POTENTIALS AND CONSTRAINTS OF KILOMBERO VALLEY AMONG AGRO PASTORALISTS COMMUNITY

BY

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ABSTRACT

Environment degradation, loss of grazing lands, high grazing intensities and drought in northern regions of Tanzania, led to massive migration of pastoralists and livestock to more resourced areas in the south. This has brought different ethnic groups into same ecological ranges there by increasing environmental degradation and resource use conflict. Kilombero valley is one area which received many pastoralists now days with highest conflict incidents reported. The objectives of this study were, (a) to identify major land uses in the valley (b) to evaluate selected land utilization types (c) to identify areas of land use conflicts and (d) to recommend remedial measures. Land unit map was established through visual aerial photo interpretation, three main physiographic units were distinguished: the Hilly, the Piedmont and the alluvial plain. PRA and questionnaire were used to collect socio-economic data and SPSS programme was used for analysis. Soil survey carried out and soil samples were analysed for physical and chemical properties important to the requirements of the selected land utilization types. The results revealed that, land uses in the valley include farming, grazing, bee keeping, wild life utilization, fishing and forest utilization. The absence of irrigation schemes, limited use of new agricultural technology, poor agricultural infrastructure and extension services are among the major constraints to farming. On livestock, overstocking and poor technical services are among the major problems. As for land evaluation, it was noted that the alluvial plain which potential for paddy cultivation, is in stiff competition with livestock grazing due to availability of pasture and water. Conflicts between farmers and pastoralists are rooted on crop damage by livestock and land disputes among others. Absence of exiting land use plan has worsened the situation. In conclusion, both pastoralists and farmers are engaged in farming and zoning for different land use types was recommended.

DECLARATION

I, PASCHAL LUCAS LUWANDA, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and it has not been submitted for a higher degree in any other University.

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The above declaration is confirmed

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DEDICATION

This work is dedicated to my mother Henirica Lorenzi Mitundula and to the memory of my beloved father, the late Lucas John Mgadusi who laid the foundation of my education.

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LIST OF ABBREVIATIONS AND SYMBOLS

ALES	Automated Land Evaluation System
API	Aerial Photograph Interpretation
CWS	Common Wealth Secretariat
DALDO	District Agricultural and Livestock Officer
DVS	Director of Veterinary Services
FAO	Food and Agriculture Organization of the United Nations
GCA	Game Controlled Area
GIS	Geographical Information Systems
ha	Hectare
KVTC	Kilombero Valley Teak Company
LECS	Land Evaluation Computer System
LMU	Land Mapping Unit
LUTs	Land Utilization Types
MD	Man Days
MIBA	Miombo Bee keeping Association
MLD	Ministry of Livestock Development
NAFCO	National Agriculture and Food Cooperation
NARCO	National Ranching Company
pH	Hydrogen ion Concentration
PRA	Participatory Rural Appraisal
QUEFTS	Quantitative Evaluation for the Fertility of Tropical Soils
SLSA	Sustaining Livelihoods in Sub Saharan Africa
URT	United Republic of Tanzania
USAID	United State Agency for International Development

WCED	World Commission on Environment and Development
WRBS	World Reference Base System
WWF	World wildlife Fund

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Land is the basis of human society because it provides food, water, energy, clothing and shelter. Land resources, however are finite and becoming scarce. Many people have inadequate access to land or to the benefits from its use. The major challenge facing humankind is to meet these increasing basic human needs while sustaining the resources (water, soil, fauna and flora) upon which these needs depend. An assessment of the land available for productive use world wide reveals an alarming decreasing trend in the per capita availability of arable land from 1.2ha in 1951 to 0.48ha in 1981 and by the year 2000 it was estimated to decline further to 0.15ha (Rao, 1991).

Human activities and the use of natural resources have affected the environment since time immemorial. According to the World Commission on Environment and Development (WCED) 1987, vast areas of forest have become pasture and crop land, rangelands have been changed to cropland or to deserts and natural wetlands have been drained and tilled in order to feed and house expanding population. Deforestation, land degradation, declined land productivity, food insecurity and land use conflicts are among the social and environmental consequences caused by overexploitation and utilization of potential productive lands in sub Saharan Africa of which Tanzania is not an exception (Mtaroni, 1997). In recent years, Tanzania experienced a very high rate of land degradation and deforestation (Mugurusi, 2006). These have been a major cause of drought, inadequacy of safe water and diminishing quality of land and hence hunger. Deforestation is a result of extensive agriculture and settlement, overgrazing, wild fires, charcoal burning and overexploitation of wood resources for commercial purposes. Most seriously, overstocking has exacerbated the rate of land degradation.

According to Scott (2005); the decreasing water, pastoral and tillable lands in sub tropical dry areas of Africa, will be a huge source of conflict over the next half-century because there still very high population growth rates in those areas but very low economic growth rates and deteriorating environments. Farmers, pastoralists and agro pastoralists in those areas are already competing for water, suitable agricultural and grazing lands and the conflict that results from this competition can turn violent, although most are settled peacefully. He further noted that, there is massive spillover of people moving out of (more stressed areas) into better-resourced areas. Similar observation has been reported by Kaihura and Mowo, (1993) who argued that in Tanzania people and stock move from overgrazed regions where vegetation degradation occurred to new areas searching for good resourced land. Mostly, they move from semi arid ecological zone, which include typical pastoral systems of Arusha, Dodoma, Shinyanga and Singida. About 40% of the national cattle herd is found in these regions. Seasonality of production, drought and overgrazing are the major problems.

Climate instability which has resulted to scarcity of resources (water and food) contribute to population movement and conflict; for instance, 20 years of below average rainfall in Sudan’s northern Darfur state have contributed to migration and conflict over land and other resources (Nicholas, 2006). To cope with devastating effects of crises particularly drought on their livestock, pastoralists developed certain cooping strategies to rescue their livestock. Mobility and migration is a key strategy used. It is used to get the necessary pasture and water especially during dry season. Pastoralists are generally classified according to their mobility. Raay, (1974), distinguished nomadic, semi-nomadic, semi-settled and settled. In terms of crop/livestock integration, it is more meaningful to classify them according to their enterprise system and their degree of contact with cultivators (Fricke, 1982). In this aspect two groups are distinguished; full time livestock keepers ranging from those who have no consistent association with a particular farming system (nomads) to those who have more or less regular contact with cropping systems at their grazing site. This group can be referred to as ‘pure pastoralists’. The second group is livestock keepers who practice some cropping, and have consistent association with a particular farming land use system, and could exploit improved opportunities for integrated crop/livestock production. These are the agro pastoralists. Studies of the Fulani pastoralists in northern Nigeria by Raay (1976) found that contrary to the past, many pastoralists prefer to settle and integrate their livestock with crop production due to the following reasons:

- Inability to survive on livestock products and revenues due to drought and diseases.
- Sanctions against cattle movement such as veterinary, quarantines or tolls
- Failure of sustaining the traditional cattle husbandry systems due to encroachment on grazing land by crop producers.
- Access to veterinary, livestock feed and social amenities such as education, health and welfare facilities

According to the Director of Veterinary Services (DVS) 2002, in Tanzania agro-pastoral system of production is commonly found in Mwanza, Shinyanga, Tabora, Singida and Dodoma regions. However due to loss of grazing lands, environmental degradation, high grazing intensities and drought in these main pastoral and agro-pastoral regions, has led into massive migration of pastoralists. Currently, there is a steady movement of livestock from the north of the country to the south. The main target areas include Morogoro, Coast, Mbeya and Rukwa regions (Mpiri, 1995). This has brought different ethnic groups into same ecological ranges, with increased potential for environmental degradation and resource-use conflicts. In some areas the immigrant pastoralists and the indigenous ethnic groups, mainly agriculturists, have forged complementary co-existence for example in Usangu plains (Kajembe *et al*, 2003). Where as, in some areas the immigrant have intensified the conflicting demands for natural resources for example in Ruvu basin (Ndagala, 1998). In some areas this led into violent clashes and loss of lives, for example in Kilosa District, Morogoro region (URT, 2001). Kilombero valley is one area in Morogoro region that have received many of these migrating pastoralists and agro pastoralists from the north. Several studies have suggested that internal and international migration can lead to tensions/conflicts in the receiving areas such as Kilombero valley.

Kilombero valley is the largest lowland fresh water wetland in East Africa, given a RAMSAR status in 2002 (Jekins and Ward, 2002). The inner part of the valley is partially protected as a Game Controlled Area (GCA), a designation that permits settlements, cattle grazing and hunting. Population increase and improvement to the transport infrastructure in the valley have led to settlement expansion and associated increase in pressure on the environment (WWF, 1992). Expanding settlement, high cattle densities and rapid land use changes in the valley are among the major contributing factors to the current deterioration of the environment. According to Kowero (1990), until the twentieth century, traditional land use was and by large in harmony with environment. That was because over the centuries, societies had developed their own social customs and regulations that ensured sustainable use of land based natural resources from one generation to another. Individual land use practices were governed by those customs and regulations that they were considered socially acceptable. The movement of people from different parts of the country to Kilombero valley has disrupted the traditional land use system thereby causing problems related to environment sustainability.

Traditionally, livelihood in Kilombero valley was based on hunting and fishing (Ramsar, 2002). As a result of recent land use changes such as introduction of protected areas, large scale plantations (sugar and teak) there has been a gradual and steady shift from hunting and fishing to small and medium agro-pastoralism. In recent past however, there has been a heavy influx of livestock keepers, who have brought in an increasingly number of cattle and also opened up large land areas for agriculture. According to (Manongi and Mwazyunga, 2004), at present there are about 160,054 Cattle and 42,751 Sheep and Goats in the valley. They further argued that, pastoralists are moving in from surrounding and overgrazed areas (Sukuma from Shinyanga/Usangu plains and Maasai/Barbaig from Manyara region). For them the valley offers excellent grazing conditions with permanent water sources. The increasing number of cattle has a serious impact on wildlife population, its unique species is going down in numbers as expanding agriculture, influx of domestic animals and degraded forests areas are destroying its habitats. The natural properties of the ecosystem i.e. the physical, chemical and biological components of the soils, water, plants and nutrients are also badly affected thereby threatening the ecosystem. The influx of domestic animals has resulted into significantly uncontrolled land use and land resource utilization leading to land use and land tenure conflicts among different land users.

Land use conflict in the valley has its roots as far back as 1994 when the first pastoralists entered the valley (Meshack, *et al.*, 2002). The authors argue further that three years later, in 1997 started an influx of pastoralists mainly of Sukuma ethnic group who entered with big numbers of cattle. Land allocated to immigrant pastoralists was insufficient for feeding their cattle. To satisfy their demand, they invaded farmlands such that, in several occasions, cattle were fed in farms that belong to indigenous farmers. Given scarce land resources, with such big numbers of cattle, clashes between farmers and pastoralists emerged.

Land use conflicts in Kilombero valley are therefore likely to continue if drastic measures are not taken in view of the current development on the utilization of the land resources in the area. However, planning and decision making depend upon information about the present land use situation, possible ways of improving this situation, and about the consequences of implementing each alternative solution (FAO, 1989). It was against this background that this study was initiated in order to develop spatial scenarios for land use planning and identify potential areas for land use conflicts among agro pastoralists community and recommend appropriate measures for regulating land resource use and conflict management.

1.2 Objectives

1.2.1 General Objective

The general objective of the study was to identify the potentials and constraints of Kilombero valley among agro pastoralists community in order to establish strategies for land resources use and conflict management.

1.2.2 The specific objectives include

i. To identify major land uses in the valley,

ii. To evaluate selected land utilization types,

iii. To identify areas of land use conflicts,

iv. To recommend remedial measures in conflict management.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Land use

Land use refers to purposes for which humans exploit land, and because land is a scarce resource, many possible land uses usually compete for the available land. Environmental constrains to land use are imposed by factors of climate, soil, land forms and vegetation in association with technology and the farmers goals (Kassam *et al.,* 1982).

According to Vink (1975), land use is any kind of permanent or cyclic human intervention to satisfy human needs, either material or spiritual or both, from the complex of natural and artifactial resources, which together are called "Land". In this sense true nomads with no fixed habitat do not practice land use, for him land use is the application of human controls, in a relatively systematic manner, to the key elements within any ecosystem, as are other organisms.

Wikipedia dictionary (2007) define land use as being the human modification of natural environment or wilderness into built environment such as fields, pastures and settlements. According to it, the major effect of land use on land cover since 1750 has been deforestation of temperate regions, while more recent significant effects of land use include urban sprawl, soil erosion, soil degradation, salinization and desertification.

Land use and land management practices have a major impact on natural resources including water, soil, nutrients, plants and animals. Land use information can be used to develop solutions for natural resource management issues such as salinity and water quality. For instance, water bodies in a region that has been deforested or having erosion will have different water quality than those in areas that are forested.

2.1.1 Livestock production land use in Tanzania

Livestock production is one of the major agricultural activities in Tanzania. The sub -Sector contributes to national food supply by converting rangelands resources into products suitable for human consumptions and is a source of cash incomes and inflation free-store of value. According to DVS (2002), Tanzania has 60 million hectares of rangelands suitable for livestock grazing. However, of the total rangelands, 60% is infected by the tsetse fly. The carrying capacity of the rangelands is estimated at 20 million animal units, but currently there about 16 million animal units being grazed. Livestock provides about 30 percent of the Agricultural GDP, and out of the sub Sector's contribution to GDP, about 40 percent originates from beef production, 30 percent from milk production and another 30 percent from poultry and small stock production. About 90% of the national cattle herd is the Tanzania Short-Horn Zebus, an indigenous breed.

2.1.1.1 Livestock production systems in Tanzania

Three livestock production systems are commonly distinguished in Tanzania as briefly explained:

(i) Commercial ranching

Commercial ranching is of minor importance and accounts for about 2% of the total herd in the country. It is mainly practiced by National Ranching Company (NARCO), now in the process of being privatized. National Ranching Company is a state owned company established in the 1970s with the support from IDA/World Bank. NARCO is responsible for managing all ranches in the country; the company operates a total of 15 ranches with a land holding of 623,000 ha and stock holding capacity of 155,300.

(ii) Pastoralism

According to French Diplomatie, (2005), pastoralism refers to methods of conducting herds to natural pasturage, and therefore to systems where livestock raising is practiced in an extensive manner with little input and without cultivation of fodder crops. More over, more than 20% of household food energy consumption consists of milk, milk products and meat. Pastoralism is a traditional production system that characterized by long-range migration, opportunistic flexibility and risk spreading. A number of factors such as increase of livestock number, human population growth and expansion of arable land into grazing areas have led to disintegration of this system. It is estimated that only 15,488 households (0.004%) of the total households in Tanzania practice this system. In Tanzania, pastoralism concentrated in the northern plateaus and plains, practiced in traditional grazing areas where climatic and soil conditions do not favour crop production. The main roles of livestock production in this system are subsistence, store of wealth and source of income. The Maasai steppe used to be the main pastoral zone, now herders are migrating to central and southern areas and cropping which was unknown before is increasing in importance in Maasai land both as a source of food and away to establish land rights. This system is under pressure due to:-

- Expansion of cultivation reducing the grazing area.
- Overgrazing and shifting cultivation reducing pasture productivity
- Lack of land tenure rights by grazers.

(iii) Agro-pastoralism

Agro-pastoralism describes the coexistence of both agricultural and grazing activities although there may be different degrees of integration of these activities, with specific consequences for land use. An economic definition is that, agro-pastoralists derive more than 50% of household gross revenue from farming and 10-50% from livestock (Swift, 1998). Extensive agro-pastoralism accounts for about 25% of the cattle and embraces sheep and goats as well. It involves interrelated crops and livestock and is found in low rainfall areas of western (Shinyanga and Tabora) and central (Dodoma and Singida) zones where shifting cultivation of sorghum are practiced (Sebastian and Mollel, 2006). Herds of 10-25 cattle are common. Intensive agro-pastoralism involves about 35% of the nation's cattle. Cultivation of maize and Cotton using draught animals is common (Shinyanga and Mwanza), banana, coffee-livestock systems (Kagera). Herd size ranges from 10 – 100 herds, sheep and goats are abundant.

According to the Ministry of Livestock, (Department of Pastoral System Development), agro-pastoralism represents 40% of agricultural households in Tanzania and it has expanded to the disadvantage of pastoralists. The ministry further report that pastoralism increased from 14% in 1984 to 29% 1995 and it contributes about 80% of beef production in the country.

Production systems in Tanzania are faced with three constrains: first lack of defined land utilization schemes for both livestock keepers and farmers which results to keeping large herds of animals and expansion of agriculture into fragile marginal lands or migration to other parts of the country. Water scarcity in semi-arid areas poses a second limiting factor especially during the dry season. Increased human and livestock population have resulted into higher competition for both land and water resources causing severe environmental degradation. Lastly, seasonal pasture fluctuation during wet and dry seasons necessitate migration of pastoralists from one area to another in search of pasture and water resulting into conflict with other land users.

Although agro-pastoralism now seems to expand at the expense of pastoralism, it has some positive and negative effects as the (World Bank, 1994) observed. In one hand, there are important unexploited complementarities between crops and animals. Complementarities is defined by one sector's supply of inputs to the other, such as using draught power and manure in crop production or crop residue as feed. Failure of integration is therefore waste of cheap inputs. On the other hand, resource competition between crop and animal production will inevitably reduce output in the absence of exogenous technological change. Short-term conflict would occur over high quality land, such as when vegetable production impairs lowland grazing or as irrigation replaces pasture. In the long run, rising population will necessitate expansion of cultivated area, replacing pasture and thereby reducing the grazing areas.

2.2 Land Evaluation

2.2.1 Basic concepts and definitions on Land Evaluation

Land evaluation is the process of estimating the potential of land for alternative kinds of use (Dent and Young, 1981). These include productive uses, such as arable farming, livestock production and forestry, together with uses that provide services or other benefits, such as water catchments areas, recreation and tourism and wildlife conservation. FAO, (1983) defined Land evaluation as an assessment of land performance when used for specified purposes, but according to FAO (1976) land evaluation is the process of collecting and interpreting basic inventories of land form (physiographic), soil, vegetation, climate, socio-economic factors and other aspects of land in order to identify and make a comparison of promising land use alternatives in terms applicable to the objectives of the evaluation. As such it provides a rational basis for taking land-use decisions based on analysis of relations between land use and land, giving estimates of required inputs and projected outputs. In land evaluation exercise, the land use planner matches land areas termed land units (LUs) with land uses, termed land utilization types (LUTs), determining the relative suitability of each land use (FAO, 1976; 1983). Therefore in evaluation the suitability is assessed, classified and presented separately for each kind of use (FAO, 1983).

The principle aim of land evaluation is to select the optimum land use for each defined land unit taking into account both physical and socio-economic considerations and conservation of environmental resources for use (FAO, 1983). However, it has been noted that land unit for suitability assessment is either based on soil unit (Kaaya, *et al.*, 1984), land mapping unit (Mwango, 2000) and or Agro ecological zone (FAO, 1984; FAO/IIASA, 1994). This study will use the land mapping unit in assessing land suitabilities.

2.2.2 Land Suitability

Suitability is a measure of how well the qualities of land unit match the requirements of a particular form of land use. Suitability is assessed for each relevant use and each land unit identified in the study. The suitability classification aims to show the suitability of each land unit for each land use. In FAO's, (1976) A *Framework for Land Evaluation*, there are two basic land suitability orders: suitable (S) or not suitable (N). Land classified suitable expected to yield benefits, which justify the inputs without unacceptable risk of damage to the land. Land suitability classes reflect the degree of suitability within orders. The number of classes to be recognized depends on the purpose and the scale of the land evaluation study. In qualitative studies, for instance, three classes are often distinguished in the ``suitable order: S1 = highly suitable; S2= moderately suitable; and S3= marginally suitable. Land suitability subclasses indicate the kinds of limitations of land that is classified in classes other than S1. For instance, subclasses S2w and S2e indicate land moderately suitable (S2) because of lack of oxygen availability to roots (w) and land moderately suitable (S2) because of erosion hazards (e), respectively. Land can be classified for its current or potential suitability for a certain use. The classifications may be qualitative or quantitative. In a quantitative land suitability classification, the ratings of the performance of the uses are usually expressed in economic terms.

2.2.3 Land Evaluation in Tanzania

2.2.3.1 Principles of land evaluation used

Land evaluations for various land utilization types such as smallholder low inputs rain fed maize and paddy in Tanzania have been computed by, determining the actual land characteristics for the land, combining these land characteristics values into land qualities, matching the land qualities with land use requirements, and finally combining these land qualities into composite suitability classes. Land evaluation in Tanzania has been carried out based on the following six principles stipulated in the guideline for land evaluation for rain fed agriculture (FAO, 1983). (i) Land suitability should be assessed and classified with respect on specified kind of use, (ii) Evaluation requires a comparison of the output obtained and the inputs needed on different types of land (iii) Evaluation is made in terms relevant to the physical, economic and social context of the area concerned (country or region), (iv) Evaluation involves comparison of more than one kind of use, i.e. Land evaluation should involve the comparison between alternatives (v) In land evaluation a multi disciplinary approach is required (vi) Suitability refers to use on a sustained basis.

2.2.3.2 Types of land evaluation carried out in Tanzania

According to FAO (1983), there are two types of land evaluation, qualitative and quantitative land evaluation. A qualitative land evaluation is one in which the results are expressed in qualitative terms only, without specific estimates of outputs, inputs, or costs and returns. A quantitative land evaluation is one in which the results are expressed in numerical terms which permit comparison between suitability of different kinds of use (FAO, 1983). Quantitative land evaluation can either be quantitative physical or economic land evaluation (Dent and Young, 1981).

In Tanzania both qualitative and quantitative land evaluation been carried out. Kaaya (1989) carried out qualitative land evaluation of central parts of SUA farm, Morogoro for rainfed crops using soil units approach. Kimaro and Kips (1991) carried both qualitative and quantitative land evaluation for smallholder low input rain fed production in Kilosa District using land mapping units (LMUs) approach. Magoggo and Meliyo (1994) carried out qualitative land evaluation for smallholder rainfed agriculture in Mbulu District using LMUs approach. Also Mwango (2000) and Kileo (2000) carried out both quantitative and qualitative land evaluation for smallholder low inputs rain fed crops of Mgeta areas and Wami areas in Morogoro rural District, respectively using LMUs.

2.2.3.3 Land evaluation systems used in Tanzania

Land evaluation systems commonly used in Tanzania are categorized into two groups known as the Conventional and computerized land evaluation systems. The assessment of the potentials and constrains of the land in different land units in Tanzania previously have been carried out using the conventional systems based on LMUs (Mushi, 1983) and soil units (Kaaya, 1989). These systems are quite tedious and time consuming, because they involved manual procedure of matching land use requirements (optimal conditions) with actual condition of the land. Recently computerized land evaluation systems such as ALES, LECS, and QUEFTS have been adopted in Tanzania (Kimaro, 1989; Mwango, 2000). These systems have been developed to facilitate the interpretation of land and soil resources information for quick land suitability evaluation. These systems have been developed following FAO (1976) Framework for land evaluation. The following sections review conventional and computerized systems. Although computer aided evaluation systems are quick, I am of the opinion that, the conversion system will continue for a long time in Tanzania because only few scientists have the know how of the former.

(i) Conventional systems

Tanzania has adopted FAO approach (FAO, 1976) as a conventional or local standard land evaluation system for evaluating land for various land uses. The FAO methodology comprises four categories in a decreasing generalization, namely land suitability orders, land suitability classes, land suitability subclasses and land suitability units. Land suitability order indicates whether the land is suitable or not for a specified kind of use, land suitability classes indicate the degrees of suitability within orders. Land suitability sub classes reflect kinds of limitations or main kinds of improvement measures required within classes, and land suitability units reflects minor differences in required management within subclasses (Dent and Young, 1981).

(ii) Computerized Land Evaluation Systems.

Most of these systems are purely physical in nature and they assess suitability for various landuses and often predict yields for specific crop under defined conditions of land, soil and climate data (Elberson, 1989). The computerized land evaluation systems, which have been applied in Tanzania include: Land Evaluation Computer System (LECS), which was proposed by Wood and Dent, (1983). Automated Land Evaluation System (ALES), which was developed by Rossiter and Van Wambeke (1989), and Quantitative Evaluation for the Fertility of Tropical Soils (QUEFTS) developed by Jansen *et al*, (1986). According to Elberson (1989), LECS and ALES are capable of incorporating the results of farming systems analysis so as to arrive at a complete agro economic suitability assessment and are both developed within the FAO framework for land evaluation. In Tanzania LECS and ALES have been tested and applied in different ways and scales by Kimaro, 1989; Kimaro and Kips 1991; Kimaro and Msanya 1999; and Kileo, 2000.

2.2.4 Land unit for land evaluation

Land units are areas of land with specific characteristics and land qualities (FAO, 1980, FAO, 1983). Therefore, land units can be described in terms of their characteristics, their qualities or both (FAO, 1980). A land characteristic is an attribute of land that can be measured or estimated and which can be used for distinguishing between land units of differing suitability for use and employed as a means of describing land qualities. A land quality, on the other hand, is a complex attribute of a land that usually reflects the interaction of many land characteristics (Dent and Young, 1981). The basic aim of defining land units is that they should approximate to land management units with uniform suitability for particular kinds of use, similar response to land improvement practices and similar management requirement. In practice, such ideals have to be compromised according to limitations imposed by mapping, particularly in low to medium intensities of survey. Land units are defined by superimposing maps of different themes of the land such as climate, soil, vegetation, and then drawing boundaries that best reflects the most important distinctions in the separate map (FAO, 1980).

An enormous number of characteristics are required to describe a single piece of land adequately (Dent and Young, 1981). Comparatively few of these characteristics are especially important in relation to a particular kind of use. Thus there is often a surprising amount of choice in deciding where boundaries should be drawn. A judgment therefore has to be made on where the most significant changes occur (FAO, 1983). However the overall aim of establishing land units for land evaluation is to enclose areas that are as nearly homogenous as possible to meet the required objectives (FAO, 1980). The intensity of the study, the scale of the mapping and the degree of details required is important in determining which land characteristics should be used to define the boundaries of a land unit (FAO, 1983). For instance, in an overview of a large region, differences in climate will largely determine these boundaries because differences in other factors such as soils are likely to be too localized to be investigated and mapped individually on such a small scale. Information on the nature and influence of these other factors, which may well change with climate, can be included in the description of the land units but will not determine their boundaries. In contrast, if the evaluation is focused on a small area, even minor differences in soils may be represented by separate land units, whilst macroclimate will be assumed to be uniform across the area and will not therefore, affect the land boundaries. Knowledge of local climate will be just as important for practical interpretation of the soil differences but, in detailed study, climatic information is generalized and confined to the land unit description. At intermediate scales (around 1:250,000) landform is likely to be decisive in locating boundaries, with both soils and climate contributing only to description (FAO, 1980). Examples of land units employed in land evaluation are: soil series, soil phases, soil variants, soil types and soil associations land systems and land facets (FAO, 1983); soil landscape and special purpose units, physiographic units (Magoggo and Meliyo, 1994); Land mapping units (Kileo, 2000); and Agro ecological zones (FAO, 1984).

However, a common practice in land evaluation for rainfed agriculture is to employ two kinds of land units at different stages. Agro climatic zones are employed for initial selection of crops for consideration. The major part of the evaluation is then based on more detailed land units, based on some combination of landforms and soils (FAO, 1983).

2.2.4.1 Soil mapping units

A soil survey for land evaluation attempts to delineate soil areas that behave differently to some specified management. Where the limiting value for soil characteristics have been established experimentally, the soil then can be grouped on an *ad ho*c basis according to similarities and differences in the key characteristics, and a map can be produced that is of high predictive value for the specified purpose.

According to Dent and Young (1981), soil-mapping units are real soil areas, and the soil individual, whether a taxonomic unit or a mapping unit, is a matter of personal judgment. The judgment is guided by the following principles and constraints:

i. Soil-mapping units should be as homogeneous as possible,
ii. Unit groups should be of practical value, and
iii. It must be possible to map the soil units consistently.

For general purpose surveys, soils are mapped according to their morphology on the hypothesis that soils, which look alike and similar in characteristics, will behave similarly and those that appear different will respond differently in many circumstances. Soil units are therefore mapped as if they were discrete three-dimensional individuals by inserting boundaries where the rate of change of their morphology with distance is greatest. In practice this has to be done largely according to their surface expression, inserting boundaries at changes in slope, vegetation or surface soil characteristics.

2.2.4.2 Land mapping units (LMUs)

A land-mapping unit is an area of land with specific characteristics employed as a basis for land evaluation (FAO, 1983). It is generally defined and mapped by natural resource surveys. The basic aim of defining land-mapping units is that they should be of maximum relevance to the range of land uses envisaged by the evaluation. Ideally they should approximate to land management units with uniform suitability for particular types of use, similar response to land improvement practices and similar management requirements. Any kind of area that possesses a degree of homogeneity in physical characteristics may be employed as a land-mapping unit

FAO, (1983) proposed the following guidelines to be followed in defining land mapping units for land evaluation:

i. Land mapping units should be as homogenous as possible,
ii. They should have practical value in relation to proposed land uses and
iii. It should be possible to map the units consistently.

The units should be defined as simply as possible and be based on properties which are readily observable in the field or with the use of remote sensing techniques. Over sophisticated mapping hampering subsequent evaluation activities should be avoided; Units should be defined according to relatively stable properties of the soil and land surface, which are unlikely to change rapidly in response to management practices A combination of landform, parent materials and soil types form land mapping units (Munisi, 2001). Munisi went on revealing that all LMUs are compound mapping units, meaning consist of landscape unit with two or more soil units.

2.2.4.3 Agro ecological zones (AEZs)

Agro ecological zone (AEZ) is a natural physical region, which is sufficiently uniform in climate, physiography and soil pattern for generalized descriptions and evaluation of the agricultural potential and constrains (De Pauw, 1984). It is therefore a fairly homogenous land area in terms of climate, physiography, soil pattern and vegetation/land use.

According to Baijukya and Folmer (1999), agro ecological zone is a geographical land unit in that physical conditions for crop and livestock production differ more between than within zones. According to Dent and Young, (1981) agro ecological zones refer to broad climatic regions suitable for certain crops or farming systems as widely recognized within the country.

2.3 Land use conflicts

2.3.1 The concept of social conflicts

There are many different perspectives and therefore, definitions of conflicts. Some definitions focus on open struggle as criteria for the existence of conflict. Other definitions focus on competing claims to scarce resources. Robbin (1994) defines conflict as a process that begins when one party perceives that another party has negatively affected something that the first party cares about. Wallensteen (1988) define conflict as a social interaction in which a minimum of two parties strive at the same moment in time to acquire the same resources. Notwithstanding, the divergent views on the concept of conflict, a couple of general themes can be found in most definitions. Firstly, a conflict is viewed as mainly a perception issue, because for a conflict to exist the situation must be perceived as a conflict by parties involved. Therefore many situations that could be described as situation of conflict may be not, if the parties involved do not perceive the conflict.

In case of resource-use conflicts, most of the parties exhibit blocking behaviour. Since resources are limited and scarce, and peoples' needs (or wants) often exceed availability, this leads to blocking behaviour, with both parties trying to get more of the resources than the other side. When one party is perceived to block the access to the resources of another, a conflict will probably result.

Understanding conflicts within natural resource conservation increases the sociological body of knowledge on how conflicts are generated and resolved by local communities. Conflict theorists have argued that societies are in constant state of change, in which conflict is a permanent feature. Conflict is often thought as the opposite of cooperation and peace and is commonly associated with violence. Lewis (1996) argues that many of the conflicts are counterproductive and destructive, leading to bad results and hostile relationships. Yet, conflicts have been said to play crucial roles not only for social change but also for the continuous creation of societies. Therefore, conflicts should not only be viewed as a dysfunctional relationship between individuals and communities that should be avoided at all cost, but also as an opportunity for constructive change and growth (Kisoza *et al.*, 2004). According to Guerrero-Arias (1995) the term also encompasses not only the observable aspects of the opposing forces but also the underlying tension between them. As such, conflicts can be expressed at different levels including outright violence, tensions, hostility, competition and disagreement over goals and values.

Resource-use conflicts may arise in any situation in which there is a clash of interests or ideas amongst groups of resource users. Usually, the interests and needs may be incompatible amongst different resource users, and sometimes these interests and needs are not properly addressed in natural resource management policies or programmes (FAO, 2000). In the context of resource conservation, resource-use conflict suggests that there is a group or groups whose interests are opposed to those of conservation institutions and authorities. Resource use conflicts, as such, may involve disagreements and disputes over access to, and control over resources use (FAO, 2000).

Conflicts over use of natural resources such as land, water, wildlife and forestry have been reported to be ubiquitous (Anyling and Kelly, 1997; Ortiz, 1999). People in different parts of the world have competed for use of natural resource they need to enhance their livelihoods (Anderson *et al*, 1996). Nevertheless, the dimensions, levels, and intensity of conflicts vary greatly. They can be of different forms and at different levels ranging from local to global scale and the occurrences depend on their relevance or result form local actors who influence decision-making process (Oviedo, 1999). The intensity of these conflicts have been reported to vary enormously from confusion and frustrations among members of the community over poorly communicated development and or conservation policies, to violent clashes between groups over resource ownership, rights and management responsibility (Kant and Cooke, 1999).

2.3.2 Perspectives on conflicts

Different theorists on the role of conflicts have advocated different views. At the one end of the continuum, some theorists posit that conflict is harmful, must be avoided and that the group relationship is breaking down and not functioning. This attitude is known as functionalism, the traditional view of conflict (Kumar, 1998). The human relations view of conflict, believe that conflict is natural and inevitable outcome in any human relationship, and that not always destructive, but has a potential to bring about positive outcomes for a group relationship. This attitude is known as humanism.

Another perspective believes that conflict is absolutely necessary for a relationship on group's survival and effective performance. This is referred to as the interaction's or subjectivist approach. The structuralists believe that conflict is a dynamic force rooted in the structure of dominations based on opposing interests. This implies that there is always an underlying structured conflict between the producers of economic wealth and those who benefit most from the economic system. The structuralists acknowledge that a society is always full of conflicting interests, but that major conflicts comes from the underlying social structures (Common Wealth Secretariat CWS, 1998)

2.3.3 Outcome of conflict

The analysis of any conflict is subject to variation in the theoretical view on outcome of conflicts. It is, therefore inappropriate to advocate that all conflicts are either good or bad. Whether a conflict is good or bad depends on the way it is handled (CWS, 1998). While the interactionists, believe that conflict is an essential part of human relations, it does not necessarily follow that all conflicts are good. If a conflict leads to improved group performance in achieving goals, then is a functional constructive form of conflict. But where a conflict hinders the achievement of goals then the conflict is destructive.

Some degree of conflict typically characterizes a situation involving competing claims to the ownership or use of the same piece of land. Whether claims are grounded in formally recognized rights or in customary use, circumstances involving groups of people, rather than individuals, significantly intensify the risk of larger-scale violent conflict. When conflict arises from use of resources by different users, we refer them to be resource use conflicts. As such, they are referred as disagreement and disputes over access to, and control over use of resources (FAO, 2000).   Land use conflicts require greater attention to scientific and technical considerations, involve longer-term (even intergenerational) impacts, and can, if mishandled, extinguish property rights that have existed for centuries or result in the destruction of irreplaceable ecological resources.

2.3.4 Factors underlying resource – use/land use conflicts

2.3.4.1 Overview

A number of factors have been identified to be underlying different resource-use conflicts. The conflicts over resource use often emerge because people use and manage resources in different ways (FAO, 2000). These conflicts usually have multiple causes. They may originate from different perceptions of the parties involved in resource management regarding who should manage, use and benefit from natural resources. Hence, a pluralistic approach that recognizes the multiple perspectives of the stakeholders and the concurrent effects of diverse causes in natural resource use conflicts is essential for understanding the initial situation and in identifying strategies for promoting change (Buckles and Rusnak, 1999). The most important factors underlying resource-use conflicts include levels of resource degradation, population pressure, characteristics of resource users, and policies and laws governing use and access to resource.

2.3.4.2 Levels of natural resource degradation

The natural resources utilized as common pool resources, are in many cases facing increasing degradation. Resource degradation creates scarcities where the demand for the resources is basically greater than the supply. A resource scarcity cause increased competition, and ultimately leads into resource use conflicts (Mandel, 1998). The greater unequal distribution of scarce resources in a system, the greater will be the conflicts of interests between dominant and subordinate segments of the society (Kisoza *et al*., 2004). The increased scarcity of resources due to a rapid environmental change, increasing demands, and their unequal distribution is therefore among the potential causes of conflicts.

2.3.4.3 Population pressure

Population pressure has many influences on resource use conflicts (Deslodges and Gauthier, 1997). This can arise as a result of increased demand and competition for definitive resources through population increase. Alternatively, resource-use conflicts may arise from immigrations, where user groups with different interests and attaching different values to the resources share the same ecological range. Population dynamics refer to growth or decline of a population in a specific territory. The main process contributing to population change includes natural intrinsic rate of population increase and migrations. The population of a given territory grows when there is excess of births over deaths or when there are more people moving in the area (immigration) than departing (out migration). Borrini-Feyerabend (1997), reported migration to be one of the main contributing factors to population dynamics and subsequently to natural resources use conflicts. The immigrations may also lead to disruption of local mechanisms controlling use of local common pool resources creating conditions for resource-use conflicts. According to Borrini-Feyerabend (1996), today many rural areas in developing world are experiencing rapid population increase. This implies an increased demand for land, water, grazing lands and fuel wood.

According to Ghimire and Pimbert (1997), population decline can also have a negative impact on local resources. It can be beneficial, particularly when the ecosystems left undisturbed revert to a richer level of biodiversity. Yet, population decline can be harmful to the environment, especially in cases where human managed environments provide a rich habitat for a wide variety of species. The breakdown of interaction between human communities and local systems may even lead to a net loss in local biodiversity.

2.3.4.4 Characteristics of resource users

The characteristics of resource users depend on their cultural backgrounds which include: ethnicity, norms, values and indigenous technologies by different resource users. According to Kajembe and Monela (2000), people use natural resources in different ways. For example, land, forest, and water are not just material resources people compete over, but are part and parcel of a particular way of life - farmers, ranchers, fishers, loggers –

ethnic identity and asset of gender and age roles. The cultural and religious diversity of resource users have implications for the way land and other resources are managed. The socially defined group may perceive themselves as having incompatible interests with those dependent upon particular resources, but who are unable to participate in planning or in monitoring its use as they are marginalized in decision-making (Desloges and Gauthier, 1997).

What changes from culture to culture is the way conflicts are perceived as something to be avoided at all cost or as an opportunity for social changes, and how they are used in a constructive, or too often, in destructive manner (Anderson *et al.*, 1996). The authors argue further that resource use conflicts occur when different categories of resource users have competing demands for shrinking resources. More importantly, the resource conflicts occur in settings that involve an array of culture, economic, and political arrangements that have some bearing on the outcomes of the conflict process (Kumar, 1998).

2.3.4.5 Policies and laws

A number of resource-use conflicts have been attributed to failure of policies governing use of resources both at national and local levels. Lewis (1996) argues that, resource-use conflicts usually result from policies governing resource use that do not involve all stakeholders in the planning or management of the resources. Also conflicts occur if policy, legal and institutional contexts are being developed without the participation of resource-dependent communities and without due considerations of their needs and aspirations (Desloges and Gauthier, 1997). Sometime resource - use conflicts emanate from personal centered interest of policy, project or program implementers at the local level. Resource-use conflicts can also result from failure of the central governments to recognize and empower local institutions to manage the local resources (Wyckoff-Baird, 1997). At most, central governments lack the in-depth local knowledge, of resource management pattern, to be able to make and enforce appropriate natural resource management regimes (*ibid*). According to Lewis (1996) resource-use conflicts may arise due to the establishment of protected areas, resource scarcity, and crop damage by wild animals. Kisoza *et al.*, (2004) argue that policies and laws governing land tenure, deficiency of local institutions for community as well as environmental degradation are some of the underlying causes of resource-use conflicts. Conflicts may also arise due to reluctance, by some government officials to take action in time to diffuse the tension or due to poor incentive structures and institutional framework.

2.3.4.6 Multiple-use Pastoral Systems

Multiple resource use is a central feature of many production systems, in particular the pastoral and agro-pastoral systems. These systems typically involve complex combinations of resource users and uses, and different sets of rights and obligations for users. Land is the most important complementary resource for pastoral production systems. Because land is multiple-use resource it is more liable for resource-use conflicts. The conflicts may stem from land resource scarcity or from different ways parties perceive how land should be used. This can enable a distinction of scarcity based or value based conflicts. A number of authors have described pastoralism in Africa in recent years in terms of resource conflicts (NOPA 1992; Velded, 1992). These resource conflicts imply that the institutional frameworks that currently exist often fail to deal adequately with disputes and conflicts (Niamir-Fuller, 1994).

2.3.4.7 Climate change

Climate change refers to the effects of human-induced increase in the concentration of greenhouse gases in the atmospheres enhancing the natural greenhouse effect (Eriksen, 2001). Eriksen further added that, the main sources are from burning fossil fuels, but also from agriculture and deforestation. He concluded by outlining the Social economic impact of climate change which include,

- Increased water and food insecurity
- Threatened human settlements and livelihood
- Adverse impacts on economic growth including agriculture and damaged infrastructure
- Destroyed biodiversity and damaged ecosystems

According to Gleditsch *et al.*, (2007), climate change could result in a significant drop in human carrying capacity of the earth's environment – food, water and energy shortages as well as extreme weather patterns. In turn, resource constrains and environmental damage could lead to geographical destabilization, skirmishes and even war. Rainfall is the biggest variable for crop and animal production, so climate change is going to have huge impact with the expansion of the number of people doing cropping in the more marginal areas. People who depend on livestock will be just as hard hit as pastures go brown, and therefore large number of pastoralists forced to move their herds southward to relatively wetter areas that are usually occupied by sedentary farmers, thus precipitating inter group conflicts.

2.3.5 Pastoralists and farmers conflicts in Tanzania

According to the World Bank (1994), conflicts between pastoralists and farmers are common in Tanzania. Such conflicts are due to differences in land use patterns (Fisher, 2000). The livestock keepers and crop growers are reported to have long standing conflicts and clashes since 1960s due to competition on scarce land resources (Brehony *et al*, 2000).

Since 1980s there has been chaos between livestock keepers and crop growers that led to massacre in 2000 whereby more than 30 people were killed in Kilosa District (Daily News of 20th December 2000, cited by Mayeta, 2004).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Physical environment of the area

3.1.1 Location

Kilombero valley is in Morogoro region, eastern zone of Tanzania. It occupies an area of 796,735 ha and lies between 08° 40´S and 036° 10´E (Manongi and Mwazyunga, 2004). The altitude is slightly less than 300m above sea level. Kilombero River divides the valley between two Districts, namely Kilombero and Ulanga Districts with a slightly larger share falling in Ulanga District. The study was done in Ulanga side of the valley (Figure1). Tectonically, the Kilombero valley is an asymmetrical rift valley depression, mainly the results of Pliocene faulting in east Africa (Jatzold, 1968). It extends some 260km by 52km. To the north and west of the valley are the Udzungwa Mountains, with the Mahenge highlands to the east, making up its catchment area that is so crucial to the hydrology of the ecosystem. The catchments area is largely forested with extensive Miombo woodland.

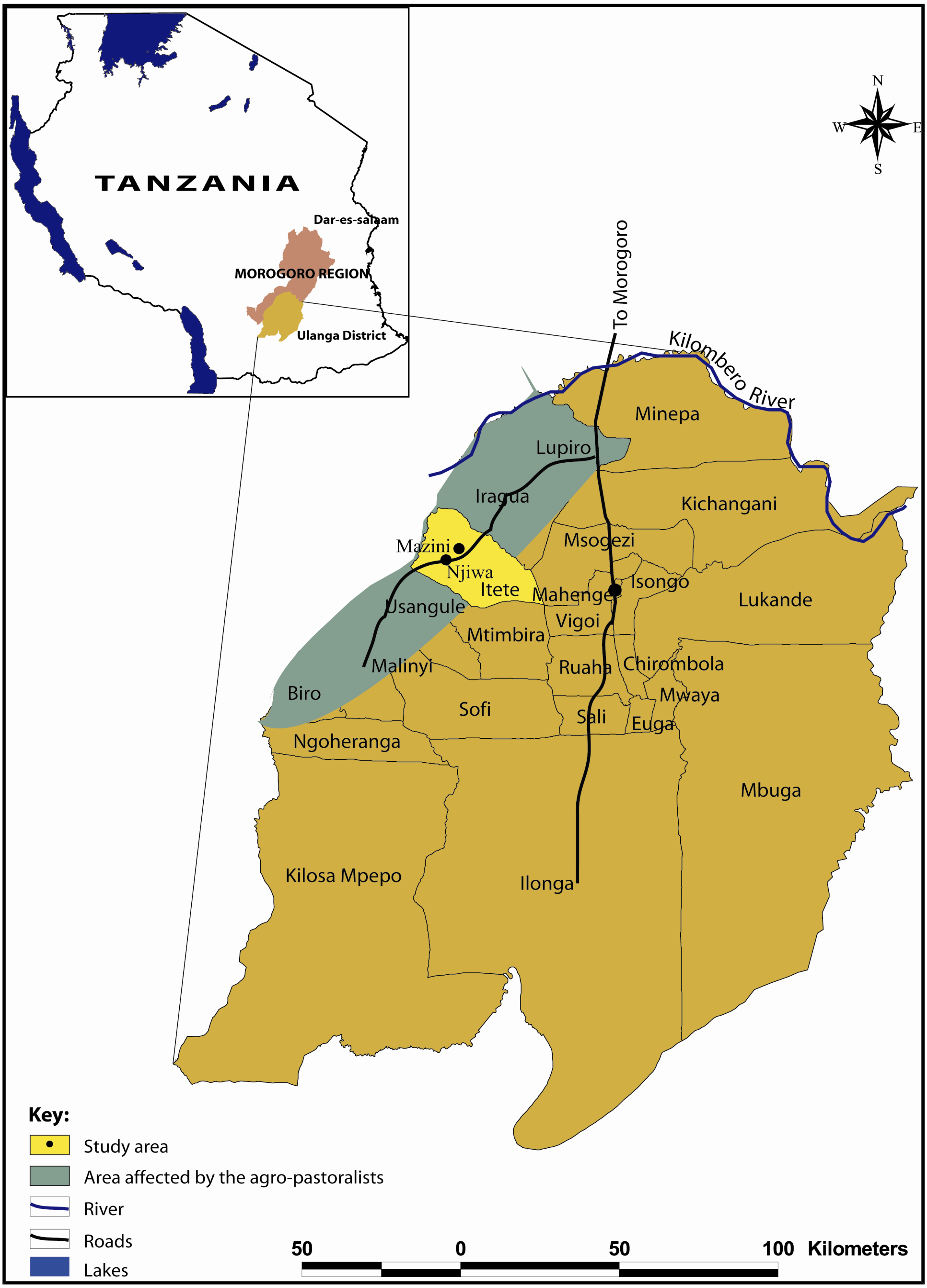

Figure 1: Location of Ulanga district, the study area

3.1.2 Climate

The rainy seasons begin as a rule towards the end of November, but it may start as early as mid October or in the last days of December. It ends between the middle and the end of May with a margin of variation from the beginning of May to the end of June. In January and February the rain easy off again and there may be acute dry spell lasting several weeks. In March the precipitation rapidly increases again until with torrential rains in April, "the long rainy season" reaches its climax and so do the flood. The mean annual precipitation in the Kilombero basin is between 1200 and 1400 mm, however there is marked differences between places (Manongi, and Mwazyunga, 2004). The temperature conditions are typical of a semi humid tropical basin. The hottest time of the year is November with a maximum of 100°F (28.15°C). The average annual minimum temperature is 65°F (18.3°C). In short four main seasons can be distinguished

i. Hot wet season from December to march
ii. Cool wet season from April to June
iii. Cool dry season from July to August
iv. Hot dry season from September to November

3.1.3 Topography

According to Kilombero farms Ltd (2004), the greater part of Kilombero valley consists of large alluvial plains situated at an elevation of slightly less than 300 meters above sea level (m.a.s.l.). On the basis of topography and consequent flooding regime, the valley may further be divided into "the alluvial lowlands", which are mostly swampy and subject to floods, and the "alluvial uplands" which form a strip of 6km. wide on either side of the alluvial lowlands. These areas are out of reach of yearly floods and parts of these areas therefore correspond to cultivated zones. Further up, marked by an escarpment, the sequence continues with the characteristic, humid savannah consisting of the Miombo forest. The hill sides rise between 700m and 1,700m extending in east-west direction.

3.1.4 Soil

The dominant soil of the flood plain is a heavy black cotton soil. There are also lighter soils that can retain water over long periods, as well as isolated areas of sandy soils occurring on slightly higher grounds. (Jatzold, 1968).

3.1.5 Vegetation

Grasses dominate the vegetation on the flood plain itself, 2-3 meters tall, with small areas of flood resistant tree species. Along river channels, there various reeds while papyrus grow around permanent swamps. Immediately outside the open flood plain, there are wooded grasslands in a transitional zone that meet extensive and very typical Miombo woodlands. Fires affect the area almost annually (Ramsar Database, 2002).

3.2 Population

According to (Manongi, and Mwazyunga, 2004), between 1988/2003, population was projected to grow at 3.4% and 2% per annum for Kilombero and Ulanga Districts respectively. They further argue that Kilombero growth rate is the highest than the rest of other Districts in the region except Morogoro urban, which is 4.6%. Population density is 24 and 8 person per km^2 for Kilombero and Ulanga districts respectively compared to regional density of 25 persons per km^2 in 2002. About 83.21% of the total districts population lives in the flood plain particularly in Ulanga District, where 63% live on the site. The total population on the wetland is 430,135 people. The dominant tribes living in the area are Wapogoro, Wandamba, Wangindo, Wabena and Wangoni for Ulanga and Wandamba for Kilombero District. As a result of influx of livestock keepers, other tribes have moved in namely the Wasukuma from Shinyanga, Rukwa and Mbeya, Wamasai and Barbairg from Arusha and Manyara Regions.

3.3 Data collection methods

In carrying out this study a combination of methods were applied which included interpretation of aerial photographs, Landsat image and maps, field observation, interviews and data collection from important local institutions as well as key local informal leaders while secondary data were obtained from records and reports.

3.3.1 Identification of major land uses in the valley

3.3.1.1 Satellite image classification

The enhanced, corrected and geo referenced Landsat TM image of 1999, was obtained from Sokoine University GIS Lab. There was difficulties in obtaining very recent image for the area hence the use of 1999 image could not be avoided. Using spatial and image analyst extension of an Arc view software and image colour composite of bands 4, 5, 3, visual interpretation was done to obtain the land use classes in the study area. This employed image elements like; colour, texture, and pattern as presented in table 1. The closed forest was delineated as dark red, grassland as light red, cropland with scattered woodland as deep green and cropland as light green. The texture was rough in the closed forest while the grassland was smooth. Fallow land and grassland behaved similar characteristics in terms of colour and texture.

Table 1: Elements used in image classification of land cover/use

Land cover	Texture	Colour	Pattern
Forest	Rough	Dark red	Irregular
Degraded forest	Rough	Dark red with green patches	Irregular
Wood land	Rough	Green	No pattern
Degraded Woodland	Rough	Green with light green patches	Irregular
Teak plantation	Slightly smooth	Reddish	Straight boundaries
Cultivation	Smooth	Light green	Small parcels
Grass with cultivation	Very smooth	Light green	No pattern
Grassland	Smooth	Light red	None
Bushland	Smooth	Dark green and light green	Clusters in repetition
Papyrus swamp	Smooth	Yellowish green	Elongated along river course

Ground truthing was conducted in the study area to identify the land use classes identified during image interpretation. These included forest, woodland, Teak plantation, grassland, cropland etc. GPS (Global Positioning System) instrument was used to locate pre-determined areas/points for the various classes during interpretation on the ground through the coordinate system.

3.3.1.2 Interview

A questionnaire was designed which it was felt, would adequately cater for the data needs of the study as it is defined by the first objective. Direct personal interview was employed in which the interviewers were asking predetermined questions in face to face contacts. During the discussion, aerial photos were at some occasions used to help discussion of land use changes that have occurred together with other changes e.g. increased degradation, areas occupied by agro-pastoralists etc.

3.3.1.3 Secondary data/information

Background knowledge on the area i.e. physical and socio-economic environment and the current land use, topographic map, reports and other literatures referred.

3.3.2 Evaluation of selected land utilization types

3.3.2.1 Materials

(a)Topographic maps at a scale of 1:50,000 (b) Boundary map at scale of 1:100,000 (c) Aerial photographs of 1978 at scale of 1:50,000 (d) GPS (e) Software (Arc View) (f) Tape measure (g) Clinometer (h) Soil auger (i) Munsell soil colour charts (j) Mirror stereoscope. (k) Tracing paper (L) Printing paper (m) Sun printer

3.3.2.2 Preparation of land unit map

In preparing for the land mapping unit map, stereoscopic interpretation of Aerial photographs was done using a mirror stereoscope, by looking at elements and characteristics such as shape, pattern, tone, texture, shadow and association of objects and features such as footpaths and tracks. Three major land mapping units were identified during the interpretation. These were the Hilly area, the piedmont (foot slope) area and the alluvial plains. These major land units were further subdivided into sub units. Having completed the aerial photograph interpretation, an overlay (the tracing paper) was placed on top of well-arranged photographs for tracing. The traced preliminary map with a legend explaining the units was then printed using a sun printer. Table 2 summarizes the land units identified: -

Table 2: Preliminary land unit map

CODE	TERRAIN FROM API 1978	LAND COVER/USE FROM 1999 LAND SAT IMAGE
H	Hilly land	
H1	Strongly dissected high hill	Forest, degraded forest, Catchments services provision
H2a	Low hill, moderately dissected	Forest, degraded woodland, degraded forest, woodland, cultivation and Teak plantation
H2b	Low hill, less dissected	Forest, Teak plantation , degraded forest and degraded woodland
P	Piedmont	
Pi1	Slopping land	Degraded forest, woodland, degraded woodland, cultivation
Pi2	Slightly slopping	Woodland, cultivation, Teak plantation and forest
Pi3	Nearly level land	Cultivation and degraded woodland
Pi4	Nearly level land	Grass with cultivation
AP	Alluvial plain	
AP1	Upper terrace	Cultivation and wood land
AP2	Middle terrace	Grassland with cultivation, Cultivation, and woodland
AP3	Lower terrace	Grassland with cultivation and Cultivation
AP4	Alluvial Fan	Cultivation, grassland, bush land and woodland
AP5	Flood plain	Papyrus swamp, grassland, bush land, grassland with cultivation and cultivation

Topographical map (scale 1:50, 000) of 1978 and geological map (scale 1:125,000) of 1962 were also interpreted visually to complement the aerial photo interpretation. Vegetation cover, land use, land form/relief, geology and drainage patterns were considered in the interpretation. The resultant land unit map compiled at a scale of 1:50,000 as base map to be used in the field and also stored in digital format after being geo referred for improvement and subsequent analysis. The boundary and topographical maps were also entered and stored in computer to be overlaid with the land unit map for marking the ward boundaries and the topographical map intended to improve the tilting effects of the aerial photographs.

3.3.2.3 Identification of land utilization types (LUTS)

Basing on the adaptation of FAO (1984) approach in land utilization identification, which considers things like present land use, agro climatic suitability, local agronomists' reports, current farming systems, market demand and government development goals or requirements, four land utilization types were selected. These were rain fed rice production, maize production, cotton production and livestock grazing.

3.3.2.4 Land use requirements of selected LUTs

Refers to appendices 9, 10, 11 and 12 for rice, maize, cotton and gazing respectively.

3.3.2.5 Soil survey

At the beginning of the survey, reconnaissance of the study area was done followed by the selection of representative transects in sample areas. One transect was on the southern part running from east to the west covering land mapping units Pi2, Pi3 and AP2. The second one was slightly laid north of the middle part, which covered mapping units Pi4 and AP5. Third traverse comprised of H1, H2a and H2b mapping units which are on the eastern part of the study area, while the last traverse was that one covering AP3, AP1 and Pi1 which lie around the middle part.

Field observation points were located on aerial photographs and on topographical maps in the field; the coordinates of each point were taken using a GPS for easy transferring on to the land unit map. A total of 11 soil pits were studied in details, in each profile pit, bulky soil samples were taken from every horizon for physical and chemical analysis. At each observation site, notes on land use, natural vegetations, relief, slopes, erosions, production methods, farming systems and drainage characteristics were studied. The soils were described using guidelines for soil profile description by FAO (1977).

(i) Laboratory method for the determination of soil physical and chemical properties,

(a) Particle size distribution,

This is the reflection of soil texture and is described as the measurement of the size of distribution of individual soil particles. Soil texture is one of the most important factors determining its permeability, water and nutrient holding capacity, easy of cultivation and erodibility. The particle size distribution of the fine earth was determined by hydrometer method after dispersing soil with calgon 5% (NSS, 1990), and the resulting textural class by USDA (1975) textural triangle.

(b) Soil pH

Soil pH is a measure of hydrogen ion concentration in the soil solution. It was determined in a 1:2.5 soil/water ratio by a standard pH meter using the electrometric method as described by (McLean, 1982).

(c) Organic matter

This was indirectly obtained by multiplying the concentration of organic carbon by 1.724 that was determined by wet combustion of Walkley and Black method as described by Nelson and Sommers (1982).

(d) Total Nitrogen

This was determined by the micro-Kjedal digestion distribution method as described by Brammer and Mulveny (1982).

(e) Available phosphorus

Available phosphorus was extracted by Bray and Kurtz-1 method (Olsen and Sommers, 1982).

(f) Available bases

The bases ($Ca2+$, $Mg2+$, $Na+$, and $K+$) were determined by atomic absorption spectrophotometer (NSS, 1987).

(g) Soil colour

The munsell colour chart (1975) used to determine soil colours. Features to note during determination of soil colour included distribution of mottles and sharp changes from reddish to grayish colours even without mottling all of which indicate water logging (FAO, 1978).

(ii) Soil classification

By using the field information and laboratory data, the soils in each land-mapping unit were classified to subclass level of the FAO-UNESCO (1974) legend.

(iii) Land qualities rating and conversion tables

Land suitability classification was done by comparing requirements of a given type of land utilization with the properties of mapped areas of land by means of land qualities and characteristics (FAO, 1976, 1984). Six land qualities were considered for land suitability evaluation in this study. These were moisture availability, nutrients availability, oxygen availability to roots, erosion hazards, capability for maintaining surface water and lastly rooting space/volume.

(a) Moisture availability

The moisture in the soils that is available to plants is determined by two factors: the water supply by rainfall and/or irrigation, and the available water holding capacity of the soil. The water supply under rain fed conditions depends on the total amounts of rainfall and potential evapo-transpiration as well as on the length of rainy season. The available water holding capacity is determined by a number of soil characteristics such as texture, structure, organic matter, depth and amount of gravels and stones in the soil. Soil moisture measurements are time consuming, costly and always not accurate. To arrive at an estimate of available moisture in case no real data are present, use is made of the textural soil properties as a Pedo Transfer Function (PTF) Wild, (1987), cited by Siderius (1992).

The relation between the soil physical properties that determine the available moisture is indicated in table 3. Values are based on a large number of analyses that has been carried out on soil samples of various textures.

Table 3: Available soil moisture of top soils

Particle size class	Mean available water capacity (mm/100mm)	Standard deviation	Number of samples
Clay	16.3	3.9	21
Silt clay	18.3	2.5	12
Sandy clay loam	17.1	2.0	23
Clay loam	17.7	4.0	111
Silt clay loam	19.9	5.0	53
Silt loam	22.5	3.3	17
Medium sandy silt loam	20.5	4.3	32
Fine sandy silt loam	22.8	2.0	9
Medium sandy loam	17.8	4.0	71
Fine sandy loam	20.2	3.6	21
Loamy medium sand	17.1	3.8	10
Loamy fine sand	18.7	3.9	11
Medium sand	13.6	2.2	3

(Source: Wild, 1987)

Table 4: Rating of available soil moisture in a profile

Rating	Available soil moisture (mm)	Remarks
1	160-250+ mm	Very high
2	120-160 mm	High
3	80-120 mm	Moderate
4	40-80 mm	Low
5	<40 mm	Very low

(Source: Wild, 1987)

(b) Nutrient availability

The nutrient availability involves the quantity of nutrients present in the soil, the form in which they are present and the capacity of the soil-vegetation system to restore nutrient supplies during periods of rest from cropping (FAO, 1984)

Consequently, nutrients availability was assessed basing on:

- Quantities of major nutrients present in the root zone from soil chemical analysis for different soil units and soil pH.

- Indicator of capacity for nutrients renewal such as content of weatherable minerals in the soil assessed during field soil profile description, total P, K and soil parent materials.

Rating of nutrients availability was based on values suggested by Landon (1991) and FAO (1983) as indicated in table 5.

Table 5: Rating of nutrient availability

Rating	pH (1:2.5 water)	Total N %	Available P ppm	K Me/100g soil
S1	5.5 – 7.0	> 0.5	> 21	> 0.6
S2	7.0-8.5	0.2–0.5	12- 20	0.2- 0.6
S3	4.5 – 5.5 >8.5	0.2–0.1	5-11	< 0.2
N	< 4.5	< 0.1	< 5	

Source: Landon (1991)

(c) Oxygen availability to roots

The occurrence of stress due to oxygen shortage depends on the occurrence of rainfall in excess of crop requirements, ability of the site to shed excess water as run-off or by infiltration, the aeration porosity and presence of ground water table (FAO, 1984). Thus landform, hydrological conditions and soils affect this land quality, against a background of the amount of rainfall and run on. This quality assessed by estimating the drainage conditions of each land unit.

The drainage condition of a soil is estimated by the frequency and duration of periods when the soil is saturated with water. These conditions are seldom accurately measured but can be inferred from soil characteristics such as texture, colour, mottling, quantity and kind of organic matter and ground water levels. Length and frequency of periods with standing water above the soil surface need also to be estimated. Thus the drainage class will be used to assess oxygen availability to roots as table 6 shows.

Table 6: Rating of drainage conditions in growing season

Rating	Soil drainage class	Land characteristic		
		Ponding hazard, frequency		
		Every 1-2 years	Every 3-5 years	Every 6-10 years
1	Good to excessive	None	None	< 2 weeks
2	Moderately good	None	< 2 weeks	2 - 6 weeks
3	Imperfect	< 2 weeks	2-6 weeks	6 – 10 weeks
4	Poor to very poor	2 -6 weeks	6-10 weeks	> 10 weeks

Source: Hof, et al., (1981)

(d) Erosion hazards.

Consideration is given to erosion by water. The susceptibility depends on the rainfall (total rainfall, intensity and frequency of showers); slope gradient and slope length, soil erodibility which is the inherent susceptibility of the soil to detachment and transport by rainfall and run off and the vegetative cover (see table7). The assessment of erosion in this study assumes a situation when the soil surface is cleared and left bare.

Table 7: Rating of susceptibility to soil erosion of an unprotected soil

Rating	**Slope gradient (%)**	**Erosion hazard**
1	0 - 4 flat to almost flat	Insignificant/ Slight
2	4 -10 gently sloping	Moderate
3	10 -16 sloping	Moderately severe
4	16 – 25 Moderately steep	Severe
5	> 25 steep to very steep	Very severe

Source: Siderius (1992)

(e) Capabilities for maintaining surface water.

This land quality was included because of suitability classification for paddy rice, which is a crop that needs to be grown in waterlogged or shallowly flooded soils. Thus soils in which surface water can be maintained are most favorable. Soils therefore, should have imperfect to poor drainage or have slow permeability and infiltration rate.

Table 8: Rating of capability for maintaining surface water

Rating	Slope %	Land characteristics		
		Micro-relief (cm)	Drainage class	Texture of surface and subsurface horizon
1	< 0.5	0 -5	Imperfectly to poorly drained	Clay, silty clay, sandy clay, clay loam, silty clay loam
2	< 2	5 - 10	Imperfectly to poorly drained	Same as above plus sandy clay loam
3	< 3	10 - 20	Moderately well drained	Same as above plus loam and sandy loam
4	< 3	> 20	Excessively to well drained	Clay to sand

Source: Hof, et al., (1981)

(f) Rooting space

According to Siderius (1992), rooting space pertains to the volume available for root development. It is not only refers to the rooting depth (two dimensional views) but also the third dimension (lateral root distribution) viz. leading to volume of soil available for roots. Total rooting depth is the soil depth till which nearly all roots occur while effective depth is the depth in which 90% of all roots occur. Rooting space evaluated using table 9.

Table 9: Rating of "rooting space"

Rating	Description	Depth hindering layer (cm)	Depth class
1	Very high	> 120	Very deep
2	High	80-120	Deep
3	Moderate	50-80	Moderately deep
4	Low	25-50	Shallow
5	Very low	<25	Very shallow

(Source: Siderius, 1985)

3.3.2.6 Land suitability rating

The conventional land evaluation system (FAO, 1976) recommended for rainfed agriculture was used in the land suitability classification. Using this classification, there are four categories or levels: land suitability orders, classes, subclasses and units. These suitability classes were assessed separately for each kind of land use type selected for evaluation with respect to each land-mapping unit in the study area. The suitability based on the limiting conditions which is the procedure of taking the lowest individual rating as limiting to overall suitability. For instance, land rated S1 on rooting conditions, S1 on erosion hazard, but S3 on moisture availability would be assessed overall as S3.

3.3.2.7 Socio-economic survey

The socio/economic survey was based on the following objectives:

- Analysis of the farming systems in the area
- Impact assessment of proposed land use changes
- Future research requirements.

The survey for financial analysis included collection of data on crop yields, input prices, labour, pesticides/ fungicides, prices of agricultural products etc.

(i) Questionnaire Development

A semi structured questionnaire was prepared for gathering data and information on land use, crop yields, input prices, labour, pesticides fungicides, prices of agricultural products. Others include resource use conflicts and socio economics of the studied area (Appendix 1).

(ii) Sampling procedure

The selection of households was performed through a stratified, multistage sampling process. For the two Districts Kilombero and Ulanga, the later was selected because of the pronounced land use conflicts. While of the two divisions which were considered to be persistent in conflicts among resource users, i.e Mtimbira was selected instead of Malinyi and lastly Itete ward which hase two villages was selected among the five wards in Mtimbira division. In order to get a manageable sample size at an affordable cost and the time available, 5% of the households in each village were chosen randomly and interviewed.

The families were the sampling frame adopted, thus the village register was used to obtain the lists of families for each hamlet. The total number of families for the two villages was 1171 and therefore 5% that is equivalent to 60 families were interviewed.

(iii) Participatory rural appraisal (PRA)

Informal and formal discussions with some villagers' representatives from the selected villages were carried out through some PRA methods namely; time lines and household interviews (Keregero *et al*., 1993; Lelo *et al*., 1995). Public meetings were held in each of the two villages. The villagers were informed about the meetings a fortnight in advance. During these meetings, discussion groups were formed representing each sub village. Issues discussed in these groups include Information related to land use conflict, land utilization types as practiced in the study area, how farms prepared and instruments used, type of produce, yields and prices, capital and labour intensity, farm size and status of farm, level of management, cultural practices, cropping calendar, marketing facilities, sketching of present land use map and level of technology. Information about existence of other farm services such as credits and extension services were also discussed.

(a) Time lines

This technique was used to identify with the farmers the local, national and international events the community considers to be important in its history and how it has dealt with land resources issues in the past. Discussions with the local residents, with special emphasis on community elders, were carried out. The discussions stimulated exchanges about problems and achievements as far back as the oldest local resident could remember. Large sheets of paper and marker pens were used to record the significant events in the history of the community.

(b) Interviews

Direct personal interview was employed in which the interviewers were asking predetermined questions in face to face contacts. At times, the interviewee were allowed to ask the interviewer where some clarifications needed. The questionnaire used in the interview is appended in Appendix 1.

3.3.2.8 Social data analysis

The data obtained was organised into manageable units. Relevant coded information was then subjected to content analysis using the Statistical Package for Social Sciences (SPSS) computer programme. Frequencies, multiple responses and cross-tabulation data analysis were used to assess socio-economic activities

3.3.3 Land Use Conflict Assessments

PRA and questionnaire administration were employed to generate data for this objective. A special checklist of questions was prepared which was given to institutions and key people in the area to be answered by them. For the PRA, focus group discussions were conducted with separate groups of farmers and agro-pastoralists. Frequency distribution and ranking were employed in data analysis.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

The results include identified land use types in the Kilombero valley, evaluation of selected land utilization types, areas of land use conflicts and recommendation of remedial measures.

4.1 Identified land use/cover types in the Kilombero Valley

Activities carried out in Kilombero Valley are influenced by the type of land resources available in the area such as fertile agricultural land, suitable climate for agriculture and livestock production, and water sources with permanent rivers, particularly the Kilombero River for fishing and irrigation purposes. The respective land use/cover types as derived from satellite image is represented on Table 10, and the spatial coverage of each land use/cover may be visualized in Figure 2. In general the major land use /cover types in Kilombero Valley include cultivation land, grassland, woodland, bush land, swamp land and forestland.

Results show that cultivated land was the largest land use/cover occupying 25.25% of total land. This finding have three implications, first it is an indication of the main occupation of the people in the study area as supported by Table 11, secondly it conforms with the report by WWF (1992) that human population in Kilombero Valley has increased in the last 20 years and with it the demand for land to produce more food. Thirdly, Kato (2007) reported that old paddy fields around villages dried up, as the result of indigenous villagers who did not maintain their paddy fields except by expanding them. Grass land rank second in the extent of coverage and divided into two namely pure grass land (19.58%) and patched grassland with recent opened farms (8.5%). Before agro pastoralists entered the Valley, the grassland was mainly occupied by wild animals. Nowdays it is occupied by agro pastoralists (mainly Sukuma) who graze their animals and utilize swampy areas for rice production. Similar trend reported by Mati *et al* (2005) in Masai Mara basin where in 1986, 69% of Masai Mara basin was under natural pasture (grassland) mostly utilized for grazing and wildlife reserves, but by the year 2000, the area reduced to 24% encroached by agriculture. Generally, the findings shown in Table 10 if compared with the national land use/cover types given by Mujule (2004), indicate an over utilization of land resources in Kilombero Valley. According to him, woodland covers 39.6% of Tanzania while there 8.3% in Kilombero, bush land covers 18.3% of the country as opposed to 10.25% in the Valley, only forest cover closer to the national data which is 2.9% against 3.03% of Kilombero Valley and cultivated land nationwide covers 20.5% while in Kilombero covers 25.5%.

To conclude, the results indicate how human activities increased markedly in the Valley, however the most prevalent use of the Valley is farming; and the majority of the population living in the area are therefore expected to be farmers. Other activities which could not be mapped but identified in discussion groups were livestock keeping, fishing, beekeeping, commercial game hunting and logging.

Table 10: Different land use/cover types of the Kilombero valley

Description	**Area (ha)**	**%**
Cultivation	9,722.2170	25.25
Grassland with cultivation	3,371.7010	8.76
Grassland	7,538.9970	19.58
Papyrus swamp	1,650.7660	4.29
Bush lands	3,944.9980	10.25
Degraded woodland	3,764.0440	9.78
Degraded forest	2,697.2780	7.01
Teak plantation	1,443.9350	3.75
Woodland	3,197.8480	8.31
Forest	1,165.5550	3.03
Total	**38497.339**	**100**

Source: Satellite image interpretation of 1999

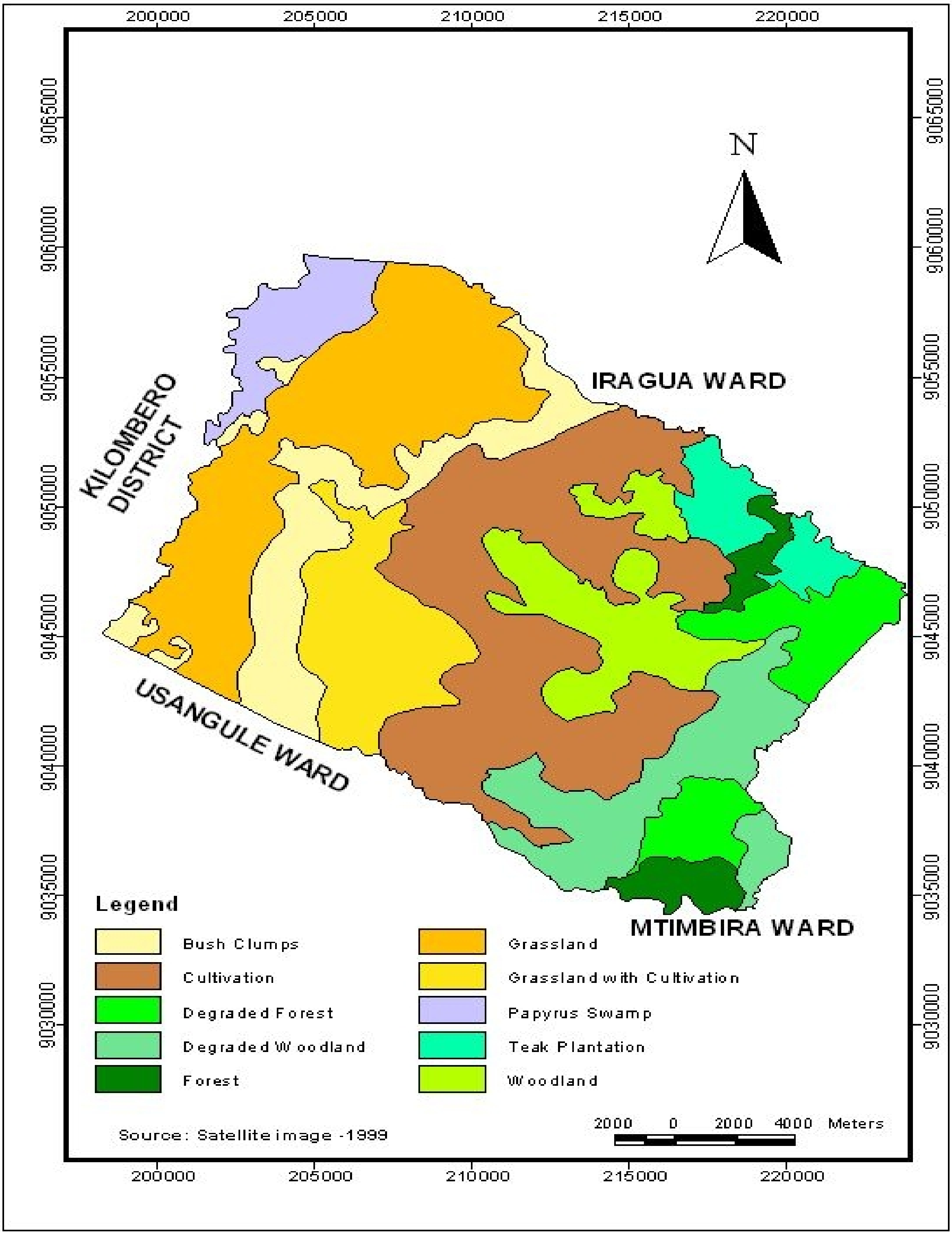

Figure 2: Land use/cover map

4.1.1 Rainfed agriculture (Farming)

Social economic survey results revealed that, small-scale farming is an important economic activity for most of the inhabitants of this Valley for both subsistence and cash income earnings. Most villagers, (about 96.6%, pure farmers and agro pastoralists) of interviewed house holds are directly engaged in crop farming, other economic activities are simply used to supplement the house hold income. Table 11 shows that, the surveyed area composed of more crop farmers (83.3%) than those who practiced both crop farming and livestock keeping (13.3%). The suitable climatic condition and soil fertility has contributed to flourishing crop production. The results are in agreement with Tanzania analytical report of integrated labour force survey (ILRS, 2000/01) which reported that, 84% of Tanzanian occupation is agriculture, but also complement the satellite image interpretation results presented in Table 10.

Table 11: Occupation of respondents

Type of occupation	Frequency	Percent	Cumulative percent
Farming	50	83.3	83.3
Farming and livestock	8	13.3	96.6
Other business	2	3.4	100
Total	**60**	**100**	

Source: Social economic survey 2007

4.1.1.1 Types of crops

Paddy which is a traditional crop for the area over many years is the main crop in Kilombero valley (Table12). Currently, the Valley is a major paddy production area, supplying about 9% of all rice produced in Tanzania (Kato, 2007). Other crops grown in the area include maize, legumes and banana as the main food crops. Cassava, sweet potatoes, cowpeas and vegetables are grown in small-scale by few farmers, while cotton sugarcane and simsim are grown mainly for cash income. Despite being a food crop, rice is a major source of income to several farmers in the area.

Table 12: Types of crops grown by respondents

Category label	Code	Count	% respondents	% cases
Paddy	1	53	45.3	89.8
Maize	2	39	33.3	66.1
Banana	3	3	2.6	5.1
Cowpeas	4	3	2.6	5.1
Groundnuts	5	4	3.4	6.8
Simsim	6	5	4.3	8.5
Coconut	7	1	0.9	1.7
Cassava	8	3	2.6	5.1
Orange	9	1	0.9	1.7
Sorghum	10	2	1.7	3.4
Sweet potatoes	11	2	1.7	3.4
Not applicable	12	1	0.9	1.7
Total responses		**117**	**100**	**198.3**

Source: Social economic survey 2007

Paddy and maize are major food crops grown in the area. Paddy is mostly grown along the valley flood /alluvial plains of Kilombero Game Controlled area and part of the alluvial fans (Fig3). These areas are very fertile and potentially rich for rice farming and cattle grazing. These areas include Nganawa chini, Ipera asilia, Mitalula, Nandanga, Mofu, Naukasha and parts of Madabadaba (Meshark, *et al,* 2002)**.**

Figure 3: Paddy field in the alluvial plains

Maize is grown on the high lying areas where there is no flooding (Fig 4). They include part of Luvili, Mahimbo, Mtupili, Mjengoni, Kikoni, Itanda, Njiwa juu, Njiwa kati and Ibuta areas. The seasonal calendar for paddy and maize is given in Table 13. Maghimbi (2007) also reported similar observation that paddy has always grown in the flood plains and river valleys of Kilimanjaro Valley. Further more, he reported maize as another important crop in slightly raised parts of Kilimanjaro Valley

Table 13: Seasonal calendar for Paddy and Maize

Monthly activities	Crop	Ja	Fe	Ma	Ap	M	J	Ju	Au	Se	Oc	No	De
Farm preparation	Maize												
	Rice												
Sowing	Maize												
	Rice												
Weeding	Maize												
	Rice												
Guarding	Rice												
Harvesting	Maize												
	Rice												
SEASON		Jan	Fe	Ma	Ap	M	J	J	Au	S	O	No	De
Long rains													
Hot season													
Cold season													
Short rains													

Source: social economic survey 2007

Figure 4: Maize field close to the forest (Itanda area)

4.1.1.2 Farm sizes and yields

The farm sizes differ from one household to another, however the majority of the populations have farm sizes ranging from 0.8 – 1.6 ha (Table 14). Few people own large farmland exceeding 4.0 ha. The level of production is not very good. About 79.6% of interviewed villagers harvest between 0.75 and 3.0 tones/ ha (Table 15). Only the remaining 31% produces more than 3.0 tones/ha. Generally this yield is some how low as compared to 4 - 5 t / ha reported by Mkangwa and Kalumuna (2005) in the same District but under irrigation production. According to Onwuene and Sinha, (1991) highest rice yields is 7t / ha worldwide.

Table 14: Farm size (ha)

Farm size in ha	**Frequency**	**Percent**	**Cumulative percentage**
0.3	1	1.7	1.7
0.4	6	10.0	11.7
0.8	7	11.6	23.3
1.0	5	8.3	31.6
1.2	13	21.6	53.2
1.3	1	1.7	54.9
1.4	1	1.7	56.6
1.6	6	10.0	66.6
1.8	1	1.7	68.3
2.0	3	5.0	73.3
2.4	4	6.6	79.9
2.8	4	6.6	86.5
3.6	1	1.7	88.2
4.0	3	5.0	93.2
4.4	1	1.7	94.9
6.0	2	3.4	98.3
12.0	1	1.7	100
Total	**60**	**100**	

Source: Social economic survey 2007

Table 15: Paddy yield (tones/ha)

Amount of yield (tones/ha)	Frequency	Percent	Cumulative %
0.75	2	3.7	3.7
1.25	5	9.3	13
1.5	4	7.4	20.4
1.75	4	7.4	27.8
2.0	11	20.4	48.1
2.5	13	24.1	72.2
3.0	4	7.4	79.6
3.5	3	5.6	85.2
3.75	6	11.1	96.3
4.5	1	1.9	98.1
5.0	1	1.9	100.0
Not applicable	6	11.6	
Total responses	**60**	**100**	

4.1.1.3 Management practices

(i) Intercropping

Intercropping is the growing of two or more crops on the same piece of land within the same period. Various forms of intercropping have been the central feature of many tropical agricultural systems for centuries. According to Mkangwa and Kalumuna, (2005), intercropping can be divided into three general categories: - full, relay and sequential cropping, depending on the extent of physical association between the crops. Full intercropping involves complete association between crops planted at the same time, while relay cropping involves only partial association, in which a second crop is planted into an already standing crop before it is harvested. Sequential intercropping is where there is no physical association, but two crops are grown on the same land in the same year. All these three forms of intercropping are common in Kilombero Valley. For instance full intercropping is practiced by growing maize with groundnuts (Fig 5), or paddy with maize (Fig 6), relay cropping was noted where cotton relayed in maize fields and in valley bottoms, sequential cropping is also common.

One of the most important reasons for growing two or more crops together is the increase in productivity per unit of land. Ecologists tell us that stable natural systems are typically diverse, containing many different types of plants, arthropods, mammals, birds, and microorganisms. In stable systems, serious pest outbreaks are rare, because natural controls exist to automatically bring populations back into balance. Planting crop mixtures, which increase farm biodiversity, can make crop ecosystems more stable, and thereby reduce pest problems. According to Preston (2003), some of the paddocks in United State of America are planted with mixture of cereal grain, flavor beans and Canadian field peas. The grain mixture is combine harvested to make energy and supplement feed to livestock as needed. Pastoralists in Kilombero Valley can also maximize land use through these practices.

Figure 5: Maize intercropped with groundnuts (Madabadaba)

Figure 6: Paddy intercropped with maize (Madabadaba)

(ii) Tillage Practices

Africa is still the world's least mechanized region. According to the Hunger Project (1990), 1% of farm power is provided by mechanical means, while 10% comes from animals. Human power accounts for 89%. With such limited mechanization, farm sizes are bound to be small and the gains of economics of scale will delude the African farmer for the foreseeable future. The study revealed that 66.7% of farmers use hand hoe, while 15.0% use animal traction and another 15.0% use tractors in land preparation (Table16). The introduction of draught animals by agropastoralists, reduced the number of farmers depended on human power, hence increased the area cultivated as compared to the past.

The area cultivated per household is strongly influenced by the source of farm power used to till the land, coupled with the ability to mobilize labour for subsequently operations. According to Clare, (2004), household reliant on hand hoe cultivation in some parts of Tanzania typically cultivates 1– 2ha, draught animal power 3– 4ha and those who depend on tractor hire 8ha while tractor owners 20ha. In the study area, hand hoe in land preparation mostly used by the indigenous farmers. Animal traction is very common to the livestock keepers who also do farming. Tractor ploughing is practiced by both local and incoming farmers with strong economic capability. Most of the communities in the study area noted that, it is the ability to cultivate land rather than access to land which is a major constraint on production.

Table 16: Cultivation method

Method of cultivation	Frequency	Percent	Cumulative percent
By hand	40	66.7	66.7
By animal plough	9	15.0	83.1
Tractor plough	9	15.0	98.3
Not applicable	2	3.3	100
Total	**59**	**100**	

Source: Social economic survey 2007

(iii) Uses of organic and inorganic fertilizers.

Farmers in the study area do not use fertilizer of any kind (Table17). The farmers claim that, there is no need of using it because the soils are very fertile. Although there are many organic fertilizer materials available in the area including farmyard manure, but these organic sources are not efficiently utilized. In recently cleared lands, litter fall is the major source of nutrients but often times it is burnt and therefore exposed to wind or water transportation away of the field. However the presences of many livestock in the area contribute positively toward the improvement of soil fertility through animal manure. According to Bayer (1984), one of the major advantages of integrating pastoral production and cropping is the readily availability of manure for crops.

Table 17: Type of fertilizer applied

Fertilizer applied	Frequency	Percent	Cumulative percentage
Organic fertilizer	0	0	0
Inorganic fertilizer	0	0	0
No fertilizer applied	58	96.7	96.7
Not applicable	2	3.3	100
Total	**60**	**100**	

4.1.2 Grazing

Manongi and Mwazyunga (2004) reported that, the number of cattle has been increasing over the last 10 to 15 years in Kilombero Valley. Figure 7, is one of the new settlement established just last year (2006) by recent immigrated pastoralist. They further estimated a population of 202,805 livestock (mainly local Zebu type) of which 160,054 cattle and 42,751 sheep and goats. Data collected from the District Agricultural Office for Ulanga, shows that Ulanga side of the Valley alone has 96,818 cattle, 86,714 goats, and 18,089 sheep while the study area Itete ward have, 29,596 cattle, 3,041 goats, 4,547 sheep, 170 donkeys and 168 pigs.

According to the Ministry of Livestock Development (MLD) 2007, livestock is among the major agricultural sub sectors in Tanzania. Out of the 4.9 million agricultural households, about 36% are keeping livestock (35% engaged in both crop and livestock production while 1% purely livestock keepers). Despite of its importance, consumption of plant cover by livestock has a major impact on the environment and overgrazing is believed to contribute substantially to desertification and land degradation (Dregne *et al*, 1991). Plant removal reduces protective plant cover, vigour and regrowth capacity, the effects of which increase exponentially with removal rates (Belsky, 1988). Indirect effects include trampling which leads to soil compaction and, when excessive (as along cattle trails and around homesteads and water points), may cause run-off and gully erosion.

Figure 7: Cattle “boma” around Sukuma homestead (Madabadaba sub village)

The environmental effects of the resulting high grazing pressure on the Valley ecosystem and loss of miombo woodland to farms have yet to be properly determined (Jenkins and Ward, 2002). A hundred percent of all livestock keepers and farmers interviewed denied of having an area allocated for grazing (Table 18). This is the biggest constraint to environmental sustainability.

Table 18: Area allocated for grazing

Is there specific area for grazing?	Frequency	Percent	Cumulative percentage
Don’t know	0	0	0
Yes	0	0	0
No	60	100	100
Total	**60**	**100**	

Eleven ethnic groups were found in the study area (Table 19). These were Pogoro (45%), Ndamba (20%), Ngoni (6.7) % and Luguru (3.3). The rest gogo, ngindo, bena, hiyao kizu, and nyamwezi each (1.7%). Among these, Sukuma, Gogo, Kizu and Nyamwezi both practice livestock keeping and practice farming (agro pastoralists).

Table 19: Tribes of respondent

Tribe	Frequency	%	Valid %	Cumulative %
Pogoro	27	45.0	45.0	45.0
Ndamba	12	20.0	20.0	65.0
Sukuma	9	15.0	15.0	80.0
Gogo	1	1.7	1.7	81.7
Ngindo	1	1.7	1.7	83.3
Ngoni	4	6.7	6.7	90.0
Bena	1	1.7	1.7	91.7
Hiyao	1	1.7	1.7	93.3
Kizu	1	1.7	1.7	95.0
Luguru	2	3.3	3.3	98.3
Nyamwezi	1	1.7	1.7	100.0
Total	**60**	**100.0**	**100.0**	

The form of livestock keeping practiced in the villages is nomadic pastoralism. This practice is not sustainable as it causes serious environmental degradation and loss of soil fertility through trampling and overgrazing (Hendrickson, *et al*, 1998). The indigenous people are mostly farmers. The sub-villages/areas where livestock grazing is commonly practiced include Madabadaba, Ipera asilia, Mofu and Kilombero Game Controlled areas**.**

4.1.3 Fishing

Fishing in Kilombero River is an important activity as a source of food and revenue for the population in the area. Fishermen have established fishing camps along the Kilombero River and undertake fishing using canoes. According to (Manongi and Mwazyunga, 2004), the most economic species in terms of their contribution to total catch up weight and market value are the Catfish species *Clavius gariepinus* and Bargra *docmac*, and Tilapia *Orechromis niloticus*. These species are popular in the market and are sold to distant markets such as Dar es Salaam, Morogoro, Dodoma as well as local markets. Fishing gears used are varied; they range from those allowed legally by the fisheries department to illegal ones that are prohibited to be used in fish exploitation.

The 1992 WWF mission used results from interviews to estimate that fishing was the primary income source for between 5 – 30% of men in villages bordering Kilombero floodplain and over 50% in villages located in the floodplain (WWF, 1992). The same study estimated that there were 5,000 – 10,000 fulltime fishers and 15,000 – 25,000 part time fishers giving a total of 20,000 – 35,000 fishers. The estimated annual harvest from the Kilombero riverine system ranges between 9,000 – 12,000 tones of fish. Income generated from the sale of fish therefore could be used for investment in other sectors of the economy like buying draught animals to assist other farming tasks there by improving tillage in terms of depth of cut as well as expanding farm sizes for increased crop yield. On the other side, having employed such big number of people, fishing industry in the Valley has lessened the pressure those people could have contributed to the agricultural land if all had to depend their entire livelihood on farming and grazing.

4.1.4 Bee keeping

Bee keeping is another area, which is being practiced on small scale. According to the District Natural Resource Officer for Ulanga District, a bee keeping association in Kilombero called Miombo Beekeepers Association (MIBA) is established to promote bee-keeping activities in the area. Production volume has not yet reached economic market scale, for example Kilombero District with 300 beekeepers (38 women and 262 men) produced only 5000kgs of honey and 500kgs of wax, an average of 17kgs per beekeeper and 1.66kgs of wax from 613 beehives about 2 per person. Beekeepers are also the target beneficiaries of any future interventions in the area. There have been no interventions in the part of this activity and just like fishery, would need awareness on resources management, training on improved beekeeping practices and processing of products. Modern honey harvesting practices and processing are crucial for accessing viable external market, but the quantities have to be increased to justify economic market sale. This activity is friendly to the Kilombero valley as it does not create pressure on it and could provide alternative activity to farming and livestock.

As opposed to agropastoralism in terms of environmental degradation, Bee keeping is one of the few environmentally benign activities and it can be carried out within buffer zones, forest areas, parks and nature reserves, without any detrimental effects on the environment. Provided it is done correctly and that all the appropriate support structures and market linkages are put in place is an activity where the twin objectives of environmental conservation and poverty reduction seamlessly converge. In Kenya for instance, 10,000 hives at maximum production, have capacity to inject over US $600,000 to the participating rural farmers in bee keeping (Equator- Initiative, 2002).

4.1.5 Wildlife utilization

Kilombero Valley is rich in wildlife and forest resources. Wildlife utilization from the area is delivered either through tourist hunting, poaching and legal hunting by residents (Brehoney *et al*, 2004). Tourists hunting is carried out in the Kilombero Game Controlled Area divided into two hunting block each with 200,000 ha. Two hunting companies namely Kilombero North Safaris Limited and Wild Footprints Limited each manage one block. Utilization of wildlife in this area is managed by quota allocation per year/species and hunting rights are for a period of four years, there after is again tendered for competition. Some species especially Puku need to be protected from extinction. Income generated from tourist hunting is paid to the Wildlife Division, of which 25% is given to the relevant District Council to be spent in village activities located in or near hunting blocks. Individuals also undertake hunting, through the use of authorized methods and weapons, after obtaining approval and allocation by Wildlife Division. This is done for game meat. Poaching activities for wildlife are common in the area and threatening the life of endangered species like Puku.

According to Kilombero Valley Wildlife Project (1997), increasing numbers of cattle in the area affect some population of wildlife. On the other side, the project report went on reporting that wild animals are significant problems for both farmers and agropastoralists. Apart from external factors, crop damage by wild animals was regarded as by far the biggest agricultural problem. Animals impose a large direct cost on people through crop damage and also considerable indirect costs due to the amount of time spent guarding crops from animals.

4.1.6 Forests utilization

In this study, forest refers to all land bearing a vegetative association whereby trees of any size (be exploitable or not, and capable of producing wood or other products) dominate. Equally, all land covered by vegetation, particularly trees of exerting influence on climate or water regime or providing shelter to wildlife and livestock is referred to as forest. They include all wood and non-wood based resources, which exists inside the forest. Two categories of forest exist in Itete ward. These are public or open forests and privately owned forests. Public or open forests are mainly found in the slightly raised and hilly areas. Scattered forest in Madabada, Alabama, Mahimbo, Luviri and Itanda are few examples to cite here. The private forest is mainly under leased land by Kilombero Valley Teak Company (KVTC).

According to URT (2002), public forestland (general land forest), is non-gazetted or non-reserved land, and is managed by the Commissioner of Lands on behalf of the president. Forests on general land (or general land forests) are, however, under the authority and jurisdiction of the Director of Forestry and Beekeeping. These areas constitute 51 percent of all Tanzania's forest land, and cover a total of 17.7 million ha. They have open-access use rights, and are characterized by insecure land tenure, shifting cultivation, and harvesting for fuel wood, poles and timber. They are under heavy pressure from conversion to other competing land uses, such as agriculture, livestock grazing, settlements and industrial development, as well as from wildfires. For instance the increased number of agropastoralists in the Valley increased the pressure to the forests. They cleared land for agriculture, cut trees for house building and sometimes they clear forest to chase tsetse flies and to have open land as the area has many predators like lions. Figure 8 represent a small part of the forest remained untouched in Itanda area. Here, forest act as water catchments and habitat for wild animals.

Figure 8: Undisturbed forests at Itanda area (Hilly land unit)

Itanda and Ilomwe forests are sources of various streams such as Luvili, Mafinji, Mchilipa and Mtumbei. Also they are common homes of a variety of wild animals particularly during flooding season.

4.1.7 Agricultural and livestock land use constraints

4.1.7.1 Agricultural land use constrains

During PRA, farmers reported many factors that are attributing to decreased crop yields. The most frequently mentioned by most of the groups include lack of irrigation schemes, crop destruction by wild animals, emergence of notorious weeds in both rice and maize fields, pest attack, disease infections and conflicts between crop and livestock producers. Others include the use of local seeds which are normally low yielding varieties, serious labour shortage during peak period in the rainy seasons and use of less efficient farm implements like hand hoes. These factors are briefly discussed as follows: -

(i) Absence of irrigation scheme

According to MAFS (2003), Kilombero valley has a potential of 330,000 ha of irrigable land. However, the most significant development in this valley is the 4,250 ha of Kilombero Sugar Estates (WAD, 2008). A small number of farmers practice small scale irrigation due to the fact that, the Kilombero Valley receives substantial amounts of rainfall (1200 – 1400mm) and the need for irrigation is not felt by many farmers. According to the District Agricultural Office for Ulanga, the study area (Itete ward alone) has a total potential irrigable area of 1046 ha as follows

i. Mtumbei River Basin - 90 ha
ii. Mchilipa River Basin – 707 ha
iii. Mafinji River Basin – 141 ha
iv. Luvili River Basin – 108 ha

Paddy production on alluvial fans depends on the floods of tributaries of Kilombero River. Thus, suitable lands for the flood cultivation system are limited to narrow riverside stripe (Kato, 2007). With irrigation, they could have expanded the production area far away from the riversides, but also could have facilitated the number of cropping from the current once per year to twice or even more per year.

Tanzania is currently importing 100,000 tones of rice per year because rice has become the second most important food crop after maize (URT, 2006). Without a drastic increase of rice production, Tanzania will soon be importing from abroad more than the current 100,000 tones. However, according to literature water is a limiting factor to crop production in many areas of Tanzania and without irrigation, any other intervention to increase production and productivity is limited in these areas.

(ii) Destruction of crops by wild animals

A serious constrain to farming is crop damage caused by wild animals. This has been acknowledged by 56.7% of the farmers (Table 20). Crop losses due to wildlife are extremely high, in spite of serious efforts to protect crops using a variety of methods during the growing season. Protection requires a substantial input of labour, even involving children who therefore are unable to attend school. Similar observations were reported by Thomas *et al,* (2004) who studied human wildlife conflict in western part of Serengeti in Tanzania. From their study, 85.7% of respondents reported that wildlife caused much or very much damage to crops, the average crop damage was 19.1% of the total crop production equivalent to an average value of 84,000Tshs per household. Compared to the reported crop damage, 34.8% claimed that they experienced no damage to their livestock. In Kilombero Valley, scaring by different approaches is the only method used by farmers, although in some cases it does not help much.

Table 20: Vermin problem to respondent

Is vermin a problem	Frequency	Percent	Cumulative %
Yes	34	56.7	56.7
No	24	40.0	96.7
Not applicable	2	3.3	100
Total	**60**	**100**	

Source: Social economic survey 2007

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(iii) Emergence of notorious weeds in both Paddy and Maize fields.

Weeds infestation such as wild rice and *cyperus spp* is increasing. This has been complained by farmers in discussion groups, but also observed by the researcher during soil survey (Fig 8). Weeds are a major problem in rice production, the level of infestation varies according to the method of planting (transplanting, direct seeding with dry or wet seed), locality etc. In Thailand, losses due to weeds have been estimated at 37-79% (Prasan, 1993). Prasan further reported that weed control in Thailand has been achieved with various measures such as ensuring the purity of rice seed, proper selection of cultivar and seeding rate, proper planting method, good land preparation and water management, hand weeding and chemical weed control, and crop rotation. In Kilombero Valley, apart from hand weeding, many farmers happen to use herbicide to control weeds especially in paddy fields (Table21). Figure 9 show wild rice on the alluvial plains of Kilombero.

Figure 9: Wild rice weeds on the flood plain

Table 21: Percentage of farmers using herbicides

Herbicide use	Frequency	Percent	Cumulative Percent
Yes	21	35.0	35.0
No	37	61.7	96.7
Not applicable	2	3.3	100
Total	**60**	**100**	

Source: Social economic survey 2007

Many considerations need to be made before popularizing any of these approaches because there are social, economic and environmental implications. For instance, hand weeding is labour intensive and very inefficient. It may take over two weeks to weed by hand an acre using family labour of 4 people. Use of herbicides requires fund, which may be a limiting factor to many small-scale farmers. Apart from money, it has health hazards to humans and may also cause environmental hazards if not properly handled.

(iv) Pests

Pest such as insects and birds like quelea quelea on rice were also mentioned as contributing factor to yield losses. For paddy this is very common during milk stage, grain filling and maturity stages. Studies carried out in Senegal and Mali by Treca (1992), reported that, losses may vary within a small area from as little as zero to 100%. Where damage is particularly severe, farmers may not bother to harvest the crop, leading to an effective total loss. Bird scaring is the only approach used by farmers as claimed by the farmers themselves. This method though effective but is limited by high labour demand, also does not go beyond the farmers rice fields. The breeding places are therefore left intact by using this control measure. On maize crop, stalk borer and elegant grasshoppers locally known "*Mbulumundu*" were common insect pests reported.

In order to sustain agricultural development, there is a critical need for control methods to mitigate the negative effects of pests and disease. Recommendations for control of crop pests and diseases include:

- Use of resistant varieties
- Use of suitable pesticides
- Biological control
- Cultural control
- A combination of two or more of the above methods.

Adherence to better agronomic practices can be the best alternative to reduce infestation of maize stalk borers and early planting will enable the crop to avoid periods of heavy pest infestation later in the season (CAB International, 2002).

(v) Conflicts between crop and livestock producers

During PRA, it was observed that conflicts between crop producers and livestock keepers are severe. The conflicts caused by livestock (cattle, goats and sheep) feeding on crops mainly during dry season. It was further reported that occasionally livestock are driven into the fields where crops are yet to be harvested and trample almost everything. In extreme situations, farmers reported that livestock are allowed to feed on croplands even when the owners are present. Similar situation was reported by Mtwale (2002) in Kilosa District where the death of 31 people reported in the clashes between farmers and pastoralists after livestock belongs to pastoralists damaged farmer’s crops. All these have caused a lot of misunderstandings in the societies where crop producers and livestock keepers co-exist. Crop losses caused by livestock destruction are enormous. In addition to crop losses, soils are compacted as a result of large livestock herds feeding on crop residues after harvesting. According to the Ministry of Agriculture, Food and Rural Affairs (MAFRA) (2003), soil compaction is one form of soil degradation along with loss of soil structure, poor internal drainage Salinization and soil acidity problems.

During the time of this study a fresh conflict was erupted between the two sides, this time the situation was different instead of livestock feeding on crop, farmers and livestock keepers were fought for the right of ownership of land. The livestock keepers happen to hold large tract of land good for farming and denied crop growers to use it. At that time of land preparation, a number of crop grower's farms were flooded due to heavy rains and therefore they had to look for farms in higher altitude areas. The conflict was tense such that the District Commissioner had to send peoples militia to oversee smooth distribution of the area to the needy. Just as reported by Brehony et al., (2000), long term solutions to this problem need to be sought. These should include land use planning, education and massive campaigns to crop producers, livestock keepers and other stakeholders on advantages of their co-existence and disadvantages of the persisting conflicts to their economy and to the national security at large.

(Vi) Use of local seed varieties

The socio-economic survey conducted revealed that 98.3% of the farmers use local seeds for many crops including paddy and maize. Local seeds are limited by their many undesirable attributes including low yielding potential, long period to maturity and tall plants making them susceptible to damage when there is fast moving wind (Mkangwa and Kalumuna, 2005). However, local seeds can be used in improvement of good crop varieties because they have wide genetic base that could be useful. During Participatory Rural Appraisal (PRA), it was noted that some farmers are using improved varieties of both maize and paddy. This could be an entry point to others who are not using improved varieties. Extension services was recommended by Aloyce *et al,* (2000), to be an important source of knowledge to farmers that significantly influenced the adoption of improved seeds and fertilizer. They further argued that, currently there is no short cut for substantial and dramatic increases in production of maize without improved seeds and use of inorganic fertilizer. In this regard, the District extension service have a duty to increase its effort of introducing more improved varieties with qualities that can fit into the growing conditions of Kilombero Valley.

(vii) Labour shortage

It was observed that human labour is mostly used in all farm operations. Starting from tillage, planting, weeding, harvesting and in some cases even transportation of crops back home. Although, there is a certain understanding in the households on who has to do what, in most cases, these tasks are unfortunately shouldered by women and children. If the available family labour and workload are carefully compared, it is apparent that some crop fields will not be effectively attended by family labour especially during critical farm operations like weeding and guarding. For this reason, some fields will be weeded only once, late weeding or not weeded at all. Weeding is one of the examples, but labour shortage cuts across all other farm and domestic operations. According to Kurtz and Steve (2003), weed management is an important aspect in crop production. They further argued that weed reduce crop yields and can lead to total crop failure if not controlled. Weeding one ha takes at least 48 person days. Timelines of weeding is crucial in reducing competition with crops and preventing seed production. Based on these labour limitations, farmers should be advised to cultivate the land that can be managed by their household labour. This is essential because the farm can be attended on time, thereby increasing the possibility of improving crop yields.

(viii) Use of less efficient farm implements

Farm power is one of the more crucial inputs in the agricultural production process. Efficient farm implements including farm tractors and draft animal power can contribute to increased crop yields. This is because soil is tilled to the required depths within a shorter time. Beside ploughing, other farm operations like planting, weeding and harvesting can also be achieved using farm implements. Although, using farm implements for all farm operations is advanced stage of farming, but some crucial farm activities like land preparation require special attention. According to Clare (2004), there is a sharp contrast between the poverty and general depression associated with the predominantly hoe systems in East Africa. Hoe cultivation is become common resulting in smaller areas under cultivation, reduced farm incomes and higher incidence of poverty where households are unable to meet their basic needs. Using hand hoes as observed (65% of farmers) is very laborious and takes unnecessarily longer time (Table 22).

Table 22: Means of land preparation

Means of land preparation	Frequency	Percent	Cumulative percentage
By hand	39	65.0	65.0
Animal traction	9	15.0	80.0
Tractor plough	8	13.3	93.3
Other means/response	4	6.7	100
Total	**60**	**100**	

4.1.7.2 Livestock keeping constraints

(i) Overstocking of livestock.

The study area of Itete ward has 29,596 Cattle, 3,041 Goats, 4,547 Sheep, 170 Donkeys and 168 Pigs. Using a Livestock Unit (LU) of 0.8 per cattle as suggested by Meshark, *et al* (2002) then there about 23,676.8 LU, again if goats, sheep and donkeys each has a value of 0.15 LU, then there (3,041 + 4,547 +170) times 0.15 which equals to 1,163.7 LU.

Thus in total Itete ward has 24,840.5 LU. If 1LU need 3ha per year as Meshark suggested, then a total of 74, 521.5ha is needed to support the available livestock for grazing. The total area of Itete ward is 38,497.34ha only, which is about half of the required area. Until the time of this study, there was no specific area allocated for grazing. This makes farming difficult as no place is safe for farming without the intrusion of livestock which feed and tramp on crops. The absence of specific area allocated for grazing contributes to the existing conflict between farmers and livestock keepers. Similar observation has been reported by Mtwale (2002) to have happened in Rundugai (Hai District) 1989 and Kilosa District in 2000. Both areas fighting between farmers and pastoralists emerged after pastoralist’s cattle devastated cropped land.

4.2 Evaluation of land utilization

4.2.1 Final land unit map

Re-interpretation of aerial photographs was done after fieldwork to correct those areas that were incorrectly interpreted in the preliminary land unit map development. Three major land units were distinguished namely; hilly land, the piedmont and the alluvial plain. The hilly unit remained with the same sub units; the piedmont was reduced to three sub units instead of the four units that were identified in the preliminary map. Full codes and their terrain names are given in Appendix 8, and Figure 10 show unit distributions.

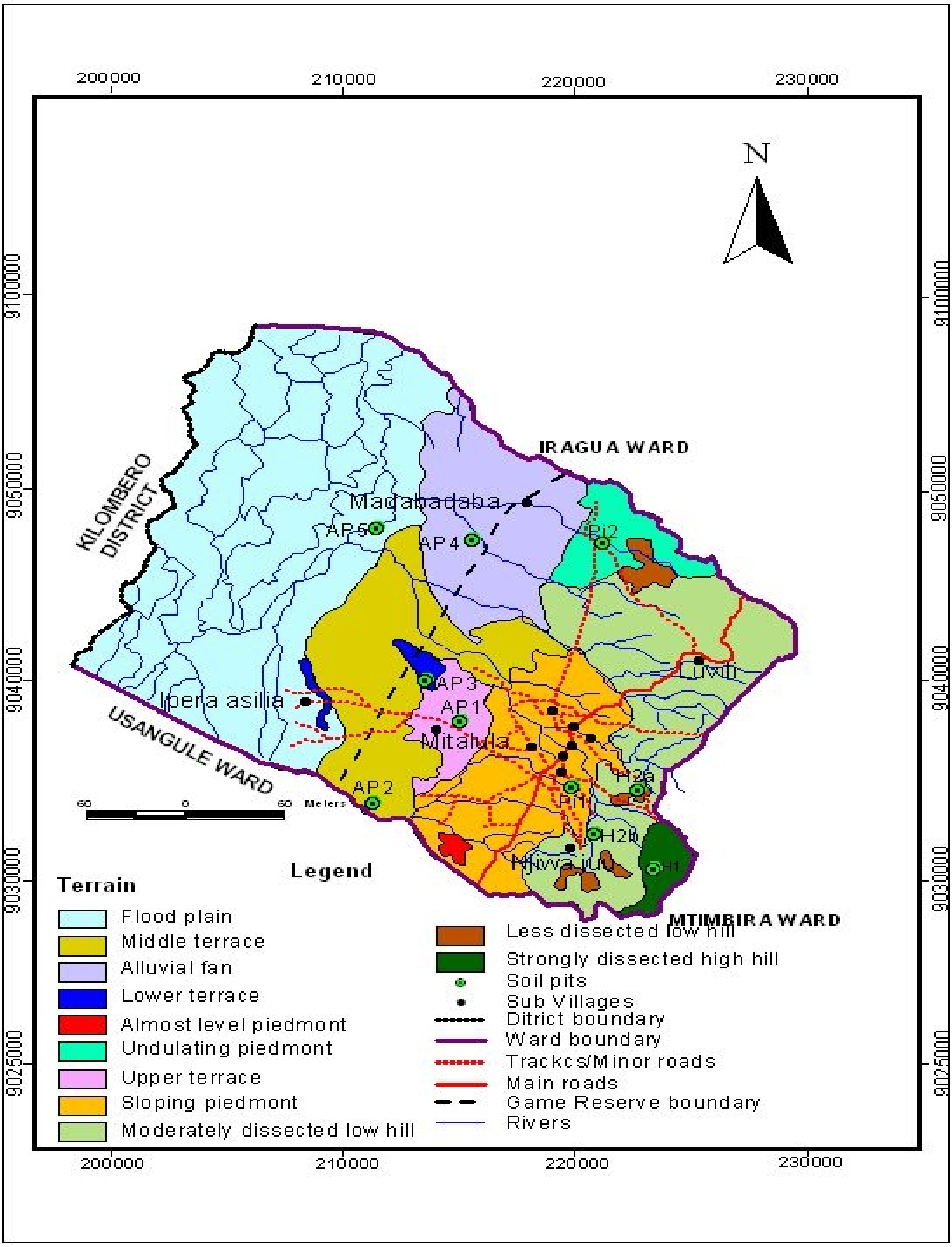


Figure 10: Land unit map

4.2.2 Selected land utilization for evaluation

Based on the adaptation of FAO (1983) approach, four land utilization types were identified as a basis for characterization and evaluation of Itete Ward land use. The analysis of the two variables was based on the site and socio-economic conditions within which the agricultural industry operates. The selected land utilization types explained in Table 23.

Table 23: Land utilization types

Land use code	Explanation of the land use type
A1	Smaller holder rainfed farming and improved traditional technology based on paddy with or without livestock
A2	Small holder rainfed arable farming and improved traditional technology based on maize with or without livestock.
A3	Smallholder rainfed arable farming and improved traditional technology based on Cotton with or without livestock
L	Smallholder livestock keeping and improved traditional breeds, (agro-pastoralism) with or without field crop.

4.2.2.1 General overview of land utilization

Generally the land users have been able to locate and reallocate specific land use types in particular sites on the landscape, a catenary sequence (Conacher and Darlymple, 1977) for particular time periods with very limited agricultural extension support. The villagers subdivided their village into three units, the upslope, the mid slope and low land commonly known as "*mbugani*". They also could mention the type of soils to be found at each land unit using soil colours and whether the soil is course textured or soft one

(Rugumamu, 2004). For that matter the upslope unit has red soils, the mid slope has mixture of red and black while the lowland has a black soils.

Paddy typifies monoculture crop and grown as both lowland and upland crop, in the study area upland rice sometimes intercropped with maize (Fig 5). However, lowland rice is the common. Maize intercropped with some legumes are grown on well drained soils of the mid slope (Fig. 4). Cotton is grown on well drained level to gently sloping land facet of the piedmont. Small holder farmers echoed that, poor marketing systems (sighting Tanzania Cotton Authority), have caused production of cotton to be abandoned in favour of other crops mainly paddy and maize. According to Rugumamu, (2004), this land use type reflects the sensitivity of small farmers to market forces. In recent past, livestock keeping has been growing very fast in the whole Valley which is mostly practiced by immigrated agro pastoralists. Basically cattle, goats and sheep rely on natural pasture under free range. The distance to the grazing land varies between the wet and the dry seasons. As a general pattern, dry season grazing is carried out in the surrounding swampy plain and beyond. During the short wet season, livestock grazing is around village land, especially on the narrow fallow land, on the stubble, and on forest land. This free-range management type opens almost all of the landscape units to livestock grazing albeit on a rotational basis with crops and other uses of the land over time. The issue of mobility of this type makes livestock grazing a critical bearing on resource stewardship and conservation. Some times some herdsmen tend to deliberately graze their stock on farmers' crops, a situation that triggers conflict.

(i) Size of farm plot ownership

Farm holding are composed of disaggregated small plots. These small plots without specific geometrical shapes appear to be located haphazardly on the land surface. The survey revealed that an average household farm size is an aggregation of small plots of about 0.8 – 1.6 ha in size. The available family labour and financial resources are the major constraints on the size of farms. The largest farm in the sample was 12ha. This is indeed bigger than the estimated national crop land available per capital of 0.3ha in 1990, which was expected to drop to 0.005ha by 2025 (Rugumamu, 2004). This implies that a problem for a small farmer in the Valley is not land but labour which governs the size of land to be farmed by household.

By way of summary, for land use A1, A2 and A3 it was found that out of 60 respondents, 31.6% cultivated less than one hectare, nearly half (41.7%) cultivated one to two hectares, about 19.9% ploughed between 2.1 and 4.0 hectares, while 5% cultivated between 4.1 and 6 hectares of land. The remaining 2% cultivate more than 6 hectares per year (Table 14). With respect to the tenure issue, it had been noted that its natural tenure has been changing in Tanzania since independence 1961, as reviewed in the National Land Policy (Ministry of Lands, Housing and Urban Development, 1995). The most conspicuous feature was the conversion of freehold titles to leaseholds under the Free holds Titles (Conversion) and Government Lease Act (Cap.523) of 1963. This system was later changed into Rights of Occupancy under the Government Leaseholds. These changes lead to a decline in customary rights and the abolition of landlord-tenant relationships (Shivji, 1998). These and other developments (Shivji 1998), have culminated in State land ownership and control. In Itete Ward, village governments hold land while individual farmers have usufruct rights. From the study sample, 43.3% of respondents stated that their land tenure ship is from inheritance, village government allocation (20%), self acquisition (23.3%) and renting (1.7%). The remaining 11.7% acquired land through other means like buying, relative land or own no land. Land use types A1, A2 and A3 are characterized by individual (private) ownership of plots under the head of a household. Grazing land is communally owned.

(ii) Market orientation

Peasantry agriculture is subsistence oriented (Rugumamu, 1996). Regarding land use A1 and A2, food crops are sold and bought within the village markets. The favourite staple food which is rice is also a cash crop that may be sold soon after harvest and re-bought just before the next sowing season as household reserves run down. The field research findings show that the Government has left the peasants in the hands of businessmen under the umbrella of economic liberalization. As a result, farmers have disengaged themselves from the production of traditional export crops like cotton and intensified the production of the ecologically delicate commodity of rice and maize, which enjoys demand in local, national and international free markets.

Land use type L produces dairy products and meat for domestic use and live animals, as well as hides and skins for local and international markets. Livestock is also a source of manure for the few progressive farmers. A formal market for livestock products was not evident. At community level, livestock are also needed for traditional ceremonies. It is against this background that agro-pastoralists prefer to keep large herds.

4.2.2.2 Description of land utilization

(i) Smallholder rain fed farming and improved traditional technology based on paddy with or without livestock

Paddy (*oryza sativa*) cultivation is the main livelihood in Itete ward and the whole Kilombero Valley at large. A household survey of 60 randomly sampled households in the Ward showed that paddy is grown by 89.8% of households. This result conforms to that of

Kato (2007), who reported that, paddy in the Valley is grown by all farmers (100%). It is characterized by low capital input but high labour input as most operations are done through family labour. However, weeding is supplemented by the use of herbicides. According to the social economic survey, the average labour is 161 man days per ha. Land preparation begins in September for those who do it manually, but for those who use animal traction and tractor ploughing do prepare their farms between mid November and December. Planting is carried out in January. Harvesting is usually done between May and July depending on whether it was early or late planted. Threshing is the hardest work in paddy cultivation and farmers sometimes hire labourers. The average yield is between 2.00 - 3.75 tones/ha (Table 15), but the highest recorded yield which is obtained under bunding cultivation by an agro pastoralists of Sukuma ethnic was 5.0 tones/ha (equivalent to 20 bags /acre). This yield is higher compared with the national paddy yield average of 2.5–3.5 tones per hectare (URT, 2006). Agro economic survey results from this study shown in Table 24.

Table 24: Agro-economic survey of paddy production in Kilombero

No.	Economic component	Unit	Range observed	Calculation based on optimum attainable yield.
A. Labour input				
i	Land preparation	MD/ha	50-60	55
ii	Planting	MD/ha	15-20	18
iii	Weeding	MD/ha	40-51	45
vi	Harvesting /cutting	MD/ha	19-30	25
v	Threshing and parking	MD/ha	16-21	18
Total labour input (Average)		**MD/ha**		**161**
Sub total lobour cost at 2,500Tshs/ MD		MD/ha		402,500
B. Material input costs				
i	Seeds (local variety) 100kg/ha @ 250Tshs	Tshs/ha		25,000
ii	Pesticides	Tshs/ha	None	
iii	Empty bags (38 bags/ha)	Tshs/ha		38,000
iv	Transport costs from farm	Tshs/ha		38,000
Sub total input costs		Tshs/ha		101,000
Total production costs (A+B)		**Tshs/ha**		**503,500**
C. Yield				
i	Average yield	Kg/ha	2000	
ii	Maximum yield	Kg/ha		3800
iii	Farm gate price	Tshs/kg		250
Total returns (max.)		**Tshs/ha**	**950,000**	
Gross margin (return – production costs) = 446,500				

Md = Man days

(ii) Small holder rainfed arable farming and improved traditional technology based on maize with or without livestock.

According to (Kato, 2007), before economic liberalization, maize was mainly produced as a source of income in Kilombero Valley, while paddy was cultivated around villages as a crop for home consumption. After the liberalization, farmers expanded paddy cultivation for income generation instead of maize. The results of this study showed that, maize cultivation is practiced by 66.1% most of them being immigrant people (Table12). The indigenous Ndamba and Pogoro ethnic tribes grow paddy as their sole food crop. Traditionally, maize food is consumed only in years of famine. It is characterized by low capital and labour input. In October before the short rains commence, the villagers begin to prepare the upland fields and sow maize immediately after the rains. The average labour is 67 MD/ha (Table 26). Average maize yield per hectare in Eastern Tanzania is very low, (less than 1 tonne) due to stem borer (NBCP, 2004). According to this study, the crop is harvested in May and the average maize yield is between 1.0 – 1.5 tones/ha (Table 25). Vermin, especially monkeys, incorrectly spacing, poor quality seeds and untimely weeding were observed to be the major contributing factors to poor crop harvest. The poor market demand for the crop caused farmers to pay less attention, however if external market is assured, probably the crop production would increase.

Table 25: Amount of maize harvested

Yield (tones/ha)	Frequency	Percent	Cumulative percentage
0.25	3	7.7	7.7
0.5	4	10.3	17.9
0.75	5	12.8	30.8
1	5	12.8	43.6
1.25	4	10.3	53.8
1.5	1	2.6	56.4
1.75	2	5.1	61.5
2.0	1	2.6	64.1
2.25	6	15.4	79.5
2.5	5	12.8	92.3
2.75	1	2.6	94.9
3.0	1	2.6	97.4
3.75	1	2.6	100
TOTAL	**39**	**100**	

Table 26: Agro economic survey results for Maize production in the Valley

No.	Economic Component	Unit	Range Observed	Calculation Based On Optimum Attainable Yield.
A. Labour input				
i	Land preparation	MD/ha	20-30	25
ii	Planting	MD/ha	08-10	9
iii	Weeding	MD/ha	10-12	11
vi	Harvesting	MD/ha	10-14	12
v	Shelling and pesticide application	MD/ha	8-12	10
Total labour input (Average)		**MD/ha**		**67**
Sub total lobour cost at 2000Tshs/ MD/ha		**MD/ha**	**134,000**	
B. Material input costs				
i	Seeds (local variety) 30kg/ha @ 500	Tshs/ha	15,000	15,000
ii	Pesticides	Tshs/ha	24,000-30,000	27,000
Sub total input costs		**Tshs/ha**	**42,000**	
Total production costs (A+B)		**Tshs/ha**	**176,000**	
C. Yield				
i	Average yield	Kg/ha	2250	
ii	Maximum yield	Kg/ha	3000	3000
iii	Farm gate price	Tshs/kg	150	150
Total returns		**Tshs/ha**	**450,000**	
Gross margin (return – production costs) = 274,000				

Md = Man days

(iii) Smallholder rainfed arable farming and improved traditional technology based on Cotton with or without livestock.

Cotton is an important cash crop for smallholder farmers in eastern and western Tanzania. It is currently rated third after cashew and coffee in terms of foreign exchange earnings (Myaka, *et al.*, 1998). Meanwhile, most farmers are reluctant to grow the crop because in the past when cooperative unions were the only sole buyer for the crop, they were not promptly paid for their crop and sometimes some of them were not paid at all (John, 2002). However, in recent past, the Government launched a campaign countrywide to revamp the crop. Farmers in Ulanga District especially those living in Mwaya Division responded positively. It is therefore anticipated that the farmers in Kilombero Valley will also emulate their fellow farmers in the District. Land preparation is carried out between December and January. Seeds and pesticides are usually provided by Tanzania Cotton Board on credit. Planting is in February and early March, while harvesting is in August. In average, the harvest is about 1050 kg/ha, and last year selling price was 300/kg. The agro economic survey results for the crop are shown in Table 27.

Table 27: Agro economic survey results for low input Cotton production in the Valley

No.	Economic Component	Unit	Range Observed	Calculation Based on Optmum Attainable Yield.
A. Labour input				
i	Land preparation	MD/ha	28-34	31
ii	Planting	MD/ha	8-12	11
iii	Weeding	MD/ha	8-10	9
iv	Pestcides spraying	MD/ha	1-3	2
v	Harvesting 20-50kg/day/Md	MD/ha	22-30	26
Total labour input (Avarage		**MD/ha**		**79**
Sub total lobour cost at 2000Tshs/ MD/ha		**MD/ha**	**158,000**	
B. Material input costs				
i	Seeds 25kg	Tshs/ha		25,000
ii	Pesticides 2litres	Tshs/ha		30,000
Sub total input costs		**Tshs/ha**		**55,000**
Total production costs (A+B)		**Tshs/ha**	**213,000**	
C. Yield				
i	Average yield	kg/ha	1050	
ii	Maximum yield	kg/ha	1100	1100
iii	Farm gate price	Tshs/kg	300	300
Total returns		**Tshs/ha**	**330,000**	
Gross margin (return – production costs) = 117,000				

Md = Man days

(iv) Smallholder livestock keeping and improved traditional breeds (agro pastoralism) with or without crop farming.

Livestock is an important source of nutrition and food security. It provides high quality food in the form of meat, eggs, and dairy products to both rural and urban populations. According to Gari (2003), apart from the nutrition value, appropriate livestock development may contribute to economic diversification; provide a practical and inexpensive means for enhancing soil fertility, improving crop productivity and saving expenses related to the use of inorganic fertilizers. Further more, livestock is an important asset for power and labour management like oxen for traction and donkeys for transport. The community of Kilombero Valley began enjoying these services after the agro pastoralists moved into the area. Most of these agro pastoralists are of Sukuma ethnicity. Currently, the absence of specified grazing areas, lead to frequent misunderstanding between farmers and livestock keepers due to crop destruction by livestock. The animals are communally grazed within or outside the village area sometimes entering in Game Controlled Area thereby causing conflict with hunting companies licensed to hunt in the area (Brehony *et al,* 2004).

Livestock is mainly perceived as wealth in which large numbers are aimed at, even if it is at the sacrifice of the carrying capacity of the available grazing lands resulting in an overgrazing problem. The livestock are kept in the homesteads at night and have to shuttle every day to the grazing lands. Grazing is generally uncontrolled, thus trampling large areas causing erosion. After the harvest of field crops, the animals are led over the fields to feed on crop residues. It was difficulty to quantify mandays required, out put, costs and other related data collection because the livestock keepers were reluctant to disclose any detailed information regarding their livestock. This is partly because of the fear they have as they are unwanted in the area.

4.2.3 Land use requirements

The land use requirements for the four Land Utilization Types are presented in Appendices 9 to 12 deduced from different sources. Land uses requirements for rice; maize and cotton are mostly found in tables of crop requirements and factor ratings by the Department of Land Development (DLD, 1985) Bankok, Thailand. Extensive grazing requirements were deduced mainly from Huizing (1987). However, specific crop requirements data for land evaluation purposes are still difficult to find.

4.2.4 Description of the land-mapping units

Description of land mapping units are presented in appendix 13

4.2.5 Land Suitability classification of Itete Ward

The different land units recognized during the survey of the area as shown on the land unit map were rated in terms of land suitability classes, in respect of relevant land use alternatives. More specifically the rating involved the confrontation of the physical crop requirements (Appendices 9 – 12) with the land qualities (Appendix 13, i - xi) in order to give a prediction of crop performance.

In correlating these factors, it may be noted that a severe or very severe limitation for agriculture in general, as indicated by rating poor or very poor of a specific land quality, will yet not cause a limitation for every one of the land use alternatives under consideration. Examples are poor drainage and severe risk of soil erosion. Poor drainage is a severe limitation in the case of rainfed uplands crops, but not for paddy cultivation. Strongly sloping land may be largely destroyed by gully erosion if cultivated with Maize, yet this condition is not severely limiting for tree crops, which give protection to the land. Thus in assessing the suitability for the different land use alternatives, different weight is given to the rating of these land qualities. Suitability rating for the identified land units are presented in Tables 28 – 38.

Table 28: Suitability rating results for strongly dissected unit (HI)

Land quality	**Land utilization types**			
	Rice	**Maize**	**Cotton**	**Grazing**
LQ1 - Moisture availability	S2	S1	S1	-
LQ2 - Soil fertility	S1	S1	S2	-
LQ3 – Oxygen availability to roots	S3	S1	S1	-
LQ4 – Rooting conditions	S1	S1	SI	-
LQ5 – Soil erosion hazards	N	N	N	N
LQ6 – Surface water ponding	N	SI	S1	-
LQ7 – Availability of drinking water	-	-	-	N
LQ8 – Accessibility in LMU	-	-	-	N
Overall class	**N**	**N**	**N**	**N**

Table 29: Suitability rating results for moderately dissected unit (H2a)

Land quality	**Land utilization types**			
	Rice	**Maize**	**Cotton**	**Grazing**

LQ1 - Moisture availability	S2	S1	S1	
LQ2 – Nutrients availability	S1	S2	S2	-
LQ3 – Oxygen availability to roots	S3	S1	S1	-
LQ4 – Rooting conditions	S1	S1	S1	-
LQ5 – Soil erosion hazards	N	S3	S3	S3e
LQ6 – Surface water ponding	N	S2	S2	-
LQ7 – Availability of drinking water	-	-	-	N1
LQ8 – Accessibility in LMU	-	-	-	S2
Overall class	**N**	**S3e**	**S3e**	**N**

Table 30: Suitability rating results for slightly dissected unit (H2b)

Land quality	Land utilization types			
	Rice	Maize	Cotton	Grazing
LQ1 - Moisture availability	S2	S1	S1	-
LQ2 – Nutrients availability	S1	S2	S2	-
LQ3 – Oxygen availability to roots	S1	S1	S1	-
LQ4 – Rooting conditions	S1	S1	S1	-
LQ5 – Soil erosion hazards	N	S3	S3	S3
LQ6 – Surface water ponding	N	S1	S1	-
LQ7 – Availability of drinking water	-	-	-	N
LQ8 – Accessibility in LMU	-	-	-	S1
Overall class	**N**	**S3e**	**S3e**	**N**

Table 31: Suitability rating results for sloping piedmont nit (Pi1)

Land quality	Land utilization types			
	Rice	Maize	Cotton	Grazing
LQ1 - Moisture availability	S3	S1	S1	-
LQ2 – Nutrients availability	S2	S3	S2	-
LQ3 – Oxygen availability to roots	S3	S1	S3	
LQ4 – Rooting conditions	S1	S1	S1	
LQ5 – Soil erosion hazards	S3	S2	S3	S3
LQ6 – Surface water ponding	N	S1	S1	-
LQ7 – Availability of drinking water	-	-	-	S3
LQ8 – Accessibility in LMU	-	-	-	S3
Overall class	**N**	**S3n**	**S3e**	**S3e**

Table 32: Suitability rating results for undulating piedmont unit (Pi2)

Land quality	Land utilization types			
	Rice	Maize	Cotton	Grazing
LQ1 - Moisture availability	S2	S2	S2	-
LQ2 – Nutrients availability	S1	S1	S2	-
LQ3 – Oxygen availability to roots	S2	S1	S1	-
LQ4 – Rooting conditions	S1	S1	S1	-
LQ5 – Soil erosion hazards	S2	S2	S2	S2
LQ6 – Surface water ponding	S2	S2	S2	-
LQ7 – Availability of drinking water	-	-	-	S2
LQ8 – Accessibility in LMU	-	-	-	S2
Overall class	**S2e**	**S2e**	**S2n**	**S2**

Table 33: Suitability rating results for nearly level piedmont unit (Pi3)

Land quality	Land utilization types			
	Rice	Maize	Cotton	Grazing

LQ1 - Moisture availability	S1	N	N	-
LQ2 – Nutrients availability	S1	S2	S2	-
LQ3 – Oxygen availability to roots	S1	S3	S3	-
LQ4 – Rooting conditions	S1	S1	S1	-
LQ5 – Soil erosion hazards	S1	S1	S1	S1
LQ6 – Surface water ponding	S1	N	N	-
LQ7 – Availability of drinking water	-	-	-	S2
LQ8 – Accessibility in LMU	-	-	-	S1
Overall class	**S1**	**N**	**N**	**S2**

Table 34: Suitability rating results for upper terrace unit (AP1)

Land quality	Land utilization types			
	Rice	Maize	Cotton	Grazing
LQ1 - Moisture availability	S2	S1	S1	-
LQ2 – Nutrients availability	S2	S3	S2	-
LQ3 – Oxygen availability to roots	S2	S1	S1	-
LQ4 – Rooting conditions	S1	S1	S1	-
LQ5 – Soil erosion hazards	S2	S2	S1	S1
LQ6 – Surface water ponding	S2	S2	S1	-
LQ7 – Availability of drinking water	-	-	-	S2
LQ8 – Accessibility in LMU	-	-	-	S1
Overall class	**S2ne**	**S3n**	**S2n**	**S2**

Table 35: Suitability rating results for middle terrace (AP2)

Land quality	Land utilization types			
	Rice	Maize	Cotton	Grazing
LQ1 - Moisture availability	S2	S1	S1	-
LQ2 – Nutrients availability	S2	S3	S2	-
LQ3 – Oxygen availability to roots	S1	S3	S2	-
LQ4 – Rooting conditions	S1	S1	S1	-
LQ5 – Soil erosion hazards	S2	S1	S1	S1
LQ6 – Surface water ponding	S1	S3	S2	-
LQ7 – Availability of drinking water	-	-	-	SI
LQ8 – Accessibility in LMU	-	-	-	S1
Overall class	**S2ne**	**S3n**	**S2ne**	**S1**

Table 36: Suitability rating results for lower terrace (AP3)

Land quality	Land utilization types			
	Rice	Maize	Cotton	Grazing
LQ1 - Moisture availability	S1	N	N	-
LQ2 – Nutrients availability	S2	S2	S2	-
LQ3 – Oxygen availability to roots	S1	N	N	-
LQ4 – Rooting conditions	S1	S1	S1	-
LQ5 – Soil erosion hazards	S1	S1	S1	S1
LQ6 – Surface water ponding	S1	N	N	-
LQ7 – Availability of drinking water	-	-	-	S1
LQ8 – Accessibility in LMU	-	-	-	S1
Overall class	**S2n**	**N**	**N**	**S1**

Table 37: Suitability rating results for alluvial fan (AP4)

Land quality	Land utilization types

	Rice	Maize	Cotton	Grazing
LQ1 - Moisture availability	S1	N	N	-
LQ2 – Nutrients availability	S1	S2	S2	-
LQ3 – Oxygen availability to roots	S1	S3	S3	-
LQ4 – Rooting conditions	S1	S1	S1	-
LQ5 – Soil erosion hazards	S1	S1	S1	S1
LQ6 – Surface water ponding	SI	N	N	-
LQ7 – Availability of drinking water	-	-	-	S1
LQ8 – Accessibility in LMU	-	-	-	S1
Overall class	**SI**	**N**	**N**	**S1**

Table 38: Suitability rating results for flood plain unit (AP5)

Land quality	Land utilization types			
	Rice	Maize	Cotton	Grazing
LQ1 - Moisture availability	S1	N	N	-
LQ2 – Nutrients availability	S1	S2	S2	-
LQ3 – Oxygen availability to roots	S1	N	N	-
LQ4 – Rooting conditions	S1	S1	S1	-
LQ5 – Soil erosion hazards	S1	S1	S1	S1
LQ6 – Surface water ponding	S1	N	N	-
LQ7 – Availability of drinking water	-	-	-	S1
LQ8 – Accessibility in LMU	-	-	-	S1
Overall class	**S1**	**N**	**N**	**S1**

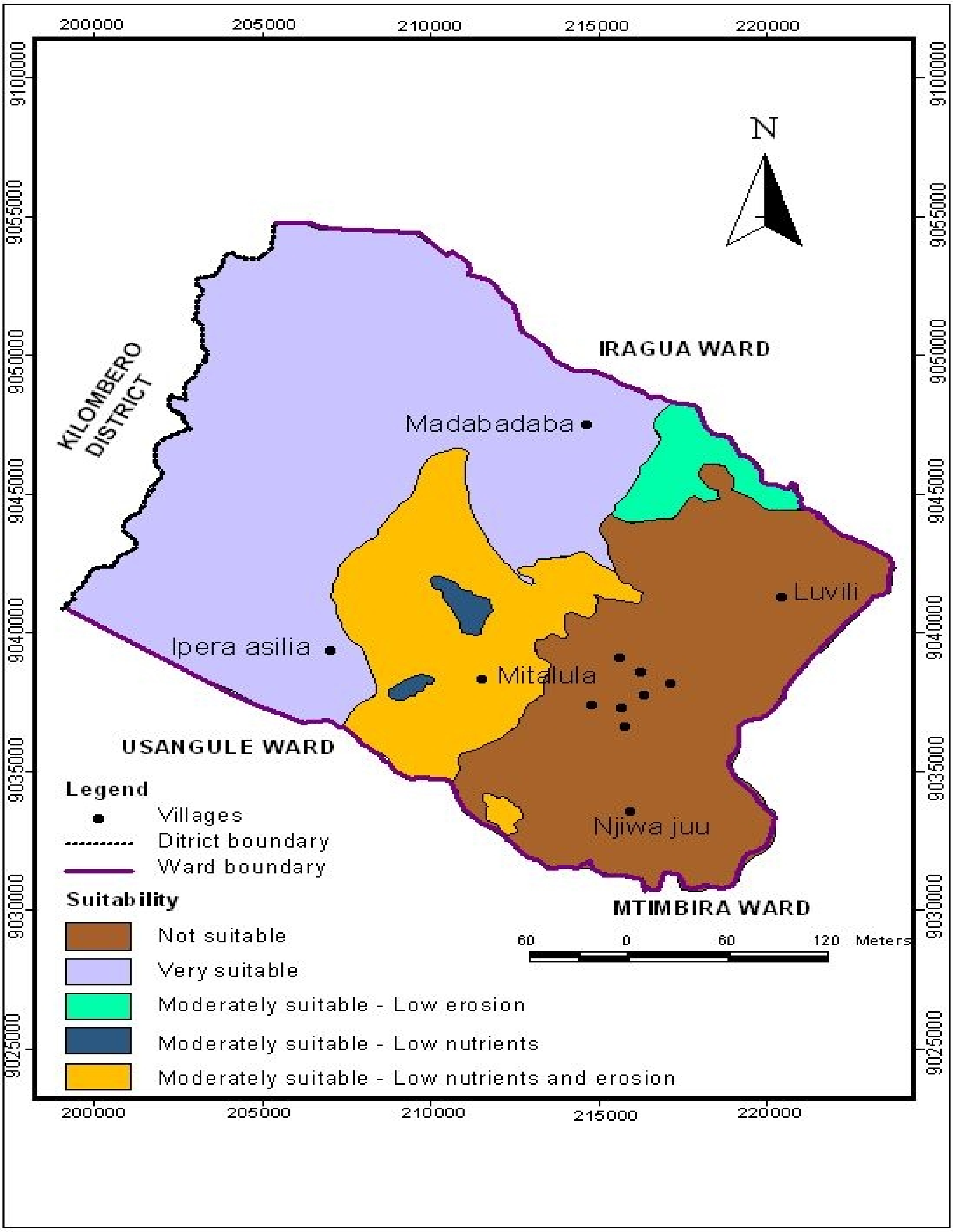
Table 39: Total area for each suitability class for the different land utilization types

LUT	Suitability level	Area to total available land in ha	Percentage
Paddy Production	S1	19,366.06	49.79
	S2e	1,293.203	3.36
	S2n	374.621	0.97
	S2ne	5,635.093	14.64
	N	12,025.98	31.24
Maize production	S3n	10,224.34	26.56
	S2e	1,293.203	3.36
	S3e	6,886.682	17.89
	N	20,093.065	52.19
Cotton production	S2n	2,390.557	6.21
	S2ne	4,537.739	11.79
	S3e	11,475.978	29.81
	N	20,093.065	52.19
Extensive grazing	S1	23,976.475	62.28
	S2	1,201.681	3.12
	S3	5,882.499	15.28
	N	7,436.684	19.32

4.2.6 Summary of suitability classification

4.2.6.1 Paddy production

Results for the preliminary matching of the land use requirements (Appendix 9) with the land qualities for the land mapping units are presented in Tables 28 – 38. Areas for each suitability class for the alternative utilization types presented in Table 39 and can be visualized in Figure 11. The result shows that paddy production is not suitable in land mapping units H1, H2a, H2b and Pi1. Common limitation is slope steepness which exposes the units to soil erosion and inability of these units to pond water. Total area rated is 12,025.98 ha (31.24%) of whole study area (Table 39). The crop is moderately suitable in land units Pi2, AP1 and AP3. The common specific limitations include soil erosion and soil fertility; however these limitations can be corrected at reasonable costs. The area is 7,302ha (18.98%). Production of paddy rated very suitable in mapping unit Pi3, AP4 and AP5. This class has an area of 19,366.06 ha (49.79%) of study area. These results conform to that of Kato (2007) who reported Kilombero Valley of having high potential for paddy rice production.

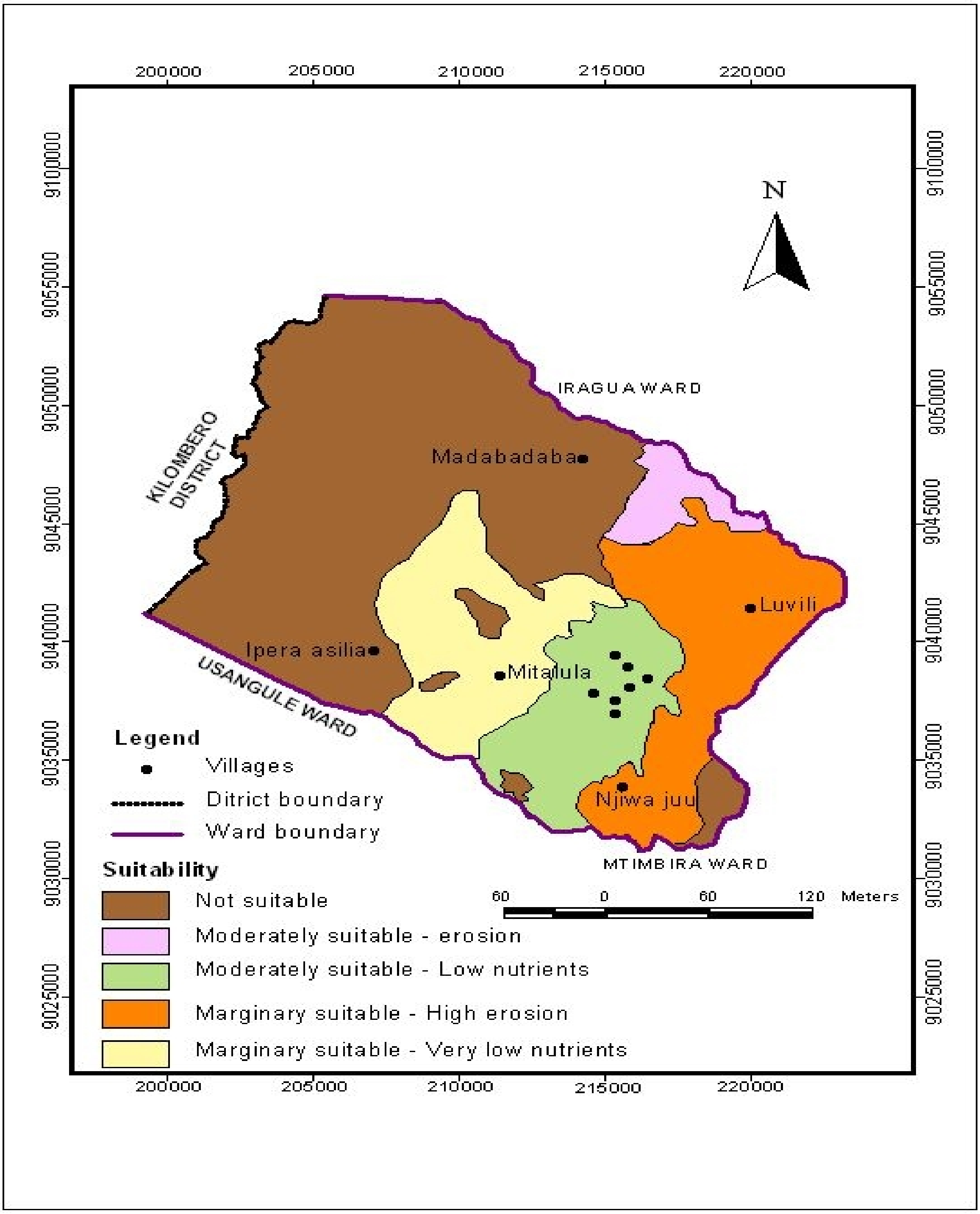


Source: Aerial Photograph Interpretation (API)

Figure 11: Suitability map for rice production.

4.2.6.2 Maize production

Preliminary matching between crop requirements (Appendix 10) and land qualities of the various mapping units are shown in Tables 28 – 38. Areas for each suitability class for the alternative utilization types are shown in Table 39 and can be visualized in Figure 12. Results show that the following mapping units are not suitable for maize production. These units include H1, Pi3, AP3, AP4 and AP5. Major limitations among others comprised of severe erosion on the hilly unit but also water logging in the plains as maize can not tolerate water around root zone for a longer period. The area concerned is 20,093.07 ha (52.19%). The second class was rated marginally suitable for maize production. This size is 17111.022 ha (44.45%) of the study area covering H2a, H2b, Pi1, AP1, and AP2 mapping units. Limitations include severe soil erosion and soil fertility. Biological and physical soil conservation methods (Morgan, 1986) can be integrated in crop production to control soil erosion hazard. The remained 1,293.203ha (3.36%) is moderately suitable for maize production, the only limitation to this being slight soil erosion. From these results, the area has little potential compared to that of paddy.



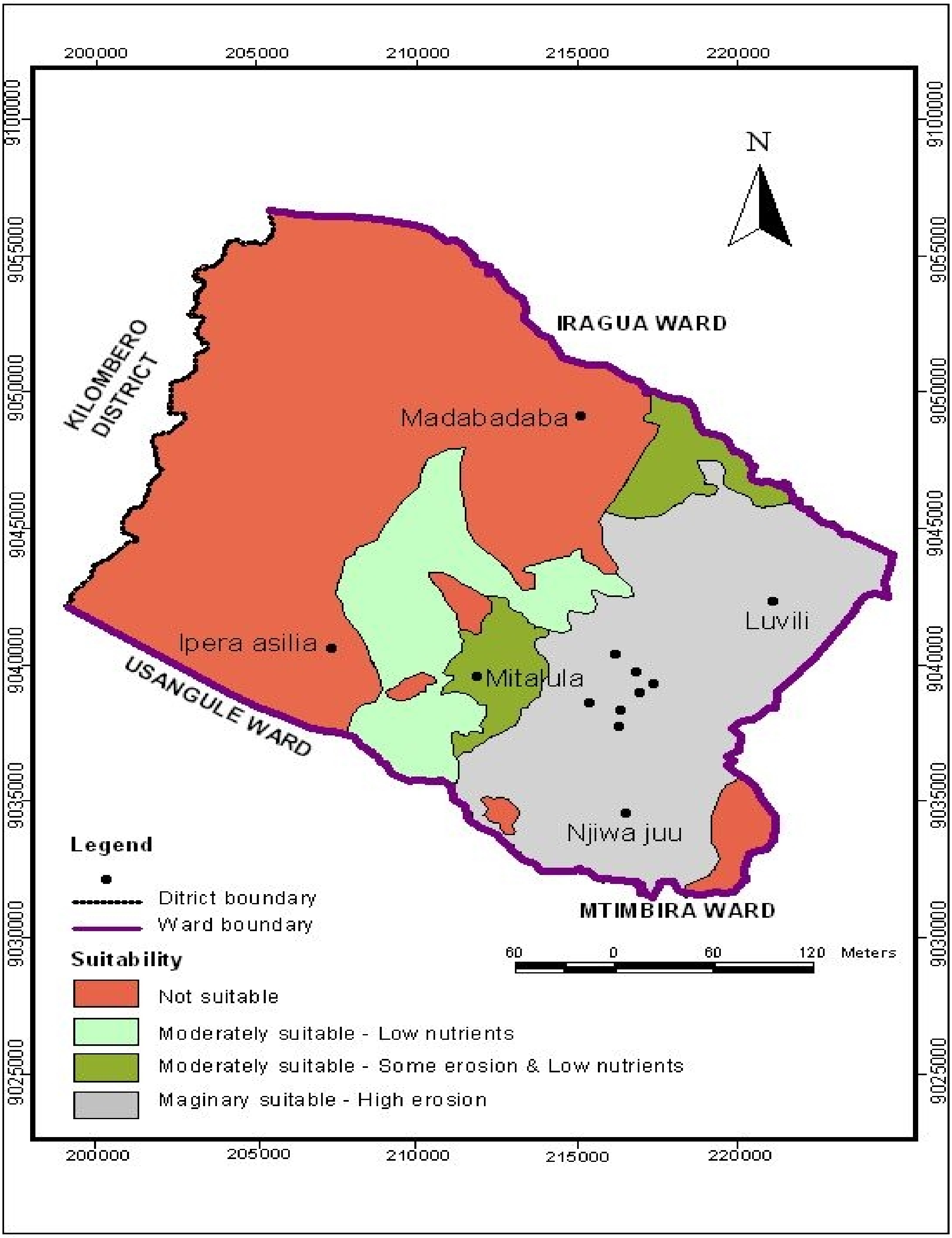
Source: Aerial Photograph Interpretation (API)

Figure 12: Land suitability map for maize

4.2.6.3 Cotton production

Results for the preliminary matching of the land use requirements (Appendix 11) with the land qualities for the land mapping units are shown in Tables 28 - 38. Areas for each suitability class for the alternative utilization types presented in Table 39 and can be visualized in Figure 13.

Suitability for cotton growing rated into three classes. About half of the area 20,093.065 ha (52.19%) is not suitable for the crop. Mapping units forming this class include H1, Pi3, AP3, AP4 and AP5. Common limitations comprised of soil erosion and water ponding. These units located on the hilly, piedmont and plain part of the study area. Marginally suitable is the second class for cotton production. This area needs high costs to produce the crop due to limitations posed by soil erosion hazards. A combination of physical and biological measures for soil conservation has to be taken if production required in these land units. The units falls under this class are H2a, H2b, and Pi1, the area covered 11,475.98ha (29.81%). The last class is rated moderately suitable for cotton production. It requires minor improvement for economical production. Limitations include soil fertility and erosion; land units rated are Pi1, AP1 and AP2. The area that falls in this class is 6,924.296 ha (18%).

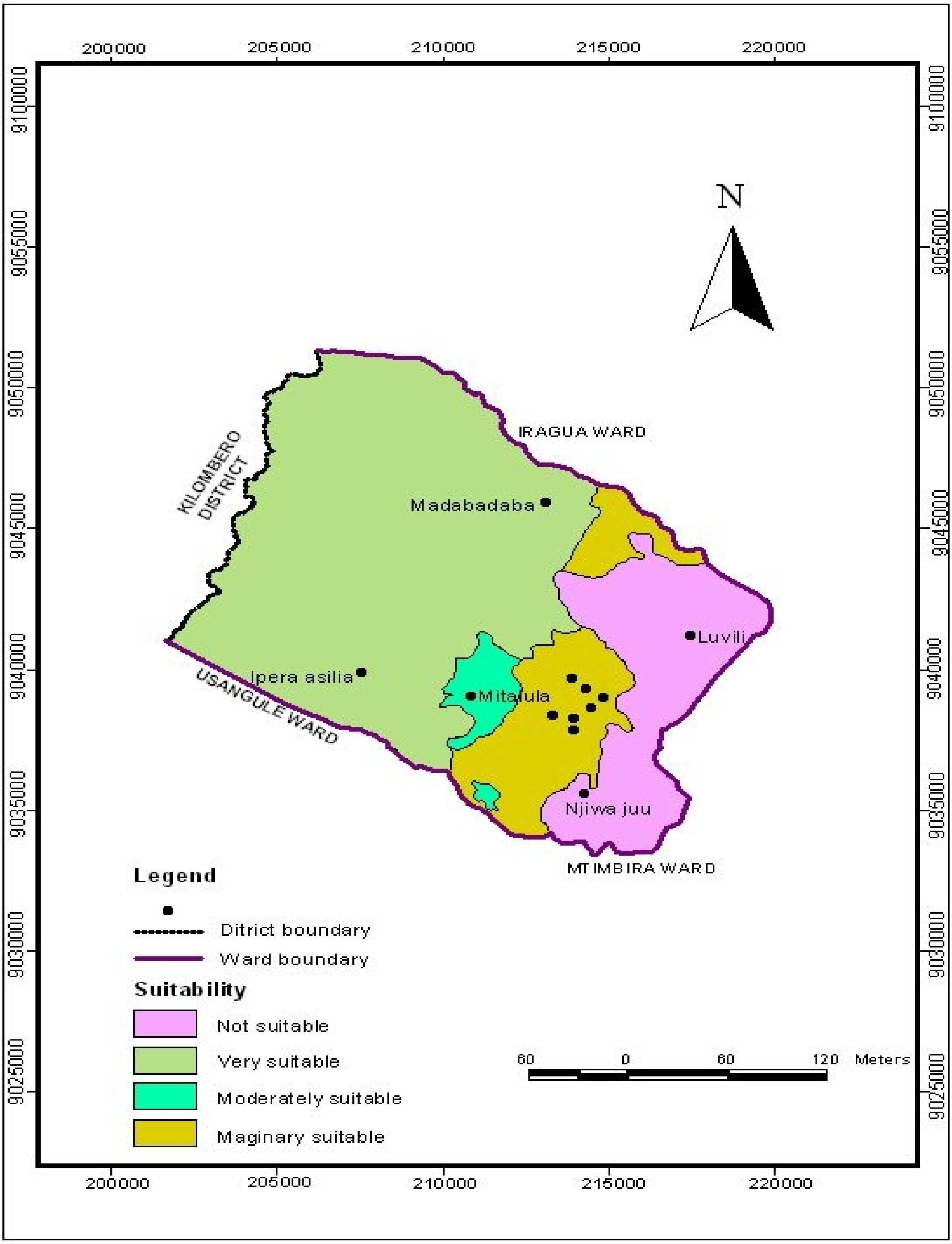


Source: Aerial Photograph Interpretation (API)

Figure 13: Land suitability map for cotton.

4.2.6.4 Grazing

Preliminary matching between crop requirements (Appendix 12) and land qualities of the various mapping units are shown in Tables 28–38. Areas for each suitability class for the alternative utilization types shown in Table 39 and can be visualized in Figure 14. Greater part of the study area is suitable for grazing, only a small part 7,436.684 ha or 19.32%) not suitable for grazing. Limitations include slope steepness which makes accessibility difficult and drinking water for the animals not available because can be found in deep channels inaccessible by animals. This is the hill unit which comprised of the following sub units, H1, H2a and H2b. An area of 5,882.499 ha (15.28%) was rated marginally suitable for grazing. Animal movement to the unit could cause considerable soil erosion and drinking water for livestock is a problem. The only unit in this class is Pi1. Third class for grazing was rated moderately suitable. This class covers a small area of 1,201.681ha (3.12%) of the study area. Limitations noted include availability of drinking water, accessibility in land mapping unit and soil erosion hazard. About two third 23,976.475 ha (62.28%) of the study area was rated very suitable for grazing. The implication here is that; if grazing is not restricted to certain areas, livestock keepers would like to utilize the conducive environment to graze their cattle everywhere there is pasture. Probably this will heighten the prevailing conflicts among resource users in the Valley. This area covers AP2, AP3, AP4 and AP5.



Source: Aerial Photograph Interpretation (API)

Figure 14: Land suitability map for grazing

4.2.7 Viability and carrying capacity analysis

Calculations of viability analysis are presented in Appendix 14, while summary of the results presented below.

The total land required for food crop in a household per year is 0.42ha, 0.5516ha, and 2.6843ha for paddy, maize and cassava respectively, which makes a total of 3.6559ha. Hence, the total land required for food production in Itete ward is:

- 3.6843 ha × 2,887 families = 10,636.60 ha

For that case, the village is currently viable in terms of food crop production, since the cultivable land is approximately 13,093.92 (Table 10, cultivation + grassland with cultivation) while the area required is 10,636ha. However the population is too big, the area will not take long before being not viable. Carrying capacity for livestock discussed in section 4.1.7.2.

4.3 Resource use conflicts

4.3.1 Overview

The introduction of livestock in Kilombero valley by immigrant pastoralists has transformed the original agriculture based system into an agro-pastoral system. Both pastoralists and farmers share common pool resources including rangelands, farmlands, water sources and wetlands. Pastoralists in the study area practice extensive livestock production system, characterized by varying levels of livestock mobility.

According to Bayer (1984), spatial integration of pastoral production and cropping permits more intensive use of land than cropping or livestock husbandry alone and also benefit both sectors. Crop residues and fallow land for instance offer better forage than natural range, and the open park like nature of cultivated land facilitates herding (Powell and

Bayer, 1984). Further more, proximity to cultivators offer pastoralists relatively easy access to markets for purchasing consumer goods and for selling livestock products. The crop farmer benefit from the ready availability of meat and milk products, but major advantage is the availability of manure for their fields.

The main disadvantage of integrating pastoral production and cropping for the pastoralists is that, animals must be closely supervised to avoid crop damage. The failure of agro-pastoralists controlling their animals from damaging farmers' crops was found to be one of the main causes of the prevailing conflicts in the valley. Thus, spatial arrangement supposed to come first before the integration to bring harmony between farming and grazing.

4.3.2 Causes of resource use conflicts

The causes of resource-use conflicts in Kilombero Valley are shown in Table 40. During the Focused Group Discussions, causes of resource-use conflicts were identified as (1) crop damage by livestock, (2) crop damage by wild animals (3) land dispute between pastoralists and farmers (4) competition of scarce resource and (5) disregard for entering villages and (6) government policy.

The first three problems shown in Table 40 are the frequently reported by different studies on conflict between farmers and pastoralists (Adebayo and Olaniyi 2008, Mtwale 2002, Kisoza *et al*, 2004, Brehoney, *et a*l 2000).

Table 40: Causes of resource-use conflicts in Kilombero Valley

Cause of conflicts	Magnitude of resource-use conflict			
	Minazini	Njiwa	Total score	Rank
Crop damage by livestock	√√√√	√√√√	8	1
Crop damage by wild animals	√√√√	√√√	7	2
Land dispute between farmers and herders	√√√√	√√	6	3
Competition for scarce resources	√√	√√√	5	4
Disregard of official procedure	√	√√	3	5
Government Policy	NA	√	1	6

Key: Scores, √√√√ - very high, √√√- high, √√- moderate, √- low

4.3.2.1 Crop damage by livestock

Crop damage by livestock was ranked first in causing conflicts between farmers and pastoralists (Table 40). It was mainly because of the presence of large herds of cattle making it difficult to control. This result is in conformity with that of Adebayo and Olaniyi (2008) who reported that, the most frequent causes of conflict between crop farmers and pastoralists are crop damage caused by animals belongs to herdsmen. Such conflict arisen from farm encroachment on cattle routes and sometimes water points. In the study area, it was reported that occasionally livestock are driven into the fields where crops are yet to be harvested and trample almost everything. In extreme situations, farmers reported that livestock are allowed to feed on croplands even when the owners are present. The results of the evaluation of selected land utilization types showed that there is stiff competition on the alluvial land unit between grazing and paddy production. This unit rated very suitable for both grazing and paddy production, farmers knows well where to do what through experience and therefore both would have liked to monopolize the unit which heightened the conflicts. All these have caused a lot of misunderstandings in the societies where crop producers and livestock keepers co-exist. Crop losses caused by livestock destruction are enormous.

4.3.2.2 Crop damage by wild animals

With reference to Table 40, this is the second source of conflicts between different resource users in the Valley. Crop losses due to wildlife are extremely high in spite of serious efforts to protect crops using a variety of methods during the growing season. Protection requires a substantial input of labour, even involving children who therefore are unable to attend schools. According to Haule, *et al* (2006), the estimated loss of yield in Kilombero Valley due to crop damage by wildlife amounted to 20.9% and 47.8% of the harvest of rice and maize respectively. However, Mkangwa and Kalumuna (2005), reported crop loss of up to 100% in the same area. The destructive animals are many like Wild pigs, Elephants, Hippopotamus popularly called (*Boko),* Monkeys, and many others just to mention a few. Scaring by different approaches is the only method used by farmers, although in some cases it does not help much. Apart from crop destruction, the communities also complained of livestock predation and human injuries by wild animals.

4.3.2.3 Land dispute between Pastoralists and Farmers

There are serious clashes between farmers and pastoralists for land, water and grass. According to DILAPS (2008), Tanzania has recently seen an upsurge in land use conflicts on several fronts: Firstly, the country has witnessed repeated conflicts between pastoralists on one hand and farmers on the other in Kiteto, Ngorongoro, Kilosa, Mbarali and Kilombero Districts. Secondly, there have been conflicts between urban villages and urban authorities. Lastly, disputes and conflicts between settlements and authorities of national infrastructure. Certainly, land is a major source of production and hence income for third

World poor. In Kilombero Valley, farmers frequently complained that pastoralists are occupying big land for grazing and farming such that, it is difficult for them to expand their farms as their families expand. Pastoralists acquired land using various approaches. Some on arrival requested land as farmers without livestock. They were given land with no restriction on size hoping each could clear land enough for farming requirements only. On top of that, areas allocated to them were considered to be the most vulnerable for vermin and wild animals. Pastoralists used this opportunity to demarcate big chunks of land, and later send some members of their families to collect their livestock back home. Others blamed the village leaders being responsible for allocating big land to pastoralists after receiving gifts of different kinds from pastoralists.

4.3.2.4 Competition for Scarce Resources Especially Along Kilombero Game Controlled Area.

Kilombero Game Controlled Area is a large tract of wetland along the Kilombero River. It straddles parts of both Kilombero and Ulanga districts. There are a number of parties who have competing interests in land especially in the KGCA as identified by Brehony *et al* (2004). These are farmers living north of the road between Lupiro and Malinyi and other farmers who cultivate rice in the wetland; Pastoralists who move their livestock into the area especially in the dry season looking for water and grazing and tourist hunting companies.

The Ministry of Natural Resource and Tourism (MNRT) is responsible for the KGCA. The director of Wildlife in MNRT has granted a license to a hunting company called Wild Footprints Company Limited to hunt in the area. According to the district game officer, the company was granted hunting license and hunting block in 1992. For a number of years they seem to operate without any major problems, but in the late 1990s the number of pastoralists coming into the valley (Ulanga side) increased dramatically. In the last few years, pastoralists and farmers began to use the game controlled area for their activities. This also infringed on hunting block area. District officials said that the pastoralists had dogs that frightened animals that moved to other hunting blocks- from Kilombero south to Kilombero North.

4.3.2.5 Disregard for official procedures

While there are official procedures for entering villages, it was learned that pastoralists do not abide by this. The researcher was informed that when a Sukuma agro-pastoralist comes to an area for the first time he usually goes to the village leader to ask permission to reside in the village. They do not inform the village that they will come with cattle. A short time later the Sukuma agro-pastoralist will show up with a herd of cattle usually brought in by unofficial routes. Sometime later, other relatives of this person will come in the same manner. In this way the number has escalated in the last six years (2001 – 2007). It was also claimed that incoming pastoralists pay some money/cattle to village leaders to allow them cross boundaries and bring in their cattle without questions. Similar observation reported by Mulley *et al*, (2004) in Usangu plains where pastoralists blamed by farmers for using their cattle to bribe law and justice enforcers to deny farmers rights of compensation for destruction of their crops.

4.3.2.6 Government policies

National-donor supported programmes and policies in different sectors have caused some of the problems, which exist in Kilombero valley today. Some Barbarg spoken to said that they had been driven out of their land in Hanang district when the NAFCO farms were started. They had to move to Babati and then further south until they came to Kilombero. Something similar could be said about the Wasukuma being moved out from Usangu plains in Mbeya region. After the government closed grazing in Usangu plains two years ago, there was greater immigration of pastoralists into Kilombero valley. This observation conform with that of Mwaikusa (1981) who reported that, Government policies in Tanzania relating to pastoralists have been inappropriate in the “human right context” and the right of pastoral communities have been violated in various ways. For example, a general tendency of regarding pastoralists as nomads with transitory or no fixed abode, underutilizing or even misusing land which they may at any time be holding. He concluded that pastoralists are often seen or treated as a problem likely to hinder the smooth implementation of one or other of the policies of the Government.

4.3.3 Roles of institutions in resolving resource use conflicts between pastoralists and farmers

Institutions are the channels through which people’s livelihoods are mediated, shaping individual and collective behaviour and the patterns of access to resources. According to the focus of Sustainable Livelihoods in Sub Saharan Africa (SLSA) 2006, all development happens through institutions, whether those of government, business or community and customary institutions. At the community level, institutions could be Village Councils, Residents Committees and Farmer Associations, women’s groups, clubs and societies. Local institutions can both promote the equitable distribution of resources, and access of people to their rights, or act to exclude certain groups of people from such resources and rights (DFID, 2003). Additionally, institutions are the channels through which people are represented, and through which their needs are articulated.

Institutional mechanisms that existed in the study area were mentioned as negotiation, mediation, both negotiation and mediation and the court procedures that involve police cases (Table 41). The study indicated that the main institutional mechanism for resolving conflicts was through negotiation and mediation (65%).

Table 41: Institutional mechanisms for conflict resolution between resource user groups

Mechanism	**Frequency**	**Percent**	**Cumulative %**
Negotiation	4	6.67	6.67
Mediation	8	13.33	20
Negotiation and mediation	39	65.00	85
Negotiation, mediation and court of law	5	8.33	93.33
Mediation and court of law	4	6.67	100
Total	**60**	**100**	

The District has made a few attempts to resolve conflicts especially those between farmers and pastoralists by forming village conflict resolution committees. However, the committees, which have been set up, have no legal powers to resolve conflicts (Brehony, *et al.*, 2004). In Itete Minazini they have a village conflict resolution committee, which has four women members. The committee was proposed by the village government and approved by the village assembly and they have solved over 40 village disputes to date.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study assessed the potential and constraints of Kilombero Valley for use by agro pastoralists through identification of present land utilization and evaluation of some of the current land utilization. It is also assessed the possible causes of conflicts linked on resource use. Based on the findings the following conclusion could be drawn.

i. The Valley has a high potential for irrigation farming due to the presence of many perennial rivers and streams, but only a small area of about 4,250ha is irrigated by Kilombero Sugar Company out of 330,000ha potential irrigable land. Most of the people (pure farmers and agro pastoralists) in the Valley are directly engaged in crop farming; however the vagaries of the weather and crop destruction by both livestock and wild animals pose a big constraint.

ii. The current land use categories in the study area include small scale farming, livestock keeping, wildlife utilization, large scale commercial farming (Kilombero Teak and Sugar Companies), fishing, bee keeping and forest utilization. Over the last two decades, the use of Kilombero Valley for agriculture increased because of increasing population of both pastoral and agro pastoral communities, and hence the resultant needs to produce more food. The environmental concerns associated with increasing use of the Valley for agriculture include deforestation and trampling of soils by increased livestock numbers and demand on water sources.

iii. Land suitability evaluation results showed that, about half of the study area is very suitable (S1) for both paddy farming and livestock grazing in its current state, the problem is competition between them. About half of the study area (52.2%), is not suitable for both maize and cotton production. Prolonged water ponding was the main limitation observed. Livestock carrying capacity analysis indicated the problem of overstocking.

iv. Crop damage by livestock was found to be the main cause of conflicts between agro pastoralists and small holder farmers. This is because of the failure for the district and village authorities to demarcate land according to the different uses existing in the area. Lack of apparent linkages between crop and livestock production systems; continue to make them unfriendly to each other due to poor cooperation and competition for land resources.

5.2 Recommendations

i. Land resources in the valley have to be zoned into different uses. Such zones have to cover the following major land uses prevailing in the valley; farming zone, grazing zone, wildlife zone, forest zone and residential zone so that each land user group member to be allocated land by the authority (village/council) in a specific zone and use it in accordance with the use specified under each zone.

ii. To solve the problem of overstocking, one of the two options need to be carried out to address the issue: Either to reduce the number of cattle so as to remain with the number that can be supported by the size of land to be zoned, or to displace some cattle to other areas outside of the valley.

iii. A comprehensive education programme has to be drawn up by the district to educate villagers and their leaders about the village land Act (1999) especially the role of the village council, the village assembly, and the different committees required under the land Act. The technical support required to carry out this work should be subcontracted to institutions with the required expertise.

iv. The provision in the village land Act of 1999 for conflicts resolution committees has to be fully implemented and such committees are to be given the training required to carry out their work.

v. In view of the limited experience in promoting integrated crop/livestock systems, it is essential that appropriate research be accelerated as soon as possible aiming at reducing conflicts between the two groups, but also improving production of crops and livestock without one sector affecting the other.

vi. To function effectively in promoting crop/livestock systems, the extension staffs have to be trained on narrow disciplines like forages, crops, animal health animal husbandry etc.

vii. Sustainable development of communities in Kilombero Valley requires multidisplinary and integrated efforts in addressing constrains in the various sectors such as agriculture, livestock, natural vegetation use, water resources and fishing

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APPENDICES

Appendix 1: Questionnaire

(1) General Information about the Household

Village name……………………………sub village……………........

Ward……………………………………Division ………………………………

Date of interview……………………………name of interviewer… …………

Respondent name………………………………Age in years……….. …………

Sex (i) Male. ( )

(ii) Female ( )

Ethnicity………………………………………………………………..

7. Duration of stay in the village…………………

8. If migrated from other areas, what incentive attracted you to this village?

9. (a) Education of respondent……………………………………………….

(b) Occupation of respondent……………………………………………

Crop grower

Pastoralist

Agro-pastoralists

Other (specify)

10. Household size… ………………………………

(B) Information on Land Use and Ownership

11. Do you own any land? (1) Yes ( ) (2) No ( )

12. If yes how did you acquired it?...

13. Total land owned in (ha)………………………….

14. Is your land enough for crop production?................for grazing……….

15. If not what are the reasons for the existing land inadequacy?.........

16. How much additional land do you need?………………

17. Have the in-migration of other ethnic groups affected the farm/land holding you previously had traditionally? (1) Yes ( ) (2) No ( )

18. If yes how

………………………….. ……………………………………………….

CROPS

19. What are the major crops grown by the respondent?...............

No	Crops	Acreage	Yield	Purpose	Price	Ownership
1						
2						
3						
4						
5						

Purpose 1=Food, 2 =Cash, 3 =Both. Ownership 1=Female, 2=Male, 3 Family

20. Problems facing agricultural production

Lack of inputs ( )

Lack of capital ( )

Poor market ( )

Lack of farm implements ( )

Other (specify) ( )

21. How do you solve them? …………………………………………………

22. Do you produce enough food to sustain the household needs for the whole year? (1) Yes ( ) (2) No ( )

23. If no what makes you unable to produce enough food to feed the household the whole year?

24. Specific information per crop

Crop:…………………………………….

Management level: Input. Low/Medium/High

2. Initial package:

(i) Seed: Local/ Improved

Do you use improved seed? Yes/No:

Where do you get?..

Quantity required………………. Kg/acre price (per kg):……………….. Tshs

Cost of transport.......................Tshs

Total cost:……………….Tshs.

(ii) Planting/Replanting

When:………………………………….

How:…………………………………..

Material used:………………………….

Own labour required:………….man-days costs per man-days:……………Tshs

Hired labour required:………….man-days costs per man-days:……………Tshs

Total cost of labour:………………..Cost of transport………………………Tshs

Total cost:……………………………………….Tshs

iii) Pesticide/Herbicides

Do you apply: Yes/No:

Type:…………………………………………………………….

When:……………………………………………………………

Material required:…………………..Price (per kg)…………………………. Tshs

Own labour required:……………man days cost per man days:………………Tshs

Hired labour required:……………man days cost per man days:………………Tshs

Total cost of labour:…………………Cost of transport……………………… Tshs

Total cost:………………………..TShs

Are you aware of any impact of this on the environment?...

Have already noticed this?..

Production package

(i) Land preparation

Do you practice: Yes/No:

When:……………………………………………..

How: Manual/Animal traction/Tractor/Others (specify):

Own labour required:…………….man days cost per man days:……….TShs

Hired labour required:…………….man days cost per man days:……….TShs

Total cost of labour:………………………………TShs

Total cost:…………………………………………………..TShs

ii) Weeding

Do you practice: Yes/No:

When:……………………………………………………….

How:…………………………………………………………..

Equipment used………………………………………….

Own labour required:……………..man days cost per man days:…………TShs

Hired labour required:………………man days cost per man days:…………TShs

Total cost of labour:…………………………TShs

Total cost:…………………………………TShs

(iii) Pruning/thinning.

Do you practice: Yes/No:

When:…………days or………….weeks after planting.

How:…………………..

Material used:………………………………..

Own labour required:…………….mandys cost per manday:………..TShs

Hired labour required:…………….mandays cost per manday:………..TShs

Total cost of labour:……………………..TShs

Total cost:…………………………………TShs

(iv) Rodent control

Do you practice: Yes/No:

When:…………days or…weeks after planting

How:…………………………………………………………..

Material used:…………….cost of material used……….

Own of labour required:……………man days cost per man days:………..TShs

Hired labour required:………man days, cost per man days: …………………TShs

Total cost of labour:……………………….TShs

Total cost:………………………………….TShs

Soil Conservation

Have you ever-experienced erosion in any of your plots?...

What kind of erosion?..

Do you practice soil conservation: Yes/No:

Why?..

When:……………………………………...

Type:………………………………………

Material used:……………………………..Cost?..

Own labour required:………………man-days cost per man days……………TShs

Hired labour required………………man days cost per man days……………TShs

Total cost of labour:……………………………TShs

Total cost:………………………………………TShs.

Land improvement activities:

Fertiliser:

Do you practice: Yes/No:

When:……………………………………………………………

How: manual:………………………………………………………

Kind of fertilizer: N/P/K/ Manure/Lime

Material used:………………………………………………………

Own labour required:………..man days   cost per man days………………………TShs

Hired labour required:……….man days   cost per man days……………………....TShs

Total cost of labour:……….....cost of transport…………………………………..TShs

Fetilizers costs

No.	Type of fertilizer	Quantity used (kg)	Price/Kg	Total cost
1				
2				
3				

Total cost:…………………………..TShs

Other farm characteristics

How far is from farm to market:…………m or……………km

Do you have credit? Yes/No.

If Yes; Purpose:………………………………………..

Condition:……………………………………….

Sources: Bank/Co-operative/family/middleman:

Where do get your fire wood?.......................km   cost?............TShs

Where do get your water?...............................km   cost?...........TShs.

Harvesting/Post-harvesting

1) Harvesting

When:………………………………………

How:………………………………………..

Material used:………………………………

Own labour required:…………..mandays   cost per manday:…………… TShs

Hired labour required:………….mandays   cost per manday:…………….TShs

Total cost of labour:……………TShs

Transport:………………………cost of transport:…………………………TShs

Total cost:………………………TShs.

(ii) Post-harvesting (shelling, threshing, winnowing, grading, packing)

Do you practice: Yes/No:

When:……………………………………………………………….

How:……………………………………………………………..

Material used:……………………………………………………

Own labour required:…………man days cost per man days:………..TShs

Hired labour required:………….man days cost per man-days………TShs

Total cost of labour……………………………........TShs

Transport:……………..Cost of transport:………….TShs

Total cost:………………………………………....TShs.

(iii) Prospect:

Are the yields improving (+) or declining (-)?...

What are causes of this trend?..

What your future expectation?

(i) To use improved seeds

(ii) To change cropping system

(iii) Others (specify)………………………………………………………

Livestock Production

25. 1. Number of livestock owned and reasons for keeping

1= Cash, 2 = Food, 3 =Manure, 4 = All of them

26. Where do you graze your livestock?

Communal grazing land ( )

In the crop field after harvest ( )

In the game reserve ( )

Own bought land ( )

27. Is there any specific area located for grazing?

Yes

No

28. If yes in question above, is the area enough (I) Yes (ii) No

29. Mention the land unit used by livestock keepers for grazing…………………….

30. Are there any restrictions on stocking rate in this village?...............

31. If yes in 30 above who imposes these restrictions?..................

32. Are there any by-laws which ban grazing to be done in some areas?

33. If yes in 33 what are these areas?..

(C.) RESOURCE USE CONFLICTS

34. Have you ever head of any resource use conflicts in this village…………

35. Who make decisions on the use of the available land resources like water, grazing lands?

Village leader ( )

Environment Conservation Committee ( )

Village government ( )

Other (specify)……………….. ( )

36. What are the causes of existing resource use conflict in the village/area?

1. Crop damage by wild animals	
2. Crop damage by livestock	
3. Livestock predation	
4. Competition over use of the same piece of land	
5. Water shortage during dry season	
6. Destruction of water points for domestic use by wild animals and livestock	

37. Which institutions in the area responsible for solving conflicts?

…………………………………………………………………………………………

38. Which land units are potential for resource use conflicts? ....

39. Institutional mechanisms for conflicts resolving

- Negotiations (pastoralists and farmers)
- Mediations (elders and village leaders)
- Both negotiations and mediations
- Court proceedings (police)

Appendix 2: Checklist of questions for key informants

1) Administrative Issues:

Village ……………………………………. Ward ………………………………..

Village registration number ………………… Date ………………………………

Village area (Ha) ……………………………………….…………………………

Village population (Total) ……………………………………….……………………

Number of Households ………………………………………..

What is the ethnic composition ……………………………………….…………………

What is the migration trends? ……………………………………….………………..

2) Economic Activities

What are the main economic activities?

How many households practicing pastoralism?

How may pastoral households practising farming?

What is the current herd size?

Do the pastoralists practice transhumant movement?

What are the main production constraints?

3) Land Resource Tenure

Which land resources are owned communually

Which rules and regulations governing access and use of communal resources

How compliance to rules is monitored and enforced?

How land is acquired?

What is the current health of the communal rangelands ?

What are the current changes in land use and land resource tenureship?

4) Local Institutions

Which customary institutions are functional in the area?

Which roles and functions falls under customary institutions?

What roles played by customary institution in access and tenure ship of land resources?

Which other institutions operating in the area?

5) Resource-use conflicts

Which are the main resource-use conflicts in the area?

When the conflicts first occurred in the area?

What is the main causes underlying the conflicts and who are the main parties involved in the conflict?

At which period of the year resource conflicts are likely to occur?

What is the local mechanism that can resolve resource conflicts?.

Appendix 3: Soil profile description

Profile number 1 Mapping unit Pi3

Region: Morogoro

District: Ulanga

Map sheet no: 250/2

Coodinates: 37L-021135, UTM- 9035917

Location: On the right side of the road Itete to Mtimbira near the boarder with Kipenyo village, a place known as Nganawa valley, Njiwa village

Elevation above sea level – 293m

Land form: flat

Natural drainage class: poorly drained

Cover: Farms

Present land use- cultivated rice fields

General landscape

Slope type, straight

- Slope position, valley bottom

Slope angle, 0.5 – 2%

Soil name - mbuga soil

Date of examination - 26.01.2007

Described by - Luwanda, P.L.

Past and present erosion, Nil

General information of the soil

Parent material – Depositional alluvial/colluvial material

Soil drainage class – Poorly drained (class 1)

Moisture condition in the profile – Moist from 20 cm to a depth of 40cm and then the soil dry again.

Depth of ground water table – Not reached

Ap 0 – 33cm black (7.5YR2/0) moist; silt clay; extremely hard dry consistency, very firm when moist, sticky and plastic when wet; sub angular block; many roots fine and very fine observed

AB 33- 69cm Dark grey (10YR4/1) moist; silt clay with mottles, sticky wet consistence, soil mass takes water very slowly, swelling in the process, aggregated sub angular block.

Bt 69-100cm Very dark grayish brown (2.5Y3/2) moist; clay with many gravel particles visible. At a depth of 70 cm the soil is very hard to dig. Hands cannot break Cloddy; the horizon very compacted

Profile number 2 Mapping unit AP2

Region: Morogoro

District: Ulanga

Map sheet no: 250/2

Coodinates: 37L-0209379, UTM- 9036569

Location: Nganawa chini, Njiwa village.

Elevation above sea level – 280m

Land form: flat

Natural drainage class: poorly drained, water ponding during main rain season

Vegetation: Bushed grass land (80% grass cover) with scattered thorny trees

Present land use- Grazing, new non permanent pastoralists' settlements and cultivated rice fields

General land scape

Slope type, straight

Slope position, mid plain

Slope angle, 2.0 – 3.0%

Soil name - mbuga soil

Date of examination - 26.01.2007

Described by - Luwanda, P.L.

Past and present erosion, Nil

General information of the soil

Parent material – Depositional alluvial

Soil drainage class – Poorly drained (class 2)

Moisture condition in the profile –very slight.

Depth of ground water table – Not reached

Effective depth- 81cm, there is hard pan

A 0 – 30cm Dark reddish brown (5YR2/2) moist, sand loam; weak, fine sub angular blocky; Somehow friable when moist, slightly sticky and very slightly plastic when wet; many pores fine, medium and course pores; many fine and course roots

AB 30- 74cm Dark reddish brown (10YR4/2) moist, silt clay; strong, fine and medium angular blocky; slightly hard when dry, slightly firm when moist, sticky and plastic when wet; broken, moderately thick cutans

Btx 74-81cm Very dark grayish brown (10YR3/2) moist, clay, mottled compacted layer, very hard to break and impenetrable by roots, very dry layer, strong aggregated course sub angular block structure.

Profile number 3   Mapping unit AP5

Region: Morogoro

District: Ulanga

Map sheet no: 250/2

Coodinates: 37L- 0209147, UTM- 9049310

Location: Mofu area, Minazini village very close to Mchilipa river beyond the confluence with Luvili river.

Elevation above sea level – 268m

Land form: flat

Natural drainage class: Poorly drained, water ponding during main rain season

Vegetation: Papyrus and wild rice along river course while grass covering some distance from the river

Present land use- Rice fields and grazing

General landscape

Slope type, straight/flat

Slope position, mid plain

Slope angle, 0.5 – 1.0%

Soil name - Mbuga soil

Date of examination - 27.01.2007

Described by - Luwanda, P.L.

Past and present erosion, Nil

General information of the soil

Parent material – Depositional alluvial

Soil drainage class – Poorly drained (class 0)

Moisture condition in the profile – Moist from surface.

Depth of ground water table – 44cm

Effective depth - 44cm

Ap 0 - 20cm Very dark gray (2.5Y3/0) moist, mottled silt loam; medium and course irregular blocky structure; firm when moist, sticky and plastic when wet.; many course pores and roots.

Bg 20 – 44cm Very dark grayish brown (10R3/2) moist, silt loam horizon, slightly sticky and plastic wet consistence; moderately strong medium sub angular structure; many medium pores; frequent fine roots and gradual irregular boundary.

Profile number 4 Mapping unit AP4

Region: Morogoro

District: Ulanga, Map sheet no: 250/2

Coodinates: 37L- 0210895, UTM- 9047427

Location: Luvili chini, Minazini village.

Elevation above sea level – 274m

Land form: flat (alluvial plain)

Natural drainage: Seasonally flooded during long rains

Vegetation: Many *kigelia aethioptica* trees scattered in cultivated area as shade

Present land use- Rice fields

General landscape

Slope type, straight/flat

Slope position, lower part of the valley

Slope angle, 1.0 – 2.0%

Soil name - Mbuga soil

Date of examination - 27.01.2007

Described by - Luwanda, P.L.

Past and present erosion, Nil

General information of the soil

Parent material – Alluvium

Soil drainage class – Imperfectly drained (class 2)

Moisture condition in the profile – Moist from surface.

Depth of ground water table – Not reached

Effective depth – 85cm (Limited by very hard graveled clay)

Ap 0 - 40cm Very dark gray (5Y3/1) moist, silt clay; few brown mottles, very firm when moist; sticky and plastic when wet; strong aggregated course sub angular block structure; many medium and course roots.

Bt 40 – 85cm Grayish brown (2.5Y5/2) moist, clay; moderate, medium, wedge shaped structure; extremely hard when dry, very firm when moist; very sticky and very plastic when wet, common fine and medium roots

Profile number 5   Mapping unit Pi2

Region: Morogoro

District: Ulanga

Map sheet no: 250/2

Coodinates: 37L- 0211660, UTM- 9047133

Location: Luvili kati, Minazini village.

Elevation above sea level – 282m

Land form: Undulating

Natural drainage: Ranges from poor to well drained

Vegetation: Shrubs with scattered trees

Present land use- newly opened farms planted with upland crops including maize, banana, groundnuts and rice

General landscape

Slope type, straight to concave

Slope position, lower near the valley bottom

Slope angle, 2.0 - 4%

Soil name – Black cotton soil

Date of examination - 27.01.2007

Described by - Luwanda, P.L.

Past and present erosion, Nil

General information of the soil

Parent material – Colluvial

Soil drainage class – Moderately well drained (class 3)

Moisture condition in the profile – Moist from surface.

Depth of ground water table – Not reached

Presence of salts or alkali – None

Effective depth – 76cm (Limited by small stones)

A   0 - 30cm Black (10YR2/1) moist; silt clay; moderate, fine crumb structure; friable when moist, slightly sticky and very plastic when wet; abundant, fine and medium pores; common, fine and medium roots.

B 30 – 41cm Dusky red (10R3/2) moist clay; strong, coarse, sub angular blocky. Extremely hard when dry, very firm when moist, very sticky and very plastic when wet; common fine pores, fine and medium roots.

BC 41- 76cm Dark reddish brown (2.5YR4/6) moist, extremely graveled clay loam mixed with stones; very weak structure to massive friable when moist, slightly sticky and plastic when wet; angular quartz fragments.

Profile number 6 Mapping unit H1

Region: Morogoro

District: Ulanga

Map sheet no: 250/2

Coodinates: 37L- 0216936, UTM- 9035612

Location: Itanda, Njiwa village.

Elevation above sea level – 404m

Land form: Hilly area, very steep

Natural drainage: excessively drained

Vegetation: Closed forest

Present land use- Catchments forest, but some illegal lumbering observed along the border.

General landscape

Slope type, straight

Slope position, lower

Slope angle, 49%

Soil name – Red soil

Date of examination - 29.01.2007

Described by - Luwanda, P.L.

Past and present erosion, Nil as the soil covered by thick vegetation

General information of the soil

Parent material –

Soil drainage class – excessively drained (class 3)

Moisture condition in the profile – Moist from top layer.

Depth of ground water table – Not reached

Effective depth – >100cm

Ah 0 - 30cm Dark reddish brown (2.5YR2/4) moist, loamy soil; soft dry, friable moist; slightly sticky, and slightly plastic wet; moderate fine and sub angular blocks; many fine pores and many fine roots; clear boundary.

AB 30 – 41cm Red (10R4/8) moist, clay; friable moist, slightly sticky and slightly plastic wet; moderate coarse and medium sub angular blocks; many fine and medium pores

B 41->100cm Red (10R4/6) moist; silt loam; soft consistence when dry, friable when moist and non-plastic non-sticky when wet

Profile number 7 Mapping unit H2a

Region: Morogoro

District: Ulanga

Map sheet no: 250/2

Coodinates: 37L- 0215855, UTM- 9037124

Location: Itanda, Njiwa village.

Elevation above sea level – 370m

Land form: Hilly area, moderately steep

Natural drainage: excessively drained

Vegetation: encroached forest

Present land use- fuel wood collection, building poles collection and timber.

General landscape

Slope type, straight

Slope position, lower

Slope angle, 10 - 20%

Soil name – Red soil

Date of examination - 29.01.2007

Described by - Luwanda, P.L.

Past and present erosion, very slight as the soil covered by vegetation

General information of the soil

Parent material – insitu

Soil drainage class – excessively drained (class 3)

Moisture condition in the profile – Moist from top layer.

Depth of ground water table – Not reached

Effective depth – >100cm

Ah 0 - 30cm Dark reddish brown (5YR3/3) moist, sand loam; soft dry, friable moist, non sticky and non plastic wet; weak fine granular; many fine and common medium pores; fine and medium roots; gradual smooth boundary

B 30 – 100cm Red (2.5YR4/6) moist, silt loam, slightly sticky and plastic wet consistence; moderately strong medium sub angular structure; many medium pores; frequent fine roots and gradual irregular boundary.

Profile number 8 Mapping unit H2b

Region: Morogoro

District: Ulanga

Map sheet no: 250/2

Coodinates: 37L- 0215971, UTM- 9037870

Location: Itanda, Njiwa village.

Elevation above sea level – 367m

Land form: Hilly area, plateau like

Natural drainage: excessively drained

Vegetation: Crops

Present land use- Upland crops cultivation, mainly maize.

General landscape

Slope type, Convex

Slope position, top

Slope angle, 2 -12%

Soil name – Red soil

Date of examination - 29.01.2007

Described by - Luwanda, P.L.

Past and present erosion, Sheet erosion, but some places small gullies developed.

General information of the soil

Parent material – Insitu

Soil drainage class – excessively drained (class 3)

Moisture condition in the profile – Moist from 28 cm depth.

Depth of ground water table – Not reached

Effective depth – >100cm

Ap 0 - 40cm Dark reddish brown (5YR3/3) moist, clay; friable moist, slightly sticky and slightly plastic wet; moderate coarse and medium sub angular block structure; many fine and medium pores.

B 40 – 100cm Red (2.5YR3/4) moist, Clay, slightly sticky and plastic wet consistence; moderately strong medium sub angular structure; few medium pores; frequent fine roots and gradual irregular boundary.

Profile number 9 Mapping unit AP3

Region: Morogoro

District: Ulanga

Map sheet no: 250/2

Coodinates: 37L- 0210405, UTM- 9042196

Location: Nandanga, Njiwa village.

Elevation above sea level – 281m

Land form: flat

Natural drainage: Imperfectly drained

Vegetation: Crops

Present land use- Wetland crops (Rice and sugarcane).

General land scape

Slope type, flat

Slope position, valley bottom

Slope angle, 0.5 – 1.0%

Soil name – Black soil

Date of examination - 30.01.2007

Described by - Luwanda, P.L.

Past and present erosion: - None.

General information of the soil

Parent material – Alluvial

Soil drainage class – Poorly drained

Moisture condition in the profile – Moist from surface.

Depth of ground water table – 100cm

Effective depth -100cm

Ap 0 - 20cm Very dark reddish brown (10YR3/2) moist, silt clay; with soft consistence when dry, friable when moist and non sticky non plastic when wet; weak fine sub angular structure, many course pores; very few weathered round feldspar gravels.

A 20 – 45cm Dusky red (2.5YR3/2) moist, Clay, slightly sticky and plastic wet consistence; moderately strong medium sub angular structure; few medium pores; frequent fine roots and irregular boundary.

AB 45 – 63 cm Dark reddish brown (5YR3/2) moist, Clay, friable moist, slightly sticky and slightly plastic wet; moderate coarse and medium sub angular blocks; many fine and medium pores

BW 63 – 100 cm Dark reddish brown (5YR3/3) moist, Silt Clay, strong, fine and medium angular blocky; slightly hard when dry, slightly firm when moist, sticky and plastic when

Profile number 10 Mapping unit AP1

Region: Morogoro

District: Ulanga

Map sheet no: 250/2

Coodinates: 37L- 0211466, UTM- 9042157

Location: Nandanga, Njiwa village.

Elevation above sea level – 295m

Land form: slightly flat

Natural drainage: good

Vegetation: Crops with some Mango, “Mitalula” and “Mikuyu” trees left around farms as shade

Present land use- Upland crops like Cotton, Banana, Coconut, Mangoes Maize, Cowpeas, Simsim and Pigeon peas.

General landscape

Slope type, Convex

Slope position, lower

Slope angle, 1.5 – 4.0%

Soil name – Black soil

Date of examination - 30.01.2007

Described by - Luwanda, P.L.

Past and present erosion: - None.

General information of the soil

Parent material – Colluvial

Soil drainage class – Moderately well drained

Moisture condition in the profile – Moist from surface.

Depth of ground water table – Not reached

Effective depth >100cm

Ap 0 - 20cm Very dark gray (5YR3/2) moist, silt clay; very soft consistence when dry, friable when moist and non-sticky non-plastic when wet; weak fine sub angular structure, many course pores.

A 20 – 44cm Dusky red (2.5YR3/2) moist, Silt clay, slightly sticky and plastic wet consistence; moderately strong medium sub angular structure; few medium pores; frequent fine roots and irregular boundary.

AB 44 – 100 cm Dark reddish brown (2.5YR3/4) moist, Silt Clay, friable moist, slightly sticky and slightly plastic wet; moderate coarse and medium sub angular blocks; many fine and medium pore

Profile number 11 Mapping unit Pi1

Region: Morogoro

District: Ulanga, Map sheet no: 250/2

Coodinates: 37L- 0215603, UTM- 9039260

Location: Njiwa juu, Njiwa village.

Elevation above sea level – 354m

Land form: Slopping

Natural drainage: good

Vegetation: Crops (Cassava field)

Present land use- Upland crops like Cassava, Mangoes, Maize, Cowpeas etc.

General landscape

Slope type, Convex

Slope position, upper

Slope angle, 3.0 – 6.0.0%

Soil name – reddish soil

Date of examination - 30.01.2007

Described by - Luwanda, P.L.

Past and present erosion: - Sheet erosion.

General information of the soil

Parent material – Insitu

Soil drainage class – well drained

Moisture condition in the profile – Moist 10 cm from surface.

Depth of ground water table – Not reached

Effective depth >100cm

Ap 0 - 10cm Very dusky red (10R2/2) moist, clay; moderate, fine and medium angular block structure, the consistence is hard when dry, firm when moist, sticky and plastic when wet. Many fine pores; few small angular fragments and common fine roots.

AB 10 – 75cm Dark reddish brown (2.5YR3/4) moist, Sand loam, fine sub angular blocky; Somehow friable when moist, slightly sticky and very slightly plastic when wet; many fine pores, medium and course pores.

Appendix 4: Soil physical characteristics

Profile/Mapping unit	Horizon	Depth In cm	Moist munsell soil colour	% Particle size distribution			Textural class (USDA textural triangle)	Silt/ Clay ratio
				Sand	Silt	Clay		
1/Pi3	Ap	0-33	7.5YR2/0 Black	5.20	46.00	48.80	Silt clay	0.9
	AB	33-69	10YR4/1 Dark gray	25.20	26.00	48.80	Silt clay	0.5
	Bt	69-100	2.5Y3/2 Very dark grayish brown	12.00	37.60	61.40	clay	0.6
2/ AP2	A	0-30	5YR2/2 Dark reddish brown	59.20	32.00	8.80	Sandy loam	3.6
	B	30-74	10YR4/2 Dark grayish brown	20.00	29.60	50.40	Silt clay	0.6
	Btx	74-81	10YR3/2 V. dark grayish brown	20.00	26.00	54.00	Clay	0.5
3/ AP5	A	0-20	2.5YR3/0 Very dark gray	27.20	52.00	20.80	Silt loam	2.5
	Bg	20-44	10YR3/2 V. dark grayish brown	17.20	62.00	20.80	Silt loam	3.0
4/A P4	Ap	0-40	5Y3/1 Very dark gray	21.00	30.00	49.00	Silt clay	0.6
	Bt	40-100	2.5Y5/2 Grayish brown	10.00	15.60	74.40	Clay	0.2
5/ Pi2	A	0-30	10YR2/1 Black	19.20	25.20	55.60	Silt clay	0.5
	B	30-41	10R3/2 Dusky red	29.20	14.00	56.80	Clay	0.2
	BC	41-76	2.5YR3/4 Dark reddish brown	57.20	5.60	37.20	Clay loam	0.2

Appendix 4 continues

Profile/Mapping unit	Horizon	Depth In cm	Moist munsell soil colour	% Particle size distribution			Textural class (USDA textural triangle)	Silt/ clay ratio
				Sand	Silt	Clay		
6/H1	Ah	0-27	2.5YR2/4 Dark reddish brown	59.20	25.20	15.60	Loam	1.6
	AB	27-54	10R4/8 Red	15.00	25.00	60.00	Clay	0.4
	B	54 - 100	10R4/6 Red	21.20	73.60	5.20	Silt loam	14.2
7/H2a	Ah	0-30	5YR3/3 Dark reddish brown	63.20	27.20	9.60	Sandy loam	2.8
	B	30-100	2.5YR4/6 Red	37.20	54.00	8.80	Silt loam	6.1
8/H2b	Ap	0-40	5.YR3/3 Dark reddish brown	11.00	23.00	66.00	Clay	0.3
	Bt	40-100	2.5YR3/4 Dark reddish brown	10.00	21.60	68.40	Clay	0.3
9/ AP3	Ap	0-20	10YR3/2 V. dark reddish brown	23.20	26.40	50.40	Silt clay	0.5
	A	20-45	2.5YR3/2 Dusky red	29.20	15.60	55.20	Clay	0.3
	AB	45-63	5YR3/2 Dark reddish brown	23.20	16.00	60.80	Clay	0.3
	Bw	63-100	5YR3/3 Dark reddish brown	24.00	28.00	48.00	Silt clay	0.6
10/AP1	Ap	0-20	5YR3/1 Very dark gray	6.80	43.20	50.00	Silt clay	0.9
	AB	20-44	2.5YR3/2 Dusky red	10.80	39.00	50.20	Silt clay	0.8
	Bt	44-100	2.5YR3/4 Dark reddish brown	19.00	25.00	56.00	Silt clay	0.4
11/Pi1	Ap	0-10	10R2/2 Very dusky red	17.20	21.60	61.20	Clay	0.4
	AB	10-75	2.5YR3/4 Dark reddish brown	63.20	29.20	7.60	Sandy loam	3.8

Appendix 5: Soil chemical characteristics

Profile No.	Mapping unit	Horizon	Depth cm	pH	Ec (us)	% OM	% N	% OC	Ca	Mg	K	Na	P
									Me/100g				Mg/kg
1	Pi3	Ah	0-33	5.77	46.20	9.67	0.04	0.23	17.17	3.91	0.12	2.32	17.10
		AB	33-69	8.78	220.00	6.61	0.07	0.28	6.00	14.82	0.10	15.91	2.75
		B	69-100	7.21	250.00	12.27	0.13	0.28	14.20	12.87	0.14	10.28	2.40
2	AP2	A	0-30	5.46	19.30	3.95	0.04	0.10	7.60	7.04	0.10	0.78	2.75
		B	30-74	6.42	33.90	11.56	0.13	0.37	12.20	9.02	0.12	2.32	2.05
		Btx	74-81	6.92	50.70	8.59	0.00	0.28	11.76	9.64	0.13	2.84	3.42
3	AP5	A	0-20	5.55	47.70	12.16	0.11	0.50	15.90	8.76	0.26	1.03	10.95
		Bg	20-44	5.90	54.20	7.00	0.13	0.24	17.90	9.91	0.12	1.19	7.52
4	AP4	Ap	0-40	5.71	34.50	20.46	0.13	0.44	5.38	13.55	0.23	1.05	4.45
		Bt	40-100	6.22	42.00	9.16	0.13	0.17	10.20	5.77	0.08	1.21	4.10
5	Pi2	A	0-30	6.02	46.20	10.38	0.07	0.37	23.42	7.96	0.29	0.37	29.77
		B	30-41	5.16	13.70	7.06	0.11	0.18	14.81	8.31	0.24	0.39	4.45
		BC	41-76	5.48	11.60	4.85	0.07	0.16	7.10	3.69	0.08	0.37	4.10
6	H1	Ah	0-27	6.00	104.80	15.42	0.17	0.46	15.78	9.31	0.65	0.32	1.70
		AB	27-54	5.06	30.20	15.99	0.07	0.34	2.59	6.76	0.42	0.30	2.75
		B	54 - 100	4.82	11.00	19.72	0.07	0.57	1.68	6.18	0.13	0.31	1.37
7	H2a	Ah	0-30	5.70	179.90	11.89	0.18	0.41	12.38	8.19	2.29	0.33	3.42
		B	30-100	4.70	11.10	6.95	0.10	0.20	2.07	2.71	0.69	0.38	2.40
8	H2b	Ap	0-40	5.88	39.80	10.96	0.10	0.24	15.58	2.58	1.35	0.34	65.03
		Bt	40-100	5.17	21.50	10.67	0.10	0.25	9.08	1.94	0.89	0.36	95.15
9	AP3	Ap	0-20	5.54	70.60	13.23	0.64	0.27	18.47	7.11	0.65	0.51	16.07
		A	20-45	5.51	25.00	3.49	0.10	0.10	11.11	5.36	0.09	0.60	6.85
		AB	45-63	5.81	28.70	6.09	0.11	0.22	9.06	4.36	0.06	0.65	1.70
		Bw	63-100	5.61	41.70	10.50	0.11	0.25	10.32	5.76	0.08	0.74	6.15
10	AP1	Ap	0-20	5.84	62.10	14.35	0.14	0.33	30.20	8.76	2.29	0.37	33.20
		AB	20-44	5.65	27.80	10.46	0.13	0.26	17.70	6.81	0.52	0.36	14.72
		Bt	44-100	5.21	13.70	12.26	0.17	0.38	13.96	5.55	0.17	0.35	3.77
11	Pi1	Ap	0 – 10	5.38	29.80	11.73	0.10	0.30	4.69	2.31	0.65	0.35	27.72
		AB	10- 75	5.38	10.70	6.55	0.10	0.16	3.82	1.93	0.42	0.35	31.15

Appendix 6: Soil classification

Profile No.	FAO World Reference Base Classification system	
	Level - 1	Level – 2
1 (Pi3)	Vertisols	Eutric Vertisols
2 (AP2)	Planosols	Plinthic planosols
3 (AP5)	Fluvisols	Cumulic fluvisols
4 (AP4)	Fluvisols	Cumulic fluvisols
5 (Pi2)	Cambisols	Haplic cambisols
6 (H1)	Ferralsols	Rhodic ferralsols
7 (H2a)	Ferralsols	Dystric ferralsols
8 (H2b)	Ferralsols	Eutric ferralsols
9 (AP3)	Gleysols	Stagnic gleysols
10 (AP1)	Phaeozems	Haplic phaeozem
11 (Pi1)	Acrisols	Ferralic Acrisols

Appendix 7: Long term mean monthly rainfall

Rainfall Data- Lumemo, Ifakara 1990 to 2004

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990	93.6	146.7	200.9	170.9	76.0	3.2	2.2	0.4	4.4	16.4	49.1	39.2	8o3.3
1991	134.3	106.5	143.1	167.6	121.2	0.0	0.0	0.4	0.0	0.0	0.0		673.1
1993			123.1	291.6	180.5	0.3	2.9	7.0	0.0	0.2	15.5	0.0	621.1
1994	103.9	51.2	113.0	253.1	73.6	1.1	0.5	0.0	0.0	33.3	1.8	57.8	689.3
1995	20.4	100.0	119.0	191.2	39.1	0.2	0.0	11.0	0.0	0.0	0.0	1.8	482.7
1996	93.9	191.4	142.2	235.9	87.7	14.4	2.3	0.0					769.8
1997	40.5	57.1	176.6		3.3	16.4	0.0	0.0	0.0	36.0	82.1	314.1	726.1
1998	96.8	132.1	109.0	136.5	35.7	0.0	0.0	0.0	9.2	0.0	0.0	0.0	519.2
2001							0.4		0.0	0.0	0.0		0.4
2002	169.9	150.0	297.4	388.7	30.3	0.0	0.0	0.0	10.4	23.7	7.4	57.8	1132.9
2003		196.4	230.9	110.9	66.0	0.0	8.4	0.0	0.0	15.0	0.0	78.5	706.1
2004	399.1	217.2	143.7	272.8	0.0	17.5	4.6	0.0	6.4				1061.3

Mahenge Meteorological Station 1993 to 2004

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1993		142.1	460.3	460.6	150.1	16.9	26.7	9.5	0.0	0.0	119.7	77.3	1463.2
1994	286.7	289.1	545.0	348.9	73.7	4.5	14.4	18.7	2.4	100.3	63.6	281.5	2028.8
1995	224.2	345.8	600.6	353.4	135.9	0.0	0.0	42.8	10.3	65.0	1.3	209.8	1989.1
1996	268.3	298.3	484.3	328.0	182.5	8.7	66.5	3.0	16.4	5.5	22.4	143.7	1827.6
1997	159.2	172.5	398.4	341.7	59.6	74.9	14.2	9.9	5.3	89.2	414.8	749.3	2489.0
1998	621.6	410.7	315.1	709.1	52.0	0.1	4.0	3.1	20.2	3.2	20.2	4.0	2163.3
1999	415.0	179.3	666.3	407.7	73.7	53.4	10.5	80.4	22.2	16.5	100.9	164.8	2190.7
2000	56.3	119.4	410.8	407.8	28.1	19.5	15.5	14.8	8.0	0.0	184.2	548.7	1813.1
2001	457.1	293.7	246.4	317.6	101.6	96.1	18.1	2.7	1.4	4.3	2.7	188.3	1730
2002	356.7	272.3	753.4	430.2	8.4	71.5	8.8	69.6	42.8	32.5	184.4	191.3	2421.9
2003	345.3	185.7	191.7	310.7	127.0	10.7	0.0	0.4	36.2	17.9	4.1	4.0	1233.7
2004	414.1	525.2	215.9	370.0	1.7	40.1	0.0	5.9	10.9	128.3	167.3		1879.4

Appendix 8: Final land mapping units

CODE	TERRAIN (FROM - API)	LAND COVER/LAND USE (FROM - LAND SAT IMAGE)
H	Hilly land	
H1	Strongly dissected high hill ranges	Forest, degraded forest, Catchments services provision
H2a	Low hill moderately dissected	Forest, degraded woodland, degraded forest, woodland, cultivation and Teak plantation
H2b	Low hill, less dissected	Forest, Teak plantation , degraded forest and degraded woodland
Pi	Piedmont	
Pi1	Sloping land	Degraded forest, woodland, degraded woodland, cultivation
Pi2	Undulating land	Woodland, cultivation, Teak plantation and forest
Pi3	Nearly level land	Cultivation and degraded woodland
AP	Alluvial plain	
AP1	Upper terrace	Cultivation and wood land
AP2	Middle terrace	Grassland with cultivation, Cultivation, and woodland
AP3	Lower terrace	Grassland with cultivation and Cultivation
AP4	Alluvial fan	Cultivation, grassland, bush land and woodland
AP5	Flood plain	Papyrus swamp, grassland, bush land, grassland with cultivation and cultivation

Appendix 9: Land use requirements for rice

Land use requirement			**Factor rating**			
Land quality	Diagnostic factor	Unit	S1	S2	S3	N
Moisture availability	Mean annual rainfall	mm	1200-2000	1000-1200	800-1000	< 800
	Water requirement in growing season	mm				
Oxygen availability to roots	Soil drainage class	Class	Some what poorly, Poorly	Very poorly Moderately well	Well	Some what excessive, Excessive
Rooting conditions	Minimum rooting depth	cm	30-60	20-30	20-10	< 10
	Stones and gravels	%	< 5	5 - 15	15 - 35	> 35
	Soil texture	Class	Sand clay, Clay, Clay loam	Sand clay loam, silt loam, silt clay loam, loam	Loamy sand, sand loam, massive clay	Gravels, sand
Erosion hazard	Slope	%	< 2	2-5	6-8	>8
	Observed erosion	Class	None	None	None	
Nutrients availability	Soil reaction	pH	5.5-7.0	7.0-8.0 5.5-4.5	8.0-8.5 4.5-4.0	>8.5 <4.0

Source: DLD, Bangkok (1989)

- S1….Very suitable
- S2….Moderately suitable
- S3….Marginally suitable
- N….Not suitable

Appendix 10: Land use requirements for maize.

Land use requirement			Factor rating			
Land quality	Diagnostic factor	Unit	S1	S2	S3	N
Moisture availability	Mean annual rainfall	mm	1100-1300	900-1100 1300-1500 450-400	600-900 1500-2500 300-400	< 600 > 2500 < 300
	Water requirement in growing season	mm	500 -800	800 -1200	1200-2000	>2000
Oxygen availability to roots	Soil drainage class	Class	Well to mod. well	Somewhat excessive	Poor Somewhat poor	Very poor Excessive
Rooting conditions	Minimum rooting depth	cm	60-90	30-60	10-30	< 10
	Stones and gravels	%	< 5	5 - 15	15 - 35	> 35
	Soil texture	Class	Sand, loamy sand, sand loam, loam, silt loam, sand clay, clay, silt clay.	Sandy clay	Silt clay, clay	Heavy clays
Erosion hazard	Slope	%	< 3	3 - 8	9-16	>16
	Observed erosion	Class	Slight	Moderate	Severe	Very severe
Nutrients availability	Soil reaction	pH	6.0-7.0	5.5-5.9 7.1-7.5	4.5-5.4 7.6-8-5	<4.5 >8.5

Source: DLD, Bangkok (1989)

- S1….Very suitable
- S2….Moderately suitable
- S3….Marginally suitable
- N….Not suitable

Appendix 11*:* Land use requirements for cotton

Land use requirement			Factor rating			
Land quality	Diagnostic factor	Unit	S1	S2	S3	N
Moisture availability	Mean annual rainfall	mm	700-1300	500-700 1300-1500 350-550	450-500 1500-1600 300-350	< 450 >1600 < 300
	Water requirement in growing season	mm	550-590	590-1100	1100-1200	>1200
Oxygen availability to roots	Soil drainage class	class	Well to Moderately well	Somewhat poor, somewhat excessive	poor	Very poor
Rooting condition	Minimum rooting depth	cm	60-90	40-60	20-40	<20
	Stones and gravels	%	<5	5-15	15-35	>35
	Soil texture	class	Sand to clay			
Erosion hazard	Slope	%	<3	3-6	9-16	>16
	Observed erosion	class	slight	moderate	severe	Very severe
Nutrients availability	Soil reaction	pH	6.5-7.0	5.0-6.4 7.1-8.0	4.3-4.9 8.1-8.4	<4.3 >8.4

Source: DLD, Bangkok (1989)

- S1….Very suitable
- S2….Moderately suitable
- S3….Marginally suitable
- N….Not suitable

Appendix 12: Land use requirements for extensive grazing.

Land use requirement	Diagnostic factors	Factor ratings			
		S1	S2	S3	N
Availability of drinking water	Average distance to water points in LMU (Km)	< 3	3-4	4-5	> 5
Erosion hazard	Erosion susceptibility (class)	Very low to low	Moderate	Moderately high	High
Accessibility in LMU	Slope %	< 16	16- 30	16-30	> 30
Grazing capacity (animals/ha/year)**	Consumable forage production (kg dry matter / ha / year)	>2500	1000-25000	400-1000	< 400
	Forage quality (crude protein in % of dry matter	>7	4 - 7	4-7	< 4

(Source: Huzing, ITC (1987

** Can be calculated on the basis of the assumption that an animal with a body weight of 250 kg needs 7.5 kg dry matter/day with a minimum crude protein % of 4. In this study grazing capacity was not assessed.

- S1….Very suitable
- S2….Moderately suitable
- S3….Marginally suitable
- N….Not suitable

Appendix 13: Description of land mapping units

(i) Strongly dissected unit -H1

The first subclass of the hilly unit defined by a series of ranges with rough profile aligned about south north of the eastern part of the valley. It has a steep slope ranging from 30% to more than 60% at an altitude of 400 to more than 900m above sea level. Slopes are straight and steeply dissected. The degree of dissection is high to some areas while the vegetation displays a thick forest cover difficult to penetrate easily. The unit is also a source of many streams which are tributaries of Kilombero River such as Mchilipa, Mtumbei, Mafinji and Luvili rivers just to mention a few. According to the geological map (1960) quarter degree sheet No.250, the range comprised of Usagaran rock representing original semi- pelitic sediments, probably fine-grained greywacke and shale, with minor intrusions of ultra basic and basic igneous rock.

Land qualities of the unit defined by soil pit number 6 . The soils are an association of very deep well drained, dark reddish brown to reddish brown loams and sand loam top soils with red silt loam sub surface soils. The unit is excessively drained due to its steep slopes, however erosion is not a problem due to the good cover of the soil but once the present cover is removed, the unit will be severely eroded. The effective depth is more than 100cm with increasing acidity from top down the profile; soil moisture is 171mm/m of soil depth, the surface soil has pH of 6.0 while from 54cm deep down the pH is below 5.0. The top soil is friable moist; slightly sticky, and slightly plastic wet; moderate fine and sub angular blocks; many fine pores and many fine roots; with clear boundaries. The soils has a pH of 6.0, rich in Potassium minerals (0.65me/100g) and moderate Nitrogen (0.17%) but very poor in Phosphorus minerals which is only 1.70mg/kg (Appendix 5). The soils classified as Rhodic ferralsols using FAO/UNESCO (1974) legend.

Assessed Land Qualities of H1 Mapping Unit – Pit 6

Land quality	Rate	Explanation
Moisture availability	1	Very high (160 – 250+mm/m)
Nutrients availability	S1	pH 5.5 to 7.0
Drainage	1	Good to excessive
Erosion	5	Very severe if forest cleared
Capability for maintaining surface water	4	Very poor due to steep slopes
Rooting space	2	80 to 100cm

(ii) Moderately dissected unit - H2a

This is the second subclass of the hilly mapping unit embracing low hills with large variety of slope steepness, length, shape and lithology. It is located just adjacent and parallel to land mapping unit H1. Elevation is moderate, around 370 or more. The gradient is very variable, ranging from rolling to hilly. Slopes are generally straight with sloping upper parts. The vegetation displays a low-density forest cover except to the highest parts. This is caused by human encroachment, some trees exceeding 40cm in diameter still remains, climbers/lianas also observed. A small part of this unit opened for maize farming in Luvili sub-village, more land under threats of being converted to farmland due to influx of immigrants in the valley. Firewood and pole collection are currently the main use of the forest in this unit, probably because of its location.

Land qualities of the unit defined by soil pit number 7. It is comprised of red-brown sandy earths covering rock at shallow depth. Has a well-drained, dark reddish brown sandy loam, with thick reddish silt clay layer underneath. Available soil moisture is 178mm/m of soil depth, the top soil consistence is soft when dry, friable moist, non sticky and non plastic wet; weak fine granular; many fine and common medium pores; fine and medium roots; gradual smooth boundary. No erosion observed, but subjected to severe erosion if opened for farming due to its steep slopes. The soils has a pH of 5.7, very rich in Potassium minerals (2.29me/100g) and moderate Nitrogen (0.18%) but very poor in Phosphorus minerals which is only 3.42mg/kg (Appendix 5). The soils classified as Dystric ferralsols using FAO/UNESCO (1974) legend.

Assessed Land Qualities of H2a Mapping Unit - Pit 7

Land quality	Rate	Explanation
Moisture availability	1	Very high (160 – 250+mm/m)
Nutrients availability	S1	pH 5.5 to 7.0
Drainage	1	Good to excessive
Erosion	4	Severe if forest cleared
Capability for maintaining surface water	4	Very poor due to steep slopes
Rooting space	2	80 to 100cm

(iii) Slightly dissected unit - H2b

The last subclass of the hilly unit presents a very smooth and gentle topography. In the study area, this unit is bordering the settlement and therefore much of its flat tops are opened for upland crop cultivation, but also is a source of firewood, building poles and charcoal making. The main characteristics are: low gradient and low altitude, around 360m. Shape and form looks like plateau, but generally can be considered as having an undulating to rolling topography. The hills usually show broad flat tops, which cleared for maize cultivation as a main crop. Very big trees observed being left here and there in different farms indicating that there had been a closed forest in the past. In the Aerial photographs of 1978, very few farms were marked, but the rate of encroachment is alarming in the moment. At hill tops, there is deep soil dark reddish brown in colour, well drained with pH around 5.80. The soils are very rich in NPK. Some sheet and rill erosion observed during field survey.

Land qualities of the unit defined by soil pit number 8. The unit range from undulating to rolling with slopes of between 2 and 12%. The soils are very deep on flattened hill tops, and moderately deep on slopping areas, they are well drained dark reddish brown clay, friable moist, slightly sticky and slightly plastic wet; moderate coarse and medium sub angular block structure; many fine and medium pores. Available moisture is 163mm/m, the soils being dry for the top 28cm and moist deep down. Soil erosion is observed to most of the maize farms, and very serious to some parts of Luvili sub village where certain farms have small gullies. The unit has rich soils in phosphorus and potassium (65.03mg/kg and 1.35me/100g respectively) but low Nitrogen 0.10% (Appendix 5). The soils classified as Eutric ferralsols using FAO/UNESCO (1974) legend.

Assessed Land Qualities of H2b Mapping Unit – Pit 8

Land quality	Rate	Explanation
Moisture availability	1	Very high (160 – 250+mm)
Nutrients availability	S1	pH 5.5 to 7.0
Drainage	1	Good to excessive
Erosion	3	Moderately severe
Capability for maintaining surface water	4	Very poor due to high slopes
Rooting space	2	80 to 100cm

(iv) Sloping piedmont unit - Pi1

This is a sloping land with an undulating topography. It separates the hilly land from the lowland thus with changing soils as one proceed from high land to the plain. The soils change from clay/clay loam to silt clay and sandy clay. The natural vegetation as well changes from woodland to wooded grassland. These raised areas, specifically refer to some parts of Njiwa juu, Njiwa kati, Kikoni, Ibuta, Luviri and Mahimbo sub- villages. This unit mainly is where the settlement situated. The sub villages grow cotton, cowpeas, sweet potatoes, banana, cassava, pigeon peas, and more significantly Maize. Also fruits crops like mango, guava, citrus trees, coconuts and pawpaw are widely grown. Soil erosion is a serious problem especially in maize farms at Luvili sub village farming area (Personal observation).

The soils of this unit are in transitional with those of the plains but hillier characterized than to the plains. Land qualities of the unit defined by soil pit number 11. The topography is gently sloping with slopes ranging from 3 to 6% at an altitude of 354m above sea level. The soils are very dusky red clay, dry for the top 10 cm, moderate, fine and medium angular block structure, the consistence is hard when dry, firm when moist, sticky and plastic when wet. Many fine pores; few small angular fragments and common very fine and fine roots. Sheet and rill erosion almost everywhere as the unit intensively used for settlement and upland crop cultivation. The soils has a pH of 5.38, very rich in Potassium and phosphorus minerals (0.65me/100g and 27.72mg/kg respectively) and low Nitrogen (0.10%) but very poor in Phosphorus minerals which is only 3.42mg/kg (Appendix 5) The available soil moisture is 122.25mm/m of soil depth and the soils classified as Ferralic Acrisols using FAO/UNESCO (1974) legend.

Assessed Land Qualities of Pi1 Mapping Unit – Pit 11

Land quality	Rate	Explanation
Moisture availability	2	High (120 - 160 mm)
Nutrients availability	S3	pH 4.5 to 5.5
Drainage	1	Good to excessive
Erosion	2	Moderate
Capability for maintaining surface water	4	Very poor due to high slopes
Rooting space	3	50 to 80cm (small stones cemented by clay)

(v) Undulating piedmont unit - Pi2

This is a low gradient inclined foot slope, sometimes gently sloping than Pi1. It presents similar characteristics to the previous class in some parts of the unit, but slopes are less straight and more gently inclined. Some places include vast plain very gently sloped to the extent of ponding some water in rainy season. In the aerial photographs of 1978, this unit was classified as wooded foot slope. The land covers and use now days changing very rapidly, agro pastoralists established settlement and use the unit both for farming and grazing, some places still wooded, but the rate of encroachment is alarming. Some of the crops observed during the survey include Rice and Maize as the main cops, while other crops include groundnuts, cowpeas, sweet potatoes, okra, banana and green gram. The unit covers a small part of Alabama and Luvili sub villages and a great part of Madabadaba sub villages.

Land qualities of the unit defined by soil pit number 5. The soils of the unit very localized from one area to another due to varying micro topography. In lowland areas the soils are sand clay, silt clay and heavy clays, and in sloping areas there is mostly clay and clay loam. Slopes ranging from 2 – 4% situated at an altitude of 280 – 285m above sea level. The soils are moderately deep and black in colour mostly silt clay, with weak medium sub angular blocky structure; slightly plastic, firm moist consistence; few interstitial pores; little angular quartz gravel and at depth of 76cm, many small stones mixed with gravels. This layer consists of buried colluvial materials undergoing weathering. Available soil moisture is 139.08 at the average depth of 76cm. The soils have a pH of 6.02, very rich in Phosphorus minerals (29.77mg/kg), moderate potassium (0.29me/100g) and very low Nitrogen (0.07%). The soils of this unit classified as Haplic cambisols using FAO/UNESCO (1974) legend.

Assessed Land Qualities of Pi2 Mapping Unit – Pit 5

Land quality	Rate	Explanation
Moisture availability	2	High (120 - 160 mm)
Nutrients availability	S1	pH 5.5 to 7.0
Drainage	2	Moderately good
Erosion	1	Insignificant
Capability for maintaining surface water	3	Moderately good
Rooting space	3	50 to 80cm (some places very deep)

(vi) Nearly flat piedmont unit - Pi3

This is the third sub unit in the Piedmont land. These are valley bottoms within the foot slope, which are almost flat. This is the deepest portion of the valley elongated on level lands. Valley bottoms change in width and shape, receive run-on water from upper elevated land during rainy season, which makes the unit rechargeable with nutrients every year for Paddy farming. During preliminary land unit preparation, this unit was divided in two units basing differentiated by land use/cover changes, but now days the whole unit is used for paddy cultivation and hence put as one unit in the final land unit map. There small stream flowing during rainy season but dries up in summer.

Land qualities of the unit defined by soil pit number 1. It is well covered with silt clay soil on the surface layer, but underneath there is a layer of very hard clay soil that cracks during dry season to the surface. Such soils always become saturated readily causing water ponding, a situation conducive for paddy growing. The soils are deep enough and during the long rains, the water flows on the surface. The topography is almost flat with slopes ranging from 0.5 to 2% at an altitude of 290 to 295m above sea level. The unit which is a run on water during rainy season has soils of moderate, medium wedge shape structure; very firm when moist, very sticky and very plastic when wet. Have very poor infiltration rate and water ponding is very common. Available water is 183mm/m and has a pH of 5.77; very low nitrogen (0.04) and moderate phosphorus and Potassium. The soils classified as vertic vertisols using FAO/UNESCO (1974) legend.

Assessed Land Qualities of Pi3 Mapping Unit – Pit 1.

Land quality	Rate	Explanation
Moisture availability	1	Very high (160 – 250+mm)
Nutrients availability	S1	pH 5.5 to 7.0
Drainage	3	Imperfect
Erosion	1	Insignificant
Capability for maintaining surface water	3	Good
Rooting space	2	80 to 100cm

(vii) Upper terrace (AP1)

The unit occupies the concave slope where the plains begin and the slopping land mark its end. The slope ranges from 1.5 to 4% at an altitude of around 295m above sea level. It is developed on deep black fine silt clay with colluvial materials from the adjacent piedmont dipping under it. The unit supports a variety of crops mostly upland crops like cotton, maize, banana and legumes. On the photographs of 1978, this unit was wooded with tree specie locally known as “*Mitalula*” the name that later called after one of the sub villages of Njiwa village. Population increase increased the demand for food that led to the clearance of the woodland and converted into farms. Those who opened the woodland settled permanently at that area and formed the sub village of “*Mitalula*”. A small part where this unit bordering the lower terrace unit, paddy cultivation is carried out.

Land qualities of the unit defined by soil pit number 10. The soils comprised of the complex of very deep well drained, dusky red silt clays with very dark gray silt clay top soils, and very deep silt clay loams top (cotton) soils developed from colluvial materials from the slopping upper parts. The soils have a moderate fine and medium sub angular block structure, friable moist, sticky and plastic wet; with many fine and few medium pores. Available soil moisture is very high (183mm/m), slightly acidic soil of pH of 5.84 and low Nitrogen content (0.14%) but very high levels of Phosphorus and potassium (33.20mg/kg and 2.29me/100g respectively). The soils classified as Haplic phaeozems (FAO/UNESCO, 1974) legend.

Assessed Land Qualities of the upper terrace unit – Pit 10

Land quality	Rate	Explanation
Moisture availability	2	High (120 - 160 mm)
Nutrients availability	S3	pH 4.5 to 5.5 and >8.5
Drainage	3	Imperfect
Erosion	1	Insignificant
Capability for maintaining surface water	2	Good
Rooting space	2	80 to 100cm

(viii) Middle terrace unit (AP2)

This unit is part of the wider plain locally known as “*mbugani*”, it occupy the middle terrace of the alluvial plain. The general landscape is flat with a slope range of 2 to 3% at an altitude of 280m a.b.s.l. in average with some mount mound micro topography here and there. It is slightly lower than the Upper terrace and occupy the area goes by the name of

"*Nganawa chini*". It is bushed grassland with scattered thorny trees of acacia *spp.* When the population was low in the past, this area was mainly used for grazing by wild animals only, but now days occupied by agro-pastoralists who established temporary settlement, opened rice farms and grazing their livestock.

The soils are well drained dark reddish brown sandy loam; weak, fine and medium sub angular blocky; very hard when dry, friable when moist, non sticky and non plastic when wet, few medium, many very fine and fine pores. At about 80cm in depth characterized with a hard pan, a layer that does not allow water to pass through, very difficult to break and above all, it comprised of mottled materials, many small hard spherical, iron and manganese nodules. Land qualities of the unit defined by soil pit number 2 and classified as Plinthic planosols (FAO/UNESCO, 1974) legend

Assessed Land Qualities of middle terrace (AP2) – Pit 2

Land quality	**Rate**	**Explanation**
Moisture availability	1	Very high (160 – 250+mm)
Nutrients availability	S1	pH 5.5 to 7.0
Drainage	3	Imperfect
Erosion	1	Insignificant
Capability for maintaining surface water	2	Good
Rooting space	2	80 to 100cm

(ix) Lower terrace unit - AP3

This is the smallest unit comprised of depressions and that surface water stagnating for about two months or more after long rains stop raining. The topography is very flat ranging from 0.5 to 1.0%. Mainly used for paddy and sugar cane growing. The area is among the highest rice producing (15 bags/acre equivalent to 3.75 tones/ha) per unit area under normal management. It is flooded every year during the long rains there by recharging its nutrients, in some places very close to river Mchilipa.

Land qualities of the unit defined by soil pit number 9. The soils are mostly silty clay to sandy clay, very dark grayish brown in colour with soft consistence when dry, friable when moist and non sticky non plastic when wet; weak fine sub angular structure, many course pores; very few weathered round feldspar gravels. The soils are moist from surface, and the water table is at 100cm. The soils classified as Eutric fluvisols (FAO/UNESCO, 1974) legend

Assessed Land Qualities of AP3 Mapping Unit – Pit 9

Land quality	Rate	Explanation
Moisture availability	1	Very high (160 – 250+mm)
Nutrients availability	S1	pH 5.5 to 7.0
Drainage	3	Imperfect
Erosion	1	Insignificant
Capability for maintaining surface water	2	Good
Rooting space	2	80 to 100cm

(x) Alluvial fan unit - AP4

This is an outspread, gently sloping mass of alluvium deposited by many tributaries flowing into the floodplain from Mahenge highlands located in the south east of the valley and have deposited sediments in alluvial fans at the margins of the flood plain. Some trees like borassus palm, *Ficus spp.* and Sausage trees (Kigelia Africana) appear on anthills scattered allover the alluvial fans which are covered by *Hyperrhenia spp*. The rain sometimes causes temporary overflows of the tributaries, and relatively narrow areas along the tributaries are flooded for several days. Paddy rice is mainly cultivated in the alluvial fan zone, depending on the short-term overflows of the tributaries.

Land qualities of the unit defined by soil pit number 4. The topography is generally flat having slopes of between 1 and 2% at an altitude of about 274m above sea level. Soils are deep, very dark gray silt loams with weak very fine platy structure; slightly sticky, slightly plastic, friable moist, hard dry and many fine roots. Some mottling in the profile is widely observed from 40cm downward. The effective depth is around 100cm where the soil restricted by rough gravely soils and the soils are moist from the surface layer. The available water in the soil is 183mm/m; soil pH is 5.71, very low in Nitrogen content (0.13%) and serious deficiencies of Phosphorus and Potassium. The soils classified as humic phaeozems (FAO/UNESCO, 1974) legend.

Assessed Land Qualities of AP4 Mapping Unit – Pit 4

Land quality	**Rate**	**Explanation**
Moisture availability	1	Very high (160 – 250+mm)
Nutrients availability	S1	pH 5.5 to 7.0
Drainage	3	Imperfect
Erosion	1	Insignificant
Capability for maintaining surface water	1	Very good
Rooting space	2	80 - 100cm

(xi) The flood Plain unit - AP5

This is the braided river zone mainly covered with tall grasses such as elephant grass, guinea grass hyperhenia spp. and reed but no trees occur due to the long term flooding (Kato, 2007). It is a flat terrain adjacent to and formed by alluviating Rivers. Irregular texture and pattern are recognizable. Point bars, natural levees, basins (back swamps) and abandoned channels are generally present. During the flood the river can spread over the entire width of the plain. A large part of it is marshy, with swamps and small lakes. Part of the plain is frequently flooded while the other part that is far away from the river course is episodically flooded depending the rainstorm of that season. The seasonal change in water dynamic is huge and the plains may become totally flooded during the wet season, while it dries up during the dry season with the exception of rivers and river margins as well as the areas with permanent swamps and water bodies. The site overlaps with the Selous Game reserve in the northeast. This part falls under Kilombero game controlled area, only part of it used for agriculture. A number of hamlets and temporary camps are located on the floodplain itself. The pastoralists used to graze their livestock in this unit there by causing conflict between game hunters and them.

Land qualities of the unit defined by soil pit number 3. The flood plain is the most fertile part of the valley due to frequently alluvium deposition. The topography is very flat; it is in the range of 0 to 1%. The soils mostly silt loam and sand loam, weak, fine and medium sub angular blocky; slightly hard when dry; friable when moist, very slightly sticky and non-plastic when wet; many fine and medium pores; common fine and medium roots. Soil pH is 5.55 and reasonable amount of Potassium minerals (0.26me/100g) but low levels of Nitrogen (0.11%) and Phosphorus (10.95mg/kg). the soils are classified as Cumulic Fluvisols (FAO/UNESCO, 1974) legend.

Assessed Land Qualities of AP5 Mapping Unit – Pit 3

Land quality	Rate	Explanation
Moisture availability	1	Very high (160 – 250+mm)
Nutrients availability	S1	pH 5.5 to 7.0
Drainage	4	Poor to very poor
Erosion	1	Insignificant
Capability for maintaining surface water	1	Very good
Rooting space	4	Shallow due to high water table (50cm)

Appendix 14: Viability and carrying capacity analysis

(a) Introduction

The study area viability analysis is the assessment of whether the available resources at Itete ward can sustain the present and future population. The term "carrying capacity" refers to the number of people that the earth can support on a sustained basis—that is, support indefinitely at a constant standard of living without destroying the natural resource base (Population report, 1997). Mean while, carrying capacity for this study refers to the number of people who can be supported by the existing land on the bases of existing dominating technology and farming systems.

(b) Objective

The aim of the ward viability analysis is to have an assessment of physical and labour resource in the ward at which either resource are available or inaccessible within the ward. From the social economic survey data gathered during field work, the ward population presented in Table 51.

Population data, Itete ward

Village name	Number of families	Number of people
Njiwa	704	10,165
Minazini	467	7,154
Total	**1,171**	**17,319**

The aim of the population figure is to help in calculating land requirement at present and future since population is dynamic while the land resources is fixed.

(c) Land required for food crops production

Food is an important source of energy for a person to live and work, either be a farmer, pastoralist or casual labourer. The energy needed by a person is identified by its calorific requirement per person per year. The aim of this analysis is to get a piece of land in which the calorific requirement can be grown. The study area has three crops people depend on to get their calories. These crops are rice maize and cassava. Composition of food crops and production per household in the area, shown in the table below.

Food composition per household and its calorific value

Food composition	**Paddy**	**Maize**	**Cassava**	**Total**
Average prods. bags of 100 (kg) / household	20	10	7	37
Bags consumed	20	10	7	37
Contribution in %	47	31	22	100
Calorific value (Cal/kg)	3600	3600	1500	

Assumption of the model - Source: Meshack et al, 2002

- Each household has two adults (father and mother) and 4 children, thus total population 17,319 (Table above) if divided by 6, there 2887 families.
- Each member of household is able to consume the available food to get the required calories every year
- The level of technology remain constant

Calorific requirement per day for a household member is as follows

- Father – 2500 cals/ day
- Mother – 3000 cals/ day
- Child – 2000 cals/ day

The total calories per house hold per day at Itete Ward is

= 2500 + 3000+ (2000 x 4)

= 2500 + 3000+ 8000

= 13,500 cals/day.

Annual calorific requirement per household is:

= 13,500 x 365 days (no.)

= 4, 927,500 calories.

(i) Land requirement for paddy

Annual requirement=Annual calories required per H/Hold x % composition

Calories/ kg

= 4,927,500 cals × 47% = 643.30Kg

3600 calories /kg

Storage loss is expected at 30%

30/ 100 × 643.30 = 193.0Kg

Rice is a basic food that makes up to 47% of the food composition.

Therefore a household requires,

643. 0Kg +193.0kg = 836.3Kg of rice per year

Known yield of one hectare

= 20 ×100kg = 2000kg

Land requirement for paddy per H/Hold

Land requirement = Required Yield of rice crop (Kg)

Yield / Ha

$= \frac{836.3kg}{2000kg / ha}$ =0.42 Ha

(ii) Land requirement for maize

The annual required for maize makes up 31% of the basic food. Using the above formula:

Annual requirement = 4,927,500 × 31% = 424.31 Kg

3600cals/Kg

- Storage loss is expected to be 30%
- 30/100 x 424. 31 Kg = 127.30 Kg

Consequently, a household required

- 424.31 Kg + 127.30= 551.60 Kg

Land required for maize per H/Hold at Itete Ward is

- $\frac{551.60\ Kg}{10\ bags \times 100Kg/ha} = 0.5516\ Ha$

(iii) Land requirement for cassava

Annual requirement for cassava makes-up 22% of the basic food.

Applying the formula:

Annual requirement~ $\frac{4,927,500}{1500cal/kg} \times 22\% = 722.7\ Kg$

- Storage loss is expected to be 30%
- 30/100 × 722.7Kg = 216.81Kg

Thus the demand of household is 722.7Kg + 216.81Kg =939.51Kg

Land required for cassava per H/Holds at Itete ward is:

- $\frac{939.51kg}{(7 \times 50kg/Ha)} = \frac{939.51kg}{350kg/Ha} = 2.6843ha$

(iv) Summary of food crop requirement

The total land required for food crop in a household per year is 0.42ha, 0.5516ha, and 2.6843ha for paddy, maize and cassava respectively, which makes a total of 3.6559ha. Hence, the total land required for food production in Itete ward is:

- 3.6843 ha × 2,887 families = 10,636.60 ha

For that case, the village is currently viable in terms of food crop production, since the cultivable land is approximately 13,093.92 (Table 10, cultivation + grassland with cultivation) while the area required is 10,636ha. However the population is too big, the area will not take long before being not viable.

Appendix 15: Aerial photographs

Aerial photographs consulted and used in the study: Sheet No. 250/2 Itete

Year	Scale	Run No.	Photo No.
1978	1:50,000	1849	37, 39, 41, 42
		1847	119, 118, 116, 114
		1843	76, 75, 73, 71, 70

Source: Survey and Mapping Unit Dar es Salaam

Appendix 16: Historical profile

Historical Profile for Njiwa and Minazini Villages

Year	**Events**
1974/75	Villagisation programme collected people from different areas, drought and famine.
1993	Contagious Bovine Pleural Pneumonia (CBPP) disease which killed many livestock.
1997	Cholera out break which claimed many human life
1998	Floods caused by el-nino rainfall resulted to food shortage and some houses destroyed.
1999	Famine
2001	Crop destruction by livestock
2002	Bumper harvest due to good rainfall
2003	Conflict between pastoralists and farmers emerged after the former graze their livestock on farmer’s fields. The District Council constructed bore holes
2004	Outbreak of crop pest