region be left to continue at the expense of cattle? This is an area needing detailed research in order to obtain more input from cattle keepers and to address the issue of dowry as well. The livestock in each village should be censused through the office of the Regional Development Director, in collaboration with the District Executive Director. Livestock numbers have to be related to available grazing areas to see if the resources available can sustain the livestock population. An action plan for each village should be made to ensure that animals and available resources are sustained. The introduction of highly nutritive grass and tree forage might enhance stock feeds and improve animal production. Agroforestry technologies could be alternative options (Nair, 1989) and would significantly reduce demand on forests and woodlands (Raintree, 1986); but it is the user who has to decide (Rhoades, 1987; Prinsley, 1990). Thus, extension should support and complement farmers' initiatives. Villages should exercise control of their natural resources, and initiatives to develop and manage the resources should come from them. Through the action plan, each village will indicate both the magnitude of their actions in terms of labour and other inputs, and, the nature and extent of trees or woodland they have to manage.

Political leaders should discuss environmental conservation activities with the people (e.g. planting and caring for trees, in-situ conservation strategies, reduction of cattle numbers and using cow manure in cropped fields), and offer their support. Periodical interim reviews of programmes annually, and, by a major 5 - year review would help to shape strategies by identifying relevant adjustments and relating targets to achievements and constraints.

CHAPTER 7: RECOMMENDATIONS AND CONCLUSIONS

The study has added to our understanding of the farmer's perceptions of ecological knowledge and how it is related to management styles and practical experiences. Thus from the study the following recommendations and conclusions are made.

Recommendations

The use and management of trees based on sound environmental conditions in the study areas will differ according to land use types (e.g. cropped fields, the 'ngitiri' system or rangeland) and the tenure system. Therefore, the selection of tree species and management practices should be based on these categories to ensure that farmers' preferences are considered. Emphasis should be on local values and those tree species both likely to support and enhance agricultural systems in the area, and also enhance environmental conservation efforts. Scientists should examine the effects of *Acacia nilotica* on crop fields as raised by farmers. This species has high potential for growing in the study areas. It grows fast, withstands browsing pressure, is drought tolerant and produces wood of high calorific value. Thus it deserves scientific attention in terms of research based on farmers' perceptions. Land and tree tenurial rights should be addressed to empower and motivate both individuals and communities in order to manage and utilize natural resources sustainably.

A detailed study involving cattle owners, and focusing on large cattle owners (over 150 cattle) at first, followed by medium and small owners respectively is recommended. This would reveal their perceptions and what they feel about environmental degradation vis-à-vis large cattle numbers. The effects of cattle on the environment (e.g. soil compaction, the suppression of plants, and regeneration and growth rates) in eastern Shinyanga need thorough investigations.

The penetration of the cash economy (i.e. cotton farming) is a good idea. However, such a move often leads to the sacrifice of natural forests and woodlands which are important for environmental conservation. The policies should aim at a balanced approach, and farmers should be encouraged to grow trees for cash incomes (i.e. poles, firewood or charcoal) as tradable products as well.

A study of the factors which determine individual levels of indigenous knowledge and the extent to which the society (local communities) values indigenous knowledge is desirable. Sound ecological practices are not followed and causation include social-cultural factors. A detailed study on these is necessary in order to suggest viable solutions

On-farm trials using multipurpose trees such as *Faidherbia albida, Acacia tortilis, Leucaena leucocephala, Sesbania* species or others (the list is not exhaustive) is an important need. Agroforestry, proper land husbandry including managing woodlands and integration of extension efforts, should be tied into the region's land-use policies to ensure sound environmental conditions.

Conclusions

Language and the untimely release of funds to translate taped interviews were the main constraints during the study. However, the following conclusions are drawn from this study:

Farmers in the study villages are quite knowledgeable of their environment and manipulate it in order to sustain their survival. Environmental degradation is a perceived problem but people are forced to take short term solutions in order to counter the effects of drought and socio-economic factors including government interventions. Since options and resources are limiting their struggle for survival (e.g. keeping more cattle or cutting trees), this lead to environmental degradation.

The current Government livestock development policy document (Published in 1986) makes no reference to the importance and contribution of forests and trees to the diet and well-being of livestock. According to local ecological knowledge, forests and trees are used by livestock as part of their diet especially during the dry season and as source of medicine for curing sick animals. Unless these issues are valued and acknowledged in the regional policies they remain a key limiting factor on rangeland productivity.

The rangeland policy also assumes equal opportunities for both farming and livestock activities. However, according to the informants', government policies deliberately favour cropping (in particular cash cropping) more than rangeland advancement. Thus, cotton farming is reckoned as a factor responsible for shrinking grazing areas.

The rangeland policy makes provision for a 10% reduction in cattle numbers $year^{-1}$ and also stipulates that stock numbers in a given locality should not exceed the ability of the resources to sustain them. But in terms of indigenous ecological knowledge there has been no tradition of interest in keeping cattle numbers low and stocking rates are regarded as not responsible for environmental degradation. In general the informants' opinion about this were that environmental deterioration is due to government intervention (e.g. the villagisation programme).

Finally, scientific and indigenous knowledge are complementary and there is scope for the scientists, especially extensionists and rural development experts, to work with the farmers and pastoralists to uplift rural life. Should antagonism arise, mutual ways of resolving issues should be reached by both.

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APPENDIX 3.1: List of settlements extracted from maps (1: 250 000)

Negezi Division	Kishapu Division
VILLAGE	VILLAGE
Itilima	Lubaga
Ikonokelo	Ndoleleji
Ikoma	Mhunze
Ilebelebe	Mwataga
Lilindilo	Mwamagembe
Mwamala	Migunga
Mwajiginya	Kishapu
Kiloleli	Ipeja
Miyuguyu	Bulekela
Muguda	Buzinza
Beledi	Masanga
Lagana	Mwajidalala
Mihama	Ng'wankalanga
Mwamadulu	Iboja
Busongo	Lalago
Isagala	Inenekeja
Gimagi	Unyanyembe
Mwamalasa	Wella
Ngeme	Gulu
Mwamashele	Sulu
Inolelo	Kakola
Kalitu	Kinampanda
Mwamagembe	Mwamalasa
Ngofila	Mwamashimba
Igaga	Bupigi
Ukenyenge	Shagihilu
Mayanji	Ngundangali

Appendix 3.2 : List of official villages in Kishapu Division

WARD	VILLAGE
KISHAPU	Lubaga
	Isoso
	Mhunze
	Mwataga
	Mwamagembe
	Migunga
	Kishapu
	Mwanuru
MASANGA	Bulekela
	Buzinza
	Masanga
	Mwajidalala
	Ng'wankalanga
MWAKIPOYA	Iboja
	Ngeme
	Mwakipoya
	Mwangongo
MWAMALASA	Kinampanda
	Mwamalasa
	Mwamashimba
	Magalata
	Mwandu
SHAGIHILU	Gimagi
	Ndoleleji
	Mwalata
	Sanjo
	Shagihilu
SOMAGEDI	Kisesa (Imalabupinda)
	Malwilo
	Wimate

UCHUNGA	Bupigi
	Kakola
	Ngundangali
	Dugushilu
	Igaga
	Inenekeja
	Unyanyembe
	Wella

List of official villages in Negezi Division

WARD	VILLAGE
ITILIMA	Ipeja
	Itilima
	Ikonokelo
	Ikoma
	Ilebelebe
	Lilindilo
	Mwamala
	Mwajiginya
KILOLELI	Kiloleli
	Miyuguyu
	Muguda
LAGANA	Beledi
	Lagana
	Mihama
	Mwamadulu
MWAMASHELE	Bubinza
	Busongo
	Isagala
	Mwamashele

NGOFILA	Inolelo Kalitu Idushi Ngofila Mwamanota
TALAGA	Kijongo Lugunya Nhobola Ngunga
UKENYENGE	Bulimba Ikonda Negezi mayanji Mwaweja Mwajiginya Ukenyenge

APPENDIX 3.3: Villages visited during preliminary surveys (Kishapu Division).

Village	Number of house holds	distance from Shi nyanga (km)	% of household with li vestock
Wella	266	30	70
Ngundangali	274	30	55
Unyanyembe	260	45	55
Igaga	227	48	70
Mhunze	1534	50	30
Isoso	205	55	70
Kishapu	274	58	65
Mwataga	255	61	70
Lubaga	230	66	60
Mwamagembe	213	70	72
Shagihilu	277	70	50
Migunga	233	72	60
Mwakipoya	308	72	70
Mwagashi	255	74	70
Ndoleleji	312	80	60
Kisesa	336	83	65
Sanjo	252	83	65
Gimagi	227	85	60
Masanga	401	98	40
Mwamalasa	308	96	70

VILLAGES VISITED DURING PRELIMINARY SURVEYS (NEGEZI DIVISION)

Village	Number of house holds.	Distance from Shi nyanga (km)	% of households with liv estock
Itilima	210	6	40
Ikonokelo	214	8	45
Nhobola	472	25	66
Mayanji	215	32	53
Negezi	271	34	58
Ukenyenge	447	35	40
Bulimba	236	39	70
Ikonda	320	39	60
Mwaweja	204	46	50
Mwajiginya	217	47	57
Miyuguyu	182	57	40
Mwamanota	359	58	68
Mwamashele	295	60	56
Kijongo	334	68	65
Lagana	282	76	62

Appendix 3.4: Provisional list of seven villages identified as potential study areas.

Division	Village identified	Distance from Divisional cent
Kishapu	Sanjo	22 *
	Migunga	17 *
	Isoso	5 +
	Igaga	2 +
	Unyanyembe	10
	Gimagi	35
	Wella	20
Negezi	Bulimba	4 *
	Ikonda	6 +
	Mayanji	5 *
	Mwamashele	25 +
	Negezi	2
	Mwajiginya	12
	Mwamanota	42

Key: * Selected study village
+ Alternative study village (reserve)

Kishapu Division

Selected: 1. Migunga 2. Sanjo Reserved: 1. Isoso 2. Igaga

Negezi Division:

Selected: 1. Bulimba 2. Mayanji Reserves: 1. Ikonda 2.Mwamashele

Appendix3.5: Questionnaire for quantitative data

1. Name....Village....Ward....Division....District....

2. Sex: male/female age....years
   Education: illiterate
   literate - primary education std i-vii
   secondary education
   adult education

3. marital status: married, single, widow, divorced

4. How many members of your family? ....

Age (years)	Males	Females
1-10		
11-18		
19-30		
31-60		
>60		

5. Occupation : farmer, herder, both, others
   (specify) ....

How much time do you spend on various activities

Type of activity	who is responsible	time used hour/day and month done
Land preparation		
planting crops		
trees		
weeding		
manuring (fertilizer)		
cow dung		
harvesting crops		
processing crops		

cooking
caring children
washing cloth
cleaning compound

6. How big is your land? ...... ha in one location or scattered?
if scattered specify locations and distances from home

A	ha	km
B		
C		
D		

7. How did you acquire your land?
inherited from parents
through government allocation
bought it
others (specify)

8. Nearest crop fields km ; far crop fields km from home
mention crops grown in each and why?

Near	Crops grown and reason
1	
2	
3	
4	
5	

Far	Crops grown and reasons
1	
2	
3	
4	
5	

9. What crops do you grow each year and reasons

type of crop	reason for growing	acreage (ha)	average yield
sorghum			
millet			
cassava			
sweet potatoes			
beans			
paddy			
maize			
cotton			
others (specify)			

10. Do you mix various crops together? if yes please specify by type and reasons for practising

type of crops mixed	Reasons for doing so
1	
2	
3	
4	
5	

11. Do you fertilize/manure your crop fields? if yes indicate below if not state reasons for not applying

Type of fertilizer/manure	amount used/ha	type of crop grown
1		
2		
3		
4		
5		

12. Do you have trees on your farm? if yes what type and why?

Name of tree	Reasons for keeping it on farm
1	
2	
3	
4	
5	

13. Do you see mixing crops with trees on your farm as a good or bad thing? please explain

14. Do you consider having more tree in your village as a good or bad thing? please explain

15. If more trees are to be planted in your village can you. suggest how best this can be achieved?

16. Please list below five tree species you prefer for planting and why?

Species name	Reason (s)
1	
2	
3	
4	
5	

17. How many trees have you planted for the last 5 years?

Name of tree	1987	1988	1989	1990	1991
1					
2					
3					
4					
5					

6
7
8
9
10

where did you get your planting stock?...............................
what type : seeds, seedlings, cuttings?
other types explain...................where did you plant them (specify)...............

18. Of the planted planted how many survived?

Name of tree	1987	1988	1989	1990	1991
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

If your trees died please state reasons leading to death?

19. Have you planted trees fodder ? if yes what type and for feeding what type of animals and if not why?
If you have how much do you feed to your animals

	type of fodder	amount given/day	Reasons
cattle			
goats			
sheep			
donkeys			
others			

20. Where do you get your wood for cooking, poles, timber from?

21. What type of tree species you prefer for firewood and why?

22. Who is responsible for firewood collection?
how much time is spent on this activity?
how often is the collection?

23. Availability of trees for where available

	1-2km	2-5 km	> 5 km	not available
firewood				
poles				
timber				
fruits				
medicines				
others (specify)				

24. Do you keep livestock? if yes how big is your herd

type of livestock	number	reason for keeping
cattle		
goats		
sheep		
donkeys		
pigs		

25. If your given opportunity to increase or decrease size of your herd which one would you prefer? what type of livestock you may decrease or increase and why?

26. How many units of livestock can one ha of grazing land support on sustainable basis?

type of animal	numbers per ha	comments
cattle		
goats		
sheep		
donkeys		

27. Where do you graze your animals?

where to graze	area (ha)	distance from home (km)
own land		
communal land		
public land		
other areas		

28. What good or bad side of livestock please explain?

Good in terms of	explanation
1	
2	
3	
4	
5	
6	

Bad in terms of	explanation
1	
2	
3	
4	
5	
6	

29. Who does the grazing?

type of livestock	one responsible (men, women, boys, girls)
cattle	
goats	
sheep	
donkeys	
calves	

Do you mix your animals together? please explain ....

....

30. Please name at least five natural tree species you know which are eaten by livestock?

Name of tree	eaten by cattle/go	part eaten: leaf/p or fruit	season when ea	comment
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Appendix 3.6: 'Ngitiri' System - statements verified

Management practices

1. Quantity of grasses ngiriti areas would increase if grazing during the wet season is restricted.
2. 'Ngitiri' areas are closed from grazing in February if soils fertility is low
3.'Ngitiri' areas are closed from grazing in March if soil fertility is high.
4. grasses in 'ngitiri' areas would increase if grazing is for eight months beginning from March.
5. 'Ngitiri' areas are closed from grazing in February if rainfall is below average.
6. 'Ngitiri' areas are divided into one ha units and each grazed at a time
7. Five cattle can graze in one ha for not more than one month
8. 'Ngitiri' areas are re-opened for grazing in October
9. 'Ngitiri' are closed from grazing in March if rainfall is normal

Biological processes

1. 'Ngobi' grasses are more drought resistant than 'supyu' grass
2. Grasses suitable for 'ngitiri' areas should have deep rooting habit
3. Suitable grasses in 'ngitiri, areas should withstand heavy grazing pressure
4. Quantity of grasses would increase if soil moisture is increased
5 Soil is suitable for 'ngitiri' if it would retain water for 2 month after rainfall
6. Grass growth rate increase if soil fertility is high
7. Grass regeneration rate would increase in 'ngitiri' if have produces adequate seeds

Interactions

1. *Acacia nilotica* in 'ngitiri' areas regenerate if goats graze there
2. Trees in 'ngitiri' areas reduce soil erosion rates.
3. Trees cause an increase in accumulation of clouds.
4.Trees in 'ngitiri' areas enable more rain water to sink into the soil.
5. 'Ngitiri' areas are a source of thatch grasses
6. Trees in 'ngitiri, areas provides resting shade to cattle during hot sun
7. I own my 'ngitiri' of _ha in which I graze _cattle (number of cattle) for _months (number of months) beginning in October

8. 'Malamata' or 'ngobi' grass types increase milk production if eaten by lactating cows in fresh condition (green)

Rangeland-tree resource base

(i) Management practices

1. Trees such as *Commiphora cuminii* or *Euphorbia tirucalli* are used to establish live fences.
2 Cuttings for establishing *Commiphora cuminii* should be 2 metres high
3 Cuttings for growing *Euphorbia tirucalli* should be 0.5-1 metre high
4. Termite attack cuttings of *E. tirucalli* if too young or too old
5. Cuttings should be planted 3-4 weeks before or after rainfall
6. Grazing is done in mbuga soil mainly during the dry season
7. Density of trees in rangelands is reduced by cutting to permit increased grass growth
8. grazing is done in 'ibambasi' soils during the wet season

(ii) Resource utilization

1. Roots of 'ngada' trees are used to treat effects of 'mashokolo' to cattle
2. Cattle can feed on leaves of such trees like *Adansonia digitata* if branches are cut
3. Roots of masagala can treat 'nkono' disease in cattle
4. Good firewood species should burn slowly producing hot fire
5 Firewood species should be easy to split and dry
6. Fruits of *Balanites aegyptiaca* are edible to humans and livestock
7. Wood resin/gum is collected from *Acacia senegal* and *A. drepanolobium* from July
8. Leaves of *Tamarindus indica* can treat aenemia (bupe)
9. Ntelengu grass is good for thatch
10. Mayoba are obtained in rangeland during April
11. *Acacia mellifera* is good for fencing
12. Migu is suitable for making 'majoki'

(iii) Biological aspects

1. Termite attack cuttings of *E. tirucalli* if too young or too old
2. Miyuguyu trees grow scattered because their seeds are difficult to germinate in ibambasi 'soil'
3. Roots of *Euphorbia tirucalli* do not grow deep

4. Trees which are deep rooted have green leaves throughout the year.
5. Roots of matunduru do not grow deep as those of malulambuli
6. Mihale trees are easily spread through animal dung
7. Inccreased soil fertility leads to increased grass growth rates
8. Acacia nilotica regenerates through seeds
9. Acacia fischeri regenerates through root suckers
10. Malula become leafless during the dry season
11. Magobeko retain leaves during the dry season
12. Digestion in cattle occur while they are resting under tree shade.

(iv) Interactions

1. People eat Fruits from *Balanites aegyptiaca*
2. 'Maturnduru' trees grow fast in mbuga soils
3. A tree will produce heavy shade if it has many branches and large leaves.
4. Trees suppress grass growth if they branch near the ground and grow like a bush.
5. Grass quantity in the rangeland will increase if trees are scattered
6. Goats eat pods of *Acacia nilotica*
7. A tree will produce light shade if has few branches and small leaves
8. Cattle eat tree leaves if they are green and sweet
9. 'Lugilanyama' grass is shade tolerant
10. Grass growing under tree shade are weak tends to be tall and thin.
11. *Acacia nilotica* degrades land because it produces large and long roots
12. *Acacia tortilis* improves soil because its leaves decompose faster than those of *Combretum abovatum*.
13. An increase in amount of rainfall causes an increase in amount of soil water.
14. An increase in amount of tree roots in the soil causes a decreased amount of soil water
15. Heavy tree shade causes a decreased amount of sun light reaching the ground.
16. Mikomagwa trees produce heavy shade
17. When cattle feed on 'mashokolo' their stomach swell.
15. Cattle grazing rate is affected if density of Acacia drepanolobium is high
17. Leaves of 'ukwaju trees are used to treat aenemia in children
18.Amount of sunlight reaching the ground is reduced if tree population on rangeland is increased.
19. Cattle cannot graze well if population of 'malula' trees is increased.
20. Mikomangwa trees produce light shade

Appendix 3.7: Informants statements of fact on the 'ngitiri'[1]

1. Ngitiri boundaries are marked by maseso (3)
2. Maseso is heaped soil which can be seen from a distance of 300 metres away (2)
3. Cattle graze in ngitiri areas when other areas have no grass (4)
4. Ngitiri are very useful to calves (6)
5. Ngitiri are useful to old cows (19)
6. Ngitiri are useful to sick cows (12)
7. ngitiri areas are divided into sections (8)
8. Ngitiri areas are a source of thatch grass (23)
9. Ngitiri areas must not be cultivated (17)
10 Cattle graze in each section of ngitiri at a time before moving into the next section (14)
11. Ngitiri reserves started during the British rule (24)
12.Ngitiri is an area which conserves grass for future grazing (39)
13 Ngitiri are closed from grazing in April IF soils are highly fertile and lots of water available (4)
14. Grass quantity will be increased IF ngitiri areas are closed from grazing in February (3)
15. Individual ngitiri areas are 1 km from the household (43)
16. Ngitiri are closed from grazing in April IF rainfall is more than the normal amount (7)
17 Ngitiri are used for grazing cattle between October and march (12)
18. Ngitiri are opened for gazing in October (8)
19 mbuga soils have a high level of soil fertility (6)
20. Trees in ngitiri areas provide resting shade to cattle(21)
21. Trees in ngitiri are a source of browse to livestock (9)
16. Ngobi grass is more drought tolerant than supyu grass (21)
17. Ngobi grass has strong roots (60)
18. Grass is suitable for ngitiri areas IF it can withstand heavy grazing pressure it has deep and strong roots (21)
19) ngitiri areas should be closed from grazing in February IF the area has shallow soils (8)
20. Grass quantity in ngitiri areas increase IF grasses have produced seeds soil moisture is adequate no grazing takes place for a period of more than 6 months (12)
21. Population of ticks is more in ngitiri areas than in others grazing areas (3)
22. Ticks increase animal disease IF deeping is not done (50)
23 Ngitiri is owned individually (39)
24. Ngitiri is managed privately (65)
25. Hazina is a type of ngitiri (5)
26. Hazina is owned communally (13)
27. Hazina is managed communally (6)

28. Size of Hazina is more than that of ngitiri (2)
29. Grasses in ngitiri areas are sustained IF grazing animals do not exceed 5 cows per hectare (10)
30. Size of rain drops from tree canopy is more than those in open areas (11 women)
31. An area is suitable for ngitiri IF it retains water for more than a month it has fertile soils grasses like ngobi are dominant (35)
32. Hazina is more than 100 hectares (10)
33. Tree density in ngitiri areas causes an increase in soil erosion rate if no grass cover underneath (18)
34. Increase in amount of soil water causes an increase in grass growth rate (19)
35. Ngitiri areas should be devided into sections for grazing (32)
36. Grazing in sections is done at a time to allow systematic grass usage (32)
37. Grass roots can dry up easily if exposed to sun shine (20)
38. Grass roots are exposed to the sun when soils are eroded by rain water (12)
39. When grass roots become dry grass leaves also become dry which leads to grass shortage ((8)
40. When some grass roots become dry rate of grass growth is also reduced (6)
41. When soil erosion rate increase gullies are created (8)
42. When gullies become many in an area land become unsuitable for grass growth (4)
43. Increased cattle numbers causes high erosion rates which lead to gullies (24)
44. Soil compaction causes loss of rain water through surface run off (62)
45. Cattle makes soils loose hence soil erosion occur (20)
46. In compacted soils grass do not grow well compared to uncompacted soil 18)
47. Ngitiri reserves causes an increase in tree density IF no oats can go there (11)
48. Ngitiri reserves results in grass conservation (52)
49. Grass conservation causes a decrease in soil erosion rate (24)
50. Decrease in soil erosion rate causes increase in soil fertility (34)
51. Grass conservation causes an increase in soil fertility (46)
52. Increase in tree density causes decrease in soil erosion rate (25)
53. increase in soil fertility causes increase in amount of grass (75)
54. Increase in amount of grass causes increase in amount of stock feed (81)
55. Increase in tree density causes increase in amount of tree forage (9)
56. Increase in amount of tree forage causes increase in amount of stock feed (17)
57. Grass conservation causes an increase in grass biomass (9)
58. Grass conservation results in grass maturity
59. Grass maturity causes an increase in amount of grass seeds (13)
60. Increase in amount of grass seeds causes increase in grass regeneration rate (10)
61. Increase in grass biomass causes decrease in surface run off (14)

62. Decrease in surface run off causes increase in amount of water in soil (11)
63. Increase in amount of water in soil causes increase in grass regeneration rate (28)
64. Increase in amount of stock feed causes increase in quantity of animal food intake (21)
65. Increase in quantity of animal food intake causes increase in animal body weight (19)
66. Increase in animal body weight causes improved animal condition (13)
67. Improved animal condition results in higher selling price conditions (3)
68. Improved animal condition causes an increase in amount of milk production (35)
69. Increase in amount of milk production causes increase in household income (29)
70. Higher selling price causes an increase in household income (3)

Rangeland-tree resource base : statements of fact from informants

1. Cattle eat leaves of mihale IF branches are cut (23)
2. Goats eat leaves of mapumbula (17)
3. Livestock eat leaves of misingisa (14)
4. Ngada tree leaves are used to relieve cattle stomach filled with gases (7)
5. Ngada tree roots are used to release gases from cattle stomach IF the cow can drink its solution (18 men)
6. Cattle eat dry pods of mihale IF drop down or branches with pods are cut for them
7. Goats eat leaves of mihale IF branches are cut or the tree is not big and goats can climb to reach the leaves (28)
8. Milusina trees have leaves all year around (8)
9. Makalinga have leaves throughout the year
10. Goats eat pods of malula (*Acacia drepanolobium*) IF had fallen down or can reach them (40)
11. Lushemeli birds eat ticks from cattle skin (12)
12. Ticks suck blood from cattle (5)
13. Livestock eat leaves of milusina (54)
14. Goats eat leaves of sawi which are plenty between October and May (3)
15. Cattle eat green leaves of mimanje trees IF can reach them or tree branches are cut for them to eat the leaves (74)
15. Minyaa trees (*Euphorbia tirucalli*) are effective in reducing the force of wind IF are closely planted (16)
16. Mawodi is type of weed which strungle cotton roots (9)
17. Magunga trees (*Acacia tortilis*) are large tress when they reach over 30 years (17)
18. Masanzu are branches of trees used for making cattle kraal (41)
19. Goats eat leaves of malugala (20)
20. Miyuguyu trees are used for samba (12)
21. Samba is a medicine to make a person be liked by others (4)
22. Miyuguyu trees do not have leaves between June and October (13)
23. Ngubaru produce sweet fruits (23 women)
24. Ngubaru fruits are ripe in February (23)
26. Miyuguyu trees grow scattered (2)
27. Ukwaju (*Tamarindus indica*) leaves are used to cure surua (10)
28. Mihale trees have large roots (58)
29. Mihale trees have leaves all year round (91)
30. Minyaa trees cannot withstand strong winds like mihale (4)
31. Malula trees attain higher rate of growth in mbuga soils than in ibambasi soil (33)

32. Goats eat flowers of malula trees IF they drop down (8)
33. Malula trees branches are closed up together (26)
34. Branches of malula trees are about 1 metres long (7)
35. Malula trees have sharp thorns (63)
36. Malula trees have many thorns (48)
37. Cattle cannot eat leaves of trees IF the trees have many long thorns (33)
38. Cattle eat leaves of miyuguyu (38)
39. Cattle eat leaves of malobashi (19)
40. Manalo produce strong natural rope (24)
41. Malugala produce strong natural rope (5)
42. Cattle eat leaves of misingisa trees IF branches are cut and fall down (15)
43. Mimanje trees have large leaves (43)
44. Leaves of mimanje trees are green even during the dry season (43)
45. Cattle eat young leaves of Mimale trees (41)
46. Trees have large roots IF they have large canopies (19)
47. Trees have quite green canopies IF they have very deep roots (52)
48. Trees with long roots can get water from far (58)
49. Livestock eat cotton stocks (90)
50 A tree has large canopy IF its branches are quite long branches are many and its leaves are large
51. Goats eat pods of magunga IF dry and had fallen down (49)
52. Mbuni is a type of bird found in mbuga (53)
53. Lonzwe is a type of plant that can cure cattle disease called nkono (45)
54. Nkono is type of disease which affects fore legs of cattle (54)
55. Matunduru trees have high rate of growth IF soil is of mbuga type (6)
56. Livestock eat crop residues between July and October IF crops are harvested (125)
57. Mwandu *(Adansonia digitata)* grow in stony areas (23)
58. Mwandu trees have big hole inside IF they are very large (17)
59. Goats eat leaves of misongoma trees (29)
61. Mwandu trees grow in reddish soils (63)
62. Malugala trees are not attacked by termites IF have matured (35)
63. Malugala trees have hooked thorns (36)
64. Cattle movements are restricted IF there are many thorny trees and with branches touching each other (46)
65.Goats browse thorny trees (26)
66. Matula are used to treat cows refusing to feed their calves. (12 men)
67. Trees produce heavy shade IF have branches 1 metre above ground, branches touch each other and have many leaves (16)

68. Cattle increase weight between December and June IF there is enough grass to eat (36)
69. Amount of rainfall received per season will govern amount of grass and tree forage. (131)
70. Wide spaced trees in rangeland allow more air to circulate (12)
71. Cattle can move more freely IF trees in grazing areas are widely scattered (16)
72. Leaves of ngada tree are used to cure cattle nkono disease (21)
73. Michongoma trees grown from seeds (15)
74. 1500 cattle can graze in 50 hectares for 1 month (2)
75. Cattle use sense of smell to select type of tree forage to eat (42)
76. Amount of greenness colour in tree leaves tracts cattle IF grasses are not found or too dry (60)
77. Solution of masagala root can cure nkono disease in cattle IF boiled and given to cattle (45)
78. Goats eat pods of matunduru IF dry and had fallen down (48)
79. Masagala is a medicinal tree (24)
80. Cattle eat pods of magunga trees IF have fallen down (19)
81. Goats eat leaves of magunga IF branches are cut or they can reach them (42)
82. Cattle eat leaves of magunga trees IF branches are cut for them (18)
83. A tree will have plenty of grass growing underneath IF has light shade and branching 5 metres above ground (60)
84. Donkeys eat tree forage (25)
85. Donkeys eat grasses (32)
86. A tree produces light shade IF it has small branches with small and few leaves ((42)
87. Goats eat dry pods of masubata IF they fall down (12)
88. Goats eat pods of magwata IF they fall on the ground or (89. Goats eat leaves of magwata trees (Acacia senegal) (23)
90. Cattle eat leaves of mikuyu IF no grasses are found (52)
91. Cattle eat leaves of mikoma trees IF the branches are cut and fall down (36)
92. Cattle eat leaves of masubata (54)
93. Cattle eat leaves of miperemese (32)
94. A tree will cause a decrease in amount of grass biomass IF it has many large leaves, and with branches 1 metre above the ground. (64)
95. Cattle eat leaves of malobashi trees (27)
96. Cattle eat leaves of midagwasa trees (34)
97. Scattered trees in gangelands minimize shading effect to grass (14)
98. Mihale trees are taller than malula (142)
99. Mihale trees grow bigger than malula (142)
100. Mitangale trees are grown from cuttings (59)

101. Tree leaves are palatable to cattle IF soft and sweet (54)
102. Cattle eat leaves of malusunga (25)
103. Cattle eat leaves of malubisu (35)
104. Cattle eat leaves of madubilo (16)
105. Makalinga are grown from cuttings (77)
106. Goats eat pods of malugala IF they can reach then or had dried and fallen down (89)
107. Milusina trees are grown from seeds (13)
108. Goats eat leaves of masagala trees (54)
109. Minyaa grow from cuttings (122)
110. Magunga are large trees IF over 10 years old (23)
111. Magobeko trees are green all year around (19)
112. Mimanje trees have leaves throughout the year (83)
113. Mlundalunda is medicinal tree which cures tambazi disease (60)
114. Mnengonengo is a medicinal tree (24 women)
115. Mondo is a medicinal tree (36)
116. Mkuta is a medicinal tree (60)
117. Minyaa trees are planted to reduce force of wind (8)
118. Goats eat leaves of misese trees (27)
119. Goats eat leaves of manalo trees (66)
120. Goats eat pods of manalo IF they fall down (21)
121. Matunduru trees have round canopy (36)
122. Magwata trees branches are very close together (18)
123. lwabu grass is shade tolerant (17)
124. Cattle eat lwabu grass (14)
125. Lugilanyama grass is shade tolerant (19)
126. cattle do not eat lugilanyama grass (36)
127. Mahombolelwa is creeping plant (24)
128. Grasses growing under tree shade have shallow roots ((58)
129. Grasses growing outside tree shade develop deep roots (8)
130. Malugala has thick round canopy (36)
131. Mikomangwa has light shade (52)
132. Masagala trees have light shade (39)
133. Soil is good for roofing matembe house IF does not allow easy penetration of water and forms a plastic like sheet when it comes into contact with water (26)
134. Ibambasi soil is good for roofing matembe houses (33)
135. Magunga has partial shade (62)
136. Malulambuli has light shade (74)
137. Mikoma trees have heavy shade (than magunga (96)

138. Ukwaju produce heavy shade because it has many leaves (42)
139. Magunga trees improve soil fertility (56)
140. Magunga leaves decompose faster than those of magobeko (56)
141. Malula trees shed leaves between June and October (70)
142. Miandu trees shed leaves between June and October (147)
143. Masagala trees attain high rate of growth IF the area has adequate moisture (19)
144. Masagala are medicinal trees (60)
145. Matunduru trees have shallow roots (25)
146. Malula trees are deep rooted (11)
147. Malulalambuli are deep rooted (23)
148. Malulambuli is a medicinal tree (36)
149. Roots of magunga trees are used as medicine (36 men)
150. Cattle eat leaves of jilyamawimba (54)
151. Jilyamawimba is a creeping plant ((46)
152. Jilyamawimba produce edible fruits and has leaves throughout out the year (37)
153. Cattle eat leaves of mahushi trees (64)
154. A tree is good for firewood IF it will produce less smoke (56 women, 14 men)
155. Mihale is good for firewood because it does not irritate eyes and it is easy to split (70)
156. Mihale is good for firewood because it can dry easily (14 men)
157. Magwata trees are good for firewood because they burn slowly producing strong and hot fire (70)
158. Cattle eat leaves of misangwasangwa trees (35)
159. Cattle eat leaves magobeko trees IF dry and have dropped down (42)
160. Mihale trees drain soil water (58)
161. Goats eat dry pods of mihale (*Acacia nilotica*) IF drop down (55)
162. Goats eat fresh leaves of malula mbuli (59)
163. Masagala trees produce lot of smoke (56 women)
164. Misingisa trees produce heavy shade (113)
165. Cattle eat leaves of mibapa trees (13)
166. Masagala trees are not good for firewood (8)
167. Roots of misongoma are used to cure children fever (24 women)
168. Miyuguyu trees produce edible fruits (64)
169. Cattle eat fresh leaves of mibuyu (*Adansonia digitata*) IF branches are cut and fall down (42 men, 12 women)
170. Goats eat fresh leaves of minyaa IF have nothing else to feed on is available (26)
171. Goats eat leaves of malula (48)
172. Small branches of mimanje trees are good for tooth brush (32)
172. Mimanje trees are not good for firewood (54 women)

173. Mimanje trees burn quickly (8 men)
174. Mimanje trees when burn produce lots of smoke and ashes (62)
175. Tree shade keeps temperatures low (46)
176. Cattle eat leaves of masagala (56)
177. Cattle rest under the tree shade when the sun becomes too hot while grazing (54)
178. Miyuguyu trees (*Balanites aegyptiaca)* are a source medicine for curing stomach (24)
179. Miyuguyu trees grow scattered (6)
180. Seeds of miyuguyu trees are hard to break (19)
181. Seeds of miyuguyu trees are not easily covered by soil (7)
182. Songa is type of natural green vegetable ((36 women)
183. Mlenda is natural green vegetable (36 women)
184. Malimbe is a natural green vegetable (28)
185. Grass biomass is more under malula trees than under mihale (35)
186. A tree produce heavy shade IF it has many branches many and leaves (25)
187. Some trees shed their leaves because of soil getting too dry (24)
188. Minyaa trees are not good for firewood (56 women)
189. Minyaa trees when burning produce irritating smoke (56)
190. Masubata trees are not good for firewood (54)
191. Poles of matunduru trees are not attacked by termites (26)
192. Trees have larger roots than grass (52)
193. Trees grow taller than grass (31).
195. Cattle eat tree forage IF grasses are not available (42)
196. Mihale trees have long roots (32)
197. Tree shade help to conserve soil moisture (13)
198. Mihale seeds can easily germinate through livestock 199. droppings as compared to matunduru seeds (54)
199. Tree leaves improve soil fertility IF they decompose (39)
200. Mihale trees produce many seeds (34)
201. Mibuyu trees can stop to produce new leave IF they are cut quite often (14)
202. Mihale trees do not improve soil fertility (66)
203 Soils under tree cover are more fertile than that in open areas (16)
204. Magobeko plants have a very closed and thick canopy (23)
205. Cattle can easily see mimanje trees in October because they are quite green (11)
206. Tree shade depends on number of branches (29)
207 Trees with many and large size leaves produce heavy shade (24)
208. Mahushi tree roots are near the soil surface (13 women)
209. Old trees are big and need more water than young trees (25)
210. Trees and grass need sunshine for good growth (15)

211. Mihale are always with many green leaves throughout the year (26)
212. Large trees normally have many and strong roots (12)
213. Large trees have many roots in the soil (32)
214. Increased tree root spreading causes a decrease in soil nutrients and moisture (42)
215. Increase in number/amount of tree roots in soil causes a reduction in soil moisture (29)
216 Increase in land degradation rates causes grasses to grow in patches (58)
216. Increase in tree leaf greenness causes an increase in leaf softness (21)
217. Increase in water uptake rate by roots causes an increase in tree leaf greenness and leaves become softness (16)
218. Green leaves of trees contain more water than dry leaves (27)
219. Increase in tree leaves softness causes increase in leaf palatability rate (38)
220. Quantity of water content in tree leaves causes increase in rate of digestibility (45)
221 Cattle eat young and soft tree leaves which make their bodies healthier (31)
222. Health cows yield more milk than unhealth cows ((29)
223. Increased cattle body food (quantity) causes an increase in milk production (46)
224. Increase in population (human and livestock) causes increase in cultivation of grazing lands (12)
225. Increase in population (human and livestock) causes increase in settlement in grazing areas (17)
226. Increase in population (human and livestock) causes deforestation (23)
227. Increased settlements in grazing areas causes deforestation (16)
228. Increase in cultivation causes deforestation (34)
229. Deforestation results in land openness (28)
230. Land openness causes an increase in ground hotness (17)
231. Increase in deforestation causes decrease in amount of water in streams (76)
232. Increase in tree crown size causes increase in amount of tree leaves (20)
233. Increase in amount of tree leaves causes increase in amount of leaves on ground (16)
234. Tree crown size causes a decrease in force of rain (13)
235. Increase in amount of leaves on ground causes increase in soil fertility IF they decompose (38)
236. Decrease in force of rain causes increase in amount of water in soil (34)
237. Increase in soil fertility causes increase in quantity of grass biomass (29)
238. Increase in amount of water in soil causes increase in quantity of grass biomass (131)
239. Increase in tree crown size causes heavy shade (12)
240. Increase in amount of tree roots in soil causes decrease in amount of soil nutrients (19)
241. Decrease in amount of soil nutrients causes decrease in soil fertility (5)
242. Decrease in soil fertility causes decrease in available grass food (15)
243. Decrease in available grass food causes decrease in grass quantity (21)

244. Decrease in grass growth rate causes decrease in grass quantity (11)
245. Decrease in available grass food causes decrease in grass growth rate (9)
246. Decrease in amount of soil water causes decrease in grass growth rate (40)
247. Increase in amount of tree roots in soil causes decrease in amount of soil water (42)
248. Heavy tree shade causes an increase in grass height (18)
249. Heavy tree shade causes a decrease in grass growth rate (12)
250. Decrease in grass height causes decrease in grass quantity (33)
251. Decrease in grass growth rate causes decrease in grass quantity (43)
252. Heavy tree shade causes a decrease in grass thickness (18)
253. Decrease in grass thickness causes decrease in grass quantity (18)
254. Increase in soil erosion causes increase in rate of gully formation (36)
255. Increase in soil erosion causes exposure of grass roots (19)
256. Increase in rate of gully formation causes increase in rate of land degradation (36)
257. Increase in exposure of grass roots causes increase in rate of grass root dryness (16)
258. Increase in rate of land degradation causes decrease in extent of grazing areas (23)
259. Increase in rate of grass root dryness causes decrease in grass growth rate (16)
260. Decrease in extent of grazing areas causes decrease in grass quantity (23)
261. Decrease in grass growth rate causes decrease in grass quantity. (15)
262. A root is a part of tree (4)
265. Branch is a part of tree (18)
264. Leave is a part of tree (3)
265. Increased human population caused an increased rate of cutting trees for firewood and poles. (61)
266 Increased grazing needs caused a decrease of forest areas.
267 Cuttings for planting migongogongo should be 2 metres long (7)
268 Destruction of planted tree trees by termites can be reduced if ash is mixed with soil during planting (5)
269 Planting of tree cuttings should be 4 weeks before or 2 weeks after the rain season. (16)
270 Mihale seeds germinate through animal dung
271 Mahushi trees can grow through root suckers (12)
272 Cattle cannot graze well if population of malula trees is increased

APPENDIX 3.8: Summary of the responses on the 'ngitiri' system

Management practices

Division	Sex	Knowing	not knowing	Total
Kishapu	women	47	13	60
	men	45	15	60
	Total	92	28	120
Negezi	women	28	32	60
	men	36	24	60
	Total	64	56	120
Biological	**aspects**			
Kishapu	women	51	9	60
	men	52	8	60
	Total	103	17	120
Negezi	women	50	10	60
	men	53	7	60
	Total	103	17	120
Component	**interactions**			
Kishapu	women	55	5	60
	men	56	4	60
	Total	111	9	120

Summary of responses on rangeland-tree resource base

Management practices

Division	sex	knowing	not knowing	total
Kishapu	women	51	9	60
	men	53	7	60
	total	104	16	120
Negezi	women	53	7	60
	men	53	7	60
	total	106	14	120

Multipurpose	use			
Kishapu	women	47	13	60
	men	48	12	60
	total	95	25	120
Negezi	women	39	21	60
	men	44	16	60
	total	83	37	120
Interactions				
Kishapu	women	54	6	60
	men	53	7	60
	Total	107	13	120
Negezi	women	51	9	60
	men	50	10	60
	total	101	19	120
Biological	aspects			
Kishapu	women	47	13	60
	men	46	14	60
	total	93	27	
Negezi	women	41	19	60
	men	40	20	60
	total	81	39	120

APPENDICES (4.1 - 4.8): RESULTS OF GOODNESS OF FIT (G^2) TEST

4.1 G^2 test for the responses on distances to crop fields

Divisions	Kishapu		Negezi	
Villages	Migunga	Isoso	Bulimba	Mayanji
Within 4 km	48	37	29	26
Beyond 4 km	12	23	31	34
	df	G^2	G^2 adj	P
Kshapu Vs Negezi	1	15.9	16.7014	3.841
Migunga Vs Isoso	1	5.702	6.605	3.841
Bulimba Vs Mayanji	1	NS	NS	
Total	3			

(4.2) G^2 test for responses on crop mixing practices

Divisions	Kishapu		Negezi	
Villages	Migunga	Isoso	Bulimba	Mayanji
Within 4 km	44	35	42	51
Beyond 4 km	16	25	18	9
	df	G^2	G^2 adj	P
Kshapu Vs Negezi	1	4.0576	NS	3.841
Migunga Vs Isoso	1	NS	NS	3.841
Bulimba Vs Mayanji	1	3.9204	NS	
Total	3			

(4.3) G^2 test on problems related to livestock keeping

Divisions	Kishapu		Negezi	
Villages	Migunga	Isoso	Bulimba	Mayanji
Within 4 km	25	24	8	11
Beyond 4 km	28	22	28	19
	df	G^2	G^2 adj	P
Kshapu Vs Negezi	1	7.057	8.01	3.841
Migunga Vs Isoso	1	NS	NS	3.841
Bulimba Vs Mayanji	1	NS	NS	
Total	3			

(4.4) G^2 test on responses on grazing responsibility

Divisions	Kishapu		Negezi	
Villages	Migunga	Isoso	Bulimba	Mayanji
Within 4 km	9	1	4	6
Beyond 4 km	43	49	23	23
	df	G^2	G^2 adj	P
Kshapu Vs Negezi	1	NS	6.348	3.841
Migunga Vs Isoso	1	7.6	5.609	3.841
Bulimba Vs Mayanji	1	NS	NS	
Total	3			

(4.5) G^2 test on responses on distances related to firewood supply

Divisions	Kishapu		Negezi	
Villages	Migunga	Isoso	Bulimba	Mayanji
Within 4 km	6	35	50	20
Beyond 4 km	54	25	10	30
	df	G^2	G^2 adj	P
Kshapu Vs Negezi	1	14.194	13.213	3.841
Migunga Vs Isoso	1	33.595	31.708	3.841
Bulimba Vs Mayanji	1	32.56	30.31	
Total	3			

(4.6) G^2 test on responses on distances related to poles supply

Divisions	Kishapu		Negezi	
Villages	Migunga	Isoso	Bulimba	Mayanji
Within 4 km	6	12	8	23
Beyond 4 km	54	48	52	37
	df	G^2	G^2 adj	P
Kshapu Vs Negezi	1	10.108	9.168	3.841
Migunga Vs Isoso	1	NS	NS	3.841
Bulimba Vs Mayanji	1	10.099	8.756	
Total	3			

(4.7) G^2 test on availability of natural fruit tree species and medicinal materials

Divisions	Kishapu		Negezi	
Villages	Migunga	Isoso	Bulimba	Mayanji
Within 4 km	44	1	12	55
Beyond 4 km	16	59	48	5
	df	G^2	G^2 adj	P
Kshapu Vs Negezi	1	8.134	7.405	3.841
Migunga Vs Isoso	1	79.021	74.174	3.841
Bulimba Vs Mayanji	1	70.195	66.488	
Total	3			

(4.8) G^2 test on responses on availability of medicinal materials

Divisions	Kishapu		Negezi	
Villages	Migunga	Isoso	Bulimba	Mayanji
Within 4 km	55	46	22	60
Beyond 4 km	5	14	38	0
	df	G^2	G^2 adj	P
Kshapu Vs Negezi	1	8.447	7.57	3.841
Migunga Vs Isoso	1	47.101	45.968	3.841
Bulimba Vs Mayanji	1	70.986	64.67	
Total	3			

Appendix 5: List of pasture species found in Kishapu and Negezi Divisions

Name in Kisukuma	Botanical name
Bongebonge	*Datura stramonium*
Bugimbi	*Dactyloctenium aegyptium*
Bupuna	*Glycine wightii*
Mwogawagole	*amaranthus* spp
Ling'hulula	*Archyranthus aspera*
Maskokolo/Kamunumunu	*Oxygonum simuatum*
Ndago	*Polygonum ovicular*a
Zunzu	*Tagetes minuta*
Matula/maditula	*Solanum nigrum*
Matindula	*Solanum incunum*
Kapindapinda	*Commelina benghalensis*
Ligunguli (nkima)	*Trichodesma zeylanicum*
Malumbalumba	*Leucas martinicensis*
Sogo	*Euphorbia hirta*
Ng'hale/makale	*Ricinus communis*
Lukuba	*Opuntia* spp
Likila lya ng'holo	*Tridax procumbens*
Maluko	*Eleusin indica*
Malusunga	*Lactuca capensis*
Lugubi/malugubi	*Pennisetum pupureium*
Malamata	*Setaria verticillata*
Supyu	*Imperata cylindrica*
Huluda/mahuluda	*Panicum coloratum*
Nibasaji	*Panicum maximum*
Shimbili	*Centrus ciliaris*
Misanza	*Glycine max*
Lwambo	*Tephrosia villosa*
Ndasa	*Heteropogon contortus*
Ngobi/malugobi	*Digitaria scalarum*
Laba/Lukumbo	*Hibiscus* spp
Mahodi/kalitongo	*Boerhavia diffusa*
Limbe/magutu	*Cucumbus spp*
Ntelengu/nhelengu	*Hyparrhenia rufa*
Lishimbili	*Chloris roxyburghiana*
Nzekenzeke/mayegelele	*Crotalaria polyseperma*

Kayeba/makayeba	*Manihot esculenta*
Masembe	*Eragrotis superba*
Ligunguli (Ngosha)	*Conyza stricta*
Nhumbu	*Ipomea batatas*
Lugaka/malugaka	*Sansevieria* spp
Nduko	*Cynodon plectostachys*

Appendix 6:Browse and other tree species mentioned by informants

Kisukuma	Botanical name	Parts eaten	When eaten
Mimanje*	*Lannea humilis?*	leaves	dry season
Magobeko	*Combretum obovatum*	leaves	wet season
Malula	*Acacia drepanolobium*	leaves & pods	wet season
Matunduru	*Dichrostachys cinerea*	leaves & pods	wet season
Migunga	*Acacia tortilis*	leaves & pods	wet season
Mihale	*Acacia nilotica*	leaves & pods	whole year
Malulambuli**	*Ormocarpum trichocarpum*	leaves	whole year
Misingisa	*Boscia angustifolia*	leaves	whole year
Kaniningwe	*Cadaba adenotricha*	leaves	whole year
Madubilo	*Acacia benthamii*	leaves	wet season
Magwata	*Acacia senegal*	leaves & pods	dry season
Mapumula	*Calotropis procera*	fruits	dry season
Mahushi	*Acacia fischeri*	leaves	dry season
Misongoma	*Senna siamea*	leaves	dry season
Malugala	*Acacia mellifera*	leaves & pods	wet/dry season
Mwandu	*Adansonia digitata*	leaves/flowers	wet/dry season
Madasho**	*Azma tetracantha*	leaves	whole year
Milobisu*	*Capparis tomentosa*	leaves	wet/dry season
Mikoma	*Grewia bicolor*	leaves	whole year
Milobashi	*Combretum parrifolium*	leaves	dry season
Misalasi	*Popowia abovata*	leaves	dry season
Mkomankuru	*Grewia fallax*	leaves	whole year
Manalo**	*Acacia kirkii*	leaves & pods	wet season
Mibapa	*Markhamia obtusifolia*	leaves	dry season
Mperemese	*Grewia pachycalyx*	leaves	dry season
Mapumbula	*Calotropis procera***	leaves (dry)	whole year
Mikwaju	*Tamarindus indica*	leaves	dry season
Masagala	*Anisotes dumosus.*	leaves	dry season
Misangwasangwa	*Thylachium africanum*	leaves	whole year
Miyuguyu	*Balanites aegyptiaca*	leaves/fruits	wet/dry season
Mimale	*Lochocarpus eriocalyx*	leaves	whole year
Minzawigutile	*Markhamia acuminata*	leaves	dry season
Waachangoko	*Radia taylorii*	leavea	dry season
Mihama	*Borrasus aethiopum*	leaves	wet/dry season
Migong'ong'ongo	*Commiphora* spp	leaves	dry season

Misesibania	*Sesbania sesban*	leaves	whole year
Milusina	*Leucaena leucocephala*	leavea	whole year
Manala	*Euphorbia tirucalli*	leaves**	severe shortage

* species browsed by cattle only

** species browsed by goats only; the rest are browsed by both.

Other tree species mentioned

Kisukuma	**Botanical name**
Masubata	*Royena* spp
Mikuyu	*Ficus sonderi*
Ngada	*Albizia antheimintica*
Mitangale	*Euphorbia bilocularis*
Minengonengo	*Securidaca longipendunculata*
Mondo	*Entandrophragma bussi*
Mibapa	*Markhamia obtusifolia*
Nkoma-nkulu	*Grewia fallax*
Ilula lyapi	*Acacia seyal*
Mipogoro	*Albizia amara*
Mlundalunda	*Cassia abbraviata*
Miponda	*Commiphora schimperi*
Lizunzu	*Combretum longispicatum*
Kaguwa	*Combretum molle*
Mikomangwa	*Cimmiphora compestris*
Misangwasangwa	*Thylachium africanum*

[1] Figures in parentheses indicate number of informants who mentioned the statement.