NATURAL RESOURCE BASE AND AGRICULTURAL PRODUCTION OPTIONS IN EAST ULUGURU MOUNTAINS

BY

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ABSTRACT

The study was conducted in eastern part of Uluguru Mountains, Tanzania between December 2007 and March 2008. The main objective was to examine natural resource base and agricultural production options in Uluguru Mountains. A cross sectional single-visit survey involving 120 farmers from Konde, Tawa and Kiswila villages was conducted in each village representing high, medium and low altitude respectively. Differences in accessibility to the market were also considered when drawing a sample. Multi-Criteria analysis was applied to assess farmers' decision making processes. Based on this analysis a decision support tool (DST) was developed to identify best cropping options suitable for specific location. Results show that there are high differences in production options within and across the villages caused by different plot position either at high or valley bottoms. Banana, clove and cassava are ideal crops for Konde village located at high altitude, banana, pineapple and maize for Kiswila village located at low altitude and banana, pineapple and cassava for Tawa village located at medium altitude. Gross margin analysis was employed for analysis of profitability in order to identify crops and livestock's corresponding specific characteristic of natural resource base. From the analysis, among the crops grown in the study area, cassava was more profitable in Konde and Kiswila villages while pineapple was profitable in Tawa village. For the case of marketability, the most ideal crop was banana for Konde village, maize for Kiswila and cassava for Tawa village. Further synthesis reveals that, banana is the best crop option especially in the high, middle and low altitudes. Promotion of cassava should be taken with care not to exacerbate NR base degradation. On one hand the study recommends promotion of pineapple production as an ideal crop for profitability and

effectiveness in natural resource (NR) management point of view. On the other hand the study finds it irrational to promote rice since its husbandry practices involve unsustainable practices of burning of the fields.

DECLARATION

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

_____ _____

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Date

The above declaration is confirmed

_____ _____

Dr. Joseph P. Hella
(Supervisor)

Date

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DEDICATION

To my parents, the late Mr Paul Wamba and Mrs Rettiner Wamba who planted the seed of my education but they are not with me to share the fruits of its accomplishment.

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ACRONYMS AND ABBREVIATIONS

AgREN	Agricultural Research and Extension Network
DST	Decision Support Tool
GTZ	Government of Tanzania
IGAs	Income Generating Activities.
LRDC	Land Resources Development Centre
MCA	Multi-Criteria Analysis
MDGs	Millennium Development Goals
NGO	Non Government Organisation
NR	Natural Resource
NSGRP	National Strategy for Growth and Reduction of Poverty
SNAL	Sokoine University National Agricultural Library
SSA	Sub-Saharan Africa
SUA	Sokoine University of Agriculture
Tshs	Tanzanian Shillings
ULUS	Uluguru Land Usage Scheme
UMADEP	Uluguru Mountains Agricultural Development Project
UMBCP	Uluguru Mountains Biodiversity Conservation Project
URL	Uniform Resource Locator
URT	United Republic of Tanzania
WCED	World Commission on Environment and Development
WCST	Wildlife Conservation Society of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Management of natural resource is a single most important element for any nation aiming at achieving sustainable development. Natural resources (NR) are components of nature such as soil, water, plants and animals, fossil fuel and gas which provide means of living or sustenance to mankind. Natural resource base is nature's wealth and natural processes, on which all human wealth and survival depend (URL, 2003). Consequently, natural resources are vitally important for poverty reduction and development.

Our resource base includes some resources we can neither use up nor destroy, such as sunlight; some which are nonrenewable, such as coal; and some which are naturally self-renewing but can be exhausted if poorly used, such as timber, soils, and biodiversity. Natural resource management refers to the processes and practices relating to the allocation and use of natural resources sustainably. Natural resource management optimizes the use of resources to meet current livelihood needs, while maintaining and improving the stock and quality of resources so that future generations will be able to meet their needs (URL, 2003).

Sustainable natural resource management options include improving agro ecosystem productivity, conserving biodiversity, reducing land degradation, improving water management, ensuring the sustainability of forests, managing the sustainability of wildlife and fisheries, and mitigating the effects of global climate change. In recent

years, increases in agricultural productivity have come in part at the expense of deterioration in the natural resource base on which farming systems depend (World Bank, 2007).

In Sub-Saharan Africa (SSA), agriculture contributes the largest share to social and economic development. In these countries land degradation is a serious problem threatening the agricultural sector. Oldeman (1992) reported that 14 million hectares of agricultural land in SSA are affected by physical degradation and 62 million hectares are subjected to chemical degradation. The land area prone to accelerated water erosion is estimated to be 227 million hectares (Lal and Singh, 1995). Therefore, in order to achieve sustainable social and economic development, land degradation in SSA should be minimized to ensure sustainable land productivity.

Many parts of Tanzania have been experiencing severe soil erosion. Factors such as population growth, deforestation and poor farming techniques have been cited as the main causes of the erosion problem (MTNRE, 1994). Land degradation caused by soil erosion has been a major threat to agricultural development. It reduces yield directly via poor seedling establishment, water logging and causing physical injury to crops. Indirectly, erosion affects crops through loss of nutrients (nitrogen, phosphorous and potassium) and organic matter, moisture deficiency and general deterioration of the structure of the soil, as well as reducing the efficiency of other inputs (Lal, 1985).

The Uluguru Mountains in Tanzania supports a high population density due to its favorable climatic conditions. Many people have inhabited the hilly slope area for agricultural production. Usually fires are used as a means of land preparation especially where shifting cultivation is still practiced. Sometimes fire is used for hunting of small animals found in the forest. At a time this fire comes out of control and burns the forest reserves. Burgess *et al.* (2000) observe that the forest has been mostly converted to rotational maize and pulse farms, with bracken (*Pteridium acquilium*) dominating the fallow periods, and the remaining forest areas heavily thinned and under planted with bananas. As a result, as Kilasara and Rutatora (1993) contend, today we see several land related problems including massive deforestation and intensive cultivation leading to land degradation and low soil productivity.

In the Uluguru Mountains, land degradation caused by soil erosion and other processes, such as leaching and salinity is a serious environmental threat that has drawn a lot of attention from both local and the international community. This study intended to examine options for sustainable production in Uluguru Mountains, of the Morogoro rural district. According to Lyamuya *et al.* (1994), ways to achieve a synchronic increase in food production and preservation of natural resources requires the world common efforts.

1.2 Problem Statement and Justification

Small scale farmers have little interest in soil and water conservation per se (Sanders, 1990). They are always after activities which have immediate economic returns, mostly in the form of higher yields, in order to sustain their living. For any

conservation programme to be effective, every effort must be made to develop practices that not only conserve the soil but also provide short-term tangible benefits to the farmers (Sanders, 1990). Short-term benefits include opportunity costs of resources needed to install conservation practices, changes in yield due to different cropping and management practices and changes in production costs (Marc *et al.*, 1989). Due to importance of the Uluguru Mountains to the national economy (Lyamuya *et al.* 1994; Mkoba, 2001; Elifakisad, 2001; Ruheza, 2003) the degradation trend we see today should not be allowed to continue unabated. Past failure should not be allowed to accumulate to the current trend. Dasgupta and Heal (2001) argue that NR base such as Uluguru's, the intertemporal sum of services provided by a given stock of NR is infinity. This means that if properly utilized can in principle provide unbounded sum of services over time. Thus it is possible to estimate a production function that maximizes production with minimum available resources. This realization is supported by the fact that farmers have an "intergenerational obligation" to choose production options that maintain the ability of land to produce and maintain a decent standard of living, yet jeopardize neither the ability of future generations of farmers to produce and maintain a decent standard of living, nor the quality of the environment for either the current or future generations.

Over years, directives to farmers were geared toward natural resource conservation without due respect on farmers involvement (Mawenya, 1994; Pamela, 1996; Sibaway, 2000). Moreover, many of the past efforts (e.g. the Uluguru Land Usage Scheme (ULUS), and studies undertaken by Kisanga (1992) and Mkoba (2001) have concerned themselves with physical system aspects (e.g. slope, soil structure, rainfall

intensity etc) of soil erosion problem leaving aside the connection between the production options and natural resource conservation. This engineering point of view of conservation has not taken into account the influence of farmers' production options on resource conservation. As a result, natural resource degradation has remained to be one of the main challenges of our time. New thinking in terms of incorporating farm production and natural resource conservation are needed. This explained the main objective of conducting this study. The study follows the general realization that it is possible to locate crop type and variety, livestock type and breed along a spatial micro-climate based on the nature of land terrain, access to market and husbandry practices and increase production without straining the resource base. Justification of this study stems also from the fact that it is in line with national interest. For example cluster I of the National Strategy for Growth and Reduction of Poverty (NSGRP) (URT, 2005) entails reduced land degradation/land use options for improving yields and loss of bio-diversity, and reduced negative impacts on environment and peoples' livelihoods among the operational targets for promoting broad-based growth. The study is also in line with goal seven of the Millennium Development Goals (MDGs) (UN, 2006).

1.3 Study Objectives

1.3.1 General objective

To examine natural resource bases and agricultural production options in east Uluguru Mountains.

1.3.2 Specific objectives

Specifically, the study is thought to:

i) Identify and characterize NR base related to small holder agriculture in east Uluguru Mountains

ii) Identify agricultural production options existing in east Uluguru Mountains

iii) Analyze the compatibility between NR bases and production options for sustainability.

iv) Propose best production options for sustainable utilization of NR base

1.4 Research Questions

i) What are natural resource bases related to smallholder agriculture in east of Uluguru Mountains?

ii) What are the characteristics natural resource base that are related to smallholder agriculture in east of Uluguru Mountains?

iii) What are the existing production options in east of Uluguru Mountains?

iv) Which are the best production options for sustainable utilization of NR bases?

1.5 Organization of the Report

This study is organized in five chapters. Chapter one presents the introduction, chapter two the review of the literature related to natural resource base conservation and agricultural production options. While chapter three details the methodology used in the study, chapter four presents the major findings of the study and chapter five the conclusions and recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Natural Resource Base Related to Agriculture

2.1.1 Land

Land is the terrestrial bio-productive system that comprises soil, vegetation, other biota and the ecological and hydrological processes that operate within the system. Land use is often affected by soil and water conservation (SWC) measures. Sometimes the technology itself has the effect of bringing land under a different use (e.g. terrace construction to create cropland on hillsides), and sometimes the SWC technology effectively defines a different land use (e.g. agroforestry) (Liniger and Critchley, 2007).

2.1.2 Water

Water is a renewable resource but finite. According to UNEP (1999), the availability of this vital resource is by no means assured for large sections of the world's population. The requirement of water for irrigation is bound to increase due to population growth and increased demand for food. Over the next two decades, it is expected that the world will need 17% more water to grow food for the increasing population in developing countries and that total water use will increase by 40% (WMO, 1997; UNEP, 1999).

To provide water of the right quality to the users, in the right quantities, at the right places and at the right time, by applying the environmentally sound techniques

and procedures is the challenge of our time. Hence there is ample need for effective management of this vital resource.

2.1.3 Forest

The study area borders the South Uluguru Forest Reserve (FR). The forest was gazetted for its extremely important water catchment value in 1906 and to protect the remaining high altitude forests (Bracebridge *et al.*, 2005). Bracebridge *et al.* (2005) contend further that although the lowland forests are being more severely degraded by charcoal burning, pit sawing, pole extraction and fire, the higher altitude forests on the western slopes have been exploited and timber extracted. Hunting for large mammals has occurred for many years, leaving an area depleted of most large fauna, except for primates and browsers such as duiker and bush pig. The west side of the mountains below the FR is intensively cultivated using terracing and fertilizers, whereas the east is less intensively farmed, planting directly on to the slopes (Bracebridge *et al.*, 2005).

2.2 Land Tenure Systems in East Uluguru Mountains

Traditionally the Waluguru practice both matrilineal and matriarchal systems, however in Matombo division, the maternal system is the most dominant. The maternal uncle wields great authority and he uses his authority to mediate various matters in the family including those related to management and distribution of family resources such as land. Young *et al.* (1960) also postulated that, land in most parts of the Uluguru was traditionally acquired through matrilineal inheritance. The

land is passed on to children, more often to the son by the head of the clan (uncles). However, an individual being allocated a piece of land has no absolute rights on that land.

In most cases people are reluctant in making long-term investment on clan's land such as planting trees and other perennial cash crops. The land that is planted with trees and other perennial crops is considered as an individual property and other members of the clan therefore cannot access it. Ohymas (2000), further emphasized that, in areas where land is inherited paternally, most of the land is dedicated to cash crops while in areas where maternal inheritance is still the norm, such as Matombo, people dedicate most of their farmlands to subsistence food crops.

As a result of an increase in immigration and commercialization, in Matombo division traditional land tenure is slowly being eroded. Land is now considered as a property and can be sold. Renting of farmland is also a common practice in most parts of the Uluguru Mountains. The rent can either be paid in crops or in cash. An individual renting land is restricted from planting trees and other perennial crops. Nair (1993), pointed out that, the relationship between a farmer and his land determines the type of crops to be grown. In instances when and individual is renting a land, he/she is not permitted to plant trees and other perennial crops on that land.

2.3 Land Degradation in the East Uluguru Mountains

Liniger and Critchley (2007) mention soil degradation as one of the most important inter-related land degradation components, defining it as decline in the productive

capacity of the soil as a result of soil erosion and changes in the hydrological, biological, chemical and physical functions of the soil. The major types include water erosion (such as inter-rill erosion, gully erosion, mass movement, off-site sedimentation), wind erosion, chemical deterioration (such as fertility decline, reduced organic matter, acidification, salinisation, soil pollution) and physical deterioration (such as soil compaction, surface sealing and crusting, water logging).

Tanzanian land use history has indicated that the Uluguru Mountains have been deforested over the last century. In response to increased land scarcity farmers resorted to cultivation on very steep slopes and encroachment into the catchment's of forests reserve, valley bottoms and wetlands, which play a key role in the protection of the environment. People started to clear parts of natural forests for crop production, livestock grazing, settlement (collection of building materials and firewood) and large scale use of uncontrolled fire to clear farms (FAO, 1971; Mawenya, 1994). As a result of these practices, most of the soil cover was removed, rivers and springs dried up and land productivity started to decrease due to soil degradation and landslides. However, Ezaza (1992) and Lyamuya *et al*. (1994) observed that land scarcity attributed to population pressure is not the only cause of natural resource degradation in the mountain.

Since 1995 one third of the Uluguru Mountains forest has been converted into farmland, principally for maize, pulse and fruits and vegetable production (Burgess *et al.*, 2000). Recently, expansion of banana production has been one of the factors influencing forest clearance in the Uluguru Mountains. Continuous cultivation on the

gentle and steep slopes made the soil loose and bare with little cover. These conditions accelerated soil erosion by water, even from low intensity rainfall (Shelukindo and Gaudens, 1993; Shenkalwa, 1989; Kimambo, 1991; Aune, 1994; Shelukindo, 1995).

The observed land degradation is seen as the result of a complex interaction of social, economic and environmental factors which lead to land abandonment and its consequent erosion. The link between poverty and land degradation is complex and poorly understood, what has been widely accepted recently is that, the activities that are performed by the rural poor increase land degradation problems that in return might precipitate poverty (Kahyarara *et al.*, 1998). Several studies in Tanzania revealed that, the extent of poverty has influence on the nature of utilization of the natural resource, as poverty compels people to over-exploit the existing natural resources in order to meet their basic needs (URT, 2003).

2.4 Land Conservation in the Uluguru Mountains

Conservation of the Uluguru Mountains is of paramount importance not only for the people residing in the area, but also for the national and global interest. The mountains is potential for the production of fruits, vegetables and spices at regional and national level and is the catchments for the spring feedings streams and rivers, which join to form the large rivers which are source of water in Morogoro, Dar-es salaam and most parts of the Coastal regions. In recent years, Uluguru Mountains drew the attention of many local and international environmental conservation practitioners for their biodiversity richness that is one of the highest in the country.

Conservation of the Uluguru Mountains first started during the German colonial period, when several forest reserves were established for the protection of the water supply and to slow erosion from the steep mountain slopes. These efforts complemented those of the chiefs of the Luguru people, who protected forest areas for their ancestors to live in.

In 1947 the British colonial government introduced several soil conservation techniques in different areas under the Uluguru Land Usage Schemes (ULUS). The objectives of these schemes were to develop an agricultural production system which would rehabilitate eroded areas and to generate information and experience on soil conservation. The focus was on controlling land degradation and ensuring that land could be cultivated without damaging the soil. The main activity was to reduce soil erosion in order to improve crop yield. Activities related to ULUS included construction of bench terraces and tie-ridges, contour cropping, demarcation of forest boundaries and tree planting (Young and Fosbrooke, 1960). In addition, new cash crops and on-farm demonstrations of improved agricultural practices were introduced. Together with these activities laws were passed for the local authority (chiefs) to put into effect. The laws prohibited cultivation on slopes over a certain degree of steepness; required mandatory tree planting on hill crests and prohibited cultivation of land near the streams and uncontrolled fires. Each household was required to construct terraces and 10 yard wide contour strips of permanent crops in at least half an acre in fields at slopes exceeding 25% and slopes under 25% respectively (Zainab and Henk, 2000).

Agricultural staffs were mobilized to enforce these laws. The chiefs and extension personnel turned police, forcing people to implement Land Usage Schemes activities and laws. A large number of people were prosecuted by chiefdom courts for not implementing conservation measures or breaking laws. As a result, Land Usage Schemes as well as extension personnel became unpopular among people. This led to passive resistance against the schemes and in some areas protest meetings and riots occurred (Kimambo, 1991). The most mentioned factors for the failure include; little regard to social organisations, culture and customs of the local people and the fact that local people derived few benefits from the tedious work of terracing (Mawenya, 1994; Pamela, 1996).

Since the failure of the ULUS, there have been few efforts towards conservation of the Uluguru Mountains. Due to this, the largest area of public forest has been severely degraded (Ohymas, 2000). Recently, the Uluguru Mountains has been receiving many conservation efforts aiming at conserving the biodiversity richness of the mountains, at improving the livelihood security of the people in the area or both. To date the most mentioned projects include the Uluguru Mountains Agricultural Development Project (UMADEP), Uluguru Mountains Biodiversity Conservation Project (UMBCP) and the Uluguru Mountains Environment Management and Conservation Project (UMEMCP). UMADEP has been working in the Western (Mgeta division) and Eastern (Mkuyuni division) Uluguru Mountains since 1993, involving small-scale farmers in land conservation and Income Generating Activities (IGAs). The project expanded its geographical coverage to include Matombo

division (East Uluguru Mountains) in 2002. While land conservation practices aim directly at conservation, IGAs also contribute indirectly to land conservation as they reduce pressure on the natural resources. The best example is the introduction of pineapples' contour farming. While the practice increases farmers' income dramatically, it also contributes to land conservation as the practice maximizes the use of farmlands (many pineapples can be grown in a relatively small area) and hence reduces clearance of forestland for agricultural expansion. The practice also reduces soil erosion.

2.5 Agricultural Production Options in East Uluguru Mountains

2.5.1 Crop production

The climatic condition in East Uluguru Mountains allows production of a wide range of tropical and sub-tropical crops such as bananas and plantains, pineapples and citrus fruit trees. Other crops include coconut, coffee, cocoa, and spices such as black pepper, cinnamon and ginger, which constitute cash crops of the area. Maize and upland rice are mainly food crops. Coffee was an important cash crop in the past, but because of marketing problems, the crop is currently less important. Except for vegetable production that involves use of industrial pesticides, crop production in the area does not use agrochemicals. Vegetable production in the area is practiced in very small scale mainly for home consumption. Few cases of vegetable selling are evident in the area. In this regard tomatoes and leafy vegetables like amaranthus and night shade are the commonly sold vegetables.

Most farmers in the study area practice mixed cropping. Under this system, more than two crops are grown on the same plot, without any systematic arrangement in rows. However, various mixing ratios are used, depending on the choice of the farmer. Where mixed cropping was found, it was common that the mixture included a woody crop, for example, where planted cassava, maize and legumes or banana, citrus fruits like oranges and/or spices were grown on the same plot. Mixed cropping is preferred as it saves time, and results in more efficient land utilization (Masawe, 1992).

2.5.1.1 Banana production

Banana is the most commonly produced cash crop in the area. Banana production under traditional practice involves clearing of land and digging random pits at a spacing of about 5m between the pits and 5m between the rows. After crop establishment no activity is done other than weeding and harvesting. Under this practice a relatively virgin land produces bunches of banana of up to 35 kg each. After about four years bunches produced may be less than 10 kg each. Banana will have developed large colonies of up to 20 plants per stool. During this time banana fields can no longer be managed easily and production becomes low compared to the labour and time investment. Subsequently look for another virgin land and open up a new field. Yield decline under traditional practices are due to deterioration of soil fertility which is caused by stools of banana growing on the same places and left to develop large colonies of plant without nutrient supplement (UMADEP, 2001).

Recently, UMADEP has promoted new practices to intervene on problems related to traditional banana production. According to UMADEP (2001), the practices involve contouring across the mountain in very steep land to control soil erosion and digging recommended sizes of holes in appropriate spacing. The practice involves also improved management practices like pruning of suckers to minimize mutual shading and nutrient competition between and within stools (UMADEP, 2001). UMADEP (2001) reports further that after project's intervention, these farmers now plant 350-400 banana suckers per acre. These are systematically thinned leaving three suckers in each hole. They harvest an average of 350-1000 banana bunches per acre per year, each weighing between 20-50 kg. The innovative farmers are earning from Tshs 0.35 million to Tshs 1.5 million per acre per year.

2.5.1.2 Pineapple production

In the East Uluguru Mountains pineapples are normally grown in pure stands, especially on steep land (Masawe, 1992; UMADEP, 2001). Pineapple plants in a traditional field are scattered at a spacing of about 1m between plants. According to UMADEP (2001), the reason behind that practice as advanced by farmers was to give enough space for plants to produce for many seasons (at least five) before the field becomes non – productive. They believed that closer spacing for pineapple could not give good yields. Experience from that practice shows that after three or four season pineapple yields drop tremendously from 3kg per fruit to about 0.5 kg. Pruning is traditionally not practiced. Traditionally managed pineapple fields look like fallow fields. Assessment of that practice indicated that the yield drop is due to declined soil fertility, poor field management such as lack of weeding and desuckering and lack use of fertilizer or manure (UMADEP, 2001).

In 2000, UMADEP introduced contour strip planting pineapple production in Matombo division. This practice involves spacing pineapple suckers in two lines of about 20 by 30 centimeters with in and between lines respectively or 30 by 45 centimeters within and between lines respectively. According to UMADEP (2001), this practice allows progressive terraces which control soil and fertility loss form fields, improving working condition and field maintenance by providing wider space between raw. Moreover, the practice allows application of organic manure, mulching and intercropping with legume plants. With contour strip cropping farmers can plant between 7 000 and 10000 pineapple suckers per acre and harvest 5 000 pineapples per year as opposed to the traditional practice of planting at random between 1 500 and 3 000 suckers per acre and harvesting 10 000 pineapples per acre per year (UMADEP, 2006). By end of 2004 contour strip cropping using pineapples had been adopted by only 89 farmers in Matombo division (UMADEP, 2006).

2.5.1.3 Rice production

Common type of rice in Matombo is upland rice. Upland rice varieties are grown without irrigation in unsaturated soils and is considered to be drought tolerant. Farmers usually treat upland rice as a subsistence crop, investing little in inputs beyond family labor (Atlin *et al*., 2005).

Yield potential of upland rice is quite low and invariably this crop is subjected to many environmental stresses. Although upland rice yields are relatively low as compared to lowland rice, it will continue to be an important crop in its growing regions due to the low cost of production and lack of irrigation facilities to grow

lowland rice (Fagaria *et al.,* 2003). Further, when upland rice is grown in monoculture for more than two to three years on the same land, allelopathy or autotoxicity is frequently reported. Allelopathy involves complex plant and plant chemical interactions. Adopting suitable management strategies in crop rotation can reduce or eliminate allelochemicals phytotoxicity (Fagaria *et al.*, 2003).

Upland rice production in East Uluguru Mountains is practiced on the hilly slopes mainly for home consumption. Mbwaga *et al.* (2002) contend that few farmers in Matombo produce sufficient rice for sale in addition to household consumption. Each growing season the rice plots are prepared by clearing and burning the vegetation cover. With this practice there is continuous decrease in soil fertility and hence declining crop yields which in turn prompts farmers to encroach the forest reserve in search for virgin land. According to Mbwaga *et al.* (2002), more than 50% of the original forest cover of the Ulugurus has been lost, largely to expansion of agriculture particularly for rice cultivation.

2.5.1.4 Maize production

Maize is the main staple and is grown as pure stand or mixed with many crops. Crop performance and yields are significantly influenced by the amount of rainfall. As a result of inherent soil moisture deficits, the period of cropping is limited to the rainy season. Intercropping is a very common farming practice as it minimizes the risks of crop failure owing to unexpected soil moisture deficits (Kayombo *et al.,* 1996). Even in good years the yields of maize on the Uluguru Mountains are extremely low when compared with yields in other regions like Ruvuma (Lyamuya *et al.*, 1994). The maize production practice in East Uluguru Mountains do not guarantee sustained high yields

because it involves no fertility improvement measures. Moreover, it involves shifting from one area to another seeking for naturally fertile lands. According to Mbwaga *et al.* (2002), as cereal yields have fallen in the Uluguru Mountains so farmers have exploited higher wooded slopes which have thin soils leading to serious erosion in the area.

2.5.1.5 Cassava production

Cassava is an important crop in East Uluguru Mountains due to being both a staple food crop and a cash crop. The crop is sometimes found in pure stands, intercropped or mixed with bananas, cocoyams or pineapples. Mixing and intercropping is preferred as it saves time, and result in more efficient land utilisation. Intercropping also helps in reducing heavy run off caused by the heavy rainfall and the steep slopes. According to Masawe (1992), the large canopy provided by cocoyams inhibits weed growth, such that weeding is done only once, during the early stages of establishment.

2.5.2 Livestock production

Besides cash and food supply, livestock production in Uluguru Mountains accounts for manure production and hence supply of plant nutrients that are necessary for sustaining crop production. Traditionally, in East Uluguru Mountains droppings from animals were swept and thrown away, but with UMADEP interventions, some farmers build shelters for goats, sheep and poultry and use the droppings to fertilize their banana fields, vegetable production and for raising tree seedlings (CARE, 2005).

2.5.2.1 Goats production

Goats are primarily owned by smallholder farmers and pastoralists and contribute significantly to the economy and food supply of the poorest sectors of the society. However, goat production in East Africa is characterized by low productivity levels in terms of growth rate, meat production and reproductive performance due mainly to nutritional constraints. Many factors contribute to such low productivity levels. However, poor nutrition is the most important factor (Adugna *et al.*,2000). The quantity and quality of fodder available from natural pasture shows seasonal fluctuation. There is an acute shortage of feed supply during the dry season and the available feed during this period is of very poor quality. Poor nutrition results in low production and reproductive performance, slow growth rate, loss of body condition and increased susceptibility to diseases and parasites.

In Uluguru Mountains livestock keeping is not a common practice due to land scarcity, culture and lack of technology of zero grazing (Gudrun, 2000). The major feeding system was tethering goats to eat a large variety of naturally occurring grasses, herbs, shrubs and trees and crop residues in fields after harvesting. Effective utilization of the available feed resources (agricultural and agro-industrial by-products and natural pastures) and appropriate supplementation of poor quality natural pasture and crop residue based diets appear to be the necessary steps to alleviate the nutritional problems of goats in the area (Adugna *et al.*, 2000).

2.5.2.1 Poultry production

Poultry production in most tropical countries is based mainly on scavenging production systems. It has been estimated that 80% of the poultry population in

Africa is found in traditional scavenging systems (Gueye, 1998; Gueye 2000). Women and children are generally in charge of poultry husbandry. The birds scavenge in the vicinity of the homestead during daytime where they may be given sorghum, millet, maize bran, broken grains, or other waste products as supplementary feed.

In East Uluguru Mountains poultry is the most common form of livestock for poorer households and women (CARE, 2005). Droppings from the local chickens kept by the farmers are used to supply plants nutrients in vegetable and banana fields. Sometimes the droppings are mixed with wastes from kitchens and home compounds to make compost for crop fields fertility maintenance.

2.6 Economic Factors Influencing the Production Options

2.6.1 Labour requirement

Labour is one of the most important factors affecting the small farmer production process, especially when we consider the fact that the small scale agricultural production in developing countries is labour intensive (Masawe, 1992). Since most farmers are fundamentally still subsistence-oriented, they usually depend on family labour to perform farm work. Labour is needed for applying yield-increasing inputs (chemical and organic fertilizers), for reducing crop competition (weeding), and for controlling yield losses (pest and disease control). In addition, labour is required for physical soil conservation activities (Ruben and Lee, 2000). Physical soil conservation measures include making contours for pineapple and banana production which improves nutrient uptake and water retention. When more organic sources of

nutrients (animal manure, green manure, compost) are used, input applications and crop management practices tend to become more labour intensive.

Farmers' decisions on crop choice and land management critically depend on availability of labour. According to Ruerd *et al.* (2006), increasing labour intensity of the cropping process can only be expected when returns to labour increase as well. There is excess of labour during most of the year. This kind of seasonal unemployment is common in the rural areas due to the fact that there is only one crop per year, and also the fact that farmers lack enough income generating activities to keep themselves busy during the off-season periods. During such periods, some farmers are involved in non agricultural activities like trading, but their number is limited (Masawe, 1992).

2.6.2 Capital

The need of cash income is growing. Farmers need to raise some money to pay for various services like child education (Masawe, 1992). This can be achieved through growing some cash earning crops like banana, cassava, pineapple and oranges. Lack of capital, markets and in particular, lack of formal credit opportunities is often highlighted as a serious constraint to investment in new technology (Schechambo *et al.*, 1999). Gill and Luckert (1995) in their study reported that, wealthier farmers adopted tree planting more than the poor smallholder farmers, because they could withstand the long investment needed (in most cases 5 – 7 years). It is therefore logical to contend that capital has an important contribution to the choice of husbandry practice for particular production option.

2.6.3 Off-farm income generating activities

Off income generating activities is one among several other livelihood strategies employed by most smallholder farmers in Africa. This strategy is used either to buffer any risk that might happen from agricultural production and/or to supplement the decreased income from farming (Chul-Woo *et al.,* 2006). It is apparent that off-farm income smoothes the path of total income for farmers. Mishra and Sandretto (2001) found that off-farm income has served to lower total variability in farm household income, even though farm income itself has not fallen in variability. Carriker *et al*. (1993) found that the marginal propensity to consume out of no farm income was larger than the marginal propensity to consume out of farm income, consistent with a potential role of off-farm income as a short-term supplement to farm income necessary to smooth commodity consumption streams. In situations where smallholder farmers have opportunities for earning off-farm income, it has been shown that farmers, no longer depend on their land to meet immediate subsistence needs (Carriker *et al.,* 1993).

2.6.4 Land

Land is very scarce in East Uluguru Mountains, due to the high population density and the mountainous nature of the land. Land is very steep and normally inherited from ancestors (Masawe, 1992). Increase in population has made it necessary for villagers to look for land in distant places and also the need to look for different types of soil to suit the different crops grown. For example, whereas pineapples grow on well-drained soil, rice grows on dry steep slope soil. This situation leads to less

protection of given crops against wild animals and birds, since farmers stay far away from their farms. Also not much attention is given to the farm in applying fertilizers and insecticides which lead to poor yield (Masawe, 1992).

2.6.5 Farm size

Farm size can influence farmer's decision on production option and husbandry practice to implement. For example, Tenge *et al.* (2004) contend that scattered fields contribute to the low adoption of improved soil and water conservation measures measures, as farmers have to decide where to invest first, depending on walking distance, labour requirements for fertilizer transport and production objectives. Tenge *et al.* (2004) observe further that some farmers are reluctant to implement soil and water conservation measures such as terraces and *fanya juu* out of fear that their small fields will be further reduced by these measures.

2.7 Social Factors Influencing Production Options

2.7.1 Cultural values and beliefs

People's knowledge and understanding of things are influenced by their culture (Steel, 1995). This means that, an innovation should be compatible with the cultural values and beliefs of the social group in which it is proposed in order for it to be well understood. However, it is also important to note that, household decisions concerning various aspects of culture and behaviour are not static but they are expected to evolve with technological change and changing opportunity and social norms (Pareena *et al.*, 1999). For example, the Uluguru Land Use Scheme (ULUS) failed to impose bench terraces in favor of the local practices of making ladder

terraces in the 1950s, because local people found the introduced practice is against their tradition and beliefs (Reij, 1995).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Conceptual Framework

Framework can bind facts together and hence provide guidance towards realistic collection of information (Mbwambo, 2000). This section provides a conceptual framework on agricultural production options and natural resource base management (Figure 1). Food production and the livelihoods of people depend upon the natural resource base. People do engage in particular production activity by using different available options aiming at profit maximization and in most cases the sustainability of activities. In their search for profitability, farmers tend to intensify the production activities and in most cases at the expense of the natural resource base, i.e. hardly do they manage to ensure profitability and natural resource base conservation simultaneously. Extent of resource exploitation is determined by various factors. Such are type of production option (crop/livestock type) and husbandry practice in relation to type of land terrain in question. Production option which is profitable but requiring comparatively bigger farm size is likely to prompt farmers to encroach into the forest reserve to seek more land. Hence, search for profitability could threaten the natural resource base. Husbandry practice which leaves the steep land bare and/or do not involve soil and water conservation measure(s) will ultimately overexploit the natural resource base.

Socio-economic factors will influence farmers' degree in engaging in particular production option. Socially acceptable practices may be implemented regardless of the kind of impact they may have on natural resource base. Income and education will influence adoption of improved practices. Income for instance may influence a shift from labour to capital intensive farming practices.

On one hand activities related to available production options will influence natural resource management. On the other hand natural resource base status will influence profitability from production options. It is possible to earn short-term profit from various production options without conserving the natural resource base. However, particular production option will earn sustainable profit if the natural resource base is sustained. While it is challenging to earn profit and ensure natural resource base management simultaneously, it is possible to locate crop type and variety, livestock type and breed along the spatial micro-climate based on the nature of land terrain, access to market and husbandry practices and increase production without straining the natural resource base.

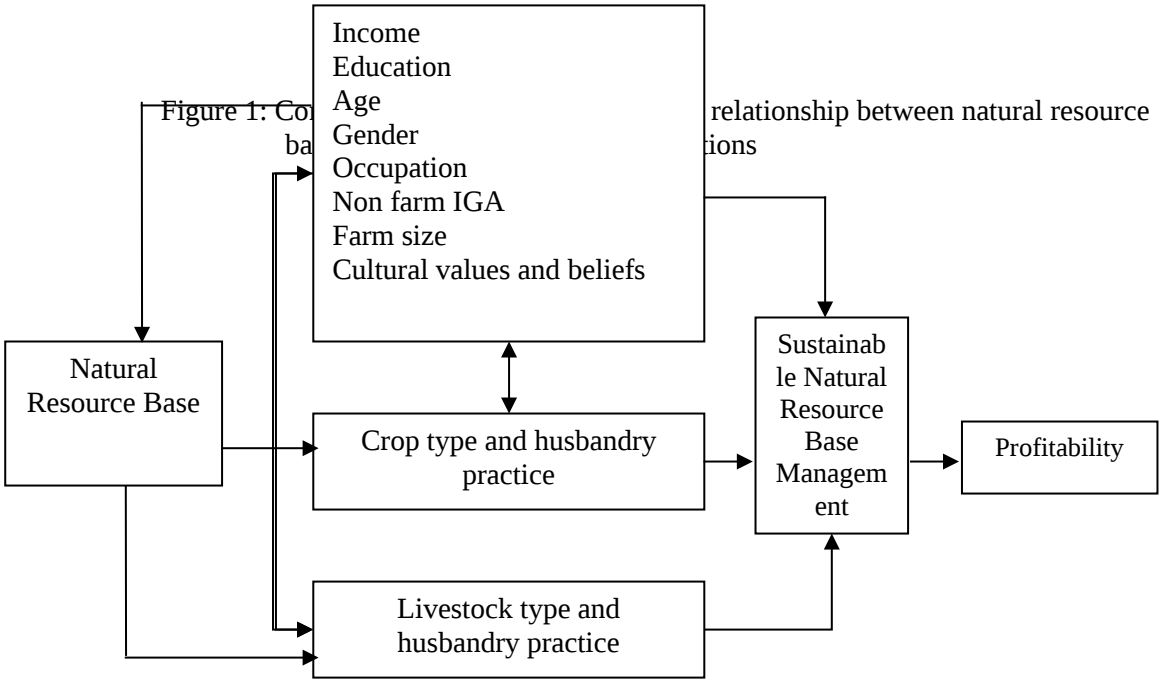

Figure 1: Co relationship between natural resource ba ions

3.2. Location of the Study Area

The Uluguru Mountains are located in eastern Tanzania, Africa. They rise steeply from the dry coastal plain to an altitude of 2 600 m. a. s. l. The Uluguru range is approximately 100 km long by 20 km wide and is isolated from other mountains by tracts of lowland savanna woodland (African Conservation, 2006).

The study was conducted in the East Uluguru Mountains. Specifically, Matombo division has been selected to represent the study area. Matombo division lies on the eastern slopes of the Uluguru Mountains, about 100 km south of Morogoro town. The altitude ranges between 400 m. a. s. l. and over 1 000 m. a. s. l, at the top of the forest reserve (African Conservation, 2006).

The area's climate is generally tropical humid at lower altitudes and subtropical at higher altitudes. The Uluguru Mountains capture moisture passing inland from the Indian Ocean and the east facing slopes are especially wet, with rainfall estimated at over 3 000 mm per annum, with some rain falling in every month which is favourable for cultivation of various crops and for livestock keeping. Matombo division is one of the areas in the Uluguru Mountains that have being under intensive agriculture and as Lyamuya *et al.* (1994) point out subjected to various forms of land, forest, wildlife and water resource degradation. Selection of this area for the study was therefore based on this fact.

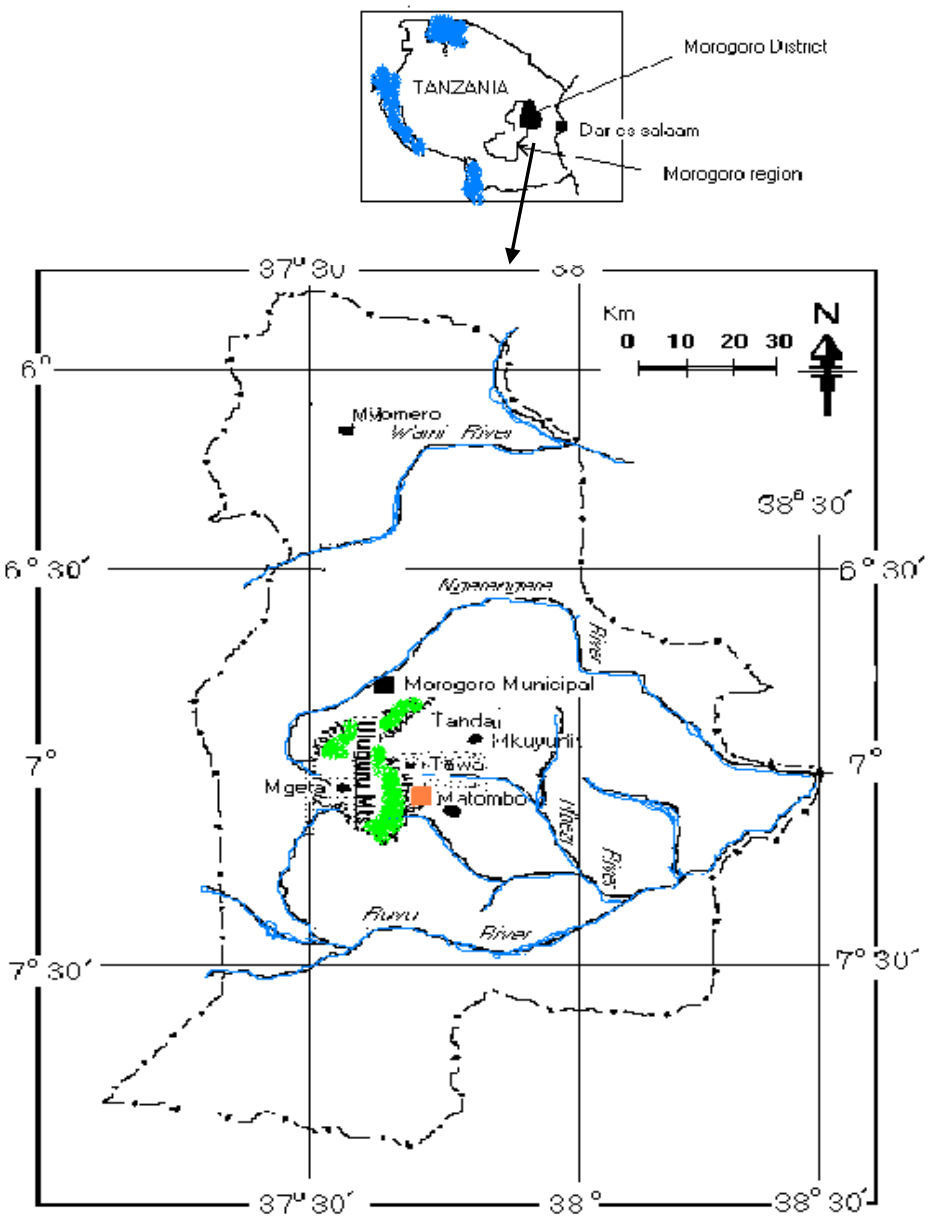

Figure 2: Map of Morogoro district showing the study area

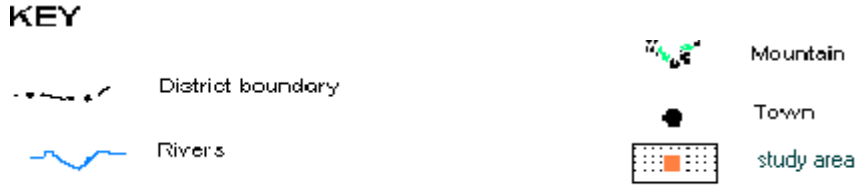

Figure 2: Map of Morogoro district showing the study area

3.3 Research Design

A cross-sectional research design was applied in this study. This design allows data on different groups of respondents to be collected at a single point in time. The design is useful for description purposes as well as for the determination of relationship between and among variables.

3.4 Sampling And Sample Size

The target population for this study was small holder farmers from selected villages, extension officers from selected wards and district as well as NGOs' staffs working in the selected ward. Three villages namely Konde, Tawa and Kiswila, were purposively selected to represent differences in altitude and degree of accessibility to the market. Konde is in higher altitude or steeper and located relatively far from the market, Tawa is at the middle altitude or moderate slope and is within the market place and Kiswila is at low altitude and far from the market place. About 120 Respondents that is 40 farmers from each village, 4 NGOs' staffs and 2 extension officers were randomly selected through a table of random numbers so as to allow the use of statistical inference tests and thus avoiding conscious and unconscious biases in selection of the respondents.

3.5 Data Collection

Primary data were collected using a structured questionnaire (Appendix 1) and checklist of questions (Appendix 2). The questionnaires were administered to farmers and checklist of questions was used to collect information from the district extension officers and the NGOs staff. Secondary data were collected from

institutions such as Sokoine University of Agriculture, Uluguru Mountains Biodiversity Conservation Project (UMBCP) and Morogoro rural District Agriculture and Livestock Office (DALDO). Internet was also used in this regard.

3.6 Data Analysis

Three main methods of data analysis were adopted

3.6.1 Descriptive statistics

After data collection, the information were coded and entered into the Statistical Package for Social Science (SPSS) version 11.5 computer programme. Descriptive statistics such as frequency distribution, means, and percentage and cross tabulation were used for objectives number 1 and 2 whereby information about type and characteristics of NR base related to small holder agriculture together with agricultural production options existing in east Uluguru Mountains were obtained. Cross tabulation was used to establish the relationship between crops and livestock production options.

3.6.2 Gross margin

Gross margin was employed for tracking profitability per hectare basis, as a return to labour based on number of days worked. The calculated gross margin was based for six different crops which includes maize, rice, banana, pineapple, cassava and cloves and three livestock which were goats, pigs and poultry. Gross margin formula given by;

$GM = TR_i - TVC_i$

Where;

GM = Gross margin ha^{-1}, labour,$^{-1}$

TR = Total revenue ha^{-1}, labour,$^{-1}$

TVC = Total variable costs ha^{-1}, i = i^{th} crop

3.6.3 Multi-Criteria Analysis (MCA)

3.6.3.1 Generation of criteria

Multicriteria analysis (MCA) was used to establish acceptable from unacceptable possibilities in relation to a particular agricultural option on the NR base for objective number three. Matrix ranking method (Van Veldhuizen *et al.,* 1997; Defoer and Ticheler, 2000) was adopted initially in analysis production options giving scores to each criterion on the scale of 1 for very poor and 5 for very good. Options with the highest total score were listed for integration in decision support tool.

Farmers determined relative importance of each criterion by pair wise ranking method, farmers were facilitated by researchers to judge each criterion as more important than another while giving reasons for their judgments. The information of farmers' ranking was expressed as weights, which is the ratio of the total scores for individual criterion on the overall scores for all criteria. Each alternative was then reassessed against the weighted criteria scores. The option with the highest total weighted scores was selected.

Major land user groups considered in this study were:

Group 1: Farmers who have plot(s) in high altitude of the mountain land

Group 2: Farmers who have plot(s) in medium altitude of the mountain land

Group 3: Farmers who have plot(s) in low altitude of the mountain

Best crop options that could be grown in the Uluguru Mountains were subjected to the financial analysis in order to assist farmers in deciding the acceptable levels for economics. Based on the above steps and the results obtained, a decision support tool (DST) based on MCA (example see Nijkamp *et al.*, 1990) was developed. Important steps in the application of the DST are hereunder described:

3.6.3.2 The Decision Support Tool (DST)

The decision support tool for selection of best agricultural option and the respective NR base management technologies in response to market has three main components, namely data requirements, data processing and the outputs (Nijkamp *et al.*, 1990).

i. Data requirement

The basic data required include farming objectives of each land user, available alternatives to achieve the objective, evaluation criteria and the impact of each alternative to the evaluation criteria

ii. Data processing

This includes standardization of the impact, formulation of weights and aggregation and ranking.

a) Standardization of the impacts

The score of all criteria have to be expressed in the same unit of measurements in order to eliminate the influence of different dimensions in which each criterion is expressed. Such transformation process to the same unit is called standardization.

This is done by dividing scores for each criterion to the highest scores of the same criterion for all alternatives as simplified by equation 1 (Voogd, 1985; de Graaff *et al*., 2001)

$e_{ji} = S_{ji} / \max S_j$ ……. (1)

Where

e=Standardised criterion

i=Alternatives I (Crop varieties/acre)

J=Criterion j

s=Unstandardized score

Max S_j=Highest score of criterion j

Equation 1 implies that the criterion with the highest unstandardised score has always the standardized score of 1. If a criterion has a negative effect, the standardized score is obtained as $(1- e_{ji})$

b) Formulation of weights

Different criteria usually have different levels of importance to each. It is therefore necessary to incorporate some form of criteria weighting to take care of their relative importance. These weights can be established directly by interviewing people concerned or actual behaviour in the past (Nijkamp *et al*., 1990; de Graaff, 1996). In this research the weights were obtained by interviewing and pair wise ranking by farmers in the research area.

c) Aggregation and ranking

The next step after formulation of the weights involves combining the weighted scores for each alternatives using the additive weighting method (equation.2) In this method the score for each alternative is obtained as the product of weight of each criterion and the standardized score of the criterion for the particular alternative. The total weighted scores are then arranged according to the size. The alternative with the highest value of the total scores (P_i) is the best alternative or crops.

$$Pi = \sum_{j=1}^{j} wj * eji \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where;

Pi = score of alternatives/crop i

wj = weight to criterion j

e_{ji} = standardized score of criterion j for alternatives I or crop

3.7 Limitation of the Study Methodology

MCA in this study used qualitative scales (example ordinal ranking of alternatives on criteria), where quantitative (or cardinal) scales could have been used and would have shown more exactly differences. That constitutes a loss of information. And as already stated in MCA methods it is difficult to incorporate the time dimension. On the other hand when subjective elements have not been indicated or when it is suggested that effects can be determined with great certainty or high mathematical schooling is required for a good insight in MCA methods, then application of MCA methods can easily lead to manipulation. The aspects of MCA methods have therefore to be clear to all the interested parties. Gross margin does not take into account of other cost such as fixed cost and can vary from time to time due to differences in market prices.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Sample Characteristics

Sample characteristics include age, marital status, level of education, family size and household land acquisition (Table 1). For this study the household is considered to be composed by people who eat and sleep in the same house (Ruheza, 2003). Results show that, age range considerably from 23 years to a maximum of 74 years with mean age of 45 years. The mean age indicate that most of the respondents belong to the productive group. The majority of the respondents (55%) were in 18 – 45 age group categories while 24% of the respondents belonged to 46 – 55 age category and 21% of the respondents were aged above 55 years. This implies that, there are a high proportion of adults in the community who mainly make up the community workforce. The fact that 21% of the respondents are above 55 years old suggesting high life expectancy (Table 1). Results further shows that, the majority of the respondents (84.5%) are married, suggesting stable society with household responsibilities which can concentrate more on production and thus may influence efficiency in production.

Level of basic education in the study area is relatively high. Out of 120 respondents, 66.7% had attained primary education, 11.6% had adult education, 5.8% had secondary education and 15.8 % of the respondents had no formal education. This implies that large percent of the respondents are relative literate. In identifying occupation of the respondents, most of the respondents 82% were depending on farming as a major livelihood source. An average of 10% of the respondents

depended on farming and casual labour, while only 8% of the respondents depended on both farming and small business (Table 1). This implies that, agriculture is the main economic activity in the study area and contributes significantly to the livelihood security of the people. Availability of non-farm income is an indicator of access to financial capital and has a positive influence on investment in SWC. Financial capital is mainly used to pay for additional labour when investing in SWC (AGREN, 2000).

Table 1: Distribution of the respondents by sample characteristics

Variable	Description	Village (%)			Total
		Konde	Kiswila	Tawa	Percent
Age	18-45 years	18(45)	27(67.5)	21(52.5)	66(55)
	46-55 years	14(35)	5(12.5)	10(25)	29(24)
	Above 55 years	8(20)	8(20)	9(22.5)	25(20.8)
Marital status	Single	1(2.5)	2(5)	4(10)	7(5.8)
	Married	33(82.5)	34(85)	34(85)	101(84.2)
	Divorced	4(10)	1(2.5)	0(0)	5(4.2)
	Widow	2(5)	3(7.5)	2(5)	7(5.8)
Education level	No formal	8(20)	5(12.5)	6(15)	19(15.8)
	Adult education	5(12.5)	6(15)	3(7.5)	14(11.6)
	Primary education	27(67.5)	27(67.5)	26(65)	80(66.7)
	Secondary education	0(0)	2(5)	5(12.5)	7(5.8)
Occupation	Farming	33(82.5)	32(80)	33(82.5)	98 (82)
	Faming and Casual labour	5(12.5)	4(10)	3(7.5)	12(10)
	Farming and small business	2(5)	4(10)	4(10)	10(8)
Household size	Small size 1-3 people	15(37.5)	7(17.5)	6(15)	28(23)
	Medium size 4-6 people	19(47.5)	28(70)	24(60)	71(59.2)
	Large size ≥ 7 people	6(15)	5(12.5)	10(25)	21(17.5)
Acquiring plots	Buying	14(35)	10(25)	10(25)	34(28.3)
	Given by mission	0(0.0)	6(15)	0(0)	6(5)
	Inheritance	25(62.5)	21(52.5)	22(55)	68(56.7)
	Rent in kind	1(2.5)	4(10)	6(15)	11(9.2)

Note: Figures in parentheses are percentages

Family size per household is important in determining the levels of production and consumption in a family. Family size is used to determine the available labour for farm work basing on the extent of contribution of each in farm work (Senkondo,

1992). However family size alone without its composition can give wrong indication of household labour available. Results show that, household size of the respondents ranged between 1 and 13 members with the average household size of 5 members. The majority of the households 59.2% had medium family size of 4 – 6 members; while 23% of the households had small family size of 1-3 members and 17.5% of the respondents had large family size of 7 and above members (Table 1).

In acquiring plot, results shows that about 57%, 28%, 92% and 5% of the respondents obtained land through inheritance, buying, rent in and given by a mission respectively (Table 1). This implies that there were decreases in the clan farmland that could be passed on to sons. Due to increase in the number of immigrants and commercialization in Matombo, land has become a commodity that can be sold. Land tenure determines the type of farming system and farmers' ability to invest in natural resource management measures (Hella, 2003). As Farmers in Uluguru Mountains depend more in renting farm for production of crops, lack of long term investment and little conservation effort is likely to be expected.

4.2 Natural Resources Related to Agriculture

Among the NRs that are related to agriculture, land was observed to be much better known by 82.5% followed by water 58% and forestry 43% (Figure 3). From these results we can say that, compared to others land is the most understood and considered to be the major natural resource that is related to agriculture in the study area. This is probably because the farming activities are undertaken directly on the land and that only few cases of irrigation practices exist. Thus, it is hard for farmers to track the relationship between water and forest to agriculture.

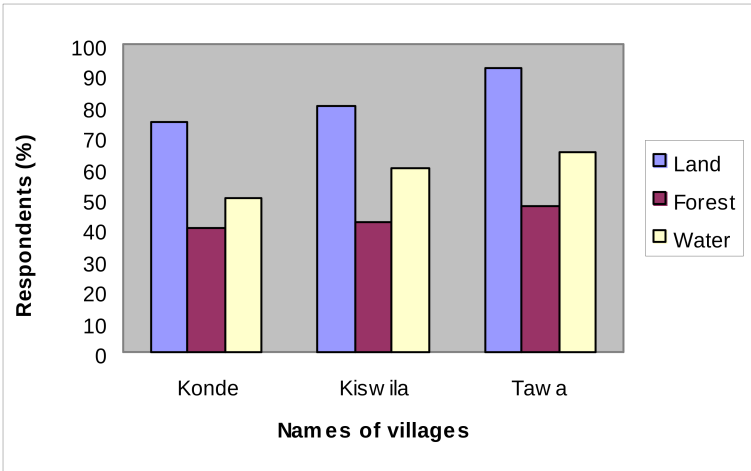

Figure 3: Natural resources base related to agriculture in the study area

4.3 Characteristics of Natural Resource Base Related to Agriculture

4.3.1 Farm size, crop types and husbandry practices

Farm size ranged from 1 acre to 2 acres in steep slope at Konde village which is in high altitude area. About 31.5% of the respondents plots were planted rice in mono cropping system, 17.5% were planted by banana in mono crop system, 7.5% of the respondents plots planted pineapple in mono crop system. Only 5% and 2.5% of the respondents' plots were planted by banana and maize respectively. While agro forestry was practiced in banana, mono crop system was adopted in maize production. For the case of moderate slope 19%, 10% and 2.5% of the respondents' plots were planted cloves, cassava and maize respectively. Agro forestry system was used in cloves and mono cropping system in cassava and maize. Gentle slope land were planted maize in mono crop system by only 5%. Farm size ranged from 3 acres to 4 acres, Konde village had a total of 7.5% of the respondents' plots which were in moderate slope whereby 5% and 2.5% of it were planted banana and rice in agro forestry and mono crop systems respectively.

Table 2: Distribution of respondents by characteristics of land

Variables	Particulars				Steep	Moderate	Gentle	Total
	Villages	acres	crops	Husbandry practices				
Types of crop and husbandry practices	Konde n=40	1-2	Banana	Agro forestry	7(17.5)	0(0)	0(0)	7(17.5)
			Pineapple	Mono cropping	3(7.5)	0(0)	0(0)	3(7.5)
			Rice	Mono cropping	15(31.5)	0(0)	0(0)	15(31.5)
			Maize	Mono cropping	0(0)	1(2.5)	2(5)	3(7.5)
			Cloves	Agro forestry	0(0)	6(19)	0(0)	6(19)
			Cassava	Mono cropping	0(0)	4(10)	0(0)	4(10)
		3-4	Banana	Agro forestry	2(5)	0(0)	0(0)	2(5)
			Rice	Mono cropping	1(2.5)	0(0)	0(0)	1(2.5)
	Kiswila N=40	1-2	Banana	Mono cropping	4(10)	4(10)	0(0)	8(40)
			Pineapple	Contouring	2(5)	5(12.5)	0(0)	7(17.5)
			Rice	Mono cropping	1(2.5)	0(0)	6(15)	7(17.5)
			Maize	Mono cropping	0(0)	6(15)	0(0)	6(15)
			Cloves	Agro forestry	0(0)	0(0)	2(5)	2(5)
			Cassava	Mono cropping	0(0)	0(0)	6(15)	6(15)
		3-4	Banana	Agro forestry	0(0)	2(5)	0(0)	2(5)
			Pineapple	Mono cropping	0(0)	1(2.5)	0(0)	1(2.5)
	Tawa n=40	1-2	Banana	Agro forestry	4(10)	5(12.5)	0(0)	9(22.5)
			Pineapple	Contouring	3(7.5)	3(7.5)	0(0)	6(15)
			Rice	Mono cropping	5(12.5)	2(5)	0(0)	7(17.5)
			Maize	Mono cropping	0(0)	1(2.5)	2(5)	3(7.5)
			Cloves	Agro forestry	0(0)	1(2.5)	0(0)	1(2.5)
			Cassava	Mono cropping	1(2.5)	2(5)	0(0)	3(7.5)
		3-4	Banana	Agro forestry	2(5)	0(0)	0(0)	2(5)
			Pineapple	Mono cropping	2(5)	0(0)	0(0)	2(5)
			Rice	Mono cropping	2(5)	0(0)	0(0)	2(5)
			Cassava	Mono cropping	0(0)	2(5)	0(0)	2(5)
			Cloves	Agro forestry	0(0)	1(2.5)	0(0)	1(2.5)
		≥5	Banana	Agro forestry	1(2.5)	0(0)	0(0)	1(2.5)
			Pineapple	Mono cropping	1(2.5)	0(0)	0(0)	1(2.5)

Note: Figures in parentheses are percentages

Tawa village is within medium altitude area. Farm size ranged from 1 acre to 2 acres in steep slope land. About 12.5%, 10%, of the respondents plots were planted rice, banana, in a form of mono crop, agro forestry and 7.5% and 2.5% of the respondents

plots were planted pineapple and cassava in contour and mono crop systems respectively. In case of moderate slope, 12.5%, 7.5% and 5% of the respondents plots were planted banana, pineapple and rice in agro forestry, contour and mono crop systems respectively. About 2.5% of the respondents plots were occupied by cloves and maize independently in agro forestry and mono crop system respectively. Only 5% of the respondents were planted maize as a mono crop in a gentle slope land. For farm size ranged from 3-4 acres, banana, pineapple and rice were planted in a steep slope as mono crop plant with 5% each. In a moderate slope land only 2.5% of land were planted clove in an agro forestry system. Farm size ranged from 5 acres and above only banana and pineapple were planted in a steep land at 2.5% in mono crop system each.

Kiswila village is within gentle slope areas in Uluguru Mountain. Farm size ranged from 1 acre to 2 acres in steep slope. About 10% and 5% of the respondents' plots were plant banana, pineapple and rice in mono crop system each. Only 2.5% of respondents plots were planted pineapple in contour system. In case of moderate slope, 15%, 12.5% and 10%, of the respondents plots were planted maize, pineapple, banana in a mono crop, contour and mono crop system respectively. About 15% of the respondents plots were planted rice and cassava each in a mono crop system and 5% of the respondents were planted cloves as a mono crop in a gentle slope land. Farm size ranged from 3-4 acres, banana and pineapple were planted in a moderate slope as mono crop plant by 5% and 2.5% of the respondents each. In a moderate slope land only 2.5% of land were planted clove in an agro forestry system. From these results it indicates that farming activities which were practiced in these villages

does not conserve land and hence may lead to infertile soil and at the end low yield in a long run. Continuous cultivation on the gentle and steep slopes with little or no conservation measures made the soil loose and bare with little cover. These conditions accelerated soil erosion by water, even from low intensity rainfall (Shelukindo and Gaudens, 1993; Shenkalwa, 1989; Kimambo, 1991; Aune, 1994; Shelukindo, 1995).

4.3.2 Livestock type and its husbandry practices

Livestock keeping is another economic activity and one among other agricultural options in Uluguru Mountains. For Konde village, in a steep slope land 17% and 15% of the respondent use free range and tethering in keeping poultry and goat respectively. In a moderate slope land 25%, 20%, use free range system and semi intensive systems in keeping poultry while 10% and 7.5% use zero grazing and semi intensive respectively in keeping pigs and goats. In Tawa village, the only livestock kept on the steep slope is poultry. The adopted husbandry practice is free range system. This was reported by 7.5% of the respondents. In moderate slope 25% and 17.5% of the respondents kept poultry in free range and semi intensive systems respectively. 10% and 7.5% of the respondents kept pigs and goats in zero grazing and tethering systems respectively. In Kiswila village, 27.5% and 10% of the respondents kept goats and poultry in semi intensive and free range system respectively in moderate slope land while 27.5%, 20%, 12.5% and 10% of the respondents kept goats in semi intensive system, poultry in semi intensive system, pigs in zero grazing and poultry in free range system respectively (Table 3). Most of the respondents were using methods which were not environmentally friendly. Thus

the need for integration of livestock in soil and water conservation (SWC) serves important food provisioning roles which should not be ignored. However the problem limiting indoor keeping is availability of food for livestock.

Table 3: Distribution of the respondents by livestock characteristics

Variables	Villages	Pariculars		Steep	Moderate	Gentle	Total
		Livestock type	Husbandry practices				
Types of livestock and its husbandry practices	Konde	Poultry	Free range	7(17.5)	10(25)	3(7.5)	20(50)
			Semi intensive	0(0)	8(20)	0(0)	8(20)
		Goat	Tethering	6(15)	0(0)	0(0)	6(15)
			Semi intensive	0(0)	3(7.5)	0(0)	3(7.5)
		Pig	Zero grazing	0(0)	4(10)	0(0)	4(10)
	Kiswila	Poultry	Free range	0(0)	4(10)	0(0)	4(10)
			Semi intensive	0(0)	0(0)	8(20)	8(20)
		Goat	Tethering	0(0)	0(0)	0(0)	0(0)
			Semi intensive	0(0)	11(27.5)	0(0)	11(27.5)
		Pig	Zero grazing	0(0)	0(0)	5(12.5)	5(12.5)
	Tawa	Poultry	Free range	3(7.5)	10(25)	0(0)	10(32.5)
			Semi intensive	0(0)	7(17.5)	0(0)	10(17.5)
		Goat	Tethering	0(0)	3(7.5)	0(0)	3(7.5)
			Semi intensive	0(0)	0(0)	2(5)	2(5)
		Pig	Zero grazing	0(0)	4(10)	3(7.5)	7(17.5)

Note: Figures in parentheses are percentages

Disposal of manure was also given consideration. About 55% of the respondents used the wastes for applying in their farmland. About 14 % of the respondents don’t use it while only 5% sell them to other farmers. It was further observed that for those who applied the wastes to their fields, almost 46% of the respondents applied it in vegetables production. Vegetables such as amaranthus, tomatoes, sweet peppers, Chinese cabbage and cabbage were being produced using the wastes. 22.5% were using the wastes for banana production (Figure 4).

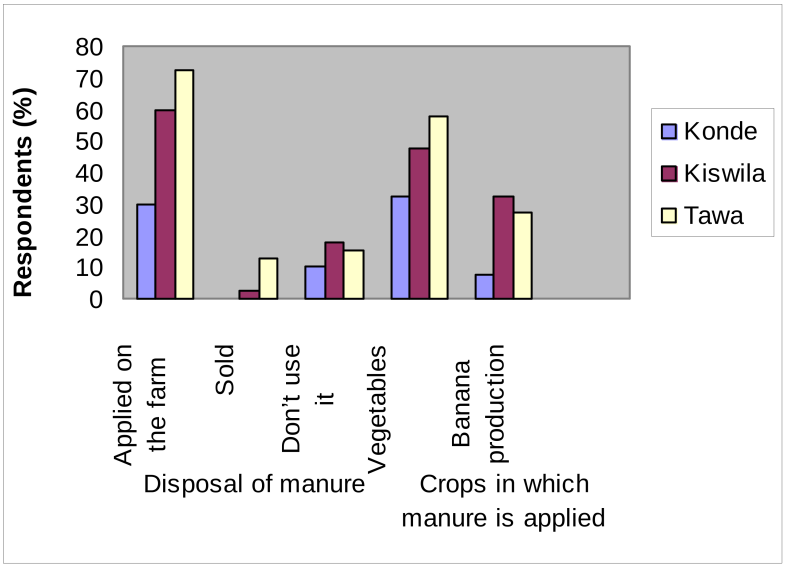

Figure 4: Disposal of manure and crops in which it is applied in the study area

The main problems faced by farmers in livestock keeping include pests and diseases as reputed by 59% of the respondents; lack of drugs with in the area by 5%, lack of extension services and lack of appropriate feed for the livestock as reputed by 2.5% and 2% respondents respectively (Figure 5). In most cases they depend on grasses for feeding animals which is not enough for good health. As a result, poor growth and diseases have continued to prevail. This problem is exacerbated by the fact that the livestock are always saved in dirty areas.

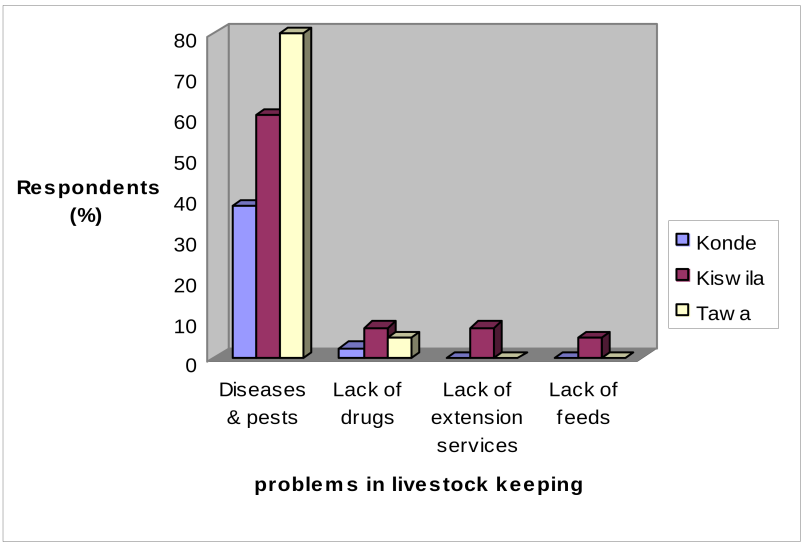

Figure 5: Problems of livestock keeping in the study area

4.3.3 Characteristics of forestry and water

From the results, about 37.5% of the respondents said the forest contains black soils and tall thick and short trees. Deforestation was a negative factor that was mentioned by 34% of the respondents as being caused by lumbering activity. About 81% said deforestation was caused by cutting trees for firewood and building materials of their houses by 13.5% and 33 % respectively. Further results show that hunting method like setting fire was another cause of forest destruction and this was said by 22.5% on average. This shows that t people in East Uluguru Mountain depend on forest for their basic needs. Another activity that was not mentioned but thought to be among other factors contributing to land degradation in the study area is the use of fire for land preparation (Table 4)

In forest management tree planting was leading in Tawa then Kiswila and Konde village by 60%, 40% and 10% respectively. Avoiding cutting trees was reported by 22.5% of the respondents, then avoiding burning by 20%, education and environmental committee by 5% and abiding by the rules and laws by 3% on average. In all these results Tawa appeared to be much more responsive to management of forest as compared to other villages. Tree planting appear to be leading in this part as farmers are now planting new orange trees that mature in short time and it was within NGO motive. However, few respondents emphasized that farmers are not taking care of the natural resource in general. Avoiding cutting trees near water sources, burning trees and planting trees near water sources were mentioned as water management practices by farmers as was accounted for by 47%, 6% and 17.5% on average in Tawa, Kiswila and Konde villages respectively.

Table 4: Distribution of respondents by forest and water characteristics

Variable	Description	Konde	Kiswila	Tawa	Total
Forest characteristics	A lot of deforestation	9(22.5)	15(37.5)	17 (42.5)	41 (34.2)
	Thick tall and short trees	14(35.0)	10(25.0)	10 (25.0)	34 (28.3)
	Contain black soil	17(42.5)	15(37.5)	13 (32.5)	45 (37.5)
Conserving forest	Abiding by the rules and laws	4(10.0)	0(0.0)	0 (0.0)	4(3.3)
	Avoiding burning	1(2.5)	9(22.5)	14(35)	24(20.0)
	Avoiding cutting trees	7(17.5)	10(25.0)	10 (25.0)	27(22.5)
	Planting trees	10(25.0)	16(40.0)	24 (60.0)	50 (41.7)
Theuseof forest	Building material	2(5.0)	0(0.0)	2(5.0)	4 (3.3)
	Fire wood	27(67.5)	37(92.5)	33(82.5)	97 (80.8)
	Timber	5 (12.5)	4(10.0)	7(17.5)	16 (13.3)
Hunting method	By setting fires in the bush	12(30.0)	10(25.0)	5(12.5)	27 (22.5)
Water	Available throughout the year	15(37.5)	13(32.5)	20 (50.0)	48 (40.0)
	Seasonal shallow rivers	10(25.0)	9(22.5)	6 (15.0)	25 (20.8)
	Destroyed water sources	5(12.5)	12(30.0)	6 (15.0)	23 (19.2)
	Avoid cultivating near water sources	18 (45.0)	17(42.5)	21(52.5)	56(46.7)
	Avoid burning trees	5 (12.5)	1(2.5)	1(2.5)	7 (5.8)
	By planting trees near water sources	8(20.0)	5(12.5)	8(20.0)	2 (17.5)

Note: Figure in parentheses are percentages

Ahlback (1994), cited by Schechambo *et al.* (1999) is emphasizing techniques of motivating and mobilising the people of Tanzania for tree-planting at village level. The role of fruit trees in the farming system is exemplified by the case of East of Uluguru Mountains, based on interviews with farmers and direct field observations. Although fruit trees were found in almost every farm, fruit production is generally neglected. Orange fruit trees have diverse functions example trees close to the house mainly serve to produce fruits for home consumption and for sale whilst the major function of those planted in remote fields is to secure land tenure. Other important

functions include soil erosion control, capital saving after retirement and as heritage asset. Generally trees receive very little care and so the quality of fruits is usually poor. On the other hand, the market is unreliable and prices are low. In those villages water is available throughout the year as presented by 40% of the respondents. About 20% of the respondent admitted that they depend on seasonal water and this as presented by 19% of the respondents is caused of the water sources (Table 4).

4.4 Gross Margin Analysis

4.4.1 Farm gate price

Financial analysis results show that among the crops that are grown in East Uluguru Mountains, cassava is more profitable than the rest of the crops in Konde and Kiswila villages at farm gate price (Table 5). However, based on the negative impact of the crop on the NR base that is, high demand for land and management practice that require heavy tillage, promotion of the crop should be taken with care not to exacerbate NR base degradation. Pineapple is more profitable in Tawa village at farm gate price. Due to being quite effective in erosion control the crop can be promoted. Below is a presentation of the crop options, arranged in order of decreasing profitability at farm-gate price for each village.

i) Konde village (High altitude)

Cassava → banana → clove → pineapple → maize → rice

ii) Tawa village (Medium altitude)

Pineapple → cassava → banana → clove → maize → rice

iii) Kiswila village (Low altitude)

Cassava → banana → pineapple → clove → maize → rice

4.4.2 Market price

For the case of selling in market where Tawa is within the market area, Kiswila a bit far and Konde more distant from market the most profitable crop is banana for Konde village, maize for Kiswila village and cassava for Tawa village (Table 5). Below is a presentation of the crop options, arranged in order of decreasing profitability at market price for each village.

i) Konde village (High altitude)

Banana → clove → maize → cassava → pineapple → rice

ii) Tawa village (Medium altitude)

Cassava → maize → banana → pineapple → clove → rice

iii) Kiswila village (Low altitude)

Maize → banana → rice → pineapple → casava → clove

Table 5: Financial benefit of the six crops grown in Matombo division

Cost &benefit	Village	Slope (%)	Banana	Rice	Cassava	Pineapple	Clove	Maize
Variable cost (Tshs/ ha)	Konde	Steep (35-55)	137 000	39 000	18 000	10 680	28 000	48 000
	Kiswila	Gentle (2 -12)	14 500	68 000	22 000	28 045	12 000	50 000
	Tawa	Moderate (12-35)	150 000	62 000	28 000	125 000	10 000	42 000
Total revenue on farm (Tshs/ ha)	Konde	Steep (35-55)	332 038	46 000	360 000	45 000	83 125	73 000
	Kiswila	Gentle (2 -12)	310 833	88 500	455 000	153 750	38 000	80 000
	Tawa	Moderate (12-35)	288 750	79 000	325 000	550 000	42 000	63 000
Gross margin on farm	Konde	Steep (35-55)	235 250	7 000	342 000	34 320	55 125	25 000
(Tshs/ ha)	Kiswila	Gentle (2 -12)	253 090	20 000	433 000	125 705	26 000	30 000
	Tawa	Moderate (12-35)	177 413	17 000	297 000	425 000	32 000	21 000
Total revenue on market (Tshs/ ha)	Konde	Steep (35-55)	332 038	12 500	60 000	45 000	155 300	155 200
	Kiswila	Gentle (2 -12)	310 833	360 000	72 000	153 750	52 000	440 817
	Tawa	Moderate (12-35)	288 750	54 000	420 000	232 600	72 000	254 444
Gross margin on market	Konde	Steep (35-55)	195 038	26 500	42 000	34 320	127 300	107 200
(Tshs/ ha)	Kiswila	Gentle (2 -12)	296 333	292 000	50 000	125 705	40 000	390 817
	Tawa	Moderate (12-35)	138 750	26 000	392 000	107 600	62 000	212 444

4.4.3 Gross margin analysis for livestock production

Gross margin analysis results show that most of animals had negative gross margin which means operating in loss. Hence farmers were not benefiting from this business. Enterprises which were found to be profitable are poultry keeping for Konde village and pig for Kiswila and Tawa villages (Table 6). Despite of the fact that livestock production appears to be not profitable, it is still rational to promote the activity as a source of protein and supply of manure in the area. Below is a presentation of the livestock options, arranged in order of decreasing profitability for each village.

i) Konde village (High altitude)

Poultry → pig → goat

ii) Tawa village (Medium altitude)

Pig → poultry → goat

iii) Kiswila village (Low altitude)

Pig → poultry → goat

Table 6: Gross margin analysis of the four livestock in East Uluguru Mountains

Cost and benefit	Villages	Slope	Poultry	Goat	Pig
Variable cost (Tshs) (Feeding, disease & pest control)	Konde	Steep (35-55)	46 269	84 700	112 800
	Kiswila	Gentle (2 -12)	126 395	349 250	162 090
	Tawa	Moderate (12-35)	125 636	23 879	219 000
Total revenue (Tshs)	Konde	Steep (35-55)	66 000	10 421	40 000
	Kiswila	Gentle (2 -12)	72 068	12 833	193 000
	Tawa	Moderate (12-35)	92 921	160 846	965 000
Gross margin (Tshs)	Konde	Steep (35-55)	19 730	-74 279	-72 800
	Kiswila	Gentle (2 -12)	-54 327	-336 410	162 090
	Tawa	Moderate (12-35)	-28 714	-77 923	746 000

4.5 Multi Criteria Analysis

4.5.1 Farmers production objectives

The main objectives of farmers in Uluguru Mountains include: improvement of food security, increase in cash income to meet other livelihood objectives and conservation of natural resource bases that are related to agriculture. Alternatives to achieve those objectives were different crops and their respective management practices. Important crops that were identified include: Banana and plantains, rice, maize, cassava, coconut, pineapple, clove and black pepper. Respective management practices were: increase in uses of animal/compost manure and residues, less expansion of cultivated area, the use contour ridges, mulching, intercropping and the use of grass strips. The main decision making problem was how to decide systematically which crop enterprises to undertake and the respective management options to achieve those objectives

4.5.2 Production option alternatives

During the discussion with farmers a total of 17 criteria were discussed on the basis of which they would assess and select production option to undertake (Table 7). These criteria were grouped according to farmers' objectives of achieving food security and increasing cash income while improving natural resource use efficiency. Objectives for food security were yields, less storage loss, drought tolerance, disease resistance, less vermin attack, seed availability and less area requirement. In case of cash income, indicators were reliable market, less labour requirement, less material inputs, fodder and employment. In management practice, indicators were increase in uses of animal or compost manure, less expansion of cultivated area requirement, the use of contour ridges, Agro forestry and grass strip planting. Some of the objectives are conflicting implying that one objective can only be achieved if another is

achieved to a lesser extent. For instance, increasing crop yields while reducing the inputs use in the area.

A multi-criteria method which considers all criteria simultaneously was employed in the process. Farmers were asked to compare the productivity prosperity of major crops grown against the proposed production criteria. Major crops which were listed by farmers for assessment and ranking include banana, pineapple, maize, rice, cassava and cloves.

Table 7: Farmers' ranking score of different crop against set of criteria

Criteria	Desired change	Rice			Banana			Pineapple			Cassava			Maize			Cloves		
		H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L
A) Food security																			
High yield (a_1)	Maximize	1	1	1	4	4	4	3	4	4	3	2	2	1	1	2	3	2	2
Less storage loss (a_2)	Maximize	3	3	3	3	3	3	1	2	2	4	4	4	4	4	4	4	3	3
Drought tolerant (a_3)	Maximize	1	1	1	2	2	22	1	2	2	4	4	1	1	1	4	4	1	1
Disease resistant (a_3)	Maximize	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	4	2	2
Less vermin attach (a_5)	Maximize	1	1	1	4	4	4	1	2	2	3	2	2	2	2	2	4	4	4
Seed availability (a_6)	Maximize	2	2	2	4	4	4	1	2	2	4	4	1	2	1	4	4	1	1
B) Cash income																			
Reliable market (b_1)	Maximize	3	3	3	3	3	3	2	4	4	3	3	3	2	2	2	2	2	2
Less labor requirement (b_2)	Maximize	3	3	3	4	4	4	3	3	3	2	2	3	4	4	3	4	1	1
less material inputs (b_3)	Maximize	2	2	2	3	3	3	2	2	2	3	2	2	3	3	3	3	3	3
Fodder (b_4)	Maximize	2	2	2	4	4	4	2	1	1	4	4	3	3	3	4	3	3	3
Employment (b_5)	Maximize	2	2	2	2	2	2	2	3	3	4	3	2	2	2	2	2	1	1
C) Management practices																			
Increase use of animal/compost manure (c_1)	Maximize	1	1	1	3	3	3	4	4	4	1	1	1	1	1	1	3	1	1
Less expansion of cultivates area(c_2)	Maximize	1	1	1	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1
The use of contour ridges (c_3)	Maximize	1	1	1	2	2	2	2	4	4	1	1	1	1	1	1	2	1	1
Agro forestry (c_4)	Maximize	1	1	1	2	2	2	2	3	3	1	1	1	1	1	1	1	1	1
Grass strip planting (c_5)	Maximize	1	1	1	3	3	3	1	1	1	2	2	2	1	1	1	4	4	2
Thinning (c_6)	Maximize	1	1	1	2	2	2	1	2	2	1	1	1	1	1	1	1	1	1
Overall scores		**28**	**28**	**28**	**50**	**50**	**50**	**29**	**44**	**44**	**46**	**38**	**31**	**32**	**31**	**38**	**49**	**32**	**30**
Rank		**6**	**6**	**6**	**1**	**1**	**1**	**5**	**2**	**2**	**3**	**3**	**4**	**4**	**5**	**3**	**2**	**4**	**5**

Scores: 4 = Very good, 3 = Good, 2 = Average, 1 = Not good;
H= High altitude, M= Medium altitude, L=Low altitude.

4.5.3 Effect of alternative on the evaluated criteria

Farmers evaluated each alternative against the set of criteria based on their experience. Banana is one of the cash crops grown by most of the farmers in the Uluguru Mountains. It requires large area, has high yield, it is drought tolerant, has less vermin attack, suckers are available, it has reliable market and it provides employment. In most cases it is intercropped with coconut, black peppers and cloves. Due to the need of large area for growing banana, the crop promotes expansion of farmland and as it is associated with little or no use of terraces, contour ridges, grass strip and mulching; it leads to increasing land degradation in most of the farmland (Table 7).

Clove was an inherited crop few years back, but now due to training from different organizations, farmers are planting new varieties especially in the high altitude areas. Yield depends much on the season. Currently yields depended upon are from inherited trees, which were generally not good. Most of the new trees are yet to attain maturity. The crop can provide employment if the yields are good. In most cases cloves are intercropped with other crops which are good for land management. In the medium and low altitude areas clove is not much grown due to high humidity and temperature which do not favour growth of the crop

Cassava was ranked as very good in food provision, cuttings availability and reliable market. However, it is susceptible to vermin attack and its production is associated with expansion of cultivated land for more yields and burning of the farms during land preparation. Moreover no any use of land management practice is observed and

hence it increases chances of land degradation (Table 7). The crop was highly produced in the low altitude as in case of high quantity production farmers usually prefer to undertake the activity in more or less gentle slope.

Maize is grown in most areas in the mountain. The crop is characterized by low yield for Konde and Tawa villages, less storage loss, it is destroyed by drought and has moderately availability of seeds. It is more depended upon for food in the area. Maize also supports degradation to a great extent as there is no conservation measure that is followed for farming on the hilly slopes in high and medium altitude areas.

Pineapple is another crop that is grown in East Uluguru Mountain. It is highly labour intensive, so is good in creation of employment. However, the crop is easily attacked by vermin. Contour strip cropping has been adopted by some farmers in pineapple production. Some incidences of burning during land preparation are also common. Absence of intercropping, strip copping and little mulching render most of the pineapple farms susceptible to land degradation especially in the high altitude areas (Table 4).

As scores in (Table 7) indicate, rice which is the main crop in the mountain areas is good in reliable markets, it is average in provision of employment to the farmers, seed availability and potential to provide fodder. Rice is also preferred because it can be stored with minimum loss. However, it is very susceptible to drought and vermin attack (bird). It also requires high labour input and large area so as to get more yields. This leads to expansion of cultivated land. In growing rice in mountains, besides

using fire for land preparation and a lot of land tillage farmers do not use contour ridges or strip cropping in their farms and hence increase in land degradation

The overall ranking of crop enterprises according to overall score of farmers' criteria revealed the following results; Crop that fulfills most of the criteria for farmers at Konde village (high altitude area) is banana followed by cloves and cassava. Other important crops to this village are maize, pineapple, and rice. For farmers at Tawa village (medium altitude) the first crop that was preferred by most farmers was banana followed by pineapple and cassava. Other crops are cloves, maize and rice. Farmers at Kiswila village (low altitude) have the same preferences as farmers in the rest of the villages for the first option i.e. banana, and as in Tawa village the second crop is pineapple. The third crop in Kiswila is maize. Other crops include cassava, cloves and rice (Table 7). Below is a presentation of the cropping pattern arranged in order of decreasing priority based on evaluated criteria for each village.

i) Konde village (High altitude)

Banana → cloves → cassava → maize → pineapple → rice

ii) Tawa village (Medium altitude)

Banana → pineapple → cassava → clove → maize → rice

iii) Kiswila village (Low altitude)

Banana → pineapple → maize → cassava → cloves → rice

4.5.4 Relative importance of farmer's evaluation criteria

The relative importance of evaluation criteria and weights given by farmers is presented in (Table 8). The results show that in order to improve food security, farmers attach relatively high importance to crop option that gives high yield in small area to attain the same benefit as the larger one, crop with seeds readily available, crop which is drought tolerant, crop with less vermin attack and less storage losses. For the case of cash income high importance is on the crops that have reliable market and crops that require less labour and material cost, crops which can provide employment and food to the community. For the case of management practices the most important criterion was less expansion of cultivated area, the use of contour ridges, and intercropping. The least important criterion in this regard was the use of animal or compost manure and the use of terracing.

Table 8: Farmers' pair wise ranking of productivity criteria

Criteria	**Pair wise ranking**						**Score**	**Weight**
A) Food security	**a_1**	**a_2**	**a_3**	**a_4**	**a_5**	**a_6**		
High yield (a_1)	x	a_1	a_1	a_1	a_1	a_1	5	0.33
Less storage loss (a_2)		x	a_2	a_2	a_2	a_2	0	0.07
Drought tolerant (a_3)			x	1	1	a_3	3	0.20
Disease resistant (a_4)				x	a_3	a_6	2	0.13
Less vermin attach (a_5)					x	a_6	1	0.07
Seed availability (a_6)						x	4	0.26
B) Cash income	**b_1**	**b_2**	**b_3**	**b_4**	**b_5**			
Reliable market (b_1)	x	b_2	b_1	b_1	b_5		4	0.4
Less labor requirement (b_2)		x	b_2	b_2	b_2		3	0.3
Less material inputs (b_3)			x	b_3	b_5		2	0.2
Fodder (b_4)				x	b_5		0	0.1
Employment (b_5)					x		1	0.1
C) Management practices	**c_1**	**c_2**	**c_3**	**c_4**	**c_5**	**c_6**		
Increase use of animal/compost manure (c_1)	x	c_1	c_1	c_1	c_1	c_1	1	0.07
Less expansion of cultivates area(c_2)		x	c_2	c_2	c_2	c_2	4	0.28
The use of Contour ridges (c_3)			x	I	I	c_3	4	0.28
Agro forestry (c_4)				x	c_5	c_6	3	0.21
Grass strip planting (c_5)					x	c_6	2	0.14
The use of Terrace (c_6)						x	0	0.07
Rank	**a_1>a_6>a_3>a_4 >a_5=a_2; b_1>b_2>b_3>b_5>b_4 and c_2= c_3> c_4>c_5>c_1 > c_6**							

Note>is more preferred = no difference in preference

Results from Table 8 show that, in order to improve food security farmers consider high yield and availability of seed to be the most important criteria at a weight of 0.3 and 0.26 with respect to the other criteria, 0.2 weight score was given to drought tolerance while 0.13 was given to disease resistance and 0.07 to both less vermin attack and less storage loss. Based on the marketing criteria, ranking according to the level of significance, reliable market and less labour requirement are the most important criteria given weights of 0.4 and 0.3 respectively. Other cash income criteria such as less material inputs was given the score of 0.2 and provision of employment and fodder were given lower score of 0.1 each (Table 8). For management practices criteria, the most important were less expansion of cultivated area and the use of contour ridges which have the weight of 0.28 each. Other management practices include intercropping and the use of grass strips which were given weights of 0.21 and 0.14 respectively. Increased uses of animal or compost manure were among the least management practices criteria and were given weight of 0.07 each.

The comparison of all criteria preference indicators (i.e. food security, cash income and management practices) make it possible to distinguish between the preferences. Analysis diagram for pair wise ranking is presented in Figure 6. In case of food security, high yield (a_1) and seed availability (a_6) show highest preference compared to drought tolerance (a_3), disease resistance (a_4), less vermin attack (a_5) and less storage loss (a_2). For the case of cash income, reliable market (b_1) and less labour requirement (b_2) showed the highest preference to less material inputs (b_3), fodder (b_4) and employment (b_5). For the

management practices, less expansion of cultivated area (c_2) and the use of contour ridges (c_3) show highest preference compared to Agro forestry (c_4), grass strip planting (c_5), increased use of animal/compost manure (c_1) and use of terraces (c_6).

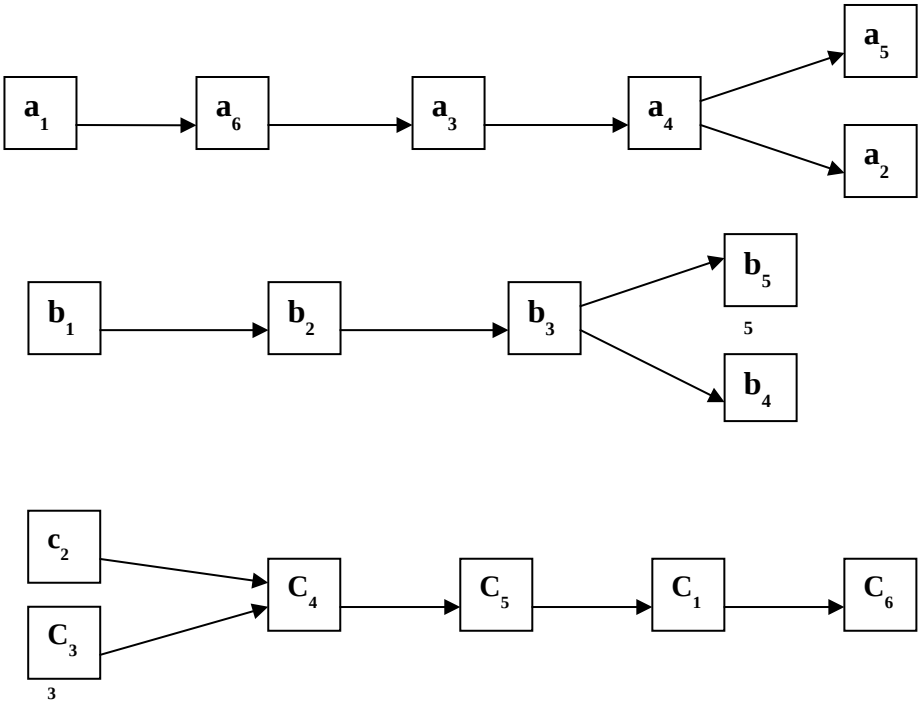

Figure 6: Preference flow diagram for different information choices

Where:

a= Food security

a_1 = High yield, a_2 = Less storage loss, a_3 = Drought tolerant, a_4 = Disease resistant, a_5 = Less vermin attack, a_6 = Seed availability.

Crops which fit this category are cassava and banana

b= Cash income

b_1 = Reliable market, b_2 = Less labor requirement, b_3= Less material inputs, b_4 = Fodder, b_5 = Employment.

Crops which fit this category are banana, cassava and maize

c= Management practices

c_1 = Increase use of animal/compost manure, c_2 = Less expansion of cultivates area, c_3 =Use of contour ridges, c_4 = Agro forestry, c_5 = Grass strip planting, c_6 = Use of terraces.

Crops which fit this category are vegetables

4.6 General Overview of the Respondents

Results show that, 80% of the respondents were aware of existence of local institutions involved in agriculture and conservation of the East Uluguru Mountains. 20% of the respondents were not aware of the existence of any local institution. The mentioned institutions are UMADEP, said by about 36% of the respondents. CARE International by 24 % of the respondents and WCST by 12.5% of the respondents. 8% of the respondents mentioned Matombo mission as another institution. The main activities for each institution are agriculture related and environmental conservation (Table 9).

With regard to problems in farming activities, the most important problem in the study area was low yield followed by poor farming tools and land degradation by 64%, 60% and 23% of the respondents respectively. Other problems were poor soil fertility by 16%, fire by 10% lack of land ownership by 6.7%, field boundaries by 5%.and drought by 3.3%. As farmers in the study area were found to be using simple tools for farm work. The common tools include the hand hoe, knifes, axes and other simple tools for ploughing and for bush clearing. All these tools are low technology tools which are hand made and give very low return to labour and not adequate for improved farming practices. No farmer was found to have used tractor or an ox-plough in farm work. Improved seed are also hardly used. This implies poor production which promotes poverty, which in turn perpetuates land degradation. Major sources of those problems include; shortage of capital to finance the implementation of new conservation measures, lack of education on appropriate way of conservation through different farming activities, unpredictable weather leading

to floods and drought and inadequacy of extension agents by 57.5%, 7%, 8% and 11% of the respondents respectively (Table 9).

Table 9: Distribution of the respondent by their general knowledge

Parameters		Konde	Kiswila	Tawa	Total
Local institutions that emphasizes conservation agriculture	CARE International	9 (22.5)	12 (30)	8 (20)	29(24.2)
	UMADEP	14 (35)	6 (15)	23 (57.5)	23(57.5)
	WCST	2 (5)	6 (15)	7 (17.5)	15 (12.5)
Activity of each institution	Planting trees	0(0.0)	14 (35)	9 (22.5)	23 (19.2)
	Agricultural activities & forest conservation	16 (40)	2 (5)	19 (47.5)	37 (30.8)
	Provision of education on environmental conservation	9 (22.5)	18 (45)	10 (25)	37 (30.8)
Problems	Low yield	23(57.5)	27(67.5)	27(67.5)	77(64)
	Land degradation	8 (20)	8 (20)	9 (22.5)	28 (23.3)
	Poor soil fertility	9 (22.5)	7 (17.5)	4 (10)	20 (16.7)
	Field boundaries	4(10)	2(5)	0 (0)	6 (5)
	Fire	5(12)	6 15)	1(2.)	12 (10)
	Drought	2 (5)	1(2.5)	1(2.5)	4 (3.3)
	Vermin	3(7.5)	2 (5)	3 (7.5)	8 (6.7)
	Lack of land ownership	5(12.5)	3 (7.5)	4 (10)	12 (10)
Major causes of problems	Poor farming tools	24(60)	26(65)	22(55)	72(60)
	Lack of capital i.e. financial problem	22 (55)	31(77)	16 (40)	69 (57.5)
	Unpredictable weather, e.g. floods, drought, etc	6 (15)	4(10)	0 (0)	10 (8.3)
	Lack of education	0(0)	3(7.5)	5 (12.5)	8 (6.7)
	Few extension agents	8 (20)	4(10)	1(2.5)	13 (10.8)
Solutions to the problems	Financial support such as loan provision	18 (45)	14 (35)	20 (50)	52 (43.3)
	Adequate extension agents	10 (25)	5(12.5)	0 (0)	15(12.5)
	Government subsidy in agrochemicals supply	0 (0)	7 17.5)	2 (5)	9(7.5)
	Early weeding	8 (20)	6 (15)	0 (0)	14 (11.7)
Cooperative society	SACCOS	2 (5)	3 (7.5)	6 (15)	9 (9.2)
	VICOBA	0 (0.0)	6 (15)	12 (30)	2 (13.3)

Note: Figures in parentheses are percentages

The proposed solution for the above mentioned problems based on farmers' perspectives include financial support such as loan. About 9% of there respondents were Savings and Credits Cooperative Societies (SACCOS) members and 13% in Village Community Bank "VICOBA" for loans and credits. Provision of adequate extension agents and appropriate education on such activities as contour planting and mulching was proposed as the best practices for land conservation on their farms as they result to improved soil fertility, increase in yield and food availability at home. Moreover, such practices reduce pest prevalence and risk of crop failure. This suggests that, farmers were knowledgeable about different traditional practices that could be used for land conservation on their farms. Extension agents and NGOs therefore could work on the existing traditional knowledge to assess their strengths and weaknesses and thereafter develop the most appropriate alternative conservation measures based on farmers' knowledge and resources.

4.7 Findings from the Village Government and Extension Staff

Findings from the village government leaders, NGOs and extension staffs elaborate the state of natural resource related to agriculture before and after being subjected to degradation and its features.

Land, water and forest resources are degrading with time. The most land degrading activities include; agricultural practices (farming without using contours in the sloppy areas, commonly termed *kilimo cha sesa*), shifting cultivation, clearance of forests for cultivation and lumbering. Lack of environmental conservation programs also has significant influence on land degradation. Features for land degradation include bare land and low fertility of soils compared to the past. All these lead to

poor crop yield. This therefore results to demand for big farm size in search for better yields. Features for water degradation include drying of rivers, that is reduced water volumes due to felling of trees around water sources and because and presence of dirty water. Features of forest degradation are less thick forest following felling down forest trees in contrast to what it used to be in the past. Forests are also cleared by bush fires, leading to bare lands. It is nowadays hard to find some indigenous trees which were in the past used for timber.

Sharma *et all*. (1995) cited by Dejene (1997) pointed out that, factors that influence land degradation are manifested themselves in market, policy and institutional failures, inadequate technologies and practices, population pressure, poverty, cultural values and individual behaviour. However, the link between poverty and land degradation is complex and poorly understood, what has been widely accepted recently is that, the activities that are performed by the rural poor increase land degradation problems that in return might precipitate poverty (Kahyarara ,1998). Several studies in Tanzania revealed that, the extent of poverty has influence on the sustainable utilization of the natural resource, as poverty compels people to over-exploit the existing natural resources in order to meet their basic needs (URT, 2003).

According to the findings from the study area, state of the natural resources before they were subjected to unsustainable production options can be describe as follows; soils were very fertile and in small areas you could get good produce just in small piece of land, there were conservation efforts and people were left freely, cultivating in slopes without using terraces. For the case of water there were heavy and regular rains 10 years ago. Water in the rivers was flowing throughout the year and good

timing of rainfall prevailed. For the forests there were very big, thick and evergreen forests with big trees for timber. The forests supported rainfall and drought could not persist

Conservation efforts increased recently but no impact realized yet. Farmers are using traditional farming systems which destroy natural resources (NRs). Practices which conserved natural resources include; land ownership by clan which was sound compared to individual ownership which is practiced today. Forest conservation was ensured under traditional rules. There were no defined conservation measures but still the forests, land and water were safe. Today, despite the local Government action of banning forests destruction by fires and encroachment people’s turn up for NR conservation is still inadequate. People were cutting trees but following traditional rules which are nowadays ignored. The Reasons for abandonment of the traditional way of managing NRs were separation of family members in different classes.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Farmers' Decision Making

Results indicate that farmers' decision-making processes involve several criteria hence the need for integration of several options, as there is no single alternative that can fulfill all the criteria. Due to this multi criteria nature of the evaluation criteria, farmers are likely to accept innovations that are divisible, flexible and financially efficient. However, the accurate decision making will depend on the adequate knowledge on the effects of alternatives to their evaluation criteria. In this case an input from scientists/researchers in that particular field is necessary; otherwise the judgment may be subjective and biased.

Farmers generated several criteria through which they could evaluate the best crop option. This indicates that farmers are also in the business of creating knowledge about their own experiences and therefore any technology that is introduced to them is evaluated against their knowledge. This implies that scientific knowledge will be accepted by farmers when it is consistent with their own understanding.

Among the farmers objectives is to properly manage the natural resource base. This implies that generally farmers have positive attitude about the environment, but they may have different views on the alternatives that could achieve those objectives in a sustainable way, profitably and in a way that satisfies their other criteria.

5.2 Decision Support Tool (Dst)

Decision support tool using multi-criteria approach enables farmers to identify criteria with which to identify crop that could ensure food security, cash income and management of natural resources while minimizing the risks of failure due to drought, diseases, market, vermin attack and burning. This increased the level of farmer's participation in development and testing of the best crop options. Through this tool farmers decision making process could be understood and integrated in technology development and dissemination.

The decision support tool in this case has been with respect to crop option but its use could be extended to any decision making problem provided that there are clear objectives, several alternatives, evaluation criteria and that the impact of the alternatives to the criteria are known.

5.3 Production Option

From the DST, banana production has come out as the best production option with respect to NR base conservation in Konde, Tawa and Kiswila villages which represent high, middle and low altitudes respectively. Challenges in banana production include need for big farm sizes and hence danger of encroachment, crop diseases (example Bacterial wilt) and pests (example Nematodes) and inadequate knowledge on the improved crop husbandry practices. In order to register success in undertaking this option it is imperative for UMADEP, CARE International and other NGOs and government institutions to vest more efforts in addressing the prevailing challenges.

Pineapple production which ranks the second in the medium and low altitude areas is also worth promoting. The fact that promotion of the same in the area is a recent intervention makes the crop less popular. The study recommends pineapple due to its effectiveness in conservation. The crop performs very well when planted in strips along the contours. Moreover, as it was observed in Tawa village where the intervention was introduced first the crop ranks the second in revenue generation at farm gate.

Cassava ranks the third in high and middle altitudes and the fourth in the low altitude. However, considering the farm-gate price, the crop ranks the first in the high and low altitude areas. Considering also the fact that the crop has dual advantages as it serves both as cash and food crop it is important that it is promoted in the whole study area. The crop promotion endeavours should take into consideration the fact that the crop's husbandry practices require regular tillage of the land especially during harvesting and that it requires large pieces of land to realise profit and hence likely to encourage encroachment and land degradation. It is therefore imperative that the land is conserved before the crop is planted.

Rice which ranked last in all villages is a crop that is produced by majority of the farmers in the study area. However, based on the fact that upland rice production involves burning of the fields during land preparation, there is a need of discouraging the option in order to rescue the NR. Promotion of alternative crops like banana and pineapple is a possible way out as farmers would earn some money from the crops to buy rice.

Being on the low altitude and with most fields under relatively gentle slope, Kiswila village is less prone to NR degradation. The study recommends extension of banana production to the area in order to discourage unsustainable production options.

More efforts should be vested in promotion of off-farm income generating activities so as, to address the problem of poverty in the area. It must be noted that, land degradation is within poverty cycle and hence conservation will hardly be achieved if poverty will not be addressed. Promotion of eco-tourism could be one of the options of vital importance because it will create people’s commitment and interest in the conservation of the Uluguru Mountains.

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APPENDICES

Appendix 1: Questionnaire for household data

Interview Id……..
Date of interview……..

A: Back ground Information

1. Name of the Village……..
2. Name of Interviewee……..
3. Age of the respondent ……..
4. Marital status
   01) Single ( ) 02) Married ( ) 03) Divorced ( )
   04) Widow ( ) 05) Separated ( )
5. Education level
   01) No formal education ( ) 2) Adult education ( ) 03) Primary education ( )
   04) Secondary education ( ) 05) Other (specify) ( )……..
6. Occupation of the head of household
   01) Farming ( ) 02) Officially employed ( ) 03) Casual laborer ( )
   04) Business (specify) ( ) …….
   05) Other (specify) ( )……
7. Household composition by age and gender

Age	Males	Females
Below 18 years		
18 – 30 years		
31 – 45 years		
46 – 55 years		
Above 55		

8. What is the farm labor force in your household?

	> 18 years (Number)	< 18 years (children)
Male		
Female		

B. Community understanding in NR

9. Mention any NRs' that are related to agriculture?
   ……
10. What are specific characteristics of each?
    ……
    ……
11. How do you do to conserve the
    Forest.....
    Water.....
    Land .....
12. How do you use the forest for?
    .....
13. Where do you obtain firewood from?
    .....

14. Do you do hunting? If yes, what is the hunting method?
.....

C. Land and land tenure

15. How many plots of farmland do you have? ……..
16. What is the size of each plot and its estimated slope

Plot number	Size of the plot	Estimated slope

17. How did you acquire your plots?.....
18. Crop information per year

Crop	Crop production system	Yield (kg/acre, bag/acre, bunches/acre, pineapples/acre)	Amount of yield that is used for home consumption	Amount of yield that is sold on farm or market		Price on farm	Price in market (per kg/ per bag)
				On farm	Market		

Criteria	Rice			Banana			Pineapple			Cassava			Maize			Cloves		
	H	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**
A) Food security																		
High yield (a_1)																		
Less storage loss (a_2)																		
Drought tolerant (a_3)																		
Disease resistant (a_3)																		
Less vermin attach (a_5)																		
Seed availability (a_6)																		
B) Cash income																		
Reliable market (b_1)																		
Less labor requirement (b_2)																		
less material inputs (b_3)																		
Fodder (b_4)																		
Employment (b_5)																		
C) Management practices																		
Increase use of animal/compost manure (c_1)																		
Less expansion of cultivates area(c_2)																		
The use of Contour ridges (c_3)																		
Agro forestry (c_4)																		
Grass strip planting (c_5)																		
Thinning (c_6)																		
Overall scores																		
Rank																		

19. List any problems you face in farming activity in order of priorities
20. Please indicate Scores: 4 = Very good, 3 = Good, 2 = Average, 1 = Not good

H= High altitude, M= Medium altitude, L=Low altitude.

D. Livestock

21. Do you have any livestock?

01) YES ( ) 02) NO ( )

22. If the answer is YES in the above question.

Type	Number	Purchase price
Total		

23. Purpose of livestock keeping?

…….

24. How do you keep your livestock? common

Type	Method used

25. What is the best way of keeping livestock that will conserve NR?

…….

……..

26. Purchased input for livestock including feeds and drugs for season.

Livestock type	Purchased input	Quantity	Price/unit or payment (Tshs)	Amount paid for hired labor (Tshs)

27. Disposal of the products for whole life span

Product	Amount produced	Amount consumed	Amount sold	Price/unit

28. What about the waste disposal and the use of the wastes?
(A)Sold ( ) (B) applied on the farm ( )
(C)Other (specify)…….

29. Which crops is the manure applied
……

30. List any problems you face in keeping livestock
……
……

E. General questions

31. What kind of farm machinery/tools/equipment do you own?
……

32. What is the frequency of contact with extension workers ……per Month/week/year

33. Mention local institutions that are emphasizing conservation in your village?
…….

34. for each of the institutions mentioned above (in 44), indicate their main activity
……

35. What are problems which are facing farming practices?
……

36. What are the major causes of those problems?
……

37. What will be the best solutions for the above-mentioned problems?
……

38. Mention any cooperative society/farmers group which you belong
……

39. What benefits do you get from it?
……..

Thank you for your cooperation

Appendix 2: Checklist questionnaire for key informants (KI)

About the interviewer and the research

- Personal introduction (the interviewer)
- Rationale for the information collection
- Expected benefits of the research to the community in question

About the interviewee

- Name …….
- Sex…….
- Age……
- Position in the community……..

Key questions

1. Are the land, water and forest resources degrading or remaining intact with time?

    - If they are intact, please characterize each of them (main features, functions, productivity, management (now vs the past)).

    - If DEGRADING, please respond to the following questions:

2. What do you consider to be the most NRs degrading activities/production options?
3. What feature(s) seen today which you consider the indicator(s) for NR degradation?
    - Land
    - Water
    - Forest
4. What do you remember to be the state of the NRs before they were subjected to unsustainable production options? Mention the period under consideration (year)
    - Land
    - Water
    - Forest
5. How can you describe the conservation efforts in the past and for the time being? What did farmers practice, which conserves NR but they do not practice it now? Reasons for abandonment?

Thank you for your cooperation.