THE ANALYSIS OF EXISTING INDIGENOUS AGROFORESTRY SYSTEMS AND THEIR RELATIONSHIP TO LAND SCARCITY PROBLEM IN UKEREWE DISTRICT, TANZANIA

BY

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ABSTRACT

This study was aimed at assessing the existing indigenous agroforestry systems practiced in Ukerewe district. The specific objectives were: to identify the existing indigenous agroforestry systems in the area of study; to identify crops and trees or livestock used in each system; to identify the yield trend of cassava crop in the past 1997-1999; to identify the constraints in productivity and sustainability associated with agroforestry systems in the area and to recommend areas of intervention for improvement. Simple random sampling technique was used in selecting divisions, wards, villages and households for which the study was carried out. Six villages were involved and three structured questionnaires were used to extract information from the farmers, village leaders and extension workers both at division and district levels. The data were analysed by using statistical package for the social sciences (SPSS) computer programme. Five farming systems were found in the area which include homegardens (agrosilvopastoral systems), mixed cropping with trees (agrosilvicultural systems), mixed cropping farming systems (purely agricultural systems), monocropping farming systems (purely agricultural systems) and valley bottoms farming systems. Out of the five farming systems found in the area only two are indigenous agroforestry systems, which are homegardens (agrosilvopastoral systems) and mixed cropping with trees (agrisilvicultural systems). The cassava yield crop in the years 1997, 1998 and 1999 was not regular. The numbers of people with surplus yield were increasing whereas those with sufficient and insufficient yield were decreasing. Land scarcity, drought, lack of reliable market for produce, diseases to livestock, inadequate farm inputs, soil fertility, water shortages, poor extension services and encroachment to pastureland were constraints prioritized as limiting productivity and sustainability of agroforestry systems in the area. Areas of intervention for the improvement of existing indigenous agroforestry systems include:-

- Stocking density of trees should be increased in both homegardens and cropland farms as well as an improvement on the arrangement of components.

- Application of organic fertilizers should be enhanced in order to increase crop yield and improve soil fertility.
- There is a need to improve livestock production through zero grazing in order to combat the shortage of farmyard manure, and soil fertility problems.
- In order to motivate farmers to produce more the market intelligence unit should be established and be responsible for searching for markets for farm produce.
- The government should assist people with land scarcity problem to shift elsewhere in the country where land is abundant.

DECLARATION

I, DINAH LEONARD TINUGA KABINGILE-RWEYEMAMU, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor concurrently being submitted for a degree award in any other University.

Signature: .....

Date: 23/11/2007

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ABBREVIATIONS

C_4	=	Carbon four
CH_4	=	Methane
cm	=	Centimetre
FAO	=	Food and Agriculture Organization of the United Nations
ha	=	Hectare
ha^{-1}	=	Per hectare
ICAR	=	Indian Council of Agricultural Research
ICRAF	=	International Council for Research in Agroforestry
kg	=	Kilogram
kg^{-1}	=	Per kilogram
km	=	Kilometre
km^2	=	Square kilometre
m	=	Metre
MNRT	=	Ministry of Natural Resources and Tourism
S/N	=	Serial number
SPSS	=	Statistical Package for Social Sciences
SUA	=	Sokoine University of Agriculture
Tshs.	=	Tanzanian shillings
US $	=	United States Dollar

CHAPTER 1

1.0 INTRODUCTION

Agroforestry is a new name for old practices (Francesco *et al.*, 1983; Nair, 1983, Nana-Sikam, 1987, Falconer and Arnold, 1991 and Dwivedi, 1994). According to Soemarwoto (1987) Agroforestry is a very old tradition which may have evolved over a long time from the practices of the hunters or gatherers and continued in the ancient civilisation up to modern times. It has been in use for at least 1300 years according to pollen records (Brookfield and Padoch, 1994 cited by Sanchez, 1995), although tree domestication probably started much earlier (Simmonds, 1985 cited by Sanchez, 1995). Therefore, agroforestry is not a new concept although it has numerous and diverse definitions in scope and content. For example Nair, (1979) defines agroforestry broadly as a land use system that integrates trees, crops and animals in a way that is scientifically sound, ecologically desirable, practically feasible, and socially acceptable to farmers. Another definition by Lundgren and Raintree (1983), Nair, (1983), Lundgren and Raintree (1983) cited by Fernandes and Nair (1986), Lundgren (1987), Rocheleau *et al.*, (1988) and Young (1989) define agroforestry as a collective name for land use systems in which woody perennials (trees, shrubs, palms, bamboo etc.) are deliberately grown in association with herbaceous plants (crops, pastures) and/or livestock in a spatial arrangement, a rotation or both, and in which there are both ecological and economic interactions between the woody and non woody components of the system. Later on Crump (1991) defines agroforestry as any system where trees are deliberately left, planted or encouraged on land where crops are grown or animals grazed. However, Leakey (1996) defines agroforestry as a dynamic, ecologically based, natural management

system that, through the integration of trees in farm and rangeland, diversifies and sustains smallholder production for increased social, economic and environmental benefits. The up- to date definition and which is most recent is the one given by Ford Foundation (1998) which defines agroforestry as a land use approach most useful on lands not suited to monocrop cultivation that seeks to improve productivity to planting trees simultaneously or sequentially on the same plot. Although this last definition is most recent, it lacks the component of animals or rangeland that is found in other preceding definitions. However, a definition that accommodates other components that contribute to agroforestry concept such as fish, birds and insects should be established.

Circumstances like land degradation and land scarcity, which are a result of high population pressure cause farmers to shift from one type of farming system to another. Vergara and Nair (1987) report the Swidden cultivation was the mainstay of subsistence livelihood in the South Pacific region, but with the increase in population, the system was causing severe environmental and land use problems and thereby suggested to be abandoned. People facing these problems have automatically adopted indigenous farming systems that can meet their basic needs. Most of these systems involve the mixing of trees and agricultural crops in an intimate combination with each other (Nair, 1989, 1993). Such land use systems are collectively known as agroforestry (Gold and Hanover, 1987). Of all farming systems, agroforestry is the best since it is capable to produce both wood, fibre and food and at the same time conserve and rehabilitate the ecosystem. For example, Griffon and Mallet (1999) document the Green and Doubly Green Revolution farming systems as not

sustainable compared to agroforestry that is seen superior in increased production. Therefore, agroforestry has been seen as a solution in areas that are facing increasing population pressure and hence land scarcity problem. For example Henrylito (1992) reports an agroforestry system developed in sloping lands in the Philippines to help alleviate the problem of intense cultivation which was the result of increasing population pressure. Also Sathees *et al.*, (1992) report a multi-storeyed intensive production which has been developed in homegarden of Kerala in South India in response to the pressures of shrinking land resources available to farm families. In the highlands of Rwanda, one of the most densely populated countries in Africa, farmers have switched from shifting cultivation to agroforestry systems since the beginning of the century (Behmel and Newmann, 1981 cited by O'kting'ati, 1985). The Wakara of Ukerewe, Tanzania were able to set up self-sustaining agriculture on the granite derived, poor soils of Ukara to support populations of up to 500 persons/Km^2 (O'kting'ati, 1985).

However, there are traditional farming or agroforestry systems which are practiced in various parts of the world which when known and documented can assist in either transfer of the knowledge or improvement on it in order to increase productivity on land which is becoming scarce while the population is increasing. For example Swaminathan (1987) reports indigenous agroforestry systems practiced in tropical Africa, Asia and Latin America to possess characteristic features of densely populated hilly areas. Saini and Misra (1992) report *Trewia nudiflora* an indigenous tree species in India as a promising tree species for agroforestry in rice fields. Also Sae-lee *et al.*, (1992) document trees in rice fields as a special feature of rice paddies in North East

Thailand compared to other regions of the country. However, in most parts of Tanzania where rice fields are found, there are no trees that are incorporated with the crop even in land scarcity areas like Ukerewe. The main reason for not incorporating trees for example in Ukerewe Main Island is that trees harbour birds, which feed on the crop. However, the Wakara in Ukara Island their reason is that the area where rice is grown is marshy and therefore they are not aware of the tree species,which can survive in that environment.

Nair (1987) justifies the rationale for undertaking the inventory of agroforestry systems is that although agroforestry systems are said to be one of the oldest land use systems in the world, information on these systems has been limited to descriptive and qualitative accounts. It is not known whether they have reached their maximum operating potential, whether they are disappearing as a result of various factors or if they can be improved and extended to other situations. However various authors report local farmers to posses up-to-date knowledge as regards different tree species requirements and tree regeneration (FAO, 1990; Indigenous Knowledge and Development Monitor, 1993; Kajembe, 1994). It is reported that traditional knowledge was formally overlooked in different disciplines. For example Barrow (1991) reports that it is only recently that the role of traditional knowledge in natural resource management has become acknowledged. Farmers in Ukerewe district like many other farmers in the world and Tanzania in general know which farming system to apply in order to combat various problems they face.

1.1 Problem statement

There are agroforestry systems in Ukerewe district that should be identified and documented. Although these systems are existing they are faced with a number of problems. The systems are under pressure due to high population which is a result of land scarcity. There is low population of livestock that is mainly due to diseases, poor veterinary services and inadequate pastures. This leads to poor supply of manure and as a result enhance the problem of soil fertility, which ultimately leads to low agricultural crop yields. Cassava crop is the staple food in the area. Besides the problem of soil fertility this crop is also faced with the problem of cassava meal bug disease, which is difficult to eradicate since some of the recommended methods to discourage it such as crop rotation, and fallowing are hardly practised. Due to land scarcity there is almost neither fallowing nor crop rotation instead mixed cropping is practiced in order to have a variety of foods. For example in one plot you can find cassava, sweet potatoes, maize, beans, millet, cowpeas, bambara nuts and groundnuts. It is recommended that the rotation age of cassava crop is two years, but due to the problems mentioned the crop is usually harvested prematurely to meet family requirements. Bulrush millet and groundnuts crops used to be cultivated in large amounts, but these crops require fertile soils and due to the decrease in soil fertility being experienced they are being cultivated in small quantities. Rice is a commercial crop in the area, and has also been affected by drought that persisted for three years consecutively. Cotton crop used to be a cash crop in the area, but since the crop doesn't accommodate intercropping, some families have abandoned the cultivation of it due to land scarcity. Even those families that still cultivate it mix it with other crops such as sweet potatoes and beans.

Trees that have to meet forest related products are also under high pressure due to high demand such that timber trees are being harvested prematurely. In the area where this study was done people are using crop residues such as cassava, maize, sorghum stalks and maize cobs for cooking. FAO's publication on restoring the balance: women and forest resources; criticises the use of crop residues due to the following reasons:

- requires a far greater bulk of material collected, moved and then burnt;
- these agricultural crop residues are an important form of fertilizer, providing the soil with both humus and inorganic nutrients;
- serving as fuel leave the soil normally deprived of their fertilising effect, and becomes impoverished;
- lack of humus leads to instability and wind and water erosion are increased; and
- lack of fertility means that farmers must cultivate even larger areas of land to provide the quantities of produce their families require or alternatively to add a lot of fertilizer which is costly.

In some small islands like Kweru and Irugwa grass is used for cooking. There used to be woodlands, which normally are found in marginal lands and have already been encroached for crop cultivation. The existing forests have been encroached to meet people's demand for agricultural land and forest related products. Despite shortages of tree products, efforts of tree planting are still low especially in Ukara island where people are customarily feeding their livestock with fodder. These fodder trees were inherited from grandparents in such a way that they are very old and do not meet the requirements since in some cases you find tree leaves completely harvested. Few

young trees are observed which might not meet the future demand of the product and there is fear that although the practice is good it might disappear in the near future.

The above problems are threats to the sustainability of existing indigenous agroforestry systems and the welfare of the people in Ukerewe district. Although these systems have been in use for quite a long time, no studies were done before to document them and therefore make them unknown both locally and internationally. The documentation is very essential for future reference, to draw attention to different actors and to act as a baseline for future research, and identify areas of intervention for sustainability purposes.

1.2 Justification of the study

Land scarcity as a result of increased population pressure is a problem facing some of the areas in Tanzania. Some of these areas include Lushoto district, in Tanga Region, Moshi district in Kilimanjaro Region, Bukoba rural district in Kagera Region and Ukerewe district an island in Lake Victoria in Mwanza Region. Practice of agroforestry or improvement on the existing systems has been a solution in many areas where land scarcity has bee a problem. In order to come up with a solution the existing indigenous agroforestry systems have to be known. It is reported by Nair (1983) that agroforestry is one of the oldest and most widely practised land use systems, yet it is among the scientifically least studied ones. For example Nair (1993) reports that the situation at present is that there are several agroforestry systems that function well, but we lack sufficient knowledge as to how they work. If we do not understand the ' how' and 'why' of their functioning, we can neither make informed

judgement and improvements in the systems nor replicate them in other locations. Some indigenous agroforestry systems which have already been studied partially in Tanzania show strengths, weaknesses, and the way to improve them (Fernandes *et al.*, 1984; O'kting'ati *et al.*, 1984; O'kting'ati., 1985; Rugalema, 1992 and Moshi, 1997). Some of the Kilimanjaro and Kagera agroforestry systems have spread quite fast all over Tanzania especially in peri-urban areas since the early 1960's when banana consumption was low. For example Alriksson and Ohlsson (1990) report the Chagga homegarden to have been established in Haraa village of Babati district by a Chagga man since 1958 which have spread by other Chaggas who came in and adopted by other ethnic groups. Also Hillbur (1998) reports the spread of Chagga homegardens to the slopes of mount Meru performed by the Meru people and their neighbours to the west of Arusha. However, Lulandala (1994) cited by Moshi, (1997) stresses that the many indigenous agroforestry systems in Tanzania have not been systematically studied and therefore remain undocumented. Ukerewe district is among those areas and therefore a research on them was inevitable in order to effect further improvements or introduce new ones which can lead to land use intensification and therefore help to solve the land scarcity problem.

1.3 Hypothesis

1. There are existing indigenous agroforestry systems in Ukerewe district.
2. There is a decline in yield of cassava crop over the years due to decline in soil fertility.
3. There is a land scarcity problem due to population increase.
4. Current agroforestry systems practised need improvement.

1.4 Alternative hypothesis

1. There are no existing indigenous agroforestry systems in Ukerewe district.
2. There is no decline in yield of cassava crop over the years due to decline in soil fertility.
3. There is no land scarcity problem due to population increase,
4. Current agroforestry systems practised need no improvement.

1.5 Objectives of the study

1.5.1 Main objective

The study aimed to assess the existing indigenous agroforestry systems practised in Ukerewe district.

1.5.2 Specific objectives

The specific objectives were:

1. to identify the existing indigenous agroforestry systems in the area of study,
2. to identifify crops and trees or livestock used in each system,
3. to identify the yield trend of cassava crop in the current three years time,
4. to identify the constraints in productivity and sustainability associated with agroforestry systems in the area, and
5. to recommend areas of intervention for improvement.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Agroforestry systems

Torres (1979) defines agroforestry systems as units that are designed to meet farmers' objectives by manipulating biological processes, and that produce crops through interactions among soil and woody components with either herbaceous or livestock components or both. However, Kaale *et al.*, (1984) define agroforestry systems as systems of using land which involve consciously raising of crops or grazing animals among specially planted or encouraged trees. However, Dwivedi (1994) regards agroforestry systems to refer to such distinct agroforestry practices in which agriculture, forestry and pastures uses of land are combined either temporal or spatially arrangement. Regardless of the system the main components of agroforestry systems are trees, shrubs, crops, pastures and livestock, together with environmental factors of climate, soils and landforms. Other components (e.g., bees, fish) occur in specialised systems (Young, 1989). According to Nair (1993) an agroforestry system meets the following:

always has two or more species of plants (or plants and animals) at least one of which is a woody perennial; two or more outputs a cycle is always more than one year, and more complex ecologically (structurally and functionally) and economically, than a monocropping system.

For any system to be easily analysed and evaluated there should be a means of classifying it. Nair (1993) suggests that the most obvious and easily used criteria for classifying agroforestry systems are the spatial and temporal arrangements of

components, the importance and role of components, the production objectives or outputs from the system and the social and economic features. These correspond to the system's structure, function, socio-economic nature or ecological environment. Therefore Nair (1985, 1993) classifies agroforestry systems on the basis of structure, function, socio-economic and ecological status.

2.2 Structural classification

Structure refers to composition, stratification and extent of the crop. The classification of agroforestry systems on the basis of the nature of composition is widely recognised and several workers have classified agroforestry systems on the basis of composition into: agrisilviculture, silvipasture, agrisilvipasture and others (King, 1979; FAO, 1979, 1981; Gholz, 1988 cited by Dwivedi, 1994; and Nair,1985,1993). Other systems include silvoaquaculture (Lightfoot, 1991 cited by Wouters, 1994), Agri-silvihorticulture (Grewal *et al.*, 1992); Agro-silvo-fishery, Apiculture with various forms of shifting cultivation (Nair, 1987). Although agroforestry systems are classified according to the above systems, subsystems can also be defined. For example an agrisilvicultural system can have several types of subsystems according to the type and arrangement of its constituent components, but another way of looking at it is based on the system's output, that is, to consider a system to be composed of several subsystems, each filling a defined " basic need" as its major output: there can be a food subsystem, an energy subsystem, a shelter subsystem a cash subsystem, and so on (Raintree, 1984 cited by Nair, 1985). Figure 1 shows categorisation of agroforestry systems based on the nature of components.

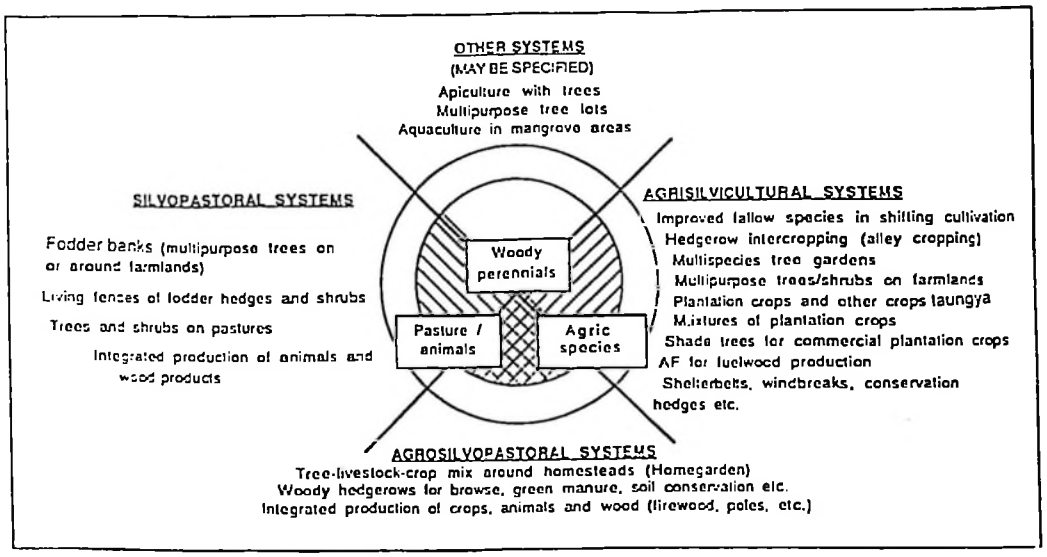


Figure 1: Categorisation of agroforestry systems based on the nature of components (with examples of common subsystems or practices under each system)

Source: Nair, (1985).

2.2.1 Structural basis

Structural basis refers to the composition of the components, including spatial admixture of the woody component, vertical stratification of the component mix and temporal arrangement of the different components (Nair, 1985). These basis have been well documented in different reports on agroforestry systems (Fernandes *et al.*, 1984; Bourke, 1985; Fonzen and Oberholzer, 1984; Liyange *et al.*, 1984; May *et al.*, 1985; O'kting'ati, 1985; Vergara and Nair, 1985; Balasubramanian and Egli, 1986; Jambulingam and Fernandes, 1986; Michon *et al.*, 1986; Miehe,1986; Nair and Sreedharan,1986; Poschen, 1986; Jacob and Alles, 1987; Leuschner and Khaleque, 1987; Okafor and Fernandes, 1987; Rugalema, 1992 and Moshi, 1997).

2.2.2 Components of agroforestry systems

In agroforestry land use systems there are three basic sets of elements or components that are managed: the tree (woody perennial), the herb (agricultural crops including pasture species), and the animal. In order for a land use system to be designated as an agroforestry system, it should always have the woody perennial component.

In most agroforestry systems, the herbaceous species component is also involved with notable exceptions such as apiculture and aquaculture with trees (Nair, 1985). However, some other cases where herbaceous species have been excluded are reported. Nair and Sreedharan (1986) report the cultivation of coffee and rubber trees, Vergara and Nair (1985) report the growing of coconut, legume tree and cacao production, Escalante (1995) reports coffee grown under shade trees and Penot (1995) reports the rubber and fruit trees. This situation is also characteristic in coffee and tea estates found in various parts of Tanzania where they are cultivated such as Arusha, Mbeya and Kagera regions. Along the coast, Mtwara and Lindi, Tanzania has similar cashew crops. In coffee estates trees are interplanted with the crop to provide shade whereby in tea estates trees are planted on boundaries as windbreaks. However the animal component is present in some agroforestry systems, such as homegardens.

2.2.2.1 Crop component

Various food and cash crops are found in various agroforestry systems. Twenty crop components were reported to be grown in Kandyan garden system in Sri lanka (Jacob and Alles, 1987). Bushes of plantain, coffee and black pepper vines are crops grown

in this system. The highest number of crops grown on a farm was 18 (on a 2 ha farm) and the lowest 4 (on a 1.2 ha farm). About 80% of the farms grew eight to 15 crops (Jacob and Alles, 1987).

Vergara and Nair (1985) documented cereals, bananas, vegetables, sweet potatoes, yams, papaya and sugarcanes as being grown in Agrisilvicultural system in the Pacific islands. Fernandes *et al.*, (1984) documented bananas, maize, beans, sweet potatoes, cocoyams, yams as food crops and coffee, cardamom as cash crops in the Chagga homegarden agroforestry system in Kilimanjaro, Tanzania. The same crops have also been documented in Bugesera - Gisaka - Migongo region in Rwanda (Balasubramanian and Egli, 1986) and in Bukoba district, Tanzania (Rugalema, 1992). According to Bourke (1985) the major species used in agroforestry systems in the Papua New Guinea highlands are numerous annual and perennial crops. The crops grown include coffee, bananas, taro, sugarcane, maize and highland 'pitpit'. Bourke (1985) further documents that the basic structure of the system is that mixed vegetable gardens are gradually converted into coffee/banana gardens and eventually into coffee/*casuarina* stands. Johnson and Nair (1985) document maize, beans, cassava, sorghum, peanuts, sesame and cotton which are grown in perennial crop - based agroforestry systems in Northeast Brazil. They further report that native ginger grass and African Guinea grass have proven to be successful on cashew plantations. May *et al.*, (1985) document rice, maize, cassava and several bean species under babassu palms in Babassu agroforestry systems of Brazil's mid - North region. Rice is by far the region's most important crop and is used as a payment for land rental, a cash crop and a principal source of sustenance. It is worthwhile to note here that

while maize serve as staple food in various places in Africa, Tanzania inclusive, in Brazil's mid - North region is used to feed animals and is rarely sold. Other crops grown in this system include cowpeas, lima beans, which are also primarily for subsistence consumption. Others include squashes, watermelon, west Indian gherkin, okra, cucumber and banana.

Hitimana *et al.* (1994) document sweet potato, cassava, cocoyam and beans as food crops whereby cash crops include coffee and banana which is mainly used to produce beer in Central Burundi. Fonzen and Oberholzer (1984) document major crops used in hill farming systems in Western Nepal as maize, pulses, finger millet vegetables, rape seed, wheat, barley and buck wheat. They further report that even around the homesteads various vegetables and banana are grown, mainly for household consumption.

Okafor and Fernandes (1987) document the dormant species used in Nigeria to include yams, cassava, cocoyams, bananas and maize which are usually grown in mixtures with several subsidiary crops such as okra, pumpkin, melon and leaf vegetables. Moshi (1997) documents maize, banana, beans, Irish potato, sweet potato, cassava, cocoyam, arabica coffee, sugarcane and cabbage as crops grown in the West Usambara homegardens in Tanzania.

2.2.2.2 Tree component

Several trees and shrub species are found in most of the agroforestry systems. However the type of species, the amount and uses depend on the climatic conditions

of the area as well as the community in which they are found. For example about 55 tree/shrub species are found in hill farming systems in Western Nepal (Fonzen and Oberholzer, 1984); 14 tree/shrub species are found in Babassu agroforestry systems of Brazil's mid - north region (May *et al.*, 1985); and 30 tree/shrub species in homestead agroforestry in Bangladesh (Leuschner and Khaleque, 1987). Most of the tree/shrub species reported in various agroforestry are multipurpose (May *et al.*, 1985; Fonzen and Oberholzer, 1984; Fernandes and Nair, 1986; Fernandes *et al.*, 1984; Okafor and Fernandes, 1987; and Moshi, 1997).

Nair (1984) cited by Fernandes and Nair (1986); Nair (1993) report that a conspicuous character of the tree crop components of the homegardens is the predominance of fruit trees. The importance of fruit trees has been stressed by Aiyelaagbe (1992) who reports that fruits generate income and improve family nutrition. These are to be promoted since it is believed that farmers of the world over already possess indigenous technologies for managing fruit crops to produce multiple services and products such as soil improvement, shade, food, medicines and fodder. Fruit trees species of multiple services and products are well documented by (Liyange *et al.*, 1984; Fonzen and Oberholzer, 1984; Balasubramanian and Egli, 1986; Vergara and Nair, 1985; Rocheleau *et al.*, 1988; Subler and Uhl, 1990 and Moshi, 1997).

Another important function of tree component in agroforestry system is fodder production. It is reported by Paterson *et al.*,(1998) that fodder trees which are in most cases part and parcel in agroforestry have proved critical to livestock especially

in harsh times due to long life span and capacity to produce fodder when other plant species are dormant. Paterson *et al.*, (1998) further report that they have high feeding quality in terms of protein and contents of some minerals and are tolerance of a wide range of management practices. Fodder tree species are well documented (Fonzen and Oberholzer, 1985; O'king'ati, 1985; and Moshi, 1997).

Forests and trees contribute to many household needs in addition to food security (FAO,1989; Falconer and Arnold, 1991). Further, both forests and farm trees supply foods and other products that may be consumed, sold directly, or processed and then sold. In terms of household food security these products serve functions which can be summarised as follows: Supplementing farm production, filling in seasonal shortfalls in food and income and providing a buffer during hardship periods.

Benjamin and John (1990); Griffon and Mallet (1999) report the roles played by trees in farmland ecosystems from soil and water protection, soil fertility and maintenance, to the provision of products ranging from construction wood and fuelwood to fodder, food, bee forage, shade, medicinal and cultural significance as to have credited agroforestry superior in increased productivity than other farming systems.

2.2.2.3 Animal component

It is reported by Nair (1985) that the animal component is not found in all types of agroforestry systems. Livestock like guinea fowls, turkeys, ducks and geese, along with pigs, goats and sheep are reported to be raised by prosperous families in agroforestry systems of Brazil's mid - north region (May *et al.*, 1985). They continue

by reporting that most families have a few chickens; some have mules, donkeys, horses and oxen as beast of burden. There is very little use of animal traction for cultivation. Small farmers rarely own cattle. Animals are fed babassu leaves from juvenile palms, kernel residues, palm heart and mesocarp meal as well as cassava peelings, corn and crop residues.

Johnson and Nair (1985) document cattle, goats and donkeys as locally raised livestock in the perennial crop - based agroforestry systems in Northeast Brazil. They further report that such livestock are grazed on spontaneous grass and shrub growth beneath the trees and cattle are brought in from the interior for seasonal grazing and these tree stands provide the much needed shade to the livestock. Livestock are removed from the fields during the harvesting of cashew fruits and carnauba palm leaves. Fonzen and Oberholzer (1984) report cows, oxen, buffaloes, goats, pigs, poultry, and their respective uses as animal component in the hill farming systems in Western Nepal.

Vergara and Nair (1985) report cattle as animal component in the agroforestry system in the South pacific region. They continue to report that cattle are grazed under coconuts to keep down the competing and fire hazardous grassy weeds. These cattle contribute to the production of animal protein for local diets, recycle the weed biomass and improve soil fertility and help increase farm income and employment of the farmers.

In government established pine plantations in Fiji, cattle are used to clear the grass and therefore save the cost of land preparation prior to planting. Again, when pine seedlings are big enough to avoid being trampled on cattle are brought in again to keep down competing grasses and to minimise the accumulation of biomass fuel that could be a fire hazard to the plantation. The system is credited as to be feasible alternative for fighting the fire problem (Silva - Pando and Fernandes, 1992).

Fernandes *et al.*,(1984) report diary cattle and pigs which are kept for sale and/or home consumption practised by the Chagga of Kilimanjaro region in Tanzania. Similarly, Moshi (1997) reports the West Usambara's homegardens to be dominated by chickens, followed by cattle whereas pigs and rabbits are small in numbers. However cases for wild animals like buffaloes and other fauna to be incorporated and grazed in agroforestry systems in Indonesia have been reported (Michon *et al.*, 1986). They further report that they play an important role in pollination and seed dispersal, although they cause damage to fruit and tuber crops.

2.2.3 Arrangement of components

This generally refers to plant components of the system (Nair, 1985). Nair (1985) stresses that, in agroforestry systems involving animals, however, the management of such animals may lead to a definite plan, such as a rotational grazing scheme. The plant arrangements in multi-species combinations can involve the dimensions of space and time. Also spatial arrangements of plants in agroforestry mixtures vary from dense mixed stands for example, homegardens to sparsely mixed stands in silvopastoral systems and the species can be in zones or strips of varying widths

(Nair, 1993). The arrangement of the components depends on the nature of the intercrop (Liyange *et al.*, 1984). They further report that a circular area of about 2 metre radius around palm is left free of intercrops and the intercrops are grown in the interspaces of coconut rows according to the recommended planting system for the sole crop of the intercrop concerned.

Fonzen and Oberholzer (1984) report the cultivation of maize as a sole crop or mixed/relay cropping sequences in a non irrigated land. On irrigated lands one crop of rice is cultivated as a sole crop. Then after the harvest of rice, the land is fallowed for one year. Trees and shrubs are grown usually in strips of 1.5 to 6 metres width along the boundaries of the fields, and the strips are spaced about 25 – 30m apart. This implies that there are about 400 running metres of tree strips of varying widths per hectare covering roughly 10% of the land area.

It is however reported in various agroforestry systems documents that generally the components do not seem to be grown according to any specific pattern or planting arrangement but they appear to be in a random though intimately mixed patterns (Fernandes *et al.*, 1984; Balasubramanian and Egli, 1986; Miehe, 1986; Jacob and Alles, 1987; Okafor and Fernandes, 1987). However, it is not logical to conclude that a system has evolved over centuries and is still providing good sustenance to the farmers, could be casual about location, spacing and site conditions of perennial cash crops. Those who practice the system know, in a practical way, what and where to plant and how to manage the plants (Jacob and Alles, 1987).

The spatial arrangement of components may be easy if they have distinguishing features due to their species density (Michon *et al.*, 1986) or due to the limited number of components (Miehe, 1986). Okafor and Fernandes (1987) report that in some agroforestry systems such as trees, shrubs and other crops are located where they can be protected, watered and harvested easily. They further report that in Nigeria, the number of crops in the compound farms, decreases as the distance increases from the household. However, Nair (1985) reports spatial arrangement in an agroforestry mixture can result in mixed dense stands, as in home-gardens, or in mixed sparse stands, as in most systems of trees in pastures to allow greater fodder yields.

2.2.4 Components' stratification

It is documented by Fernandes and Nair (1986) that homegardens are characterised by high species diversity and usually three to four canopy strata and therefore indicating the intimacy of plant associations. The homegardens are usually carefully structured systems with every component having a specific place as well as function. This is contrary to the apparent appearance of random arrangement of species. However, MacDicken (1990) document the homegarden as often possessing a complex and layered vertical structure. MacDicken (1990) further indicates that the upper storey is often of tree and palm species that produce timber, fuelwood, fodder, shade and food in the form of edible fruits, nuts, flowers and leaves. The middle storey may produce coffee, cacao, pawpaw, bananas, fruits and species from shrub or small statured tree species. The understorey may consist of beans, and pulses, root crops, grasses or legumes for fodder and a variety of herbs and medicinal or

ornamental plants. However, the west African compound farms are characterised by a four - layer canopy dominated by a large number of indigenous tall growing fruit trees (Okafor and Fernandes, 1986). The storeys categorised by MacDicken (1990) are also found in studies made others (Fernandes *et al.*, 1984; O'kting'ati, 1985; Balasubramanian and Egli, 1986; Michon *et al.*, 1986; Rugalema, 1992; Moshi, 1997).

2.2.5 Components interactions

Nair (1993) reports the component interactions as to refer to the influence of one component of a system on other components and the system as a whole. In some systems the data for component interactions do not exist (Jacob and Alles, 1987). What is reported as the distinguishing character for example, the Kandyan garden system of Sri -Lanka from other land use systems is the intensive utilisation by plants of both the above ground and the below ground resources both vertically and laterally. Further, being a mixture of many crop species, the risk of crop pests and diseases associated with monocropping systems is minimal. However, in some agroforestry systems the interactions are reported. Fonzen and Oberholzer (1984) report the interaction involved in the use of multipurpose trees in hill farming systems in Western Nepal to include both positive and negative, in both space and time. The direct interactions involve those between tree strips and field crops (soil conservation, shading by trees on adjacent rows of crops), fodder trees and animals cattle (manure) and crops.

One of the main competitive interactions is the use of grass for thatching versus for cattle feed. Then there are cyclic interactions involving the use of crop residues for soil protection and fertility build-up. Contour strips of trees and shrubs on the hills with slopes up to 40% also exist. These, besides protecting soil erosion they also provide the much needed fodder, firewood, fence posts and other types of farm timber. The positive interactions are appreciated by farmers in such a way that negative ones which include shading and consequently lower yields of crops near the trees, damage to young crops by coalescing drops of rain from the overstorey are undermined.

The direct interactions, however, differ from one agroforestry system to another. Fernandes *et al.*, (1984) document the direct interactions to include fodder trees/shrubs and livestock; trees/shrubs and bees; cattle manure and crops, trees/shrubs. While Balasubramanian and Egli, (1986) document trees/shrubs and food crops; grass strips and coffee; and cattle manure and crops, trees/shrubs. The negative interactions involve shading which consequently lower yields of crops near the trees (Fonzen and Oberholzer, 1984; Verinumber and Okali, 1985) or some competitive and complementary interactions, in the planted woodlots, between the young tree seedlings and the interplanted food crops (Balasubramanian and Egli, 1986). Damage of young crops by coalescing large drops of rain from overstorey is also reported (Fonzen and Oberholzer, 1984).

Water competition is likely to occur in most agroforestry systems at some period in time and this period may vary from a week or so and the effect of these events

depends on the severity of the drought and the drought tolerance of the plants (Nair, 1993). Singh *et al.*, in Nair (1993) report that in their study on Leucaena with cow pea, sorghum under semi arid conditions in India, competition for water appeared more important than shading effects. Competition for nutrients is a problem where trees or shrubs have established root system which can dominate that of the newly planted annual crops (Young, 1989).

2.3 Functional classification

Two fundamental attributes of all agroforestry systems are productivity and sustainability (Nair, 1985). This implies that agroforestry systems have a productive function (producing one or more products, usually basic needs) as well as a service role (of protecting and maintaining the production systems) Nair (1985) further documents that all agroforestry systems have both productive and protective roles, though to varying degrees of magnitude and relative importance. System functions of agroforestry are well documented in literature. For example, the production function which involves agricultural crops, fodder, firewood and other farm products which include fruits, poles, timber, animals and honey are well documented (Fonzen and Oberholzer, 1984; Liyange *et al.*, 1984; Nair, 1990; Young, 1990, Moshi, 1997).

Allen (1985) reports the yield estimates of different crops practiced in the lowlands of Papua New Guinea as follows: Dioscorea crop ranges from 10 - 20 t $^{ha-1}$, when rice was grown yields ranged from 0.45 - 2.8 t $^{ha-1}$ and coffee yields are about 115 - 120 t $^{ha-1}$. However, the average price of dry parchment coffee at 'farm gate'prices for 1982 was 0.55 kina kg^{-1} (1 kina = 1.2 US$) thus coffee provided the average family

with a cash income of around US$ 60 in 1982. Fonzen and Oberholzer (1984) report the average annual yields of agricultural crops on the sloping bari land in Western Nepal as 899 kg $^{ha-1}$ for maize, 637 kg $^{ha-1}$ for wheat, 206 kg $^{ha-1}$ for millet and 186 kg $^{ha-1}$ for rapeseed.

The Chagga homegardens produce about 148 kg $^{ha-1}$ of beans, 412 kg $^{ha-1}$ of coffee and 404 banana bunches $^{ha-1}$. Despite crop production the Chagga homegardens produce fruits, vegetables, sufficient fodder from trees, shrubs, bananas and grasses (Fernandes *et al.*, 1984). Fernandes *et al.*, (1984) further report that the Chagga homegardens produces 1.5 to 3.0m^3 of fuelwood per hectare annually. Yield quantities for crop, fruits, timber, fodder, fuelwood as well as trend of livestock production are well documented (Moshi, 1997). On steep slopes, for instance, agroforestry systems play an important role in minimizing erosion and nutrient loss (Nair, 1985). May *et al.*, (1985) document the palms grown on hillsides of the Brazil's mid-north region as to appear to prevent soil erosion, both through crown protection against exposure to erosivity caused by direct rainfall and root binding of soils. May *et al.*, (1985) further report on the utilisation of babassu fruit husks for charcoal reduces deforestation pressure on other woody species that would otherwise be used as fuel sources. Nair (1984) and Young (1989) report the protective roles of agroforestry systems as to be facilitated by the vegetative cover provided by the trees, crops and grasses.

FAO, (1976); Depominier (1985); Le Houérou (1987) and Rocheleau *et al.*, (1988) report the role of windbreaks and shelter belts in controlling wind erosion. It is also

suggested by Liyange *et al.*, (1984) that practising intercropping and adopting prudent land management practices for the intercrops can minimise the use of soil and water conservation practices such as terracing, preparation of bunds and contour drains and burying coconut husks in pits and trenches near the palms to conserve moisture practiced in monocrop stands of coconuts. Fernandes *et al.*, (1984) report the use of fences in homegardens as some sort of keeping out livestock or wild animals. Also in areas where animals are threat for tree seedlings and vegetables, live fences are useful (Rocheleau *et al.*,1988).

2.3.1 Land tenure

Evidence suggests that increasing population pressure and growing market orientation lead to the individualisation of land rights (Feder and Noronha, 1987; O'kting'ati, 1992, Migot-Adholla *et al.*, 1991 cited by Neef and Heidhnes, 1994. Land that could be used temporarily in former times becomes an estate which could be utilised for a whole lifetime and transferred to descendants. O'kting'ati and Mongi (1983) report that in most parts of Tanzania it is prestigious and respectful for a parent if his sons and grandsons inherit land. This practice has led to fragmentation of land to plots that are uneconomic to run.

It is reported by Vergara and Nair (1985) that land tenure patterns in the Pacific region vary from country to country. The pattern that is common to most of them is the traditional clan exercising extended family control or ownership of land. Clan owned lands may either be cultivated communally, with each clan member receiving a proportionate share of the outputs, or apportioned among the individual households

of the clan and used in a semiprivate manner. This type of land tenure could have either positive or negative influence to agroforestry. It is further reported by Vergara and Nair (1985) that farmers in the Eastern Highlands of Papua New Guinea plant perennial crops in combination with their annual food crops and thus clan land tenure favours and encourages agroforestry. This is opposite to the Western Highlands of Papua New Guinea where clans prohibit the raising of permanent perennials such as fruit trees, for fear that clan lands will be fractured into small plots and taken from clan control for permanent use by individual household. In this situation agroforestry is discouraged. Allen (1985) reports the land tenure in the lowlands of Papua New Guinea as land is being occupied under laws which guarantee rights to customary owners and access to land under the control of leaders of extended families. Inheritance of land rights is normally from father to son, but daughters, particularly widows have no difficulty in obtaining land for food crops. Land which is not cultivated is open to all village residents for collecting firewood and building materials or for hunting. Land for coffee is more restricted.

When the land tenure history is traced it is obvious that land has become an object of economic transactions as lease or sale. Thereby, land is now not only a factor of production but to a growing extent a factor of power and speculation. There are problems that are associated with land tenure. O'kting'ati and Mongi (1983) report that due to population increase and land tenure problems in some areas, livestock population have been decreasing drastically since 1950. However the issue on land tenure in agroforestry is repeatedly cited in the literature as an indirect risk factor. Hoskins (1987) reports that part of the yields of agroforestry are obtained after some

waiting period. People who have insecure or short - term rights of access to land can obviously not be expected to make the long term investments involved in tree planting. Hoskins (1987) continue by reporting that this can even take place within a household where women are given temporary use of fields and/or have no permission to tree planting which are under ultimate control of the male head of household. O'kting'ati (1992) reports tenure systems in Sub-Saharan Africa to show what is often referred to as a bewildering diversity and this is due to differencies in aspects such as ethnic origins, agricultural production systems, histories of conquest and surbordination. In this case each individual has a number of tenure rights or bundles of rights to different natural resources. These rights often differ between individuals and categories of individuals. Typically women have inferior rights to men. Several individuals may claim rights to one and the same resources. This is the typical case for common property such as forest and grazing land. O'kting'ati (1992) continues by reporting that dynamism is one important characteristic of indigenous tenure systems in Sub-Saharan Africa.

2.3.2 Land use types

Land use types in various parts in the world have been reported. According to FAO, (1975, 1976) cited by O'kting'ati (1985) approximately 40% of tropics is forest land, 20% is agricultural lands, while 40% is under woodlands and other uses. Extensive cultivation, particularly shifting cultivation, coupled with overgrazing and gathering of fuelwood posses a major threat to many tropical ecosystems (Avery, 1979; Digernes, 1979; Myers, 1980) cited by O'kting'ati, (1985). Four major land use types namely: urbanisation, cultivation, grazing and forestry are found in Tanzania

(O'kting'ati, 1985). In each of the four major categories a wide range of utilisation intensities may be found (Bene *et al.*, 1977 cited by O'kting'ati, 1985). The land use types are based on the ecological and geographical factors of altitude and climate, particularly rainfall with soils playing a big role. The pattern has also been strongly influenced by political situations, tribal cultures and cash crop production.

In areas where land management became poor, it resulted into deforestation and soil erosion problems (O'kting'ati, 1985). For example in the deforested Mwanza region women spend between 4.5% to 7% of their working day fetching water and fuelwood respectively (Shapiro, 1987 cited by O'kting'ati, 1985). However agroforestry type of land use has been seen as a solution in areas which are facing increasing population pressure and hence land scarcity problems (O'kting'ati, 1985; Balasubramanian and Egli, 1986; Rocheleau *et al.*, 1988; FAO, 1989; Henrylito, 1992; Sathees *et al.*, 1992; and Rugalema *et al.*, 1994). Agroforestry systems have been reported to have potentials to rehabilitate land from further degradation. Cases of rehabilitated land have been reported (Prinsley, 1993; Le Houérou 1993; and Pratap, 1998). Some agroforestry systems for example agrosilvicultural can be carbon sinks (Dixon, 1995). However some of the agroforestry systems if not properly planned have negative effects. For example the establishment and management of agroforestry systems incompatible with prevailing edaphic and climatic conditions can accelerate soil green house gas emissions. Silvopastoral systems and rice paddy agrisilvicultural systems are well documented as sources of CH_4 which significantly contribute to the global CH_4 budget (Dixon, 1995).

2.4 Ecological and socio-economic aspects of agroforestry systems

2.4.1 Ecological aspects

It is reported by Nair (1989) that application of certain agroforestry systems depends very much on the environmental conditions and ecological suitability for the systems in question. Nair (1989) further reports that there can be a set of agroforestry systems in certain regions such as semi-arid, tropical highlands, lowlands and humid tropics. Nair (1985) also stresses that much of the agroforestry systems documentation pertains to specific ecological situations from different ecological regions. For example Vergara and Nair (1985) report the agroforestry systems practised in the South Pacific region, which is formed by a group of islands. Fonzen and Oberholzer (1984) report on hill farming systems practised in Western Nepal. Liyange *et al.*,(1984) report on the intercropping under coconuts in Sri-Lanka which is a tropical island. Leuschner and Khaleque (1987) report on the homestead agroforestry practised in Bangladesh which has four general physiographic regions which include hills, delta, plains and dry land regions. May *et al.*, (1985) document the agroforestry systems practised in both upland sites and along bottom valleys in Brazil's mid-north region. Johnson and Nair (1985) document agroforestry systems practised in North East Brazil which comprises three important zones whereby precipitation is the key environmental factor of ecological significance. These zones include the narrow humid coastal strip in the east, middle zone of moisture deficiency which accounts for the largest portion of the Northeast and the third comprises high rainfall located in the Western Maranhao. Agroforestry systems from Papua New Guinea highlands and Papua New Guinea lowlands are documented (Bourke, 1985; Allen, 1985). Other examples include the Chagga homegarden system in mount Kilimanjaro in Tanzania

(Fernandes *et al.*, 1984) and the multipurpose tree integration on the highlands of Rwanda (Neumann, 1983).

However, Nair (1985) warns that the agroecological zonation alone cannot be used as a satisfactory basis for the classification of agroforestry systems. Several agroforestry systems and practices are relevant to any major agroecological zone, depending on the special conditions of a zone, the emphasis of the system or practice will vary. In tropical highlands, for example, one of the main considerations may be the protective role (soil conservation potential) of agroforestry, whereas in sparsely populated semiarid savannah, silvopastoral systems for production of livestock and fuelwood might be given priority.

2.4.2 Socio-economic aspects

Nair (1985) report socioeconomic aspects such as scale of production and level of technology input and management that have also been used for classifying agroforestry systems. However Lundgren (1982) classifies systems into commercial, intermediate and subsistence.

2.4.2.1 Commercial agroforestry systems

The term commercial is used where the market oriented production of an important output, usually a single commodity is the major aim of the system (Nair, 1985). Examples of this include, the Babassu palm in the agroforestry systems of Brazil's mid - north region (May *et al.*, 1985). Introduction of Robusta coffee in shifting cultivation areas in the lowlands of Papua New Guinea (Allen, 1985), commercial

production of shade tolerant plantation crops like coffee, tea and cacao under overstorey shade trees (Johnson and Nair, 1985; Alvin and Nair, 1986), commercial grazing and pulp plantation (Joffre *et al.*, 1988).

2.4.2.2 Intermediate agroforestry systems

Intermediate agroforestry systems are those whose scale lies between commercial and subsistence production and management (Nair, 1985). Examples are the integration of perennial cash crops and subsistence crops on medium to small sized farms where the perennial crops generate cash incomes, while food crops meet the family's food needs. Nair (1985) continues by reporting that several agroforestry systems in many parts of the world can be grouped together as intermediate systems, especially those based on plantation crops such as coffee, cacao, coconut, and the like. Examples of these are well documented (Bourke, 1985; Liyange *et al.*, 1984; Escalante, 1995 and Penot, 1995).

2.4.2.3 Subsistence agroforestry systems

Subsistence agroforestry systems are those in which the use of land is directed toward satisfying basic needs (Nair, 1985). They are primarily managed by the owner occupant and family. Cash crops, including surplus production of basic commodities, may be a part of these systems. Nair (1985) further reports that most of the agroforestry systems practised in various parts of the developing world fall under the subsistence category. Traditional shifting cultivation found throughout the tropics is the most widespread example. However, Nair (1985) warns that not all forms of subsistence agroforestry systems are as resource depleting as traditional shifting

cultivation under high population pressure. Progressive agroforestry systems which fall under this category are like those in various reports(Wiersum, 1980; Michon *et al.*, 1986; Fernandes and Nair, 1986). Several commendable systems of a subsistence nature as cited by Nair, (1985) can be found in Latin America (Wilken, 1977), arid West Africa (von Maydell,1979) and humid West Africa (Getahun *et al.*, 1982) and India (ICAR, 1979). Other well-documented subsistence systems include silvopastoral systems in arid, semiarid, sub humid, and humid climates in Africa (Le Houérou 1987; von Maydell, 1987) and taungya (Hofstad, 1978) and hill farming systems in Western Nepal (Fonzen and Oberholzer, 1984).

It can be concluded that agroforestry systems are very crucial in meeting subsistence needs and income generation. Fernandes and Nair (1986) stress that most of the farm production in subsistence systems is for home consumption only but any marketable surplus can provide a safeguard against failure and security for the period between harvests of agricultural crops.

Fonzen and Oberholzer (1984), O'kting'ati (1985), Rugalema (1992), Moshi (1997) document that a large proportional of the products of agroforestry systems are utilised by farm families themselves, and therefore providing a high degree of food security. For example, Oduol (1986) reports that it is estimated that the shamba system in Kenya accounted for about 18 million kg of maize that are about 200,000 bags and this formed about 16% of the total national production.

It is further reported that family income was greatly improved as farmers saved cash, which could have been spent on food. Although the yields emanating from subsistence systems are low, they contribute to income and nutrition especially to the poor. For example in Thailand, most of the rice produced is used for consumption but occasionally some of it may be sold to generate cash (Boonkird *et al.*, 1984). It is also further reported by Boonkird *et al.*, (1984) that an average income of US$ 266 per year per family originated from the sales of agricultural crops that were grown in forest plantations and in the homegardens during that period. It is further reported by Balasubramanian and Price (1983) that in 1983, coffee accounted for 11.7% of the total cash income for the families in Rwanda while bananas contributed 38.3%, 13.9% for other food crops and their products and5.2% for livestock.

The Chagga homegardens in Tanzania contributed 52% of Tanzania's coffee export which made the country to earn US$ 65 million (Fernandes *et al.*, 1984). Soemarwoto (1987) reports the Lima gardens of Peru, with an average size of 0.02 ha to have produced an income of US$ 28.33 in five months and this is reported to have added almost 10% to the family income during the period. Okafor (1982) reports that a single mature tree of *Irvingia gabonensis. Var. Gabonensis* fetch a total of about US$300 annually. Moshi (1997) reports the income per household from the agricultural crops as Tshs 495 091/= per year which is equivalent to approximately 618.9 US$ in West Usambaras, Tanzania.

Fernandes *et al.*,(1984) also report a $1m^3$ *Olea welwitschii* tree species in Chagga homegardens in Tanzania to be sold at Tshs 10 000/= during that time which was

equivalent to US$ 803.2. It is reported by Alvim and Nair (1986) that in Bahia, Brazil, 350 000 tonnes annual production of dry cocoa fetch an estimated US$ 700 million annually to the national economy. From this therefore it is not worthwhile to underrate the contributions of the agroforestry systems to the household and nations' economies.

2.5 Agroforestry as a sustainable agricultural system

The merits of agroforestry interventions in making many agricultural systems more robust, can clearly be seen on the less well endowed areas where rainfall is erratic, the soil is less infertile, topography is difficult and farmers have limited land and capital resources. Under such circumstances the mettle of agroforestry can be shown in terms of environmental sustainability, even with low use of external inputs. Sustainability can be described in terms of conserving the soil, enhancing biodiversity, conserving carbon in terrestrial ecosystems, and enhancing nutrient capture and retention (Sanchez, 1995).

Lassoie and Buck (1999) insist that as one set of strategies, which is emerging with others associated with sustainable agriculture and forestry, agroforestry will develop as a set of practices as the infrastructure supporting it evolves. For example agroforestry approach known as Greenbelt movement founded and continued by women in Kenya is commended to agricultural land use in Africa and is expected to benefit the agroeco-system and most important, provide the basis for sustainability. This is because it has been successful in reforesting areas around local farms and

producing better soil, livestock fodder and a local supply of firewood (Brown and Thomas, 1990).

2.6 The relevance of indigenous knowledge in the improvement of agroforestry systems

Farmers have an intellectual capability to use a survival mechanism that incorporates sustainability. As stated concisely by Chambers (1980) cited by Natalie (1990): " Scientists must recognise there is a parallel farmer system of knowledge to their own, which is complementary, usually valid, and in some respects superior". Indigenous knowledge can and often does lead to sustainable systems. For example during periods of war, economic stress, or intensive population pressures, the compound farm is a sustainable system (Natalie, 1990).

On the one hand, there is a tremendous depth of indigenous knowledge about particular traditional systems under very site specific circumstances (Michon, 1983; Nations and Komer, 1982; von Maydell, 1979; Nair, 1987; Feornandes and Nair, 1986; Foley and Barnard, 1985; Okafor, 1980, 1981; Weber and Hoskins, 1983; Clay, 1983; Brokensha *et al.*, 1980) cited by (Dianne and Rocheleau, 1988). Walker *et al.*,(1995) stress that indigenous knowledge is a potentially powerful source of understanding that may often be complementary to scientific knowledge. For example Peter (1998) emphasices on the importance of conserving and utilising indigenous knowledge. Peter (1998) further reports on the increasing rate of disappearance of traditional and indigenous knowledge of biodiversity. Traditional knowledge of how the forests, the coasts, the oceans, the fresh waters and how the biodiversity in these

ecosystems can be used is not only of great value now but can have significant meaning for the future sustainable development. It is only recently that the role of traditional knowledge in natural resource management has become acknowledged (Barrow, 1991).

D'Arcy (1989) insists that people have a wealth of indigenous knowledge and skills that could be complemented with scientific or other knowledge to accomplish together what neither could do alone. However, there is a danger of ignoring indigenous knowledge. Backson (1997) reports that in the past indigenous knowledge and African traditional resource utilisation practices have been ignored. They have been scoffed and dismissed as pagan, uncultured and primitive. The accumulated knowledge and experience of millions of people have been belittled. This has contributed to the current " poverty" in resource management strategies. Evaluation of the combined knowledge of farmers and researchers related to interdisciplinary land use problems offers the possibility of targeting research more precisely to gaps in knowledge constraining the productivity and sustainability of the farming systems. For example (Bene *et al.*, 1977; Steppler and Nair, 1987 cited by Sanchez, 1995) report that agroforestry was brought from the realm of indigenous knowledge into the forefront of agricultural research less than two decades ago and was promoted widely as a sustainable practice that combines the best attributes of forestry and agriculture.

The grafting technique known as Mukibat is an indigenous know - how for homegarden improvement practised in Indonesia which enhances underground

material, which was developed and tested by individual farmers outside research station (de Bruijn and Dharmaputra, 1974 cited by Foresta *et al.*, (1994). Also Paul (1993) reports the existence of indigenous knowledge about the trees and traditional ma`nagement systems in the Zvishavane area in Zimbabwe and Turkana area in Kenya. In fact the indigenous knowledge is very essential in every respect. It doesn't only bring forward traditional agroforestry into modern science but penetrates other fields applicable to Africa and the tropics in general. FAO (1994)for example, stresses that traditionally, in many parts of Africa, Africans have protected biodiversity by means of culture and religious rules. Trees have been protected in sacred groves, taboos have limited the harvest of certain species of plants and animals, farmlands have been allowed to remain fallow periodically and local plant varieties have been nurtured. It is without doubt that generally speaking tribal peoples have a vast amount of environmental knowledge. Farmers know farming systems that can yield multiproducts such as food crops, cash crops, fruits, fodder, fuelwood, timber, medicine and at the same time conserves the environment. Cases from Tanzania are well documented (Kajembe, 1994; Kessy 1995, 1998). Thapa *et al.*,(1995) insist on the importance of incorporating indigenous knowledge in the planning, monitoring and evaluation of agroforestry research and extension.

2.7 Constraints and potentials in agroforestry systems

2.7.1 Constraints

2.7.1.1 Competition between components

Nair (1989) reports reduction of output of food crops where trees compete for use for arable land and/or depress crop yields through shade and root competition. In

order to avoid the effect of shade, Poschen (1986) suggests the incorporation of deciduous trees such as *Faidherbia albida* which shed their leaves on the onset of the rains. While Swaminathan (1987) suggests the incorporation of *Dalbergia sisoo* which sheds leaves during autumn to enrich the soil and at the same time availability of solar radiation under tree canopy increases.

2.7.1.2 Incompatibility

Free grazing, burning, common fields which make it difficult to protect trees may lead to incompatibility of trees to agricultural crops (Nair, 1989). However, Lulandala (1994) cited by Moshi (1997) reports the allelophathic effects either of the trees on the crop or vice versa may cause incompatibility of trees to agricultural crops.

2.7.1.3 Diseases and pests

Lulandala (1994) cited by Moshi (1997) reports the presence of trees on the land management unit that may attract wild animals that can in turn cause problems to the associated crops and livestock. Besides attracting wild animals, trees also harbour birds for resting, food and nesting and therefore easy for them to feed on crops. The crop and tree residues encourage pathogen infestation and cause disease problems to the whole system (Lulandala, 1994 cited by Moshi, 1997). Although the pest and disease control associated with agroforestry has been rarely studied, but integrated pest management which involves non overlapping pest crops and conservation of natural enemies is very crucial (Swaminathan, 1987).

2.7.1.4 Others

Various constraints in various agroforestry systems have been documented and they vary according to the agroforestry system in question and agro-ecological zones. Establishment and management of agroforestry systems incompatible with prevailing edaphic and climatic conditions can accelerate soil green house gas emissions. Liyange *et al.*, (1984) report the constraints in intercropping under coconut in Sri-Lanka as drought, lack of funds, price instability, lack of technical know how, timely availability of labour, availability of planting materials and farm inputs.

However, May *et al.*, (1985) report low current fruit productivity, pasture encroachment, juvenile palms to be considered as noxious weeds by ranchers, suppression of stands maintained over pasture, low utilisation of existing stands for kernels, inequitable land distribution as constraints which exist in Babassu palm agroforestry systems of Brazil's mid-north region.

Balasubramanian and Egli (1986) report soil degradation and demographic pressure, scattered distribution of farmers and farm families all over the region which create difficulties in effective extension services for agroforestry. Rugalema (1992); Rugalema, *et al.*, (1994) report declining soil fertility, banana weevils, increased population pressure, low livestock population as some of the constraints for homegardens in Bukoba district, Kagera region in Tanzania.

Michon *et al.*, (1986) report the population increase in Indonesia as a constraint in the multi-storeyed agroforestry garden system. Fernandes *et al.*, (1984) report the

migration of youths to urban areas whereby old people are left in rural areas which presents difficulties for extension workers to introduce innovations in Chagga homegardens in Kilimanjaro region, Tanzania. However the constraint for the improvement of the Kandyan gardens of Sri-Lanka is that it has not been understood scientifically (Jacob and Alles, 1987).

2.7.2 Potentials

MacDicken (1990) reports the two important potentials for enhanced agroforestry development in the humid tropics which include firstly the richness in species diversity and adaptability and secondly high potential productivity. Evans (1982) as cited by MacDicken (1990) suggests that tropical rain forests commonly contain 70 - 100 tree species per hectare. This diversity exists also in cropped land. May *et al.*, (1985) report the opportunities of Babassu palm in the agroforestry systems of Brazil's mid - north region as follows:

- Babassu's attributes are a provider of a wide range of products. Its ease of establishment and maintenance, and its current close integration with extensive production systems on marginal lands could be enhanced by a breeding programme to upgrade productivity of apparent natural hybrids of babassu with palms such as *Maximiliana maripa* and *Orbignya oichleri* to select strains more tolerant of dry and nutrient poor soils.
- Babassu palms could be retained on hillsides in fertile regions as a means of preventing soil erosion; increased market demand for whole babassu fruits will make this attractive to landowners.

- ❖ There is a potential for stand and yield improvement through dissemination of seed from prolific stands encountered in the wild, or genetically improved stands.
- ❖ Available technology for mechanical processing of whole babassu fruits can be scaled down to the level of the producer.

Jacob and Alles (1987) report Sri-Lanka's environmental conditions to allow a vast number of high value export crops to be grown.They continue to suggest that there is a good possibility for stepping up the production of the crops in marginal lands of degraded small holdings of tea and rubber through appropriate crop diversification efforts.

Agroforestry systems are also seen as cost effective compared to other systems. For example farmers in tropical areas incorporate trees in their farming systems in an agroforestry setting in order to maintain soil fertility using low cost external inputs (Nair, 1993; Sperow and Keefer, 1975 as cited by Nduwayezu, 1997).

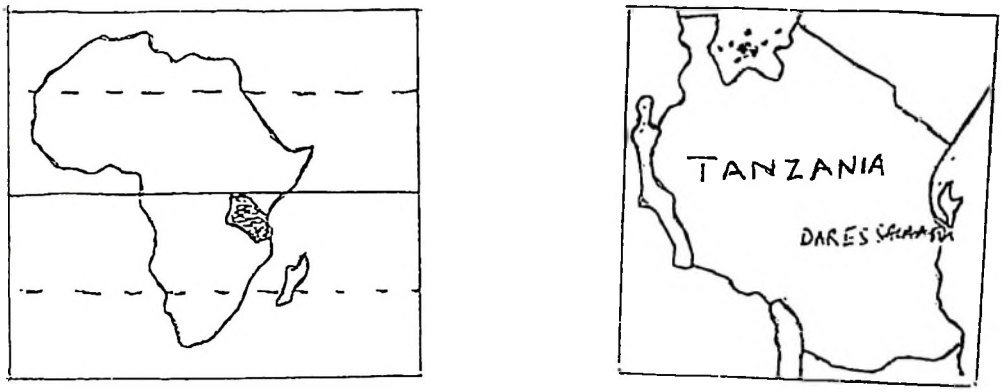
CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 General description of the study area

3.1.1. Geographical location

Ukerewe district is an island in Lake Victoria. It is located between latitudes $1^0$5'S to $3^0$30'S and longitude 34^0 to 35^0E. It is the smallest and most densely populated district in Mwanza region. It has a total area of 6400 square kilometres of which 640 square kilometres is land and the rest 5760 square kilometers is water; the main water body being Lake Victoria. The island is made up of 27 islands out of which seven are permanently occupied by people and the rest are temporarily occupied by fishermen. Administratively, Ukerewe is divided into four divisions namely, Ilangala, Mumbuga, Mumulambo and Ukara (Figure 2). It is also comprised of 24 wards and 74 villages. The study was concentrated in two divisions namely Mumulambo and Ukara respectively.



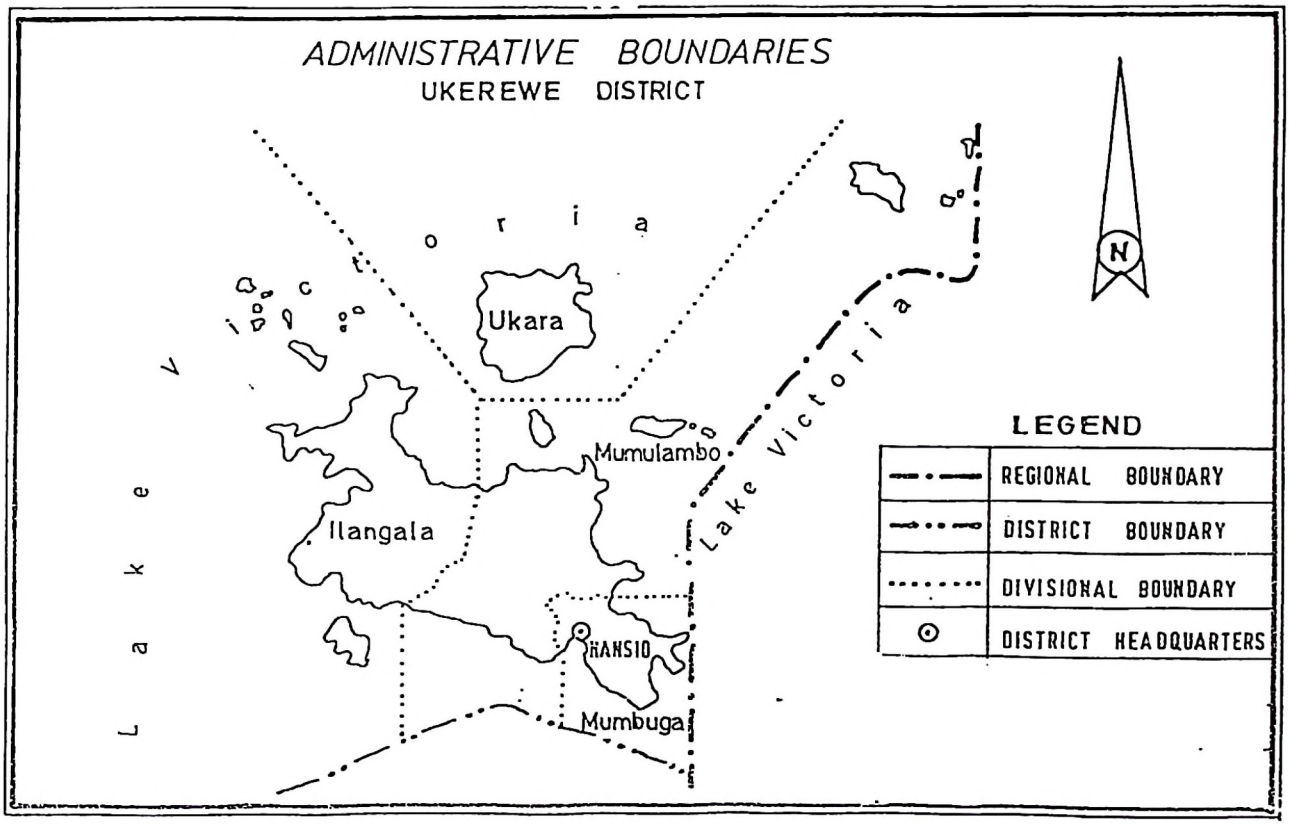


Figure 2: Administrative boundaries of Ukerewe district.

3.1.2 People and their occupation

According to 1988 census the population of Ukerewe district was 177893 with a population density of 277 people per square kilometre (Bureau of statistics, 1992). By year 2000 when the study commenced, the human population in the district was 232523 with a population density of 364 people per square kilometre and a growth rate of 2.2% (District Medical Office). This is an average population although in some areas like Ukara the population density is up to 500 persons per square kilometre (O'kting'ati, 1985). However, Murutunguru village which was among the villages in the study area, has a population density of 570 people per square kilometre, and it is anticipated that in some areas of the district the population density is above this figure.

The people of Ukerewe are mainly subsistence farmers. They depend on rain-fed agriculture supplemented by fishing. In the former days fishing activity was the leading income earner for most of the people in the district followed by agriculture (Kabingile, *et al.* 1996). Due to expensive fishing gears, few people are currently engaged in fishing activities compared to agriculture. Even those who are engaged in fishing activities have poor facilities and alternatively work as labourers for fish processing industries who have high quality fishing gears. Bulrush millet used to be a staple food in Ukara Island, but due to decrease in soil fertility, the crop together with other indigenous crops such as bambara nuts, and groundnuts are cultivated in small amounts compared to the former days. Cassava crop remain the staple food throughout the district. Other food crops such as sweet potato, rice, sorghum, beans, cowpeas, finger millet and maize are also cultivated.

Cotton used to be a cash crop in the area, but due to uninvestigated reasons many people have abandoned it although it is anticipated that land scarcity problem is among others since it is a monocrop and therefore requires abundant land. Coffee crop was grown in large amounts in Ilangala division only but, the crop has been introduced in other areas of the district and therefore it is expected that in future it will be a cash crop since it accommodates intercropping. There is no common cash crop in the area, therefore currently fishing, rice, cassava, sweet potatoes are important source of income. Other crops such as sorghum, finger millet, coffee and cotton are source of income for some few families who possess them.

Orange and mango fruits are produced in large amounts and could be a good source of income but unfortunately there is no reliable market or processing industries and therefore majority of them remain to rot in farms. Products are sold within the district and neighbouring areas that include Mara, Mwanza municipal, Uganda and Kenya.

Livestock is also a source of income although it is kept at a small scale due to inadequate pasture that is caused by land scarcity problem, diseases and lack/or expensive drugs. Table 3.1 shows the livestock population in the district.

Table 3.1: Livestock population and uses

Type of livestock	Number	Uses
Cattle	53468	Manure, income, consumption, ceremonial.
Goats	3182	Manure, income, consumption, ceremonial.
Sheep	203	Manure, income, consumption.
Rabbits	750	income, consumption.
Pigs	105	Manure, income, consumption, traditional/cultural.
Ducks	60000	Manure, income, consumption.
Guinea fowls	250	Income, consumption.
Pigeons	100000	Income, consumption.
Turkeys	12	Income, consumption.

Source: District Livestock Officer (2000).

3.1.3 Climate

The area has both short and long rains. Under normal circumstances the short rains start from September to December followed by a dry spell, which starts from January to mid February. The long rains start form mid February up to May and sometimes up to the end of June. The rainfall pattern is not uniform as it ranges from 900 to 1200mm per annum. The mean annual temperature ranges from 23 to 27^{0}C.

3.1.4 Soil and vegetation cover

The land is fairly flat with few rock outcrops. In general the soils are sandy loam with few scattered patches of clay soils especially in termite mounds and swampy areas. Since the population density is high, the area of cultivated land including settlement is large relative to uncultivated land. According to MNRT maps (1996) the area is distributed into land cover and land uses. Ukara Island comprises two types of land covers, which include bushland, and grassland, which are used as bushland with scattered cropland respectively. Kweru and Irugwa islands are covered with cultivated land that is used for mixed cropping. However there is Busyengere Island,

which is among Kweru islands, which is covered with bushland and is used as bushland with scattered cropland. Ukerewe Main Island has five land covers. These comprise bushland, which is used as bushland with scattered cropland; cultivated land, which is used as, cultivated land with tree crops, mixed cropping and cultivation with herbaceous crops; grassland used as grassland with scattered cropland; forest used as natural forest and plantation forests and finally water features which are used as permanent swamp/marsh (Table 3.2).

In relation to the vegetation, the eastern part of the district that is made up of Mumbuga and Mumulambo divisions has wooded savanna type of vegetation. The western part, which is made up of Ilangala division has rainforest type of vegetation whereas the northern part that is made up of Ukara division is mostly dominated by grassland and bushland savanna types of vegetation.

Table 3.2: Land cover and land use.

Geographic area	Land cover	Land use
1. Ukara island	1. Bushland	1. Bushland with scattered cropland
	2. Grassland	2. Grassland with scattered cropland
2.Kweru island	1. Cultivated land	1. Mixed cropping
3.Busyengere island	1.Bushland	1. Bushland with scattered cropland
4. Irugwa island	1. Cultivated land	1. Mixed cropping
5. Ukerewe main island	1. Bushland	1. Bushland with scattered cropland
	2. Cultivated land	1. Cultivation with tree and crops
		2. Mixed cropping
		3. Cultivation with herbaceous crops
	3. Grassland	1. Grassland with scattered cropland
	4. Forest	1. Natural forests
		2. Plantation forests
	5. Water features	1. Swamp/marsh (permanent)

Source: MNRT maps (1996).

There are five government forest reserves that occupy in total 2990 ha which is equivalent to 29.9 km^2, which is about 4.7% of the total land area. All these forest reserves are located in Ilangala division and they include; Rubya owned by central government, Negoma, Itira, Kabingo and Mkigagi owned by the local government authority. There are also few reserved village and individual woodlands that were established in 1997/98 commonly known as "NGITIRI".

Most of the area has been invaded by a woody species known as *Lantana camara* which makes accessibility difficult is some areas. However the species is urged to be useful since it is reported to reclaim the infertile soil by adding enough litter within a short period of about two years fallowing . The species also used for medicine, hedge, firewood and as fodder for goats. The district is also affected by deforestation that is characterised by denuded hills and prominent huge stones that in former days were covered by trees.

3.1.5 Wildlife

The island does not have much and big game, the only big game being hippopotamus found in the lake. On the land there are various species of birds, rats, snakes, monkeys and rock hyrax. With the exception of the snakes, the rest of wildlife is vermines.

3.1.6 Communication

Total road network coverage in 344 km, with almost all villages in the main island of Ukerewe being accessible by road throughout the year. However, road traffic is very

low. In the small islands there are no motor vehicles with the exception of Ukara island where there are government owned vehicles for the health center and some few motorcycles used by extensionists. However water transport using canoes, sailing boats, engine boats, ships and a ferry is quite effective and reliable in this district.

3.1.7 Sample villages

The locations of the sample villages are indicated in figure 3. The roads within the villages are accessible although the traffic is low and irregular. People use bicycles and head loads as a means of transporting various items.

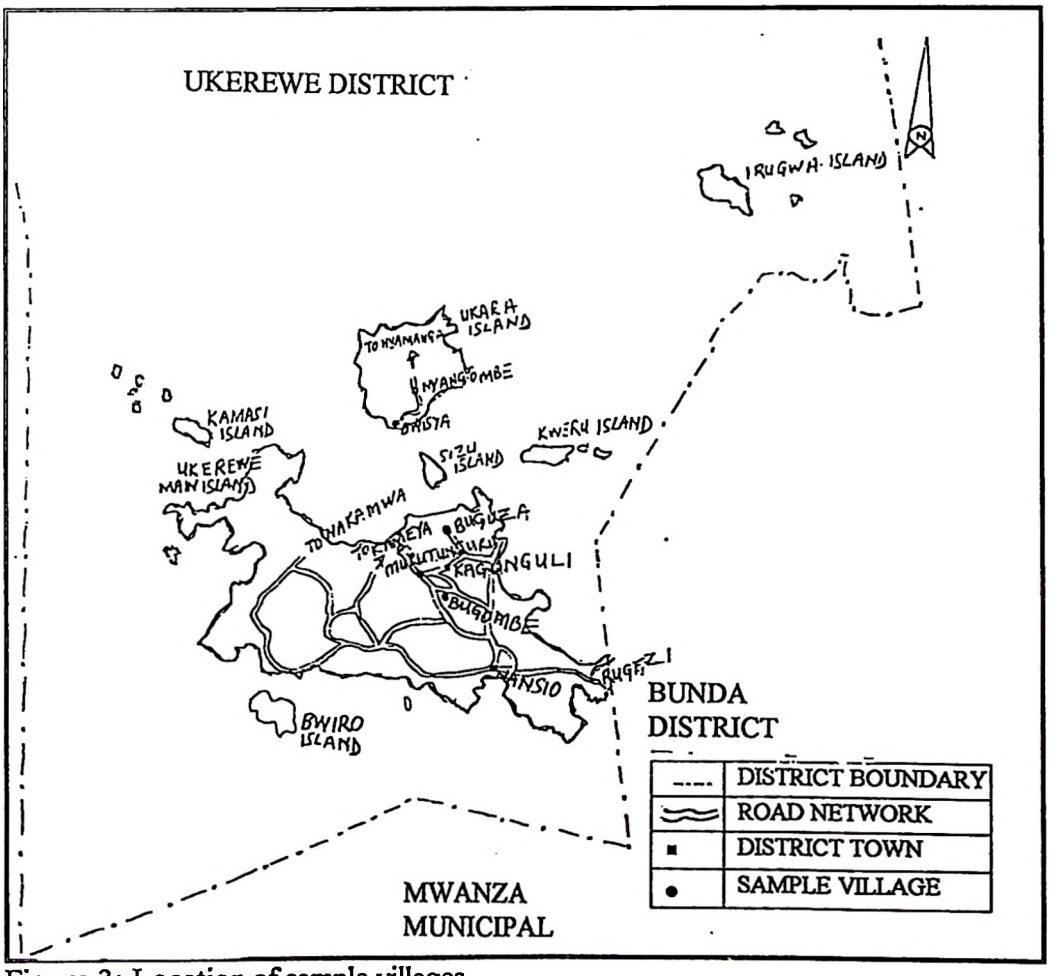


Figure 3: Location of sample villages.

The population of the surveyed villages is shown in table 3.3.

Table 3.3: Population of the surveyed villages

Village	Number of households	Number of people	Average people per household
Bwisya	472	4825	11
Nyang'ombe	428	3239	8
Murutunguru	790	3963	5
Bugombe	240	1479	7
Kagunguli	810	6560	9
Buguza	558	5836	11
Total	2598	25902	10

Source: Respective village council offices (2000/2001).

3.2 Data collection

3.2.1 Sampling technique

The simple random sampling technique was used in selecting divisions, wards, villages and households for which the study was carried out. In this study the household was a sampling unit. Boyd, *et al* (1981) suggest that in order for a random sample to be representative, it should at least constitute 5% of the total population. This suggestion was followed up to village level. Due to time, material and funds constraints, approximately 3.9% of the households available were sampled.

3.2.2 Sampling unit

According to Rocheleau (1990) households consist of men, women and children whose rights, responsibilities and interests may compliment or be in conflict. According to the nature of the study only either or both of the couples from each of the sampled households was interviewed. The study was conducted in two divisions, three wards and six villages. Two wards were from Mumulambo division that has in

total six wards and one ward was from Ukara division that has in total four wards. Two villages were from Ukara division and four villages were from Mumulambo division. In Ukara division 100% of the villages were taken from a ward since each ward has only two villages. In Mumulambo division at least 40% of the villages were taken form each of the two wards.

A list of households for each village was obtained from the respective village council office. The household heads were arranged in three age groups 20-39, 40 – 59 and 60 or more years of age. At least 3% of the age group was randomly selected. A total of 102 households were surveyed (Table 3.4).

Table 3.4: The distribution of the number of respondents per village

	Number of respondents	Percentage of the sample
Bwisya	15	14.7
Nyang'ombe	13	12.8
Murutunguru	24	23.5
Bugombe	8	7.8
Kagungul	25	24.5
i	17	16.7
Buguza		
Total	102	100.0

3.2.3 Questionnaires

Three structured questionnaires were used to extract information from the farmers, village leaders, and extension workers both at division and district levels. In this case there were no extension workers at village level. The preliminary draft of the questionnaire was established and pretested on 10 households during the month of August 2000. The results obtained led to the refinement of the questionnaire whereby

some or parts of the questions were dropped out and new ones were included. The questionnaires are presented in appendices 1a, 1b and 1c.

3.2.4 Primary data

Primary data was collected from the head of the household who was either a male or a female, married or single, divorced, widowed or separated. Any other adult household member who happened to be present was encouraged to participate in the interview and to supplement the answers of the survey.

3.2.4.1 Farmers interviews

The interviews were done during data collection. These demanded information such as the farmer's name, age, level of education, marital status, family size, farm size, whether raising trees with food crops or not, plant species found in the farm and their uses. Others include; amount of each tree species, source of seedlings, period involved since started tree planting, type of work the farmer was doing before taking farming, revenue and its source. Other information included estimated cassava yield in terms of surplus, sufficient and insufficient for a maximum of three years, livestock identification, their population and function, constraints and opinions as regards to production (Appendix 1 a).

3.2.4.2 Farm visits

The reconnaissance survey was done in the respective sampling units to confirm the information obtained during the interview and to identify various plant species since the farmers used local names and for unknown species, specimens were collected for

appropriate identification. The arrangement of components was also observed during farm visits.

3.2.5 Secondary data

Secondary data was obtained from village council leaders, Divisional extension workers since there were none at village level, District livestock officer as well as the District forest officer. In this case structured questionnaires were used. Also there was informal interviews with the District planning officer, District medical officer and District community development office.

From the extension staff, data such as farmers acceptability of advises provided, problems facing farmers, ways tried to solve the problems, availability and use of farm inputs, market and prices of crops as well as cassava yield in the last three years from 1997 to 1999 were gathered (appendix 1c).

3.3 Data analysis

The data collected were edited, summarized, condensed, coded from the questionnaire and entered into the computer for processing. The data were analysed by using the Statistical Package for the Social Sciences (SPSS) programme. Qualitative data was analysed by statistical measures of central tendency (means), statistical measures of dispersion (range, standard deviation) and percentages. Quantitative data were analysed by use of descriptive statistics.

Linear regression analyses models were used to predict the relationship between the following:-

- Total number of *Citrus sineusis* tree species in farm fields (Y) in relation to fruit production in bags per season.
- Total number of *Mangifera indica* tree species in the farm (Y) in relation to average fruit production in bags per season.
- Average cassava crop production in bags per season (Y) in relation to total number of family members in the household, upland farm size.
- Total number of trees/shrubs planted or retained in farm (Y) in relation to farm size of the upland in hectares and time period since trees planting started.
- Revenue in Tshs. from oranges in relation to total number of orange trees in the households farm fields.
- Revenue in Tshs. from mangoes in relation to total number of mango trees in the household farm fields.
- Total number of trees/shrubs planted or retained in the respondent's farm fields (Y) in relation to total revenue from agroforestry components in Tshs.

The regression models were as follows:-

(i) Simple linear regression. $Y = a + bx$

Where Y is the dependent variable

a = intercept of the line with Y – axis

b = slope of the line, that is the change of the Y (dependent variable) units per unit change of X (independent variable).

(ii) Multiple linear regression

$$Y = a + bx_1 + bx_2 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + e.$$

Where the rest of the variables are as in simple linear regression except e which is an unexplained error component.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1. Household characteristics

4.1.1. Origin and reason for migration

About 53% of the respondents originated from Bukoba district in Kagera region, 38.2% from Musoma district in Mara region and 8.8% originated from other areas of Lake Victoria Zone (Table 4.1). These people migrated for various reasons as summarized in Table 4.2.

Table 4.1: Origin of respondents

	Respondents	% of total
Bukoba	54	53.0
Musoma	39	38.2
Other areas of Lake Victoria zone	9	8.8
Total	102	100.0

Table 4.2: Reason for migration

Reason	Respondents	% of total
Fishing	53	52
Agricultural land	14	13.7
Hunting	9	8.8
Rulers	4	3.9
Refugees	4	3.9
Unknown	18	17.7
Total	102	100.0

From the results it is obvious that the inhabitants of Ukerewe district are not indigenous. Being an island it is also possible for higher percentages of people to migrate there for fishing activities especially in 20 small islands, which are temporarily

occupied by fishermen. People have been moving from one place to another since time immemorial and for different reasons as it is stipulated in various chapters in the Holy Bible (Bible society, 1994).

4.1.2 Land tenure and land use

About 60% of the people got the farms through inheritance, 19% through inheritance and purchases, 7% through inheritance and village councils, 7% from village councils, 6% purchased and 3% purchased and acquired from village councils (Table 4.3).

Table 4.3: Mode of land acquisition

Type	Respondents	% of Total
Inherited	60	58.8
Purchased/inherited	19	18.6
From village council	7	6.9
Part from village council/inherited	7	6.9
Purchased	6	5.9
Part from village council/purchased	3	2.9
Total	102	100.0

From the results it is obvious that 86% of the people in Ukerewe district got land through inheritance and only 14% got land through other sources such as purchases and village councils. Land inheritance is common in most parts of Tanzania where land is passed from parents to sons and grand children (O'kiting'ati and Mongi, 1983). Although 86% of the respondents have inherited land from their parents but due to population increase which has led to land fragmentation to plots, which are uneconomic to run some of 86% members have been forced to purchase or seek more land from the village council. About 67.6% of the sample reported that their farms are not enough for farming activities. However about 32.4% of the respondents reported

that their farms were enough for farming activities, but the respondents indicated that there was no possibility of acquiring more land, due to reasons provided in table 4.4.

Table 4.4: Reasons for no possibility to acquire more land

Reason	Number of respondents	% of total
The population is high and the land is scarce	54	52.9
Land is scarce	25	24.5
Land is scarce and every piece has owner	18	17.6
Every piece of land has owner	5	4.9
Total	102	100.0

Although 32.4% of the respondents reported that their farm plots are enough, it does not mean that there is a solution to the land scarcity problem since all the respondents agreed that there is no possibility of acquiring more land. Land scarcity and population pressure problems observed in Ukerewe district concur with earlier reports (O'kting'ati, 1985; Balasubramanian and Egli, 1986; Henrylito, 1992 and Rugalema, 1992).

All the respondents reported to integrate trees with agricultural crops, but 70.6% of them indicated shortages of forest products, while 40.2% reported forest products to be found in a distance greater than 20km from villages. The average number of trees per household is 79. This means that although every farmer integrates trees in the farm, these are not enough to meet the household demands. This therefore calls for an intervention for the improvement of the existing indigenous agroforestry systems.

The reasons for shortages of forest products include; few trees have remained within the villages, trees are still young and there is no market for forest products where they

can be purchased. These reasons have an implication that in the former days trees were enough but since the demand for them increased they were felled without planting new ones and now after realizing the shortages of the resource, they have started planting but the trees are still young. Since people acknowledge the problem, it is easy to mobilize them on tree planting activities. Due to shortages of tree products it has been found that 19.6% purchased fuelwood, 10.8% charcoal, 21.6% poles and 52% timber within a period of three years before this field survey. However, 9.8% of the respondents sold fuelwood, 4.9% charcoal, 6.9% poles and 17.6% timber. When comparing the percentages of people who sold forest produce to those who purchased it is obvious that there is shortage of the produce since the demand is higher than supply.

For those who purchased forest products they got them from different sources, which include 37.5% purchased within the village, 34.4% from Rubya forest plantations, 25% from distant villages and 3.1% from Mwanza municipal. However 92.9% of those who sold forest products got them from their farms and 7.1% got them from the woodlands. This shows a high potential for cash generation at the household level. The distances in kilometres from where the forest products are obtained are presented in table 4.5.

Table 4.5: Distance from where the forest products are obtained

Distance (km)	Respondents	% of total
0-5	40	39.2
6-10	1	1.0
11-15	6	5.9
16-20	14	13.7
>20	41	40.2
Total	102	100.0

The results indicate that about 53.7% of the people obtain forest products from distance greater than 15 km. This implies that there is shortage of the resource within homesteads as well as wastage of time, which could be used for doing other developmental activities.

4.1.3 Household composition

Table 4.6 gives results on household composition.

Table 4.6: Household composition

Status	Number	% of of total
Children	393	63.0
Father	5	0.8
Mother	33	5.3
Other relatives/dependants	193	30.9
Total	624	100.0

Family sizes range from 2 to 17 people with the mean of approximately 8 people per household. It was further found that on average, each family comprised of other family members apart from the husband and a wife of whom 623.0% were children, 0.80% fathers, 5.3% mothers and other relatives or dependants constituted 30.9%.

In traditional African societies, the primary obligation to the family, in most cases, extends beyond sons, daughters, husband and wife to include both close and distant cousins. The pursuit of collective interests, which characterizes most of African societies, does not promote the spirit of independence and self-reliance which is more important in order to make any progress. This also diminishes the capacity for individuals to make any meaningful savings out of their incomes. That's why during

working hours it is easy to find male youths in jobless corners even if they are married because they know that the household head, who is the father, will take care of everything at home. This shows high dependency of relatives on nuclear family members. Although these relatives might be contributing to household farm labour on one way or another, they are contributing to land scarcity problem and shortage of other resources.

The age groups of the respondents show that 36.3% are 20-39 years of age, 45.1% are 40-59 years of age and 18.6% are > 60 years of age (Figure 4).

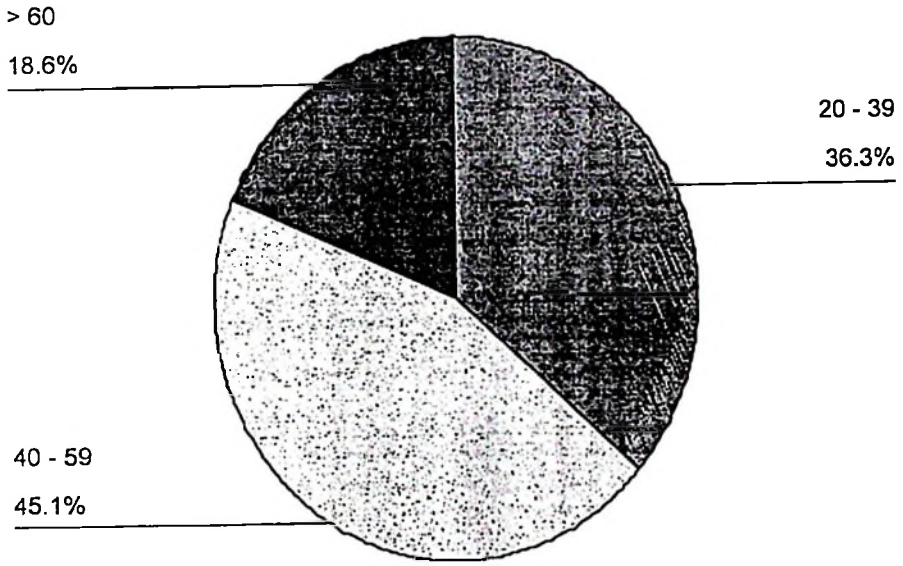


Figure 4: Age of the respondents in years

This has an implication that the society comprises higher percentages of energetic people to contribute in household labour force. The levels of education for the respondents are categorized into three. These include no formal education, primary education and secondary education of which their percentages are summarized in appendix 2. Adult education was not reported in this category of people.

The women's levels of education are also in three categories as summarized in appendix 3. Other family members' levels of education are categorized into four as presented in table 4.7

Table 4.7: Level of education for other family members.

Level of education	Number of people	% of Total
No formal education	257	41.2
Adult education	1	0.2
Primary education	339	54.3
Secondary	27	4.3
Total	624	100.0

The low level of education is contributed by the following; firstly those who were lucky enough to be educated never stay in villages instead they stay in towns with the exception of very few retired employees. Secondly, there are only four secondary schools within the district compared to 81 primary schools available. Therefore very few primary school pupils proceed to secondary schools. With respect to sex, it seems females are the disadvantaged group since this category has higher percentages of no formal education and has none who has attained secondary education. The highest percentages of no formal education in other family members group is contributed to the higher percentage of children who have not attained age for primary school enrollment. However on the other hand since majority of the respondents have primary education, there is adequate knowledge to support agroforestry systems existing in the area. The level of education possessed by farmers is sufficient to enable them to seek, receive and understand better technologies and technical advice from extension workers. They can read posters, leaflets and publications prepared in Kiswahili and containing relevant information for their well-being.

In the sample households the males were 395 and the females were 432, which make 47.8% and 52.2% respectively of the total people. These results indicate higher percentages of females than males. Therefore more inputs for the well being of the community is expected to emanate from females, who are the majority. This means that women involvement in most developmental activities is mandatory for sustainablity purposes.

As in appendix 4 the marital status of the respondents is categorized into single, 1% married, 94.1%, separated 2.0% and widowed 2.9%. Former work types of respondents before taking farming are presented in appendix 5, but fishing activity seems to rank high in this respect. However the respondents' current occupations involve 49.0% are peasants and the rest 51% have a combination of peasantry and other activities (Appendix 6).

About 99% of the housewives are peasants whereby only 1% represent a household head without a wife (Appendix 7). The occupations of other household members (Table 4.8) indicate that over 30% have no defined type of occupation.

Table 4.8: Occupation of other household members

Type of occupation	Number of people	% of total
None	217	34.8
Peasantry	180	28.9
Schooling	198	31.7
Petty business	2	0.3
Peasantry & Fishing	21	3.4
Fishing	4	0.6
Peasantry & petty business	2	0.3
Total	**624**	**100**

The results revealed that 55.9% of the respondents were engaged in other activities before taking to farming. This has an implication that the majority of people have low experience in farming activities compared to the 44.1% of the people who are experienced farmers and thus contributing to the agroforestry sustainability and productivity. With the exception of the wives, 99% of which, are peasants, only 28.9% of other household members are peasants. This high percentage of women engaged in farming activities is an indicator of the need to involve women in technologies which aim at improving farm productivity. However the low percentages of people who are engaged in farming might be among reasons contributing to low yield in farm produce. The results show that 14.8% of the people in sampled households own land whereby 85.2% have no land (Table 4.9).

Table 4.9: Land ownership among family members

Status	Owns lands	No land ownership	Total members	% of total
Husbands	97	-	97	79.5
Wives	13		101	10.7
Female head of households	5	88	5	4.1
Others family members	7	-	624	5.7
		617		
Total	122	705	827	
% of total	14.8	85.2	100	100.0

Since only 14.8% among family members own land, this is a clear evidence of the impending land scarcity problem in the area.

4.2 Farming systems practiced in Ukerewe district

Four farming systems were observed in Ukerewe district and these are classified into two major types: upland and valley bottom farming systems. Upland farming systems

are practiced on upland areas where irrigation and water storage is not possible and therefore depend on rain fed cultivation. Valley bottom systems, on the other hand, are practiced on watershed areas which are either marshy and water for irrigation is possible. Upland farming systems are categorized into four groups: homegardens, mixed cropping with trees, mixed cropping without trees and monocropping. A farmer may employ one or more of these farming systems. The upland farms range from 0.20 to 5.06 hectares with a mean of 1.4 hectares and standard deviation of 0.96 hectares. For valley bottom farming systems, two groups are categorized: mixed cropping and monocropping. In all these farming systems various plant species are found (Appendix 8). The homegardens and mixed cropping with trees in cropland are indigenous agroforestry systems categorized as agrosilvopastural and agrosilvicultural systems respectively as categorized by (Nair, 1985).

4.2.1 Upland farming systems

4.2.1.1 Homegardens

This is a land use form on private lands surrounding homesteads, where several valuable tree species, fruit trees, perennial and annual crops, medicinal plants as well as livestock are found. These homogardens are of the size 0.2 ha commonly known as SABINI that is 32 m x 64 m. .In homegardens *Agave sisalana* species is planted and among other uses serves as hedge and boundary marking. The homegarden type of farming system characterizes the agrosilvopastoral agroforestry system. In this system three components exist which include agricultural crops, animals and trees. These homegardens play roles such as productive, service and protective ones (Nair, 1990; Young, 1990).

4.2.1.2 Mixed cropping with trees systems

These are upland farms whereby trees are either planted or retained in the farms. Most of these farms are found away from the homestead although some of them are near homesteads depending on land availability. In these farms indigenous tree species are mostly retained and encouraged. About 99% of the respondents who own these farms usually have planted or retained indigenous trees in their farms such as hedges of *Lantana camara, Harrisonia abyssinica* and *Erythrina abyssinica* species to protect the farms from livestock. Trees found in farms include *Rothmannia fischeri, Vitex mombassae, Vitex doniana, Mangifera indica, Kigelia africana, Albizia petersiana, Trichlia emetica, Markhamia species* and *Baikiaea insignis ssp.* Minor, agricultural crops interplanted include cassava, sweet potatoes, maize, cowpeas, bambara nuts, groundnuts, finger millet, sorghum, beans and bulrush millet for the case of Ukara island. This is a typical agrosilvicultural system.

4.2.1.3 Mixed cropping farming systems

These are upland farms whereby only agricultural crops are cultivated in mixture without trees. Their reason for not integrating trees in their farms is that trees provide shade and therefore reduce crop production. Farmers also indicated that the farms are small and if trees are incorporated, agricultural crop yield may be reduced. People in Ukara however, due to the low soil fertility found in their area almost every farmer apply organic fertilizer in the farm. In this case if one doesn't have livestock (cattle or goats) to provide manure or if the prepared manure is not enough to adequately fertilize the soil, forest litter (twigs and leaves) collected from farm trees and woodlands is used. These twigs and leaves are tied into bundles, piled together on

rocks to form a heap, allowed to decompose two to three weeks before the onset of rains. Then when the rains fall, they are taken to the farms where they are spread and therefore incorporated to the soil during tilling. For those having livestock, even if the tree twigs or leaves do not serve as fodder, they are collected from the woodlands or farms and then put in the stall pit where they incorporate with manure. Therefore although these farms do not have trees but there is tree crop interaction through the tree/forest litter which is incorporated into the soil to provide nutrients to agricultural crops (Plates 1 and 2). This is purely agricultural crops production system.

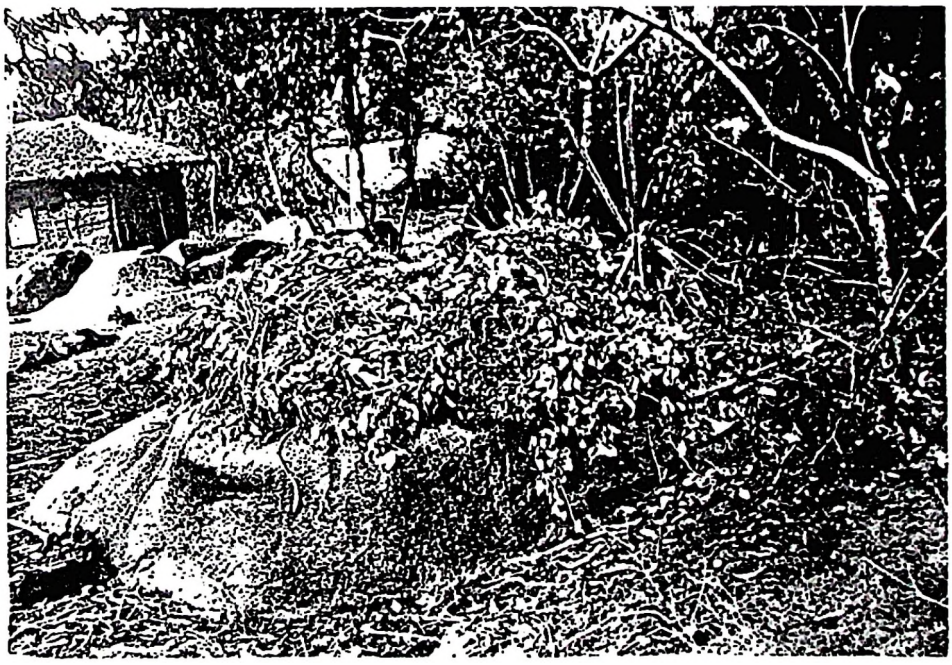


Plate 1: Tree/forest litter prepared at homesteads using farm and woodland trees in Ukara Island.

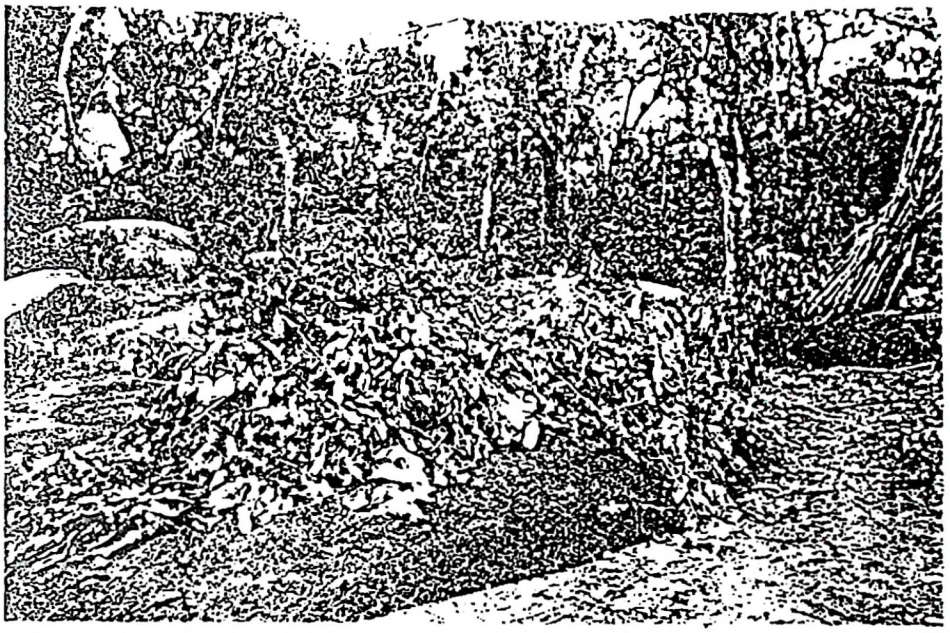


Plate 2: Tree/forest litter prepared by use of woodland trees in Ukara Island.

From the results it can be concluded that these people realize the need to incorporate tree component in their farms but the way in which trees can be integrated in their farms without providing shade and reducing crop production in land scarcity area is a challenge which need to be investigated further.

4.2.1.4 Monocropping farming system

This is a type of farming system in upland areas and used to be popular in former years when cotton was grown as a cash crop in the district. Land scarcities among other problems made many farmers to abandon it and even some few families who cultivate it intercrop other crops such as sweet potatoes and cowpeas at the edges of the terraces. The crop is still enforced in primary schools. The results of this study show that 11 people out of 102 people in the surveyed households still cultivate cotton, comprising 10.8% of the total respondents (Table 4.10).

Table 4.10: Response on cotton as a commercial crop per village

		Cotton is a commercial crop		
		Yes	No	Total
Bwisya	Count	1	14	15
	% within Village	6.7	93.3	100.0
	% of total	1.0	13.7	14.7
Nyang'ombe	Count	2	11	13
	% within Village	15.4	84.6	100.0
	% total	2.0	10.8	12.7
Murutunguru	Count	3	21	24
	% within Village	12.5	87.5	100.0
	% total	2.9	20.6	23.5
Bugombe	Count		8	8
	% within Village		100.0	100.0
	% total		7.8	7.8
Kagunguli	Count	3	22	25
	% within Village	12.0	88.0	100.0
	% total	2.9	21.6	24.5
Buguza	Count	2	15	17
	% within Village	11.8	88.2	100.0
	% total	2.0	14.7	16.7
Total	Count	11	91	102
	% total	10.8	89.2	100.0

These results indicate that monocropping is not favourable in land scarcity areas where farmers expect a variety of crops from a small piece of land. Probably this is the main reason most farmers have abandoned it. Those who still cultivate cotton apply mixed cropping in order to maximize returns and the utilization of their land.

4.2.2 Valley bottom farming systems

These are small plots up to 1.6 hectares with a mean of 0.28 ha found along rivers and lake shores as well as on very flat land. These are areas where rice is cultivated during the rainy season and just after harvesting rice, sweet potatoes and bambara nuts are grown while the soil is still moist. Few farmers grow vegetables in these areas such as tomatoes and cabbages. In most cases these areas serve as pasture during the dry season whereby livestock are either tethered or free grazed especially after the harvest

of sweet potatoes and bambara nuts or before the land is tilled after the harvest of rice. In these areas trees are neither planted nor retained in farms, the major reason being that trees harbour birds which feed on rice. However, according to agricultural expertise rice is a shade bearer crop (C_3 plant) and therefore survives well under low light intensity. Since they do not incorporate tree component but incorporate livestock and agricultural crop production, therefore this type of system is categorized as mixed farming system (Leatherdale, 1982).

In these farming systems, there are only herbaceous crops with heights up to a metre and the components are cultivated and harvested during a certain part of the year only. This concurs with earlier report by Nair (1993). Animals are also grazed in these areas during a certain part of the year and this temporal arrangement can be referred to as time dominant. The crops cultivated take almost four months in farms from cultivation up to the end of harvesting. Animals are grazed in the areas for about two to three months in a year. However there is no specific density for crops, for example, sweet potatoes and bambara nuts are mixed together and are planted on mounds. Depending on the slope of the area, cabbages and tomatoes are either planted on mounds or on gentle slope. Rice however is grown on flat ground with raised edges, which control the inflow and outflow of water. Farm inputs applied are only organic fertilizers and local herbs in the treatment of pests and fungi. The practices are environmentally friendly since they do not contaminate or pollute the environment. This type of farming system is very important in food security and cash flow for household maintenance. However the linkages which exist between livestock keeping and agricultural crop production have to be maintained. This is because livestock

pastured in these areas leave manure which is used by crops to increase production. However these valley bottom gardens contribute to environmental degradation in one way or another. Firstly no tree component is incorporated in this system thus the benefits realized from trees on environmental conservation are not captured. Secondly people cultivate the land up to the riverbanks and lakeshores and therefore result in soil erosion and siltation of rivers and the lakeshores. Research on cost benefit analysis of this system as regards environmental conservation is therefore required.

4.3 Indigenous agroforestry systems, their structure and components

There are two indigenous agroforestry systems which have been identified in Ukerewe district which include agrosilvopastoral and agrosilvicultural systems.

4.3.1 Homegardens

Among the objectives of the study was to map the arrangement and composition of the system. The homegardens (agrosilvopastoral systems) were found to constitute the three agroforestry components which include trees/shrubs, agricultural crops and animals (livestock).

4.3.1.1 Components in homegardens

- **Trees/shrubs components**

People customarily plant and or retain trees in their homegardens. The most tree species planted or retained in the homegardens especially in Ukara Island are fruit trees, valuable timber tree species and fodder trees. The most important tree

species in order of their abundancy and uses for Bwisya and Nyang'ombe villages in Ukara division are shown in appendices 9 and 10 respectively. Average trees per farm in Bwisya village is 57.7 approximately 58 trees but only 39 tree species were identified scientifically. At Nyang'ombe village however average trees per farm is 33.5 approximately 34 trees but only 26 tree species were identified scientifically.

The most abundant tree species in Ukerewe main Island and their uses for each village is as shown in appendices and 11 for Murutunguru, 12 (Bugombe), 13 (Kagunguli) and 14 (Buguza) villages.

The proportion of tree species per village in relation to the total is also shown inTable 4.11. Some homegardens however have hedges of *Jatropha curcas, Delonix elata, Erythrina abyssinica, Tetradenia riparia, Vernonia amygadalina* and *Dracaena mannii* tree/shrub species of which their population was difficult to determine.

With the exception of Nyang'ombe village, *Citrus sinensis* which is a fruit tree species is leading in abundance for the five villages. The tree species which follow serve for other related tree products. The abundance of fruit tree species in homegarden has also reported in literature (Fernandes *et al;* 1984; Tejwani, 1987; Brieriza Jr. and Yared, 1991; Mizrahi *et al.*, 1991; Maghembe and Seyari, 1991and Aiyelaagbe and Jolaoso, 1992).

Table 4.11: Proportion of tree species per village in relation to the total

Village	Total trees	Average trees per household	% of total trees
Bwisya	865	58	10.7
Nyang'ombe	435	33	5.4
Murutunguru	2453	102	30.4
Bugombe	569	71	7.1
Kagunguli	2343	94	29.1
Buguza	1392	82	17.3
Total	8057	79	100.0

Fruit trees in this respect play a role in food security by providing fruits to family members and when sold provide cash for household use. The prunings are sources of fuelwood and the trees also influence climate regulation and soil conservation roles. Fruit trees are planted in homegardens to make them available for children and secondly to make them secure. Other tree species planted around homesteads also meet required wood products such as timber, poles, fuelwood and medicines. Such trees are also protected from theft and livestock damage if planted in homesteads. However, since around homesteads, there are also livestock, live fences are common to establish stalls (livestock enclosures) to protect them from destroying homegarden plants. The appropriate amount of trees population to be left in farms as well as the spacing for each type of tree species need to be investigated.

- **Crop components**

The common agricultural crops which are cultivated in the homegardens are as presented in table 4.12. The crops found in Ukerewe homegardens concur with those found in other homegardens already documented. These include the Chagga homegardens in Tanzania (Fernandes *et al.*, 1984), Indonesia homegardens (Michon *et al.*, 1986), Rwandan homegardens (Balasubramanian and Egli, 1986), Bukoba

district homegardens in Tanzania (Rugalema, 1992) and West Usambaras homegardens in Tanzania (Moshi, 1997).

Table 4.12: Agricultural crops grown in the homegardens

Botanical name	Functions/uses
Manihot esculanta	Staple food, fodder, firewood, vegetable & local brew.
Ipomea batatas	Food & fodder.
Vigna unguiculata	Food & vegetable.
Zea mays	Food, fodder, firewood & local brew.
Phaseolus vulgaris	Food & fodder.
Musa spp	Food, fodder, juice & local brew.
Coffea arabica	Cash crop & firewood.
Cucurbita maxima	Food, vegetable & medicines.
Ananas comosus	Fruits, juice & local brew.

❖ **Animal components**

Livestock identified in the area of study include cattle, goats, chicken, ducks and pigeon (Table 4.13).

Table 4.13: Livestock population

Village	Livestock population *				
	Cattle	Goats	Chicken	Ducks	Pigeons
Bwisya	40 (14.4)	19 (8.3)	95 (16.0)	54 (18.1)	2 (3.5)
Nyang'ombe	38 (13.7)	38 (16.7)	26 (4.4)	33 (11.0)	- (0)
Murutunguru	72 (26)	59 (25.9)	173 (29.3)	81 (27.2)	40 (70.2)
Bugombe	22 (8.0)	24 (10.5)	62 (10.5)	8 (2.7)	- (0)
Kagunguli	64 (23.1)	51 (22.4)	167 (28.3)	41 (13.8)	15 (26.3)
Buguza	41 (14.8)	37 (16.2)	68 (11.5)	81 (27.2)	- (0)
Total	**277 (100)**	**228 (100)**	**591 (100)**	**298 (100)**	**57 (100)**

* Figures in parenthesis are percentages

The overall mean livestock per household is as follows: cattle (2.71 ≈ 3), goats, (2.24 ≈ 2), chicken (5.81 ≈ 6), ducks (2.92 ≈ 3) and pigeons (0.56 ≈ 1). However the average livestock per village per type is shown in table 4.14.

Table 4.14: Average livestock per village per type

Village	Mean livestock per village *				
	Cattle	Goats	Chicken	Ducks	Pigeons
Bwisya	2.67(3)	1.26 (1)	6.33 (6)	3.6 (4)	0.13 (0)
Nyang'ombe	2.92 (3)	2.92 (3)	2	2.54 (3)	0
Murutunguru	3	2.49 (2)	7.2 (7)	3.375 (3)	1.67 (2)
Bugombe	2.75 (3)	3	7.75 (8)	1	0
Kagunguli	2.56 (3)	2.04 (2)	6.68 (7)	1.64 (2)	0.6 (1)
Buguza	2.41(2)	2.18 (2)	4	4.76 (5)	0
Overall average	2.71 (3)	2.24 (2)	5.81 (6)	2.92 (3)	0.56 (1)

* Figures in parenthesis are numbers rounded up or down

The results show chicken to comprise the highest population, followed by ducks, then cattle, goats and pigeons the least. The highest population of chicken and ducks is due to the fact that they are local breeds which are free range. In Ukara island different from Ukerewe main Island, chicken spend their night on trees like any other wild bird while in Ukerewe main Island they spend their night in the same house with the people. The average chicken per household concur with that reported in the Chagga homegardens (O'kting'ati and Mongi, 1983).

According to the inadequacy of pasture and shortage of pastureland accelerated by land scarcity problem the overall average of 3 cattle and 2 goats is satisfactory since this can be easily managed especially under zero grazing method and thereby to provide adequate manure to be used in farms and at the same time to provide other needs such as milk, cash income and meet traditional and cultural functions as well (table 4.15). Types of livestock do not differ much from one household to another. A household may rear of one or more than one type of livestock.

Table 4.15: Uses of livestock

Type of livestock	Uses
Cattle	Farmyard manure, income, consumption, cultural & traditional
Goats	purposes.
Chicken	Farmyard manure, income, consumption, cultural & traditional
Ducks	purposes
Pigeons	Consumption, manure & income
	Consumption, manure & income
	Consumption & income

However the range of livestock varies: cattle (0-16), goats (0 – 13), chicken (0 – 30), ducks (0-24) and pigeons (0-24). Respondents who keep livestock are shown on table 4.16.

Table 4.16: Respondents who keep livestock

Types of livestock	Respondents	% of total
Cattle	76	74.5
Goats	69	67.6
Chicken	77	75.5
Ducks	50	49.0
Pigeons	5	4.9

Number of respondents who keep livestock are out of 102 respondents surveyed. These results have an implication that to keep 16 cattle or 13 goats in an area with inadequate pasture and land scarcity problem is labourious. Those people with many livestock should be advised to destock and those without especially for cattle and goats which are expected to produce a considerable amount of manure to be used in farms to increase soil fertility should be encouraged to keep them.

4.3.1.2 Arrangement of components

The spatial arrangement of components of the homegardens was irregular and random. However, the vertical arrangement of different storeys were obvious and clearly recognized (Plate 3). The lowest stratum of 0-1m consisted of different herbaceous plants which include beans (*Phaseolus vulgaris*), cowpeas (*Vigna unguiculata*), *Cucurbita maxima, Ipomea batatas*, egg plant (*solanum incanum*), *Withania somnifera, Aloe* spp, hot pepper (*Capsicum frutesceris*), cucumber (*Cucumis anguria)*, wax gourd (*Benincasa hispida*), pineapple (*Ananas comosus*), tomatoes (*Lycopersicon esculentum*)

The second stratum of 1 – 3m consisted of cassava (*Manihot esculanta*), maize (*Zea mays*), coffee (*Coffea arabica*), pigeon peas (*Cajanus cajan*), *Rinorea ilicifolia,* sugarcane (*Saccharum officinarum*). The third stratum of > 3 – 5m consisted of *Citrus spp,* mango (short variety), sisal, *Annona muricata, Carica papaya, Cocos nucifera,* red palm oil, *Jatropha curcas,* ceara rubber*(Manihot glaziovii),* bananas (*Musa spp*), *Psidium guajava.*

The fourth stratum of > 5m – 25m comprise of *Maesopsis eminii,* mango (tall variety), *Markhamia lutea, Baikiaea insignis spp minor, Delonix elata, Ficus spp, Melia azedirach, Tamarindus indica* and *Trichilia emetica.* Since the homegarden comprises of many types of species with different requirements it was difficult to estimate the species density especially for other plant species other than tree species. However the homegarden tree species in Ukerewe district range between 25 to 101 with an average of 78 trees in a homegarden of size 0.2 ha. Unfortunately there is no

homegarden, which have a size of a hectare, but on average 395 trees are found per hectare.

Plate 3: Vertical arrangement of different storeys in homegardens in Ukerewe district

However there is no specific tree spacing; most depends on where they are planted. Trees in the center of the farm, for example *Citrus sinensis* are planted at a spacing of 3m to 5m. The spacing is the same for *Mangifera indica* (short variety). However for *Maesopsis eminii*, the spacing is somehow wider than this. *Melia azedrach* and *Markhamia lutea* usually found on the farms boundary are planted at a spacing of 2m to 3m. Tree density in homegarden is higher in Ukerewe district compared to that reported by Moshi (1997) in West Usambaras homegardens which is 25 trees ha $^{-1}$.

There, however no uniformity with respect to types of species found in individuals homegardens. Each farmer knows where to fit each type of crop and tree species in order to benefit from both sunlight and soil nutrients. Singh (1987) reports the tallest component to have foliage tolerant to strong light and high evaporation demand and the shorter components to have foliage tolerant to shade and high humidity. The arrangement of components in Ukerewe homegardens concur with those reported by several scientists (Fernandes *et al.*, 1984; Michon, 1983; Okafor and Fernandes, 1986; Rugalema, 1992 and Moshi, 1997).

4.3.1.3 Interaction of components

The components found in Ukerewe district homegardens which include trees/shrubs, crops and animals interact with each other in both space and time and these interactions have both positive and negative effects. The direct interactions involve trees which provide shade to both crops and animals, provide fodder to animals, and serve as windbreaks to crops and homesteads. Trees are used as pesticides for to crops, and medicine for both animals and people. Trees shed leaves which form forest litter and thereby provide mulch and humus to crops, while their prunings besides providing fodder, also provide firewood, fruits, timber and poles. Crop residues also provide subsidiary feeds to animals and protect soil erosion, besides being sources of food for people and cash income which can be used for household use or for the management of livestock and/or trees.

Animals on the other hand provide manure which is used by both crops and trees when incorporated in the farm. Animals also provide cash, food, and are useful for traditional and cultural purposes.

The negative effects include for example, trees of dense shade such as mango, 2 – 3m from the base of tree stem is usually left unplanted and therefore reduces land to be used for other crops compared to the light shade trees understorey. *Maespopsis eminii* species have large seeds and it is self-pruning; therefore when seeds or branches fall on understorey crops become damaged. Also since livestock are kept in compounds, when they accidentally escape, they feed on crops. However the positive effects gained such as fodder, firewood, fruits, timber, poles, food, cash and manure for the case of livestock surpass the negative effects, since they are rare occasions.

There is also cyclic interaction which exists between crop residues, livestock manure, tree litter and household wastes in nutrient cycling. Household wastes together with the crop residues are either fed to livestock or used to make compost or applied directly as mulch with the object of generating enough organic fertilizers. The tree litter is collected and incorporated to the soil during land cultivation. Farmers are aware of these interactions and that is why they apply tree management such as thinning, pruning, pollarding and weed their farms. They are also aware of importance of tree and crop spacing.

Although these farmers do tree management, they lack technical know how. This is because you may find in some households pruning is done to the leading shoot of the tree.

4.3.2. Mixed cropping with trees (Agrosilvicultural systems)

4.3.2.1 Components

Two components were identified in this system, which include mixed crops and trees/shrubs. The main crops in this system include cassava, sweet potatoes, maize, beans, cowpeas, bambara nuts, groundnuts, sorghum, finger millet and bulrush millet. Elephant grass (*Pennisetum purpreum)* is usually grown along farm and road sides. The tree component includes mangoes (*Mangifera indica)*, *Senna siamea* and various indigenous tree/shrub species such as *Albizia petersiana, Baikiaea insignis spp. minor, Combretum molle, Rothmannia fischeri, Trichlia emetica, Vitex mombassae, Vitex doniana* and *Markhamia lutea.* These trees are sparsely scattered in farm or planted along farm boundaries (Plates 4 & 5).

Plate 4: Trees planted along farm boundaries in cropland

Plate 5: Trees scattered in cropland

Two strata in vertical arrangement were identified. The first stratum of 0-2m constitutes agricultural crops whereby the second stratum of > 2m up to 20m constitutes tree/shrub species. The farms are normally bordered with live fences (hedges) of *Lantana camara, Harrisonia abyssinica* and *Erythrina abyssinica.*

Retaining or planting trees in cropland where they are in most cases sparsely scattered is a widespread practice in the tropics (Rocheleau *et al.*, 1988). Nair (1985) classifies this type of agroforestry system as agrosilvicultural system. Trees left or planted in cropland in Ukerewe district apart from meeting household requirements on forest related products they save as security for land tenure. The importance put on trees in Ukerewe district cannot be undermined, this is so because if someone sells land, the

ownership of trees in the land remains to the seller and these are inheritable. And if a tree is to be sold then it has to be agreed upon among family members incase the household head has already died. If they agree to sell it then the money accrued from the sales is shared among all family members. This is good since it helps to protect trees. However trees left or planted in cropland are susceptible to theft. About 35.3% of the respondents reported this as a problem and may be that is why tree density in homegardens is higher than that in cropland. Also due to theft problem some farmers do not allow these trees to grow to larger sizes. They are usually cut down during cropping season and used as firewood thereby maintaining stumps which coppice annually. With the exception of cassava crop which stays in farm for two years, the rest are just seasonal crops. When harvested, cassava serve as food and cash from the sales of the surplus (Table 4.17). However trees have productive and service roles, although efforts of retaining/planting trees have been demonstrated, 70.6% of the respondents still complain of the shortage of forest product resources in such a way that crop residues are used for cooking (Plate 6).

Table 4.17: Respondents in percentages who use certain agricultural crops as food and/ or commercial crops

Type of crop	Food crop %	Commercial crop %	Both food and commercial crop %
Cassava	100.0		72.5
Sweet potatoes	94.1		39.2
Maize	71.6		2.9
Cowpeas	64.7		2.9
Beans	64.7		0.0
Bambara nuts	63.7		4.9
Banana	58.8		0.0
Rice	58.8		72.5
Bulrush millet	26.5		11.8
Sorghum	25.5		4.9
Finger millet	16.7		10.8
Groundnuts	7.8		2.0
Coffee		5.9	
Oranges			36.3
Mangoes			6.9
Cotton		8.8	
Coconut palm			2.9

Plate 6: A pile of cassava stalks to serve as firewood

Cassava crop is a (C_4) plant which requires high light intensity and it is the major crop cultivated in the area. Sparsely scattering few trees in the cropland probably is due to favouring cassava crop from being affected by shade. For this matter there is a need

for research on either cassava varieties which survive well under shade or tree species which can be integrated with cassava crop.

4.3.2.2 Arrangement of components

The temporal arrangement of components in the system is not constant but intermittent, and this is space dominant. The cassava crop under normal circumstances has a life span of two years. When planting cassava, it is initially mixed with other crops which include sweet potatoes, maize, beans, cowpeas, bambara nuts and groundnuts. In this case both cassava and sweet potatoes are planted on top of the terrace at alternating pattern. The other crops are planted on either side of the terrace. In the following growing season when cassava is almost one year old, cassava stalks are cut down to 15 cm from the ground level. The terrace is tilled and raised then other crops with the exception of sweet potatoes are planted with cassava. The practice is good since enables farmers to intensify land use. There is no specific spacing but a farmer just estimates the interval between crops and thus are randomly planted.

Farmers are knowledgeable of whatever they do, for instance cassava and sweet potatoes, are both tubers, therefore in order to avoid nutrient competition between the two, sweet potatoes are not planted with cassava on the following planting season. However other crops such as maize, beans, cowpeas, groundnuts and bambara nuts are shallow rooted and thus do not compete with cassava which is deeper rooted. May be the other reason of not mixing sweetpotatoes with cassava is

to avoid complications in the harvesting of sweet potatoes since this can lead to the disturbance and damage to cassava tubers which have to remain.

The density of trees in cropland in Ukerewe district ranges from 56 to 72 trees per ha $^{-1}$ with the average of 63 trees ha $^{-1}$. This range concur with the examples provided by Rocheleau *et al.*, (1988), although a single tree species was cited for each example. In Ukerewe district however, there is a mixture of species which is heavily weighted by indigenous trees species. However there are examples cited by Rocheleau *et al.*, (1988) which have 200 to 300 trees ha $^{-1}$. For a district with high demand for forest products like Ukerewe, the present stocking density is still low and therefore needs an improvement.

4.3.2.3 Interactions of components

Since the trees are usually pruned especially in Ukara island where they serve as fodder, the shading effect is minimal. However other tree species with dense canopies such as *Mangifera indica,* crops are normally not planted near the stem base, 2 – 3m on either side of the stem being left unplanted. Some tree species such as *Vitex mombassa*e are reported to improve soil fertility and therefore even if crops are cultivated as close as to the base of the stem, yields are not affected by competition. Apart from these interactions, trees in farms provide forest related products such as timber, poles, fuelwood, medicine and fruits. Mango trees are preferred in cropland since when the fruits are ripe, can be eaten during farm activities and therefore the farmer stays longer occupied for periods. Since many people have realized the use of organic fertilizers livestock manure is ferried to the farm although it requires more

labour as transport facilities such as wheel barrows or bicycles are not readily available.

4.4 Indigenous tree/shrub species found in Ukerewe indigenous agroforestry systems

About 79 tree/shrub species were identified to exist in Ukerewe indigenous agroforestry systems (appendix 15). Of the 98% respondents reported to leave or plant indigenous trees in their farms. These indigenous tree species have benefits which in most cases cannot be obtained from the exotic tree species. They provide medicine, fruit, wood, shelter, fodder and some are important for cultural and traditional beliefs. Some indigenous species are popular for fodder, others medicinal and others have termite resistant wood.

4.5 Trees/shrubs preferred most in the study area and their uses

The trees/shrubs preferred most in the study area are presented in two tables. Table 4.18 shows trees/shrubs preferred most in the study area by village and table 4.19 presents overall trees/shrubs preferred most in the study area. About 72% of the respondents reported to have tree species they prefer most.

Table 4.18: Trees/shrubs preferred most in the study area by village

VILLAGE	TREES/SHRUBS	USES/FUNCTIONS
BWISYA	*Maesopsis eminii*	Timber, firewood, compost, litter, hoe handles, fodder & poles.
	Senna siamea	Poles, fuelwood, timber, compost, litter & livestock bedding.
	Rothmannia fischeri	Fuelwood, fodder, poles, hoe handles, medicines, litter & compost.
	Mangifera indica	Fruits, fuelwood, fodder, litter, compost & medicines.
	Citrus sinensis	Fruits, firewood & hoe handles.
NYANG'OMBE	*Mangifera indica*	Fruit, firewood & fodder.
	Maesopsis eminii	Timber, firewood, compost litter, hoe handles, fodder & poles.
	Vitex mombassae	Timber, fuelwood, fodder, poles, fruits, medicines & compost.
MURUTUNGURU	*Maesopsis eminii*	Timber, firewood, hoe handles & poles.
	Citrus sinensis	Fruits, firewood & hoe handles.
	Melia azedirach	Timber, firewood, poles & fodder.
	Albizia gummifera	Timber, poles & fuelwood.
	Mangifera indica	Fruits, fuelwood & medicines.
	Rothmannia fischeri	Fuelwood, poles, hoe handle & medicines.
BUGOMBE	*Maesopsis eminii*	Timber, firewood, poles & hoe handles.
	Mangifera indica	Fruits, fuelwood & medicines.
	Citrus sinensis	Fruits, firewood & hoe handles.
KAGUNGULI	*Citrus sinensis*	Fruits, firewood & hoe handles.
	Maesopsis eminii	Timber, firewood, poles & hoe handles.
	Mangifera indica	Fruits, fuelwood & medicines.
	Melia azedirach	Timber, firewood, poles & fodder.
	Albizia petersiana	Timber, poles, fuelwood & medicines.
	Elaeis guineensis	Oil, firewood, fruits, shade, timber, thatching, brooms & medicines.
BUGUZA	*Maesopsis eminii*	Timber, firewood, poles & hoe handles.
	Citrus sinensis	Fruits, firewood & hoe handles.
	Mangifera indica	Fruits, fuelwood & medicines.
	Cedrella mexicana	Timber, firewood & medicines.
	Markhamia lutea	Poles, firewood, hoe handles, paddles & timber.
	Melia azedirach	Timber firewood, poles & fodder.

Table 4.19: Overall trees/shrubs preferred most in the study area

TREES/SHRUBS	USES/FUNCTIONS
Maesopsis Eminii	Timber, Firewood, compost, litter, hoe handles, fodder & poles.
Citrus sinensis	Fruits, firewood & hoe handles.
Mangifera indica	Fruits, fuelwood, fodder, litter, compost & medicines.
Melia azedirach	Timber, firewood, compost, poles & fodder.
Senna siamea	Poles, fuelwood, timber, compost, litter & livestock bedding.
Albizia petersiana	Timber, poles, fuelwood, fodder, compost, litter & medicines.
Rothmannia fischeri	Fuelwood, fodder, poles, hoe handles, medicines, litter & compost.
Markhamia lutea	Poles, firewood, compost, litter, fodder, timber, paddles & hoe handles.
Albizia gummifera	Timber, poles, fodder & fuelwood.

Maesopsis eminii is an indigenous tree species mostly preferred by people in the study area, because it is fast growing, easy to regenerate and provide high quality timber which can be used for boat making. It also has a variety of uses such as timber, firewood, compost, litter, fodder, poles and hoe handles, and some villagers have reported to get cash from the sales of timber and fuelwood from the tree species.

After *Maesopsis eminii*, *Citrus sinensis* and *Mangifera indica* which are fruit trees come next (refer table 4.19). These are very important sources of fruits for household use and when sold increases household cash income which can be used to meet other family requirements. However there is no predictable market for the produce and prices are not reliable. The problem is compounded by the non existence of electricity in the district which could attract investors to establish fruit processing industries. The rest of the tree species preferred are easy to establish, manage and propagate.

4.6 Management of agroforestry systems components

4.6.1 Tree management

Farmers manage their trees by thinning, pruning, pollarding, coppicing and weeding. Pruning is commonly done just before planting of annual crops in order to allow sunlight to reach crops in the lower strata. Thinning is done mostly on coppices to give room for trees with good stem form to increase in diameter. Thinning is also done to naturally regenerating trees if found in closer space. Weeding as usual is done when a farmer is weeding agricultural crops.

The pollard system however is mostly applied in Ukara island especially for fodder trees which are usually multipurpose. Before the tree is cut down, during its life it yields poles, withies and fodder which are harvested whenever required. The main stem however depending on the tree form and type of species is exploited into timber and firewood when they reach rotation age. Tree species which are commonly managed in this way especially in Ukara island involve all *Ficus spp, Trichlia emetica, Baikianea insignis spp minor, Rothmannia fischeri* and *Vitex spp.*

Mangifera indica also provide good fodder, but since is expected to yield fruits it is only pruned. Due to shortages of wood products especially in Ukara island where the tree species population is lower compared to other areas where survey was done (refer table 4.11) the pollarding system is practiced in order to fill the gap and is a sustainable tree management practice.

The above management practices are expected to improve the quality of the tree products as well as to reduce the crop tree interactions such as the shading effect and nutrients competition. Interactions such as animal/tree component is increased due to the production of fodder through the tree management practices. Interactions between tree and household level is also increased since products from the tree management practices serve for fuelwood, poles, withies and cash flow once sold. Interaction between crop and tree which involve litter, mulch and/or compost making is increased. However negative interaction between crop and tree through these practices involve crop damages which might occur during the process of harvesting.

These practices are however, not excellently done, for example, pruning is not done to stem level, you find part of the branch protruding outside the stem which finally leads to loose knot. The ratio of canopy tree stem is not considered and in most cases there is over pruning. Number of stems to be left on coppicing trees is done on trial and error basis. The same goes for the thinnings as there is no exact space between tree plants. All in all the work done by farmers have to be commended since they gain skills through experience without obtaining any formal knowledge.

4.6.2 Crop management

Despite weeding, organic fertilizer application in farms is the order of the day. It has been found that all of the respondents apply organic matter fertilizer in their farms. These fertilizers include livestock manure, compost, litter, household waste/refuse, weeds and crop residues. Over 40% apply livestock manure and household refuse, 20.6% apply livestock manure and compost, 17.6% apply livestock manure, compost,

household refuse and litter in combination. The rest of them (17.7%) are biased on one type of livestock's manure and other organic fertilizer, such as goats manure and litter or cattle manure and litter or ducks manure and mulch. Plate 7 shows livestock manure in Ukara Island ready to be taken to the farm. All respondents do not use inorganic fertilizers, due to unavailability (55.9%), lack of cash (17.6%) or preference (26.5%). Uses of other organic fertilizers which include household waste, crop residues, and weeds are shown in tables 4.20, 4.21 and 4.22. Table 4.23 presents reasons doe burning household wastes.

Plate 7: Livestock manure ready to be taken to the farm in Ukara Island

Table 4.20: Uses of household waste

Type of use	Number of respondents	% of total
Fed to livestock	6	5.9
Mixed with dung in livestock stall	22	21.6
Spread in homegardens	49	48.0
Compost making	24	23.5
Burnt	1	1.0
Total	102	100.0

Table 4.21: Uses of crop residues

Type of use	Respondents	% of total
Fed to livestock	25	24.5
Left to rot in farm	2	2.0
Burnt	1	1.0
Fed to livestock, firewood, thatching & others left to rot in farm	74	72.5
Total	102	100.0

Table 4.22: Uses of weeds

Type of use	Number of respondents	% of total
Fed to livestock	26	25.5
compost	4	3.9
Mulch	47	46.1
Burnt	10	9.8
Fed to livestock, livestock bedding, others let in farm & compost	6	5.9
Burnt, mulch	9	8.8
Total	102	100.0

Table 4.23: Reasons for burning

Reason	Respondents	% of total
To kill couch grass	14	13.7
To kill pests and diseases	1	1.0
Fast fertilizer (ash)	3	2.9
To kill couch grass, pest and diseases	2	2.0
Do not burn	82	80.4
Total	102	100.0

In Ukara Island using organic fertilizer in a farm is a habit since people know for sure that without fertilizing the soil the yield will decline. For this matter livestock manure

(cattle, goats) is applied in cropland whereby manure from chicken and ducks is applied in homegardens.

Due to land scarcity, low yield and decrease in soil fertility, most of the people in the Ukerewe main island have adopted organic manure application. However the use of trees/shrubs litter as in neighbouring Ukara is not yet adopted. People who don't have livestock, hire cattle which are tethered in their farms and even to stay there overnight until enough manure is obtained. The rent is negotiable but ranges from TShs. 25,000/= to 50,000/= for a period of two to three months before land preparation. Farmers are already aware of soil infertility, low yield and land scarcity problems they face and therefore have tried to solve these problems through the application of organic fertilizers in their farms.

Although these farmers apply organic manure in their farms this study was unable to investigate the amount of fertilizer applied in order to realize a reasonable harvest. However the major problem associated with manure application is the transportation of manure to the cropland which in most cases is very far from the homestead. Another problem is that not all farmers keep cattle or goats which provide manure in large quantities compared to chicken, ducks and pigeons found in the area and therefore there are shortages of the item. And this deficit cannot be bridged by the use of forest litter since there is already a shortage of forest related products. Inorganic fertilizers however is not applied in the area, as a result the area is less contaminated with the chemicals associated with inorganic fertilizers application The use of organic fertilizers should be encouraged through the promotion of cattle or

livestock keeping for those who don't have and advise those who are keeping many cattle to destock so as to balance with the carrying capacity available.

However apart from livestock manure other types of organic fertilizers are used. This is good since it maintains nutrient cycling. However some of these organic fertilizers are diverged to other uses which do not contribute to nutrient cycling, e.g. crop residues used for thatching or as fuelwood. This makes maintenance of soil nutrient cycling impossible. Others burn crop or weeds (Table 4.23), a good percentages of them with very excellent reasons since these are considered to be better approaches for killing cautch grass, pest and diseases than pesticides application which contribute to environmental degradation.

However burning is also associated with negative effects such as killing beneficial micro-organisms living in the soil, soil erosion since the soil remain loose and bare. About 82% of people don't burn, which is a very good indicator that people are aware of the bad effects associated with the burning process.

4.6.3 Livestock management

Livestock feeding methods differ from one farmer to another. However, the most common method is loci grazing whereby the livestock (cattle and goats) are tethered on pegs wherever the pasture is found and provided with cassava peelings and other crop residues when they come back home. During the peak of the dry season, however cattle can be free ranged in valley bottom farms during the period that no crops are found. The other method include zero grazing, which is most common in

Ukara island whereby a male cattle is stall fed principally for manure production and secondly for income generation whereby other livestocks are tethered. It has been found that fodder collection is an activity shared by all family members (Plates 8 and 10). However if a farmer happens to have no male cattle, cows and sometimes goats are stall fed for manure production.

Plate 8: A husband with a headload of fodder

Plate 9: Women coming back home from fodder collection

It was also found that 36.3% of the respondents grow fodder crops, which include *Pennisetum clandestinum*, *Pennisetum* spp grown along lake shores, stream banks and well banks (Plates 10 and 11).

Plate 10: *Pennisetum spp*

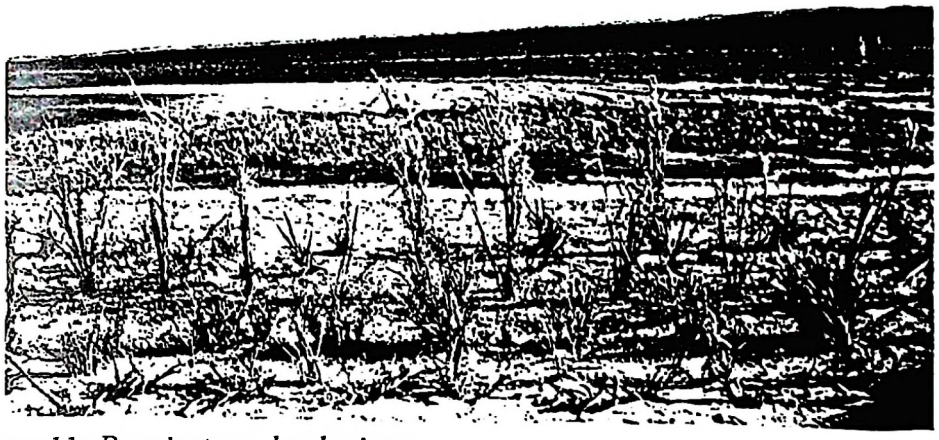


Plate 11: *Pennisetum clandestinum*

Penisetum purpreum and Tripsacum fasciculatum are fodder plants grown along farm borders and valley bottom sites. *Crotalaria pallida* is also a fodder crop which is found scattered in farms. But this is grown by few respondents compared to others since only 4.9% of the respondents reported it. Fodder trees, however are grown in various sites which include homegardens, scattered in cropland, and farm boundary.

In Ukara island animals are kept and stall fed in sheds so that they yield high quality manure. Pits of about 2m x 2m and 1.5m depth are dug whereby bulls are kept. Household wastes, non fodder materials collected for the purpose of making organic fertilizer and non-woody remnants of livestock feeds are damped in the pit for the aim of making enough compost for the coming cropping season. Even the loci grazed animals when they come back they are also kept in the shed where they share the collected fodder with the stallfed bulls and at the same time add manure (Plates 12, 13 and 14) .

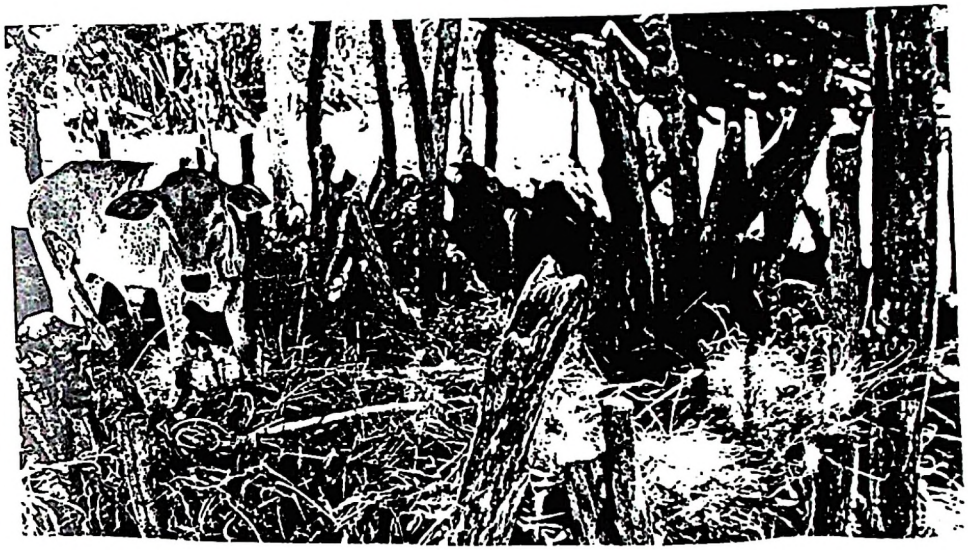


Plate 12: Livestock stall feeding in Ukara Island

Plate 13: Goats stallfed to increase manure production

Plate 14: Fodder collected for feeding livestock in Ukara Island

In Ukerewe main Island however, stall feeding is done to diary cattle, the rest are either tethered, which is commonly practiced or free range which is rare. However chicken, ducks and pigeons are free range. Table 4.24 shows the livestock feeding methods.

Table 4.24: Livestock feeding methods

Feeding methods	Frequency	% of respondents who practice it
Loci grazing, subsidiary feeding	41	49.9
Loci grazing	17	16.7
Zero grazing, loci grazing, subsidiary feeding	13	12.7
Free range	12	11.8
Zero grazing	5	4.9
Zero grazing, free range, subsidiary feeding	2	2.0
Free range, loci grazing, zero grazing, subsidiary feeding	2	2.0
Total	102	100.0

With the exception of free range method, which is appropriate in areas where land is plenty, the rest of the methods are commendable. However, the zero grazing method

is most appropriate since it is expected to increase manure production and hence alleviate the soil inferlity problem. The opportunities to improve livestock management are high since some of the people are already practicing stall feeding and cultivate fodder crops. Therefore people should be encouraged and helped to solve problems which are beyond their capacity.

Chicken and ducks are most destructive especially to the agricultural crops, although this was not mentioned as a problem but the opportunities to contain them and stall feeding are high since there is fish called "dagaa" and snails which can be used to prepare chicken feeds. What is required is how to do it and the willingness of the people to accept and adopt the idea.

4.7 Sources of tree seedlings and propagation methods

4.7.1 Sources of tree seedlings

Table 4.25 summarizes sources of tree seedlings in the study area.

Table 4.25: Source of seedlings

Type of source	Respondents	% of Total
Wildlings	13	12.7
Seeds	12	11.8
Individual nursery owner	5	4.9
Natural regeneration	2	2.0
Wildlings/seeds	29	28.4
Wildlings/seeds/natural regeneration	32	31.4
Wildings/seeds Vindividual nursery /natural regeneration	9	8.8
Total	102	100.0

Tree seedlings sources are known and therefore assures sustainable tree planting activities within the district. However few tree nurseries are available and therefore seedlings to be planted depend on the onset of rains. Also the size of the seedlings to be planted vary. With the exception of nurseries other sources are cheaper since they exclude nursery costs.

4.7.2 Methods of tree propagation

About 47.1% of the respondents seem to know other methods of tree propagation. There are four methods in which tree species are commonly propagated, which include roots, coppicing, cuttings and layering. Some tree species can be propagated in more than one method. Tree species propagated by use of roots include *Rothmannia fischeri, Milicia excelsa, Citrus sinensis, Balanites aegyptiaca, Melia azedirach, Albizia petersiana, Albizia gummifera* and *Vitex doniana.*

Tree species propagated through coppicing include *Maesopsis eminii, Citrus sinensis, Terminalia ivorensis, Markhamia lutea, Markhamia obtusifolia, Ficus spp, Cedrella mexicana, Melia azedirach, Senna siamea, Baikiaea insignis spp minor, Rothmannia fischeri, Albizia petersiana, Albizia gummifera, Trichlia emetica.* Cuttings are used for propagating *Ficus* spp, *Erythrina abyssinica, Cedrella mexicana, Trichlia emetica, Lannea fulva, Manihot glaziovii, Macaranga monandra* and *Baikiaea insignis spp minor.*

Layering is used for *Citrus sinensis*, *Macaranga monandra* and *Cedrella mexicana.* The methods used in trees propagation ensures perpetuation of tree species especially for those which can be propagated in more than one method.

4.8 Socio-economic functions of the indigenous agroforestry systems

4.8.1 Farm inputs

The only farm inputs used by farmers are the hand hoes, machetes and organic fertilizers. Farmers store seeds to be used in the previous cropping season. Hand hoes and machetes are primitive tools compared to the modern technology available in other areas of the world. Therefore farmers in Ukerewe district still spend much labour on agricultural production. Storage of seeds by farmers help to combat shortages of the resource during planting season. However it is not easy to store seeds when there is drought which is associated with famine. Therefore in this situation all responsible actors should make sure seeds are available and therefore farm production is not affected.

4.8.2 Sources of cash to households

Tables 4.26 and Table 4.27 show sources of cash for households.

Table 4.26: Agricultural crops, as source of income

Source of income	% who sell the crop of respondents	% of respondents who don't sell the crop
Cassava	72.5	27.5
Sweet potatoes	39.2	60.8
Maize	2.9	97.1
Cow peas	2.9	97.1
Bambara nuts	4.9	95.1
Rice	72.5	27.5
Bulrush millet	11.8	88.2
Sorghum	4.9	95.1
Finger millet	10.8	89.2
Groundnuts	2.0	98.0
Coffee	5.9	94.1
Oranges	36.3	63.7
Mangoes	6.9	93.1
Cotton	8.8	91.2

Table 4.27: Other sources of income

Source of income	% of respondents engaged	% of respondents not engaged
Fishing	17.6	82.4
Timber	2.0	98.0
Petty business	9.8	90.2
Fuel wood	12.7	87.3
Carpentry	6.9	93.1
Local brew	2.0	98.0
Fishing and employment	2.0	98.0
Fishing, employment, petty business	1.0	99.0
Fishing and livestock	3.9	96.1
Livestock	20.6	79.4

Average revenue from various sources is presented on table 4.28.

Table 4.28: Average revenue per household from various sources (Tshs)

Source of income	Tshs.
Fishing	1618563.70
Rice	85558.80
Carpentry	72549.00
Cassava	42819.60
Employment	40371.40
Petty business	28632.35
Oranges	23946.10
Cattle	23441.20
Local brew	13725.50
Sweet potatoes	8323.50
Other sources	6940.20
Finger millet	3696.10
Tree products	3176.50
Sorghum	2656.90
Mangoes	2509.80
Bulrush millet	2500.00
Cotton	2407.80
Goats	1607.80
Coffee	1294.10
Chicken	652.00
Maize	98.00
Total	1985470.35

Since the family size in the surveyed households has an average of 8 people,therefore average per capita income is Tshs 248,183.79 which is approximately Tshs 248,183.80.

From table 4.26 it can be seen that most people get their cash income from cassava, rice, sweet potatoes and oranges. However the sources of income which contribute highly to the total income to the area such as fishing and carpentry are undertaken by few people. This is because these activities require expensive gears and on top of that carpentry requires technical know how.

4.9 Farm production

About 43.1% of the respondents reported farm production to be decreasing, while 34.3% of the reported that it is increasing and 22.5% indicated that it is stable (Table 4.29). Increase and stability of farm production is an indicator for the sustainability of the system. However, the decreasing trend could be reduced through appropriate extension.

Table 4.29: State of farm production

		State of farm production			Total
		Stable	Increasing	Decreasing	
Village					
Bwisya	Count	1	7	7	15
	% within Village	6.7	46.7	46.7	100.0
	% of total	1.0	6.9	6.9	14.7
Nyang'ombe	Count	5	3	5	13
	% within Village	38.5	23.1	38.5	100.0
	% total	4.9	2.9	4.9	12.7
Murutunguru	Count	7	9	8	24
	% within Village	29.2	37.5	33.3	100.0
	% total	6.9	8.8	7.8	23.5
Bugombe	Count		1	7	8
	% within Village		12.5	87.5	100.0
	% total		1.0	6.9	7.8
Kagunguli	Count	7	10	8	25
	% within Village	28.0	40.0	32.0	100.0
	% total	6.9	9.8	7.8	24.5
Buguza	Count	3	5	9	17
	% within Village	17.6	29.4	52.9	100.0
	% total	2.9	4.9	8.8	16.7
Total	Count	23	35	44	102
	% total	22.5	34.3	43.1	100.0

The reasons for increase in productivity were mainly the use of farm manure, proper tending and use of tie ridges, while decrease in farm productivity were attributed to decline in soil fertility or due to drought, lack of fallowing, crop rotation, or crop diseases. The yield of cassava crop in the years 1997, 1998 and 1999 were reported as presented in table 4.30.

Table 4.30: Yield of cassava crop

Year		Surplus	Sufficient	Insufficient	Total
1997	Count	28	40	34	102
	% of total	27.5	39.2	33.3	100
1998	Count	30	41	31	102
	% of total	29.4	40.2	30.4	100
1999	Count	38	36	28	102
	% of total	37.3	35.3	27.5	100

Farmers in Ukerewe district are aware of factors which increase production and vice versa, therefore it is easy to take remedial action accordingly. However some of the factors that lead to decrease in farm productivity are beyond farmers' capacity. For example, it is not easy to control drought. Due to the land scarcity problem, which persists in the area, it is not easy to do fallowing or apply crop rotation. However the mixed cropping agricultural system practiced is the best approach since once one type of crop is affected by disease, farmers can get some harvests from other types of crops. From the results, the cassava yield crop was not regular. People with surplus yield were on the increase while those with sufficient or insufficient yields were decreasing. The increase in production is possibly due to most farmers using it as a source of income and food and thereby increases its production. The average production of certain agricultural crops in bags/season are presented in table 4.31.

Table 4.31: Average production of agricultural crops in bags/season per household

Type of produce	Average production in bags/season
Cassava	36.7
Sweet potatoes	17.8
Rice	11.1
Maize	1.2
Bambara nuts	0.7
Beans	0.3
Cow peas	0.4
Groundnuts	0.4
Bulrush millet	0.8
Finger millet	0.4
Sorghum	0.3
Coffee	0.0
Cotton	0.1
Oranges	16.0
Mangoes	8.2

From the results it is obvious that the crops which were reported to contribute highly to household income (table 4.26) are highly produced compared to those which have least contribution.

4.10 Constraints limiting the productivity of the indigenous agroforestry systems

Constraints limiting the productivity of indigenous agroforestry systems in the study area are presented in Tables 4.32 – 4.36.

Table 4.32: Constraints in crop production

Type of constraint	Respondents	% of total
Soil fertility	87	85.3
Drought	68	66.7
Land scarcity	67	65.7
Farmyard manure	67	65.7
Cassava meal bug	58	56.9
Low yield	38	37.3
Farm inputs	34	33.3
Vermine	18	17.6
Crop fed to livestock	18	17.6
Crop theft	13	12.7
Poor extension services	10	9.8
Uncertainty in price and market for farm produce	10	9.8

Table 4.33: Constraints in livestock production

Type of constraint	Respondents	% of total
Diseases	74	72.5
Inadequate pasture	74	72.5
Shortage of drugs/expensive drugs	51	50.0
Land scarcity	27	26.5
Encroachment to pastureland	15	14.7
Water shortages	14	13.7
Theft of livestock	7	6.9

Table 4.34: Tree management constraints

Type of constraint	Respondents	% of total
Land scarcity	70	68.6
Drought	46	45.1
Tree theft	36	35.3
Diseases/pests	35	34.3
Unreliable market for mango and orange fruits	29	28.4
Parasitic plant known as *Oncocalyx fischeri*	2	2.0
Tree debarking	1	1.0

Table 4.35: Other constraints which limit agroforestry production systems

Type of constraint	Respondents	% of total
Transport	72	70.6
Low income	3	2.9

Table 4.36: Priority problems in Agroforestry in the Islands

Type of constraint	Number of respondents	% of total
Land scarcity	45	44.1
Drought	20	19.6
Lack of reliable market for produce	8	7.8
Diseases to livestock	7	6.9
Farm input	6	5.9
Soil fertility	5	4.9
Water shortages	4	3.9
Poor extension services	2	2.0
Encroachment to pastureland	1	1.0
Total	102	100.0

These problems require serious attention in order to sustain the agroforestry systems existing in the area. The biggest problems among those mentioned in all productions were ranked as in table 4.48. From table 4.48 it seems land scarcity is the biggest problem, followed by drought. The land scarcity problem is something which cannot be solved by individuals alone, it draws attention for other actors within and outside the district. For example, education on family planning should be stressed as well as responsibilities of parents regarding the future of their children.

Drought is another problem which has persisted in the district for almost three consecutive years, seriously affecting rice production. For other crops, such as cassava and sweet potatoes, were not very much affected since they are drought resistant. This is probably the reason why some respondents reported that they had cassava crop sufficiency and surpluses. Lack of reliable market for agricultural produce is a problem which was ranked third. This is so because in the former days people used to sell their crops to cooperative unions or National milling cooperation

whereby the prices were fixed. However, at present farm products are bought by individual buyers who set their own purchasing prices (free market) and there is no special market price guarantees. They just move around in the villages whereby prices are negotiable. This is expected and that is why people are forced to search for markets even in neighbouring countries of Kenya and Uganda through the so called illegal business or black market. Diseases to livestock is another problem which hinders livestock production. There are no dips, drugs are expensive and therefore some farmers have decided to use local herbs and thus promoting indigenous knowledge. Farm inputs such as wheel barrows to assist in the ferrying of manure and crops can promote crop production.

Also it was reported by 55.9% of the respondents that inorganic fertiliser is not available, 17.6% lack cash and 26.5% do not prefer it. Soil infertility is another problem reported to hinder agroforestry production systems in the area. This could be due to inadequate soil nutrients replenishment. From the results it seems that the land has been in use for centuries resulting in being passed from generation to generation. Ukerewe district has sandy loamy soils therefore loss of nutrients through leaching is also possible. Due to the land scarcity problem there is no farm fallowing and some of the crop residues, which could be used to replenish soil nutrients are used for cooking. However it is important to encourage the use of organic fertilizers in the soils with high leaching capacity of Ukerewe district. Apart from this organic fertilizers are friendlier to the environment than the inorganic ones.

Permanent cropping results in the net removal of nutrients from the site which must be replenished to provide a lasting cropping base (Scholes, *et al.*, 1994). In order to combat the problem, there should be maximum use of the locally available organic fertilizers and encourage those who don't keep livestock to do so in order to have enough manure to use in farms.

Water shortage has been caused by some of farmers who destroy water sources through cultivation along river courses, which make them dry during the dry season. This can be solved by educating farmers on the importance of conserving these sources and they should be encouraged to dig more wells.

Poor extension services was another problem reported by farmers. This is true because in the study area extension workers were found at division levels and they had no transport facilities to make them mobile. Whatever system the farmers practice, it is on try and error basis. In order to increase production the situation should therefore be arrested.

Encroachment to pastureland is made by people who have inadequate land. In order to come up with a solution to this problem, people should be encouraged to practice zero grazing. Pastureland is possible where land is abundant but in a land scarcity area other methods of livestock feeding such as zero grazing should be practiced or encouraged.

4.11 Farmers responses to problems

4.11.1 Land scarcity problem

About 94.1% of the respondents apply farmyard manure in order to improve productivity on small plots while 36.3% hire land. Over 40% of the respondents follow proper agricultural practices such as prescribed tending methods, manure application, crop spacing and establishment of terraces. All respondents apply mixed cropping in order to have a variety of foods from a small piece of land. Approaches adopted by farmers to address land problems are appropriate, however there should be a system of fairness in land distribution to discourage the system of land hiring. This is because farmers who hire land are not responsible for land development such as tree planting or soil nourishment. They use the land and if it is no longer productive, new land will be hired.

4.11.2 Inadequate pasture/pastureland

About 65.7% of the respondents collect and or grow fodder in order to solve the pasture problem, whereas 20.6% apply zero grazing. Farmers responses to inadequate pasture/pastureland are shown in appendix 16. The approaches are good in arresting the problem, other people should be encouraged to adopt the idea.

4.11.3 Crop diseases

In order to combat crop diseases, about 50% of the respondents uproot and burn the affected crops, others practice crop rotation, and in some cases, disease resistant plant varieties are grown. Farmers' responses to crop diseases problem are shown in appendix 16. It seems the people are aware of the problem and know how to combat

it, what is required is to encourage them and look for a possibility to introduce more disease resistant crop varieties.

4.11.4 Soil infertility and low yield

About 96.1% of the respondents apply farmyard manure in their farms and 3.9% rotate livestock (cattle/goats) in farms for at least two to three months before land preparation in order to solve the soil infertility/low yield problems. Farmers use their experience to apply manure. The responses of farmers to soil infertility and low yield problems are shown in appendix 16. However, demonstration plots should be established to demonstrate on the amount of organic fertilizer to apply in order to solve the problem.

4.11.5 Livestock diseases and drugs

About 20.6% of the respondents apply local drugs for treatment of livestock diseases. However 45.1% seek advises from veterinary officers. The responses of farmers to livestock diseases and drugs problems are shown in appendix 16.

Research on the local drugs should be promoted since these are cheaper in terms of time and cost and are friendly to the environment compared to ones manufactured. Livestock drugs should probably be subsidised for farmers to afford them.

4.11.6 Inadequacy of farmyard manure

Most farmers apply tree/forest litter in order to solve farmyard manure problem. Farmers response on inadequacy of farmyard manure problem is shown in appendix

16. It is already reported that the area has a shortage of forest related products. Therefore to use tree/forest litter as an organic fertilizer is not a sustainable solution. The immediate solution is to encourage people to keep few livestock who can provide enough manure through zero grazing and plant more trees to increase forest related products.

4.11.7 Laws on livestock production

About 30.4% apply a customary law which prohibits a livestock keeper to graze or tether livestock in other peoples fields. If a farmer does not want anybody to graze or tether livestock in his/her field he/she inserts a branch of *Rothmannia fischeri* tree species in the farm. If a livestock keeper sees it then he/she knows that the farm owner prohibits tethering or grazing livestock in the farm. This customary law is practiced in Ukara Island. However about 35.3% follow set government laws to solve the problem. Farmers responses on laws on livestock are as they appear in appendix 16. Customary laws are good and seem to be more effective in some areas than the set government laws.

4.11.8 Drought

About 53.9% reported the cultivation of drought resistant crops such as cassava and sorghum as a solution to drought problem. However about 54.9% reported the growing of fast growing crops as a solution to drought and about 4.9% reported food storage as a means to combat the problem. Farmers responses to drought problem are shown in appendix 16. Fortunately Ukerewe district possesses a variety of crops that can be used to tackle the problem. Farmers have both drought resistant and fast

growing crops. These crops include cassava, cowpeas, sweet potatoes, sorghum, bulrush millet, finger millet and beans.

4.11.9 Water shortages for livestock

About 12.7% of the respondents reported digging of wells or taking livestock to the lake as a solution to water shortage. Farmers response on water shortages for livestock is shown in appendix 16. It is not hygienic for the livestock to drink water in the lake. Also some of the villages are very far from the lake and therefore it consumes both time and labour which could be used for other activities. It is recommended that the digging of wells for livestock and water diversion from water sources so that it is easily accessible to livestock.

4.11.10 Vermine

About13.7.% of the respondents do hunting and uniformity cultivation commencement of farms cultivation within the same period in order to have joint efforts in attacking vermine and therefore combating the problem. Farmers' response to vermine problem is shown in appendix 16. Farmers who live along lake shores are mostly affected since they have removed all the vegetation along lake shores which could be used for pasture and breeding areas for marine life. These people are mostly affected by hippopotamus who apart from feeding on crops sometimes endanger or kill people. People should be advised to leave these areas uncultivated. Other vermines include, monkeys, rats and birds.

4.11.11 Tree diseases

About 11.8% of the respondents apply local herbs to combat tree diseases which are fungal and pests in nature especially for fruit trees. Farmers response to tree diseases problem is shown in appendix 16.Apart from applying local herbs, it was observed that some farmers do not prune dead branches from fruit trees and therefore these harbour pests and diseases which spread to the whole tree and other trees in the farm. Also it was observed that farmers don't have pruning saws and therefore use machetes which in most cases leave the cut areas rough and unhealed and therefore become entry points for pests and diseases.

4.11.12 Markets

About 29.4% of respondents sell their farm produce to individual buyers in order to earn cash. Farmers response to market problem is shown in appendix 16. It is within the government capacity to promote markets for its people since it is not fair to promote cultivation of certain crops without allowing for free development of markets.

4.12 Implications of the sustainability of agroforestry systems in Ukerewe district

- About 33.3% of the respondents suggested that the government must assist people to move elsewhere in Tanzania where land is still abundant. Out migration is a common phenomenon in densely populated areas of the tropics. For example Beets (1990) cited by Rugalema (1992) reports out migration as a response to land scarcity in densely populated areas of the tropics. In

Ukerewe district this is not a new thing, for example the government in 1974 shifted some people in Ukara Island to Uzinza Island in Sengerema district in response to the high population density and land scarcity problem in the area. During that period government initiated the move and some people were against the idea but after realizing the benefits gained by the people who agreed to shift, others followed and moved.

- About 45.1% of the respondents suggested the need for a greater availability of farm inputs such as wheelbarrows, pesticides and ploughs at reasonable prices. Others also indicated the need of veterinary services such as technical advice, drugs and dips to be available at affordable costs. The energy used in farm manual labour could be saved and used in other productive activities. Also veterinary services are very important for the livestock development in the area without those then organic manure which is very important in farm production will be limited and this will accelerate the soil fertility loss and low yield problems.

- Some farmers suggested the establishment of market for agricultural produce and processing industries for oranges and mangoes. The idea is good since currently individual buyers purchase the fruits at very low prices and take them to Mwanza municipality or neighbouring countries of Kenya and Uganda where they fetch higher prices. This also applies to other agricultural produce such as rice, cassava and sweet potatoes. What the farmer gains is not enough to pay his/her costs in terms of time and labour. However for the processing

industries it is the duty for the government to bring in the area, electricity that will attract investors to invest in processing.

- The need for technicians in all fields to be available and ready to provide technical advice was suggested. In the area where this study was undertaken there were no technicians at ward or village levels. The technicians were found at divisional level and didn't have any transport means to visit farmers. In most cases they concentrate on the villages close to their offices. Improvement on extension services is very important in this respect.

- Some farmers recommend keeping manageable livestock numbers in order to combat the pasture and pastureland problems while others requested for the government to introduce pure breeds which will enable them to have enough manure and milk which when sold could increase their family income. The study found 36.3% of the respondents who grow animal fodder and this suggests that the rest of the people should be encouraged to do the same.

- In order to combat the drought problem some of the respondents suggested growing of bulrush millet since it is believed to be fast growing, drought resistant, nutritious and indigenous in Ukerewe Island. Further, it is not susceptible to diseases but to bird attacks.

- Some respondents recommended to reinforce the use of local drugs in order to combat crop, tree and livestock diseases. Local drugs are easily available and

therefore dependable. However the conservation and proper utilization of plant species, which yield drugs should encouraged.

- About 8.8% of the respondents suggested a need to introduce cassava varieties which are resistant to the cassava meal bug. The promotion of research activities in the area is urgent and inevitable. Also the cultivation of other crop types should be encouraged so that in case cassava fails people should not suffer from complete crop failure.

- The need to create awareness to people especially youths to maintain and plant more trees in their farms was highlighted by some respondents. In this study it was observed in Ukara Island that the population of old trees which are nearly or have passed rotation age is higher than the young ones. Fodder for livestock is completely harvested in some fields. It was reported in this study that the youth were required to plant fodder trees which will be used later in their adulthood. This habit is almost disappearing. It is recommended that this idea should be initiated again for the sustainability of the system.
- The establishment and enforcement of by laws, which could assist the sustainability of crop and livestock production as well as tree management was suggested. By laws have proved more effective compared to laws set by the government since the local people are empowered. A very good example is the Sungusungu army prominent in Sukumaland area and the conservation of some of reserved forests like Duru Haitemba in Babati district.

- ❖ Of all the systems practiced in the area, agroforestry systems have proved to be the best due to the multiple products obtained compared to the others since all farmers interviewed mix crops and trees in their farms. Generally there is decrease in farm production mainly due to reduced soil fertility, drought, diseases and inadequate farm inputs. However, the biggest problem in the area is land scarcity which is a result of increased population pressure.

4.13. Regression analysis

The results are summarised in appendices 17a – 17g.

The study results in appendix 17a, suggest that average orange fruit production in bags per season, have a statistical significant ($P<0.01$) relationship with variations of the total number of *Citrus sinensis* trees in the farm fields. The results were expected since the *Citrus sinensis* trees are well tended and do not have much competition from other plant species in the farm.

From the results in appendix 17b, R^2 is very small meaning that 10% of the variation in total number of *Mangifera indica* fruit trees is explained by mango fruit production in bags/season. The remaining 90% are unexplained which are in error term. Perhaps some trees have very high yields, while this is possible for other productions such as fodder and fuelwood which were not considered and thereby led to higher percentages of unexplained variation. However the results suggest that mango fruit production in bags per season, have a statistical significant ($P<0.01$) relationship with variations of the total number of *Mangifera indica* tree species in farm fields. The

results were expected since *Mangifera indica* tree species are well tended and healthy.

From the results in appendix 17c, R^2 was very small may be due to other factors such as manure application and weeding which were not considered. The study results suggest that total number of family members in the household have no influence on cassava crop production. The expected negative relationship between total numbers of family members in the household to cassava crop production in bags/season was not statistically significant ($P>0.05$) in the regression results. The results further indicated that farm size of the upland has a statistical significant ($P\leq 0.01$) relationship with variations of cassava crop production in bags/season. The results were expected since cassava crop production depends on land size. As a result people with adequate land produce more than those with land shortages.

The study results in appendix 17d suggest that both farm size of the upland and time period since tree planting started have influence on total number of trees/shrubs in the respondent's farm fields. The expected positive relationship between time period since started tree planting was not statistically significant ($P>0.05$) in the regression results. The results further indicated that farm size of the upland has a statistical significant ($P<0.01$) relationship with variations of total number of trees/shrubs in the respondent's farm fields. The results were expected since people with abundant land have higher chances of planting trees compared with those with land shortages since many concentrate on agricultural production.

The results in appendix 17e indicate that total number of *Citrus sinensis* trees in respondent's farm fields have a statistical significant ($P<0.01$) relationship with variations of the average amount of revenue from oranges in the regression results and also have influence on the amount of revenue realized. The results were expected since there are farmers who have *Citrus sinensis* trees but don't sell oranges for either lack of market or *Citrus sinensis* trees are still too young to yield oranges. Also the negative constant implies that in order for a farmer to realize revenue from *Citrus sinensis* he has to sell oranges.

The results in appendix 17f suggest that total number of *Mangifera indica* trees in respondent's farm fields have no statistical significance ($P>0.05$) with variations of revenue in the regression results. The results were expected since although there are many *Mangifera indica* trees species and produce an abundance of fruits, but due to lack of market, they are consumed at household level and the surpluses are left to rot in farms.

The results in appendix 17g suggest that total revenue from agroforestry components have a statistically significant ($P<0.01$) relationship with variations of the total number of trees/shrubs in the respondent's farm fields. The results were expected since as a farmer realizes income from agroforesry components, he/she becomes motivated to increase tree planting. However the R^2 was small and may be due to the exclusion of other variables, which contribute to tree planting such as land availability and climate.

4.14 Areas of intervention for the improvement of the existing indigenous agroforestry systems in Ukerewe district

4.14.1 Arrangement of components and increase of forest related products

This study has found that forest related products are not adequate in the area in such a way that some people get them from a distance of ≥20 km. Also it has found that the stocking density of trees is low. Therefore there is a need to make an improvement on this for both homegardens and cropland. For example Rocheleau *et al.*, (1988) report a stocking density of up to 300 treesha^{-1} is possible for *Acacia senegal.* Therefore through experimental plots in the area the stocking density for the tree species found in the area can be established. However the stocking and arrangement should be done properly to ensure positive mutual interactions between the components (Lulandala, 1994 cited by Moshi, 1997). Also in order to increase forest related products all main roads and feeder roads should be planted with trees by people with farms which border them.

The possibility of incorporating trees in rice farms should be studied. For example Sae-lee, *et al.*, (1992) report trees as a special feature of rice paddies in Northeast Thailand. Also Saini and Misra (1992) report *Trewia nudiflora* an indigenous tree species in India as a promising tree species for agroforestry in rice fields.

Since the area is faced with land scarcity problem due to population pressure and agroforestry components have to meet household needs appropriate arrangement and stocking of these components in order to increase their productions for fodder, agriculture and forest related products is necessary.

4.14.2 Crop yield and soil fertility

In order to increase crop yield and improve soil fertility, application of organic fertilizers should be enhanced. For example it is reported by Michon, *et al* (1983) and Balasubramanian and Egli (1986) that application of livestock manure is popular in subsistence farming systems of the tropical Africa where most subsistence farmers cannot incur costs associated with artificial fertilizers. Introduction of alley cropping as reported by Rocheleau, *et al.*, (1988) could be the best approach since the farmers will be able to solve problems of soil fertility and forest related products such as fuelwood, building poles, food, medicine and fodder.

4.14.3 Livestock production

There is less production of farmyard manure and this is associated with the inadequacy of livestock and livestock feeding methods. Not all farmers who rear cattle or goats are able to give enough manure and even those who keep them the feeding methods they use do not provide a good environment to collect enough manure. Improvement on the livestock production for at least to keep two cattle or three goats under zero grazing management could help to solve the problem. In order for farmers to realize greater benefits diary cattle or goats may be introduced in the area. Improvement on fodder and pasture production by planting more fodder trees and growing of pastures could enhance the zero grazing feeding methods.

4.14.4 Markets for farm produce

In order to motivate farmers to produce more the district could establish the market intelligence unit, which should be responsible for searching markets for farm produce and make farmers aware of those markets through mass media instruments.

CHAPTER 5

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

This study has identified two major types of farming systems which include Upland and Valley bottom farming systems. The upland farming system is further subdivided into four farming systems. These include:

- Homegardens (Agrosilvopastoral systems) in which all three agroforestry components which include trees/shrubs, agricultural crops and animals are found and managed together on the land surrounding individual houses.
- Mixed cropping with trees (Agrosilvicultural systems), where trees are either planted or retained in farm where agricultural crops are cultivated.
- Mixed cropping farming systems (Purely agricultural systems) in which only agricultural crops are cultivated together in mixture.
- Monocroping farming systems (this is purely agricultural systems), where only one type of agricultural crop is cultivated.

Valley bottom farming systems are watershed areas whereby rice is cultivated during rainy season and during dry season other agricultural crops are cultivated and often animals grazed during the peak of the dry season.

Out of the five farming systems found in the area only two are indigenous agroforestry systems. These include homegardens (agrosilvopastoral systems) and mixed cropping plus trees (agrisilvicultural systems). The remaining three systems are

purely agricultural, which include mixed cropping, monocropping and valley bottom farming systems.

Of all the systems practiced in the area agroforesty systems have proved to be the best due to the multiple products obtained compared to the others since all farmersinterviewed mix crops and trees in their farms. Generally there is decrease in farm production mainly due to reduced soil fertility, drought, diseases and inadequate farm inputs. The biggest problem in the area is land scarcity, which is a result of increased population pressure. Among the opinions made by farmers emigration was given the first priority with the assistance from the government.

5.2 Recommendations

5.2.1 Areas of intervention for improvement

- Stocking density of trees/shrubs species in both agrosilvopastoral and agrosilvicultural systems should be increased through increased tree planting on farm boundaries and on the entire farm by incorporating trees species which are reported to increase soil fertility such as *Vitex mombassae.* It is reported by Benge and Ciesielski (1977) cited by Escalada and Ratilla (1998) that *Leucaena leucocephala* has been found to show great potential in improving soil fertility which led to the production of high total root crop yield of 26.16t ha^{-1}. The root species are cassava and taro crops, which are similar to those in Ukerewe district.

- ❖ Demonstration plots on alley cropping should be introduced in the area since this is expected to increase crop production, fodder and other forest related products. These are very important as stressed by Etienne and Rapey (1999) that farmers' ability to innovate through agroforesty practices is limited by the lack of relevant references and effective decision support systems to compare and assess prospective scenarios at the farm level.
- ❖ Experimental plots on incorporating trees in rice fields should be established.
- ❖ The Mukibat technique as reported by de Bruijn and Dharmaputra (1974) cited by Foresta de, *et al.* (1994) should be tested in the area by use of experimental plots.
- ❖ In order to have enough manure to be used in farms people should be encouraged to keep manageable livestock under zero grazing method.
- ❖ Family planning education should be strengthened in order to combat the population increase in the area.
- ❖ The knowledge of agroforestry is lacking among extension workers in such a way that each member stresses the component of his/her speciality. For the sustainability of agroforestry practices and systems training on the subject should be made to the extensionists in the respective field components.

5.2.2. Further research

- ❖ Socio economic analysis of each indigenous farming systems practiced in the area should be made in order to assess them.
- ❖ Further research on soil fertility in order to come up with the amounts of manure to be applied and redress the situation is required.

- ❖ Research on indigenous plant species, which are of medicinal use in the treatment of crops, trees, animal and human should be done.
- ❖ Research on the nutrition value of fruits from indigenous tree species should be undertaken.

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APPENDICES

APPENDIX 1a: QUESTIONNAIRE FOR FARMERS

Introduction

Good morning/afternoon

My name is ....., from Sokoine University of Agriculture, Morogoro. In collaboration with Winrock International and International Centre for Research in Agroforestry, we are carrying out a study in the district with the aim of analyzing the indigenous agroforestry systems practiced in the district and their relationship to land scarcity problem. Your household has been selected randomly among others from which data will be collected. All the information will be treated confidentially and therefore you are requested to be free to give any information that I will be requested.

D. Background information

D1. Date .....

D2. Sex of the household head .....

D3. Name of the respondent .....

D4. Division .....

D5. Ward .....

D6. Village .....

D7. Household number .....

D8. What is your age? 1 = 20 – 39 2 = 40 – 59 3 = ≥ 60 years

D9. Level of education
- 1 = No formal education
- 2 = adult education
- 3 = primary
- 4 = secondary
- 5 = higher (specify)

D10. What is your marital status?
- 1 = single
- 2 = married
- 3 = living together
- 4 = separated
- 5 = widowed

6 = divorced
7 = other (specify)

D11. What was the type of work you were doing before taking farming?

D12. What is your occupation?
1 = Teacher
2 = Religious leader
3 = Village council leader
4 = Ten cell leader
5 = Peasant
6 = Other (specify)

D13. What is the total number of family members in the household?

D14. Household composition (in the last column I wish to know who owns the land)

Family members	Sex	Age (years)	Relationship to head of household	Education	Occupation	Land ownership
Husband						
Wife						
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						

Footnote V = owns land
X = no ownership

E: Farm size and land use

E1. When did your ancestors come to this area? .....

E2. From where? .....

E3. Why did you or your ancestors move? .....

E4. For how long have you been in this village?

.....

.....

E5. How did you acquire the farm?

1 = Purchase
2 = Inherited from parents
3 = Given by the village council
4 = Acquired myself through clearing of open access forest/bushland
5 = Others (specify)

E6. If you cleared the land how was it?

.....

.....

E7. What is the size of your farm? ...1=Homegarden..... acres
2=Valley bottoms.....acres
3=Cropland.....acres

E8. Is your farmland enough for farming activities? 1 = Yes 2 = No

E9. Is it possible to acquire more land? 1 = Yes 2 = No

E10. If Yes in E9 from where? .....

E11. If No in E9 why?

.....

.....

E12. Are you raising trees with your crops ? 1 = Yes 2 = No

E13. If No in E12 why? And how do you meet forest related products?

.....

.....

Forest related products such as
1 = fuelwood 2 = poles 3 = timber 4 = fruits

E14. What other tree products do you use?

.....

.....

E15. Where do you get them?

.....

.....

E16. Do you ever buy or sell fuelwood, charcoal, poles, or timber? If so when and from where?

.....

.....

E17. Is it difficult to get? 1 = Yes 2 = No

E18. If Yes in E17 why?

.....

.....

E19. How far is it ?

.....

E20. What plant species are found in your farmland and their uses/functions and for the case of tree species how many?

Common name	Vernacular name	Scientific name	Uses/functions	Number of tree species

E21. Are there tree species at homegarden ? 1=Yes 2=No

E22. If Yes in E21 what are they and what other plants are found ?

.....

E23. Are there tree species at valley bottoms farms ? 1=Yes 2=No

E24. If Yes in E23 what are they and what other plants are found ?

.....

E25. If No in E23 why ?

.....

E26. Are there tree species at cropland farm? 1=Yes 2=No

E27. If Yes in E26 what are they and what other plants are found ?

.....

E28. If No in E 26 why ?

.....

E29. Do you mix crops with trees in a special pattern ? 1=Yes 2=No

Why ?

.....

E30. If Yes preferably which trees/shrubs with which crops ?

.....

E31. Are there tree species you prefer most ? 1=Yes 2=No

E32. If Yes which are those ?

.....
.....

E33. Why ?

.....

E34. Where do you obtain tree seedlings ?

.....

E35. Have you used other methods to propagate trees ? 1=Yes 2=No

.....

E36. If so which methods and for which species ?

.....

E37. How long have you been planting trees ?.....year(s).

.....

E38. Are there any indigenous trees which you leave or plant in your farm?
1 = Yes 2 = No

E39. What are their uses?

.....
.....

E40. How are they managed?

1 = coppiced 2 = pollarded 3 = pruned 4 = others (specify).

E41. Which are your food crops?

.....

.....

E42. Which are your commercial crops?

.....

.....

E43. What are other sources of income?

1 = Fishing
2 = Timber
3 = fuelwood
4 = others (specify)

E44. How much revenue do you get from each of the source on average/year?

.....

.....

E45. Is the production in your farm

1 = stable
2 = increasing
3 = decreasing

E46. If there is a change what are the reasons?

.....

.....

E47. What is the average production per season per crop?

1 = food crops
a = cassava
b = sweet potatoes
c = rice
d = others (specify)

2 = cash crops
a = coffee
b = cotton
c = citrus
d = mangoes
e = others (specify)

E48. What is the yield of cassava crop in the following years.

1997 = 1 = surplus 2 = sufficient 3 = Insufficient
1998 = 1 = surplus 2 = sufficient 3 = Insufficient
1999 = 1 = surplus 2 = sufficient 3 = Insufficient

pasture ..... How?
composite ..... where?
mulching ..... where?
burning ..... Why?

E57. Do you use inorganic fertilizers in your farmland.
1 = Yes 2 = No

E58. If yes which type of fertilizer and why that type?
.....
.....

E59. If No give reasons as to why you don't use inorganic fertilizer?
1 = not available
2 = lack of cash
3 = don't prefer
4 = other reasons (specify)

E60. What kind of problems do you face regarding

1 = crop production

2 = livestock keeping

3 = trees management

4 = others (specify)

E61. Of the problems you mentioned, which is the biggest?

E62 How do you solve the problems in E59 above ?

F. Personal views

F1. What is your general personal views about your

1 = farmland
2 = livestock
3 = forest related produce
4 = others (specify).

Thank you for your time.

APPENDIX 1b: QUESTIONNAIRE FOR THE VILLAGE LEADERS

Name of the respondent.....
Division .....
Ward .....
Village .....
Date .....
Form Number .....

C. General information

C1. How many households do you have in your village?
.....

C2. How many people are there in your village?
.....

C3. What is the area of your village? .....km^2/hectares.

C4. Can a farmer get more land if required?

1 = Abundant 2 = Adequate 3 = Limited 4 = Scarce 5 = More

C5. What is the form of land tenure here?

C6. Are your village roads accessible throughout the year?

C7. Where do your farmers sell their produce?

1. Nearby market
2. Individual buyers
3. Cooperative union

C8. Where do you procure agricultural inputs?

Are they readily available when they are needed?

C9. What is the major source of fuel in the village?

C10. How far is the nearest natural forest from the village?

C11. What are the major problems do you have in your village pertaining to farmland production?

C12. Have you ever tried to solve some? How?

C13. What are your opinions pertaining to the

1. farmland production
2. livestock keeping
3. forest related produce

other(s) specify.

APPENDIX 1c: A QUESTIONNAIRE TO DISTRICT AGRICULTURAL AND LIVESTOCK OFFICER, DISTRICT FOREST OFFICER AND VILLAGE EXTENSION WORKERS IN THE VILLAGE

A. District Agricultural and Livestock officer and District Forest Officer

A1. How is the extension service in the villages?
1 = Bad 2 = Good 3 = Very good 4 = Excellent

A2. Do farmers accept and implement technical advises? 1 = Yes 2 = No
If Yes how? .....
.....
If No why?.....
.....

A3. What type of farm activities are carried out in the area .....
.....
.....

A4. Do all people in the district integrate trees in their farmland?
1 = Yes 2 = No
Why?

A5. Approximately how much income per acre do farmers obtain from agroforestry products
1 = Trees
2 = Crops

3 = Livestock
4 = Others (specify)

A6 How was cassava crop yields in the following years
1997 1 = surplus 2 = sufficient 3 = insufficient
1998 1 = surplus 2 = sufficient 3 = insufficient
1999 1 = surplus 2 = sufficient 3 = insufficient

A7. Is the production in the farmlands
1 = stable 2 = increasing 3 = decreasing
If there is a change what are the reasons

A8. In your opinion, do the villagers own enough land for farm activities?
1 = Yes 2 = No

A9. If no in 8. why?

A10. Is it possible for farmers to obtain additional land?
1 = Yes 2 = No

A11. If Yes how?

A12. How do farmers get agricultural inputs?

A13. Are the agricultural inputs reliable all the time?

A14. How is livestock production?

Livestock	Number	Uses
Cattle Sheep Goats Chicken Ducks Others		

A15. What are the constraints and opportunities of livestock production in the district.

1. Constraints
.....
.....
.....
.....

2. Opportunities
.....
.....

.....
.....

A16. What are your comments/recommendations as regards to:

1. Crop production

2. Livestock keeping

3. Tree management

4. Other (specify)

B. Village extension workers

B1. Do you reach all the villagers in your area of work?
1 = Yes 2 = No

B2. If yes, how many times in a month?

B3. If no, why?

B4. What major activities do you cover in your work?
.....
.....
.....
.....

B5. Do farmers accept and implement your technical advise? 1 = Yes 2 = No

B6. What are the common problems facing the farmers in your area of work?

1 = Availability and use of crop inputs

2 = Market and price of crops

3 = Others (specify)

B7. What problems do you face in your work execution
.....
.....
.....

B8. How do you solve the problems in 7

.....
.....
.....
.....

B9. How do you help the farmers to solve their problems

.....
.....
.....
.....

B10. What is your general comments/recommendations is regards to

1 = crop production

2 = livestock production

3 = trees management

4 = others (specify)

APPENDIX 2: LEVEL OF EDUCATION OF HOUSEHOLD HEADS

Village	Count	Level of Education			
		No formal education	Primary education	Secondary education	Total
Bwisya	% within Village	5	10		15
	% total	33.3	66.7		100.0
	Count	4.9	9.8		14.7
Nyang'ombe	% within Village	3	10		13
	% total	23.1	76.9		100.0
	Count	2.9	9.8		12.7
Murutunguru	% within Village	2	20	2	24
	% total	8.3	83.3	8.3	100.0
	Count	2.0	19.6	2.0	23.5
Bugombe	% within Village		7	1	8
	% total		87.5	12.5	100.0
	Count		6.9	1.0	7.8
Kagunguli	% within Village	2	22	1	25
	% total	8.0	88.0	4.0	100.0
	Count	2.0	21.6	1.0	24.5
Buguza	% within Village	2	12	3	17
	% total	11.8	70.6	17.6	100.0
		2.0	11.8	2.9	16.7
Total	Count	14	81	7	102
	% total	13.7	79.4	6.9	100.0

APPENDIX 3: LEVEL OF EDUCATION FOR WOMEN

Village		Education of women				
		.00*	No formal	Adult education	Primary education	Total
Bwisya	Count		6		9	15
	% within Village		40.0		60.0	100.0
	% of total		5.9		8.8	14.7
Nyang'ombe	Count		4		9	13
	% within Village		30.8		69.2	100.0
	% total		3.9		8.8	12.7
Murutunguru	Count		4		20	24
	% within Village		16.7		83.3	100.0
	% total		3.9		19.6	23.5
Bugombe	Count				8	8
	% within Village				100.0	100.0
	% total				7.8	7.8
Kagunguli	Count	1	6	1	17	25
	% within Village	4.0	24.0	4.0	68.0	100.0
	% total	1.0	5.9	1.0	16.7	24.5
Buguza	Count		3		14	17
	% within Village		17.6		82.4	100.0
	% total		2.9		13.7	16.7
Total	Count	1	23	1	77	102
	% total	1.0	22.5	1.0	75.5	100.0

*0.00 is a household whereby a husband has separated from his wife.

APPENDIX 4: MARITAL STATUS OF THE RESPONDENTS

		Marital status of the respondent				
Village		**Single**	**Married**	**Separated**	**Widowed**	**Total**
Bwisya	Count		14		1	15
	% within Village		93.3		6.7	100.0
	% of total		13.7		1.0	14.7
Nyang'ombe	Count		13			13
	% within Village		100.0			100.0
	% total		12.7			12.7
Murutunguru	Count	1	20	1	2	24
	% within Village	4.2	83.3	4.2	8.3	100.0
	% total	1.0	19.6	1.0	2.0	23.5
Bugombe	Count		8			8
	% within Village		100.0			100.0
	% total		7.8			7.8
Kagunguli	Count		24	1		25
	% within Village		96.0	4.0		100.0
	% total		23.5	1.0		24.5
Buguza	Count		17			17
	% within Village		100.0			100.0
	% total		16.7			16.7
Total	Count	1	96	2	3	102
	% total	1.0	94.1	2.0	2.9	100.0

APPENDIX 5: TYPE OF WORK BEFORE THE RESPONDENT TOOK TO FARMING.

Village		Type of work before the respondent took to farming							Total
		Fishing	Cook	Petty business	military	Teaching	Carpentry	Not applicable	
Bwisya	Count	4				1		10	15
	% within Village	26.7				6.7		66.7	100.0
	% of total	3.9				1.0		9.8	14.7
Nyang'ombe	Count	4		1				8	13
	% within Village	30.8		7.7				61.5	100.0
	% total	3.9		1.0				7.8	12.7
Murutunguru	Count	1	2	2	1	1	3	14	24
	% within Village	4.2	8.3	8.3	4.2	4.2	12.5	58.3	100.0
	% total	1.0	2.0	2.0	1.0	1.0	2.9	13.7	23.5
Bugombe	Count	3			1		1	3	8
	% within Village	37.5			12.5		12.5	37.5	100.0
	% total	2.9			1.0		1.0	2.9	7.8
Kagunguli	Count	12	1	3		1	2	6	25
	% within Village	48.0	4.0	12.0		4.0	8.0	24.0	100.0
	% total	11.8	1.0	2.9		1.0	2.0	5.9	24.5
Buguza	Count	10		2	1			4	17
	% within Village	58.8		11.8	5.9			23.5	100.0
	% total	9.8		2.0	1.0			3.9	16.7
Total	Count	34	3	8	3	3	6	45	102
	% total	33.3	2.9	7.8	2.9	2.9	5.9	44.1	100.0

APPENDIX 6: RESPONDENTS OCCUPATION

Village		Respondent's occupation									
		Peasant	Peasantry & teaching	Peasantry & religious leader	Peasantry & Ten cell leader	Peasantry & accountancy	Peasantry & cook	Peasantry & Fishing	Peasantry & petty business	Peasantry & carpentry	Total
Bwisya	Count	9		1	1			4			15
	% within Village	60.0		6.7	6.7			26.7			100.0
	% of total	8.8						3.9			14.7
Nyang'ombe	Count	9		1.0	1.0			3	1		13
	% within Village	69.2						23.1	7.7		100.0
	% total	8.8						2.9	1.0		12.7
Murutunguru	Count	11	1			2	2		1	3	24
	% within Village	45.8	4.2		4	8.3	8.3		4.2	12.5	100.0
	% total	10.8	1.0		16.7	2.0	2.0		1.0	2.9	23.5
Bugombe	Count	3			3.9	1		1		1	8
	% within Village	37.5			2	12.5		12.5		12.5	100.0
	% total	2			25.0	1.0		1.0		1.0	7.8
Kagunguli	Count	9			2.0	1		4	4	2	25
	% within Village	12		2		4.0		16.0	16.0	8.0	100.0
	% total	48.0		8.0		1.0		3.9	3.9	2.0	24.5
Buguza	Count	6		2.0				7	1	1	17
	% within Village	35.3			2			41.2	5.9	5.9	100.0
	% total	5.9			11.8			6.9	1.0	1.0	16.7
					2.0						
Total	Count	50	1	3	9	4	2	19	7	7	102
	% total	49.0	1.0	2.9	8.8	3.9	2.0	18.6	6.9	6.9	100.0

APPENDIX 7: OCCUPATION OF HOUSEWIVES

			Occupation of housewives		
			* 0.00	Peasant	Total
Village	Bwisya	Count		15	15
		% within Village		100.0	100.0
		% of total		14.7	14.7
	Nyang'ombe	Count		13	13
		% within Village		100.0	100.0
		% total		12.7	12.7
	Murutunguru	Count		24	24
		% within Village		100.0	100.0
		% total		23.5	23.5
	Bugombe	Count		8	8
		% within Village		100.0	100.0
		% total		7.8	7.8
	Kagunguli	Count	1	24	25
		% within Village	4.0	96.0	100.0
		% total	1.0	23.5	24.5
	Buguza	Count		17	17
		% within Village		100.0	100.0
		% total		16.7	16.7
	Total	Count	1	101	102
		% total	1.0	99.0	100.0

*0.00 is a household whereby a husband had separated from his wife.

APPENDIX 8: PLANT SPECIES FOUND IN FARMLAND IN UKEREWE DISTRICT AND THEIR FUNCTIONS/USES.

S/N	BOTANICAL NAME	COMMON NAME	VERNACULAR NAME		FAMILY	USES/FUNCTIONS
			KIKARA/ KIJITA	KIKEREWE		
1.	*Acacia polyacantha*	Fallon's claw	-	Amagu	Mimosaceae	Firewood, timber, poles
2.	*Acrocarpus fraxinifolius*	Acrocarpus	-	Iposolina	Caesalpiniaceae	Timber, firewood
3.	*Agave sisalana*	Sisal	Likatani	Ikatani	Agavaceae	Ropes, poles, hedge, compost, boundary marking
4.	*Albizia lebbeck*	Woman's Tongue			Mimosaceae	Timber, fuelwood
5.	*Albizia gummifera*	Mkenge	Liyenjeyenje	Iyenzeyenze	Mimosaceae	Timber, poles, fuelwood, fodder.
6.	*Albizia petersiana*	Mkenge	Limeya	Imeya	Mimosaceae	Timber, poles, fuelwood, fodder, compost, medicinal, litter
7.	*Aloe Spp.*	Mshubiri	Ingaga/Ing'aka	Enkaka Humba	Aloaceae	Medicinal, flowers
8	*Anacardium occidentale*	Cashew nut	Likorofya	Ikorosho	Anacardiaceae	Fruits, firewood, timber
9.	*Ananas comosus*	Pineapple	Linanaji	Inanazi	Bromeliaceae	Fruits, juice, local brew
10.	*Ancylobothrys petersiana*	-	Ing'irwa	Ikamila	Apocynaceae	Fruits, firewood, food storage
11.	*Annona muricata*	Soursoap	Litafeli	Itofeli	Annonaceae	Fruits, firewood, handles, poles
12.	*Annona senegalensis*	Wild custard apple	Likonyo	Ikonyo	Annonaceae	Firewood, ropes, fruits, gum, medicinal, poles tool handles
13.	*Antiaris toxicaria*	False mvule	Lirundu	Irundu	Moraceae	Firewood, poles, timber
14.	*Antidesma venosum*	Tassel berry	Litoketoke	Itoketoke	Euphorbiaceae	Fruits, firewood, medicinal

15.	*Antidesma membranaceum*	Tassel berry	-	Irurumwa	Euphorbiaceae	Fruits, firewood, poles
16.	*Arachis hypogaea*	Groundnuts	Inkaranga	Enkaranga	Papilionaceae	Food
17	*Argomuellera macrophylla*	-	Litoma	Itoma	Euphorbiaceae	Fodder, firewood
18.	*Azadirachta indica*	Neem	Mwarobaini	Mwarobaini	Meliaceae	Firewood, poles, medicinal, insecticide
19.	*Balanites aegyptiaca*	Desert date	Libamba ngoma	Ibamba ngoma	Balanitaceae	Medicinal, firewood poles, shade
20.	*Baikiaea insignis spp. minor*	-	Litobolo	Ikobekobe	Caesal piniaceae	Fodder, firewood, poles, timber, canoe, gum, mark the main entry to the household
21.	*Bambusa vulgaris*	Golden bamboo	Lisekeyanda	Isyekeyanda	Gramineae (Poaceae)	Poles, medicinal, firewood
22.	*Benincasa hispida*	Wax gourd	Liyoba	Echungu	Cucurbitaceae	Food, vegetable, medicinal
23.	*Blighia unijugata*	-	-	Itajwanana	Sapindaceae	Poles, firewood
24.	*Borassus aethiopum*	Borassus palm	Lihama	Ihama	Palmae (Arecaceae)	Firewood, local brew, wine, medicinal, thatching, weaving
25.	*Bridelia micrantha*	Mkarati	Likarati	Ikarati	Euphorbiaceae	Fruits, firewood, timber, tool handles, medicinal
26.	*Cadaba farinosa*	-	Litamunyu	Ametamunyu	Capparaceae	Fuelwood, poles, medicinal
27.	*Cajanus cajan*	Pigeon pea	Ebitendegwe	Ebitendegwe	Papilionaceae	Food, protect cassava from rotting in farm, firewood
28.	*Canthium burttii*	-	Lisangati	Isangati	Rubiaceae	Poles, firewood, medicinal fruits
29.	*Carica papaya*	Paw paw	Lipapayi	Ipapai	Caricaceae	Fruits, vegetable, fodder, medicinal
30.	*Capsicum frutescens*	Hot pepper	Lipilipili	Ipilipili	Solanaceae	Spice, firewood

31.	*Cedrela odorata*	West Indian cedar	Lisidireli	Isidireli	Meliaceae	Timber, firewood, medicinal
32.	*Citrus aurantifolia*	Lime	Indimo	Endimo	Rutaceae	Fruits, firewood, medicinal
33.	*Citrus limon*	Lemon	Lilimau	Amalimo	Rutaceae	Fruits, firewood, handles, poles medicinal
34.	*Citrus reticulata*	Tangerine	Lidalina	Idalina	Rutaceae	Fruits, firewood
35.	*Citrus sinensis*	Sweet orange	Lichungwa	Ichungwa	Rutaceae	Fruits, firewood, hoe handles
36.	*Cocos nucifera*	Coconut palm	Inaji	Enazi	Palmae	Fruits, fodder, firewood, timber
37.	*Coffea arabica*	Arabica coffee	Inwanyi	Emwani	Rubiaceae	Cash crop, firewood
38.	*Combretum molle*	Mlama	Lirama	Irama	Combretaceae	Medicinal, firewood, poles, handles
39.	*Combretum paniculatum*	-	Ligombya	Igombya	Combretaceae	Firewood, medicine
40.	*Craterispermum schweinfurthii*	-	-	Isekelaholo	Rubiaceae	Poles, medicinal, firewood
41.	*Crotalaria pallida*	Marejea	Lilegea	Ilegea	Papilionaceae	Compost, fodder, firewood
42.	*Croton megalocarpus*	Croton	Olwesha	-	Euphorbiaceae	Medicinal, firewood
43.	*Cucumis anguria*	Cucumber	Litanga	Itanga	Cucurbitaceae	Vegetable, food
44.	*Cucurbita maxima*	Maboga	Impwanyi	Epwani	Cucurbitaceae	Food, vegetable, medicinal
45.	*Deinbellia fulvotomentella*	-	-	Ikarabarogi	Sapindaceae	Poles, firewood, fruits
46.	*Delonix elata*	Mfausiku	Lifyakiro	Ifyakiro	Caesalpiniaceae	Firewood, hedge, shade, medicinal, poles
47.	*Dioscorea alata*	Greater yam	Echisyoma	Echira	Dioscoreaceae	Food
48.	*Dracaena mannii*	Long leaved dragon tree	Ligobole	Igobole	Dracaenaceae	Hedge, goats fodder
49.	*Ekebergia capensis*	Ekebergia	Lisiibi	Isiibi	Meliaceae	Poles, handles, fuelwood
50.	*Elaeis guineensis*	Red palm oil tree	Ligaji	Ikinda	Palmae	Oil, firewood, fruits, shade, thatching, timber, fodder, brooms, medicinal

51.	*Eleusine coracana*	Finger millet	Obulelo	Endwelo	Gramineae	Food, fodder, medicinal
52.	*Erythrina abyssinica*	Red hot poker	Liyebete	Ilinzi	Papilionaceae	Medicinal, firewood, hedge
53.	*Eucalyptus tereticornis*	Eucalyptus	Likaritusi	Ikaritusi	Myrtaceae	Firewood, timber
54.	*Euphorbia candelabrum*	Candelabra tree	Lituwa	Ikururu	Euphoribiaceae	Medicinal, firewood
55.	*Euphorbia grantii*	-	-	Itolasongo	Euphorbiaceae	Medicinal, poisonous
56.	*Euphorbia tirucalli*	Mnyaa	Lisongolwa	Olukoni	Euphorbiaceae	Hedge, firewood, medicinal, goats fodder
57.	*Ficus exasperata*	Msasa	Lisenwa	-	Moraceae	Fodder, firewood, weaving, leaves as sandpaper
58.	*Ficus natalensis*	Mrumba	Lifiti	Ichwandimi	Moraceae	Handles, fodder, firewood, poles
59.	*Ficus sycomorus*	Sycomore fig	Likuyu	Ikunu	Moraceae	Fodder, firewood, fruits, timber, canoe, mortar, rituals
60.	*Ficus thonningii*	Mrumba	Lirumba	Irumba	Moraceae	Fodder, firewood, ropes, poles, timber, litter, compost
61.	*Ficus wakefieldii*	Fig	Likobe	Mkoko	Moraceae	Fodder, firewood
62.	*Garcinia buchananii*	Granite garcinia	Lisaraji	Isarazi	Guttiferae	Poles, fruits, medicinal
63.	*Gardenia imperialis*	-	Likundambejo	Ikundambeizo	Rubiaceae	Timber, handles, medicinal firewood
64.	*Glycine max*	Soya	-	Ebijutwa	Papilionaceae	Food
65.	*Gossypium hirsustum*	Cotton	Ligafu	Igafu	Malvaceae	Cash crop, firewood
66.	*Grevillea robusta*	Silky oak	-	Grevilia	Proteaceae	Timber, firewood
67.	*Grewia bicolor*	Mkole	Likomakoma	Ikomakoma	Tiliaceae	Firewood, poles, handles, medicinal
68.	*Hallea*	Mromberombe	Lilambwa	Ilambwa-nsatu	Rubiaceae	Firewood, litter, timber,

	rutrostipulata					poles, compost
69.	*Harrisonia abyssinica*	-	Lisawa	Isawa	Simaroubaceae	Medicinal, hedge, firewood
70.	*Hevea braziliensis*	Rubber tree	Lipira	Ipira	Euphorbiaceae	Gum, firewood
71.	*Ipomea batatas*	Sweet potatoes	Amasya /Inumbu	Amagoye /Amagoye	Convolvulaceae	Food, fodder
72.	*Jacaranda mimosifolia*	Jacaranda	-	Jacaranda	Mimosaceae	Firewood, timber, ornamental
73.	*Jatropha curcas*	Pysic nut	Likalenkale	Ikalenkale	Euphorbiaceae	Medicinal, fuel(seed), hedge, firewood
74.	*Kigelia Africana*	African sausage tree	Lijungute/lisamwa	Izungute	Bignoniaceae	Fodder, firewood,, medicinal, mortar, timber, ceremonial, carvings, dug out canoes
75.	*Lannea fulva*	-	Lisesya	Ilangalala	Anacardiaceae	Firewood, litter, medicinal, poles, fruits
76.	*Lantana camara*	Lantana	Linyanunda	Inyanunda	Verbenaceae	Firewood, medicinal, compost, fodder, hedge
77.	*Lawsonia inermis*	Mhina	Liina	Eina	Lythraceae	Dyes, firewood, medicinal
78.	*Leucaena leucocephala*	Mlusina	-	Lukina	Mimosaceae	Fodder, firewood, compost
79.	*Lycopersicon esculentum*	Tomatoes	Inyanya	Inyanya	Solanaceae	Vegetable, medical
80.	*Macaranga monandra*	Macaranga	Litongo	Itongo	Euphorbiaceae	Fodder, poles, firewood, compost, litter
81.	*Maesopsis eminii*	Musizi	Lisizi	Isira	Rhamnaceae	Timber, firewood, compost, litter, hoe handles, fodder, poles
82.	*Mangifera indica*	Mango tree	Linyembe	Inyembe	Anacardiaceae	Fruits ,fuelwood, fodder, litter, compost, medicinal
83.	*Manihot esculanta*	Cassava	Lilibwa	Ilibwa	Euphorbiaceae	Food, fodder, firewood,

						vegetable,local brew
84.	*Manihot glaziovii*	Ceara rubber	Lipira	Ipira	Euphorbiaceae	Fodder, vegetable ,firewood
85.	*Manilkara obovata*	Mgama	-	Omubelebele	Sapotaceae	Fruits, poles, handles, firewood, medicinal
86.	*Markhamia lutea*	-	Libungai	Isambya	Bignoniaceae	Poles, firewood,compost, hoe handles, paddles, litter,fodder, timber
87.	*Markhamia obtusifolia*	Mtalawanda	Likora	Ikora	Bignonaceae	Poles, firewood, handles
88.	*Melia azedirach*	Melia	Imburumatare	Emburumatare	Meliaceae	Timber, firewood, compost, poles, goat's fodder
89.	*Milicia excelsa*	Mvule/iroko	Lijure	Omuzule	Moraceae	Timber, poles firewood, medicinal, ceremonial
90.	*Morus nigra*	Black mulberry	-	Isosowadi	Miraceae	Fruits, firewood
91.	*Musa spp*	Banana	Echitoke	Ekitoke	Musaceae	Food, fodder, juice, local brew
92.	*Obetia radula*	Stinging mettle tree	Lichambeba	Ibabanzozu	Urticaceae	Medicinal
93.	*Ochna ovata*	-	Liigebui	Itibare	Ochnaceae	Poles, firewood, medicinal
94.	*Ocimim suave*	Vumbasi	Nyabayengele	Nabayengele	Labiatae	Medicinal
95.	*Oncocalyx fischeri*	Kirukia	Ingurukizi	Engurukizi	Loranthaceae	Medicinal
96.	*Opuntia vulgaris*	Mafurahisha	Kamata	Ikamata	Cactaceae	Hedge, fruits
97.	*Oryza sativa*	Rice	Imbuga (omuchele)	Empuga	Gramineae	Food, pasture, thatching
98.	*Oxytenanthera abyssinica*	Green stem	Lisekeyanda	Isyekeyanda	Gramineae	Poles, medicinal, firewood
99.	*Parinari curatellifolia*	Mobda plum	Limonyi	Inazi	Chrysobalanaceae	Fruits, medicinal, fuelwood, fodder
100.	*Passiflora edulis*	Passion fruit	-	Amapasheni	Passiloraceae	Fruits, juice
101.	*Pennisetum glaneum*	Mawele/blush millet	Obubele	Obulo	Grammineae	Food, fodder, local brew

102.	*Pennisetum purpreum*	Elephant grass	Lisaru	Ibingo	Grammineae	Fodder, weaving, building, fishing traps, medicinal
103.	*Persea americana*	Avocado pear	-	Avocado	Anacardiaceae	Fruits, timber, firewood
104.	*Phaseolus vulgaris*	Beans	Liharage	Iharage	Papilionaceae	Food, fodder
105.	*Phoenix dactylifera*	Date palm	Litende	Omutende	Palmae	Fruits, poles
106.	*Phragmites mauritianus*	Reeds	Lisahunga	Isahunga	Gramineae	Fodder, building, fishing tools
107.	*Piliostigma thonningii (Bauhinia thonningii)*	Monkey bread	Lisindaga	Isindaga	Caesalpiniaceae	Medicinal, firewood
108.	*Pinus caribaea*	Caribean pine	Caribea	Caribea	Pinaceae	Timber, firewood
109.	*Pithecellobium dulce*	Madras thorn	-	Mchongoma	Mimosaceae	Hedge, firewood
110.	*Pseudospondias microcapa*	-	Lifiru	Omuziro	Anacardiaceae	Fruits, firewood, fodder, litter
111.	*Psidium guajava*	Guava tree	Lipera	Ipera	Myrtaceae	Fruits, firewood, poles, handles, medicinal
112.	*Psydrax schimperiana*	-	-	Ichunda	Rubiaceae	Fiewood, medicnal compost, goats fodder
113.	*Punica granatum*	Pomegranate	Iikomamanga	Ikomamanga	Punicaceae	Fruits, firewood, medicinal
114.	*Rauvolfia vomitoria*	-	Litereko	Obwitabusinde	Apocynaceae	Compost, firewood, handles, poles, litter
115.	*Rhus natalensis*	Mtishangwe	Lisese	Isese	Anacardiaceae	Fruits, medicinal, firewood, handles
116.	*Rinorea ilicifolia*	Mfua fedha	Omwitango	Omwogabagole	Violaceae	Medicinal, rituals
117.	*Rothmannia fischeri*	-	Liyebe	Iyebe	Rubiaceae	Fuelwood, fodder, poles, hoe handles, medicinal, litter, compost
118.	*Saba comorensis*	Prickly pear	Libungo	Ibungo	Apocynaceae	Fruits, food storage, firewood

119.	*Saccharum officinarum*	Sugar cane	Liguhwa	Igusa	Gramineae	Medicinal, juice
120.	*Salacia elegans*	-	-	Isongolamnwa	Celastraceae	Fruits, medicinal firewood
121.	*Sapindus saponaria*	Soap berry	Lifilimbi	Ifilimbi	Sapindaceae	Fodder, compost, timber, firewood, seeds used to play
122	*Senecio sp*	-	Linyirisha	Inyirisha	Compositae	Medicinal
123.	*Senecio multicory mbosus*	-	Nyakatereko	Omugango	Compsitae	Medicinal, firewood
124.	*Senna floribunda*	-	-	Ichwerambogo	Caesalpiniaceae	Medicinal, firewood
125.	*Senna siamea*	Iron wood	Lisongoma	Isongoma	Caesalpiniaceae	Poles, fuelwood, timber, compost, livestock bedding, litter
126.	*Sesamum orientale*	Sesame	Obukanu	Obwonja	Pedaliaceae	Food
127.	*Solanum incanum*	Sodom apple	Inobolo	Itobolo	Solanaceae	Medicinal, vegetable (fruits)
128.	*Solanum melongena*	Egg plant	Libilinganya	Ibilinganya	Solanaceae	Vegetable
129.	*Sorghum vulgare*	Sorghum	Obugusa/obungumba/ obuyemba	Omugusa	Gramineae	Food, fodder, local brew, firewood.
130.	*Spathodea campanulata*	Nandi flame	-	-	Bignoniaceae	Timber, firewood
131.	*Steganolaenia araliacea*	Mnyonga mpembe	-	Omugurukwanoni	Umbelliferae	Medicinal
132.	*Strychnos spinosa*	Mtonga	Likome	Ikome	Loganiaceae	Fruits, firewood, medicinal
133.	*Synadenium grantii*	Muwi	Likasaka	Likasaka	Euphorbiaceae	Poisonous sap, medicinal, ceremonial
134.	*Syzygium cumini*	Java plum	Lizambarau	Izambarau	Myrtaceae	Fruits, timber, firewood
135.	*Syzygium guineense*	Water berry	-	Mzambarau pori	Myrtaceae	Firewood, poles, fruits
136.	*Tamarindus indica*	Tamarind	Lisisya	Isisya	Caesalpiniaceae	Fruits, spice, medicinal, shade, firewood, poles
137.	*Teclea nobilis*	-	Lifyo/	Omuzyo	Rutaceae	Compost, firewood, poles,

			linyabwere			livestock bedding, litter, medicinal
138.	*Tectona grandis*	Teak	-	Mtiki	Verbenaceae	Timber, firewood
139.	*Terminalia catappa*	Indian almond	-	Mkungu	Combretaceae	Fruits, timber, compost
140.	*Terminalia ivorensis*	-	Mwavuli	Mwavuli	Combretaceae	Timber, firewood, compost
141.	*Terminalia sp*	-	-	Ihongola	Combretaceae	Poles, fuelwood, medicinal
142.	*Tetradenia riparia*	-	-	Omusunsu	Labiatae	Medicinal, hedge
143.	*Theobroma cacao*	Cacao	-	Kokoa	Sterculiaceae	Cash crop, firewood
144.	*Trema orientalis*	Mzungu zungu	-	Omuhohwe	Ulmaceae	Firewood, poles, medicinal, fruits
145.	*Tricalysia ruandensis*	-	Lisomang'wena	Isomang'wena	Rubiaceae	Hunting tools, firewood
146.	*Trichlia emetica*	Natal mahogany	Lisuguti	Isuguti	Meliaceae	Fodder, fuelwood, poles, compost, timber, litter
147.	*Tripsacum fasciculatum (T.laxum)*	Guatemala grass	-	Guatemala	Gramineae	Pasture (fodder)
148.	*Turraea robusta*	-	Lihololo	Ihololo	Meliaceae	Fodder, firewood, timber
149.	*Vangueria infausta*	Mviru	Lifyetanda	Ifyitanda	Rubiaceae	Firewood, fodder, fruits, poles, medicinal
150.	*Vernonia amygadalina*	-	Libiliji	Ibilizi	Compositae	Compost, firewood, medicinal, litter, hedge
151.	*Vigna unguiculata*	Cowpeas	Insorogo	Enkole	Papilionaceae	Food, vegetable
152.	*Vitex doniana*	Mfudu	Lifunene	Ikoroto	Verbenaceae	Fruits, medicinal, timber,firewood, poles, compost
153.	*Vitex mombassae*	Mfudu maji	Lihunda	Ihunda	Verbenaceae	Timber, fuelwood, fodder, poles, fruits, medicinal, compost
154.	*Vitex shirensis*	Mfuru	Lisungwa	Isungwa	Verbenaceae	Fruits, firewood, medicinal
155.	*Voandzeia*	Bambara nuts	Injugu	Empande	Papilionaceae	Food, fodder

	subterranea					
156.	*Withania somnifera*	-	Lifubefube	Ifubefube	Solanaceae	Medicinal
157.	*Ximenia caffra*	Mpingi	Lisyeka	Isyeka	Olacaceae	Fruits, medicinal, firewood
158.	*Zea mays*	Maize	Malingwa	Amalingwa	Gramineae	Food, fodder, firewood, local brew

APPENDIX 9: THE MOST ABUNDANT TREE SPECIES IN BWISYA VILLAGE AND THEIR USES.

Tree species	Uses	% of total in the village
Citrus sinensis	Fruits, firewood & hoe handles.	16.3
Markhamia lutea	Poles, firewood, compost, hoe handles paddles, litter, fodder & timber.	14.0
Rothmannia fischeri	Fuelwood, fodder, poles, hoe handles, medicines litter & compost.	9.6
Mangifera indica	Fruits, fuelwood, fodder, litter, compost & medicines.	7.3
Manihot glaziovii	Fodder, vegetable & firewood.	6.9
Maesopsis eminii	Timber, firewood, compost, litter, fodder, poles & hoe handles.	6.8
Citrus limon	Fruits, firewood, handles, poles & medicines.	5.4
Senna siamea	Poles, fuelwood, timber, livestock bedding & litter.	4.6

APPENDIX 10: THE MOST ABUNDANT TREE SPECIES IN NYANG'OMBE VILLAGE AND THEIR USES.

Tree species	Uses	% of total in the village
Albizia petersiana	Timber, poles fuelwood, fodder, compost, medicines & litter.	11.3
Mangifera indica	Fruits, fuelwood, fodder, litter, compost and medicines.	9.9
Citrus sinensis	Fruits, firewood and hoe handles	7.4
Rothmannia fischeri	Fuelwood, fodder, poles, hoe handles, medicines, litter & compost.	6.7
Markhamia lutea	Poles, firewood, compost, hoe handles, paddles, litter, fodder & timber.	5.5
Maesopsis eminii	Timber, firewood, compost, litter hoe handles, fodder, poles.	5.3
Baikiea insignis ssp. minor	Fodder, firewood, poles, timber, canoe wood & gum.	5.3

APPENDIX 11: THE MOST ABUNDANT TREE SPECIES IN MURUTUNGURU VILLAGE AND THEIR USES.

Tree species	Functions	% of total in the village
Citrus sinensis	Fruits, firewood & hoe handles	12.7
Maesopsis eminii	Timber, firewood, hoe handless & poles.	9.9
Melia azedirach	Timber, firewood, poles, & fodder.	8.4
Citrus reticulata	Fruits & firewood.	6.0
Mangifera indica	Fruits, fuelwood & medicines.	5.9
Annona senegalensis	Firewood, ropes, fruits, gum, medicines, poles & tool handles.	5.1
Albizia gummifera	Timber, poles & fuelwood.	3.7
Albizia petersiana	Timber, poles, fuelwood & medicines	3.1
Elaeis guineensis	Oil, firewood, fruits, shade & thatching, timber, fodder, brooms & medicines	3.0

APPENDIX 12: THE MOST ABUNDANT TREE SPECIES IN BUGOMBE VILLAGE AND THEIR USES

Tree species	Functions	% of total in the village
Citrus sinensis	Fruits, firewood & hoe handles.	14.2
Bambusa vulgaris	Poles, medicines & firewood.	8.8
Mangifera indica	Fruits, fuelwood & medicines.	8.6
Maesopsis eminii	Timber, firewood, poles & hoe handles.	8.4
Elaeis guineensis	Oil, firewood, fruits, shade, timber, thatching, brooms & medicines.	6.2
Melia azedirach	Timber, firewood, poles & fodder.	4.7

APPENDIX 13: THE MOST ABUNDANT TREE SPECIES IN KAGUNGULI VILLAGE AND THEIR USES.

Tree species	Functions	% of total in the village
Citrus sinensis	Fruits, firewood & hoe handles.	27.5
Albizia petersiana	Timber, poles, fuelwoo &, medicines.	10.0
Melia azedirach	Timber firewood, poles & fodder.	5.8
Mangifera indica	Fruits, firewood & medicines.	5.7
Rothmannia fischeri	Fuelwood, poles, hoe handles & medicines.	5.1
Maesopsis eminii	Timber, firewood, poles & hoe handles.	4.5
Annona senegalensis	Firewood, ropes, fruits, gum, medicines, poles & tool handles.	4.0

APPENDIX 14: THE MOST ABUNDANT TREE SPECIES IN BUGUZA VILLAGE AND THEIR USES

Tree species	Functions	% of total in the village
Citrus sinensis	Fruits, firewood & hoe handles.	28.0
Maesopsis eminii	Timber, firewood poles & hoe handles.	13.6
Albizia petersiana	Timber, poles, fuelwood & medicines.	10.0
Markhamia lutea	Poles, firewood, hoe handles, paddles & timber.	9.3
Melia azedirach	Timber, firewood, poles & fodder	9.3
Rothmannia fischeri	Fuelwood, fodder, poles, hoe handles & medicines.	3.9
Cedrella mexicana	Timber, firewood & medicinal.	3.8

APPENDIX 15: INDIGENOUS TREE/SHRUB SPECIES FOUND IN UKEREWE DISTRICT INDIGENOUS AGROFORESTRY SYSTEMS

S/NO	BOTANICAL NAME	USES/FUNCTIONS
1.	*Acacia polyacantha*	Firewood, timber, poles
2.	*Albizia gummifera*	Timber, poles, fuelwood, fodder
3.	*Albizia petersiana*	Timber, poles, fuelwood, fodder, compost, litter, medicinal
4.	*Ancylobothrys petersiana*	Fruits, firewood, food storage
5.	*Annona senegalensis*	Firewood, ropes, fruits, gum, medicinal, poles, tool handles
6.	*Antiaris toxicaria*	Firewood, poles, timber
7.	*Antidesma venosum*	Fruits, firewood, medicinal
8.	*Antidesma membranaceum*	Fruits, firewood, poles
9.	*Argomuellera macrophylla*	Fodder, firewood

10.	*Balanites aegyptiaca*	Medicinal firewood, poles, shade
11.	*Baikiaea insignis spp. minor*	Fodder, firewood, poles, timber, canoe, gum, mark the main entry to the household
12.	*Bambusa vulgaris*	Poles, medicinal, firewood
13.	*Blighia unijugata*	Poles, firewood
14.	*Borassus aethiopum*	Firewood, local brew, wine, medicinal, thatching, weaving
15.	*Bridelia micrantha*	Fruits, firewood, timber, tool handles, medicinal
16.	*Cadaba farinosa*	Fuelwood, poles, medicinal, fruits
17.	*Canthium burttii*	Poles, firewood, medicinal, fruits
18.	*Combretum molle*	Medicinal, firewood, poles, handles
19.	*Combretum paniculatum*	Firewood, medicinal
20.	*Craterispermum schweinfurthii*	Poles, medicinal, firewood
21.	*Croton megalocarpus*	Medicinal, firewood
22.	*Deinbellia fulvotomentella*	Poles, firewood, fruits
23.	*Delonix elata*	Firewood, hedge, shade, medicinal, poles
24.	*Dracaena mannii*	Hedge, goat's fodder
25.	*Ekebergia capensis*	Poles, handles, fuelwood
26.	*Erythirina abyssinica*	Medicinal, firewood, hedge
27.	*Euphorbia candelabrum*	Medicinal, firewood
28.	*Euphobia tirucalli*	Hedge, firewood, medicinal, goat's fodder
29.	*Ficus exasperata*	Fodder, firewood, medicinal, goat's fodder
30.	*Ficus natalensis*	Handles, fodder, firewood, poles
31.	*Ficus sycomorus*	Fodder, firewood, fruits, timber, canoe, mortar, rituals
32.	*Ficus thonningii*	Fodder, firewood, ropes, poles, timber, litter, compost
33.	*Ficus wakefieldii*	Fodder, firewood
34.	*Garcinia buchananii*	Poles, fruits, medicinal
35.	*Gardenia imperialis*	Timber, handles, medicinal, firewood
36.	*Grewia bicolor*	Firewood, poles, handles, medicinal
37.	*Hallea rutrostipulata*	Firewood, litter, timber, poles, compost
38.	*Jatropha curcas*	Medicinal, fuel (seed), hedge firewood
39.	*Kigelia africana*	Fodder, firewood, medicinal, mortar, timber, ceremonial, dug out canoes
40.	*Lannea fulva*	Firewood, litter, medicinal, poles, fruits
41.	*Lantana camara*	Firewood, medicinal, hedge, compost, goat's fodder
42.	*Macaranga monandra*	Fodder, poles, firewood, compost, litter
43.	*Maesopsis eminii*	Timber, firewood, compost, litter, hoe handles, fodder, poles

44.	*Markhamia lutea*	Poles, firewood, compost, hoe handles, paddles, litter, fodder, timber
45.	*Markhamia obtusifolia*	Poles, firewood, handles
46.	*Manilkara obovata*	Fruits, poles, handles, firewood, medicinal
47.	*Milicia excelsa*	Timber, poles, firewood, medicinal, ceremonial
48.	*Obetia radula*	Medicinal
49.	*Ochna ovata*	Poles, firewood, medicinal
50.	*Opuntia vulgaris*	Hedge, fruits
51.	*Oxytenanthera abyssinica*	Poles, medicinal, firewood
52.	*Parinari curatellifolia*	Fruits, medicinal, fuelwood, fodder
53.	*Pennisetum purpreum*	Fodder, weaving, building, fishing traps, medicinal
54.	*Phragmites mauritianus*	Fodder, building fishing tools.
55.	*Piliostigma thonningii*	Medicinal, firewood
56.	*Pseudospondias microcapa*	Fruits, firewood, fodder, litter
57.	*Psydrax schimperiana*	Firewood, medicinal, compost, goat's fodder
58.	*Rauvolfia vomitoria*	Compost, firewood, handles, poles, litter
59.	*Rhus natalensis*	Fruits, medicinal, firewood, handles
60.	*Rothmannia fischeri*	Fuelwood, fodder, poles, hoe handles, medicinal, litter, compost
61.	*Saba comorensis*	Fruits, food storage, firewood
62.	*Salacia elegans*	Fruits, medicinal, firewood
63.	*Senecio multicorymbosus*	Medicinal, firewood
64.	*Senna floribunda*	Medicinal firewood
65.	*Steganolaenia araliacea*	Medicinal
66.	*Strychnos spinosa*	Fruits, firewood, medicinal
67.	*Syzygium guineense*	Firewood, poles, fruits
68.	*Teclea nobilis*	Compost, firewood, poles, litter, medicinal, livestock bedding
69.	*Terminalia sp*	Poles, fuelwood, medicinal
70.	*Tetradenia riparia*	Medicinal ,hedge
71.	*Trema orientalis*	Firewood, poles, fruits, medicinal
72.	*Tricalysia ruandensis*	Hunting tools, firewood
73.	*Trichlia emetica*	Fodder, fuelwood, poles, compost, timber, litter
74.	*Turraea robusta*	Fodder, firewood, timber
75.	*Vangueria infausta*	Fruits, firewood, fodder, poles, medicinal
76.	*Vernonia amygadalina*	Compost, firewood, medicinal, litter, hedge
77.	*Vilex doniana*	Fruits, medicinal, timber, firewood, poles, compost
78.	*Vitex mombassae*	Timber, fuelwood, fodder, poles, fruits, medicinal, compost

79.	*Vitex shirensis*	Fruits, firewood, medicinal
80.	*Ximenia caffra*	Fruits, medicinal, firewood

APPENDIX 16: FARMERS RESPONSES TO PROBLEMS

Type of problem	Response
Land scarcity	Manure application (94.1), Land hiring (36.3), proper agricultural practices (41.2) mixed cropping (100)
Inadequate pasture/pasturelands	Collect and or grow fodder (67.5), apply zero grazing (20.6)
Crop diseases	Uproot and burn affected crops (50), apply crop rotation (8.8), grow disease resistant plant varieties (50, Plant disease free seeds (48)
Soil infertility and lowyield	Manure application (96.1), Livestock rotation in farms (3.9)
Livestock diseases and drugs	Apply local drug (20.6), Seed advises from veterinary officers (45.1)
Inadequacy of farmyard manure	Apply tree/forest litter (39.2),
Laws on livestock	Reported Application of customary law (30.4), Follow set government laws (35,3)
Drought	Cultivate drought resistant crops (53.9), Plant fast growing crops (54.9), Food storage (4.9)
Water shortages for livestock	Digging of wells/taking livestock to the lake (12.7)
Vermine	Hunting and commencement of farms whin the same period (13.7)
Tree diseases	Application of local herbs (11.8)
Markets	Sell farm produce to individual buyers (29.4)

Numbers in parentheses are in percentages.

APPENDIX 17a: *CITRUS SINENSIS* TREE SPECIES IN FARM FIELDS

Variable	Beta coefficients	t-statistics	t-significance
Constant	8.4	5.0	0.000
Average orange fruit production in bags per season	0.5	10.4	0.000***
Unadjusted R^2	0.5		
F-Ratios			107.2***
N	102		

*** Significant at 1%

APPENDIX 17b: *MANGIFERA INDICA* TREE SPECIES IN FARM FIELDS

Variable	Beta coefficients	t-statistics	t-significance
Constant	3.5	6.0	0.000
Average mango fruit production in bags per season	0.1	3.4	0.000***
Unadjusted R^2	0.1		
F-Ratios			11.3***
N	102		

*** Significant at 1%

APPENDIX 17c: AVERAGE CASSAVA CROP PRODUCTION

Variable	Beta coefficients	t-statistics	t-significance
Constant	20.3	1.5	0.1
Total number of family members in the household	-0.01	-0.1	0.9
Farm size of the upland in hectares	0.3	2.6	0.01**
Adjusted R^2	0.05		
F-Ratios			3.4**
N	102		

** Significant at 5%

APPENDIX 17d: NUMBER OF TREE /SHRUBS IN FARM FIELDS

Variable	Beta coefficients	t-statistics	t-significance
Constant	5.2	0.3	0.8
Farm size of the upland in hectares	0.5	5.6	0.000***
Time period since started tree planting	0.02	0.2	0.8
Udjasted R^2	0.3		
F-Ratios			17.5
N	102		

*** Significant at 1%

APPENDIX 17e: REVENUE FROM ORANGES

Variable	Beta coefficients	t-statistics	t-significance
Constant	-7643.5	-1.7	0.09
Total number of *Citrus sinensis* tree species in respondents' farm fields	2013.8	12.1	0.000***
Unadjusted R^2	0.6		
F-Ratios			146.3***
N	102		

*** Significant at 1%

APPENDIX 17f: REVENUE FROM MANGOES

Variable	Beta coefficients	t-statistics	t-significance
Constant	498.3	0.3	0.8
Total number of *Mangifera indica* tree species in the respondents' farm fields	429.2	1.8	0.07
Unadjusted R^2	0.03		
F-Ratios			3.4
N	102		

APPENDIX 17g: RELATIONSHIP BETWEEN FARM TREES AND REVENUE FROM AGROFORESTRY COMPONENTS

Variable	Beta coefficients	t-statistics	t-significance
Constant	48.8	4.5	0.000
Total revenue from agroforestry components in Tshs.	2.5	4.6	0.000***
Unadjusted R^2	0.2		
F-Ratios			21.4***
N	102		

*** Significant at 1%