

**INDIGENOUS SOIL-WATER MANAGEMENT PRACTICES AND FOOD
SECURITY: THE CASE OF THE MATENGO PITS FARMING SYSTEM
IN MBINGA DISTRICT, TANZANIA.**

BY

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ABSTRACT

This study presents an analysis of the dynamics of indigenous soil-water management practices, namely the Matengo pits farming system and their implications on household food security in Mbinga District, Tanzania. The study aimed at establishing the current changes of Matengo pits system, including emerging new practices and their driving forces and their effects on household food security. The study employed both qualitative and quantitative research methodologies to obtain the data which were analysed using the statistical package for social science computer programme (SPSS). The findings indicated that some modifications have started taking place within and outside Matengo pits system. A total of 28.8% of interviewed farmers reckoned ploughing grasses under the soil after less than a week which was un-traditional because of having few grasses and timing of activities. About 14% of farmers have modified the grass alignment pattern into parallel lines down slope to simplify the work. However, about 50% of farmers claimed digging shallow pits mainly because of relying on communal or hired labour. Meanwhile, 75% of farmers acknowledged constructing medium sized Matengo pits for more space for crop planting. Around 17% of women were reported to have assumed full responsibility of slashing and organising grasses in their fields like men. Likewise, adult males had gone against their norms and traditions by taking part in digging Matengo pits. Social networks for sharing labour among the Matengo people were noted to have assumed new forms. *Chama* remained practised at family level, meanwhile the *ngokela* is currently organised through cash instead of sharing food. Penetration of the western culture and money economy into Matengo highlands

propelled by globalization has contributed to these social changes. Institutional changes and agro-ecological variability have similarly played a pivotal role in changing the Matengo pits system. As for implication to food security, 62.9% of households were food insecure mainly because of poor crop yields. However, changes in Matengo pits farming system had no statistical significant relationship to household food security status. The findings call for further research on the effects of climatic change towards Matengo pits system, and its mitigation potential to enhance its sustainability.

DECLARATION

I, Justus Vincent Nsenga, do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my original work and it has not been submitted for higher degree award in any other University.

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DEDICATION

I dedicate this work to my beloved mother, the late Anna A. Nsenga, my aunts Christina A. Nsenga and Asia A. Nsenga who decided to take me to school with the limited resources they had. To the memory of my grandmother, Tausi Masua Wa-Nsenga for her motherly care offered to me during my childhood. I also dedicate this work to my sons Ian and Neville so that it can instil in them a hard working spirit in their academic endeavours.

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LIST OF ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
COSTECH	Tanzania Commission for Science and Technology
DALDO	District Agricultural and Livestock Development Office
FAO	Food and Agriculture Organization
FFS	Farmer Field School
FGD	Focus Group Discussion
GDP	Gross Domestic Product
HIV	Human Immunodeficiency Virus
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISWM	Indigenous Soil and Water Management
KILICAFE	Association of Kilimanjaro Specialty Coffee Growers
MWARP	Miombo Woodland and Agro-ecological research Project
NBS	National Bureau of Statistics
NGO	Non-Governmental Organization
NSGRP	National Strategy for Growth and Reduction of Poverty
PHDR	Poverty and Human Development Report
PRA	Participatory Rural Appraisal
RALDO	Regional Agricultural and Livestock Development Office
TaCRI	Tanzania Coffee Research Institute
TAS	Tanzanian Shilling(s)
TIP	Traditional Irrigation Development Programme

TTM	Trans-theoretical Model of behaviour change
UN	United Nations
URT	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tanzania like many other Sub-Sahara African countries still relies on agriculture as the main economic development pillar. The agricultural sector in Sub-Saharan countries contributes an average of about 20-30 per cent of the Gross Domestic Product (GDP) (Shiferaw and Holden, 1999). According to the National Sample Census of Agriculture conducted in Tanzania during 2002/2003, the agricultural sector contributed about 46% of the GDP (URT, 2006a). As of recently, however, the contribution of the agricultural sector to the GDP has declined from 29% in 2001 to 24% in 2010 being surpassed by the services sector contributing 43.9% to the GDP (URT, 2012). The agricultural sector still has remained supporting three quarters of the total population in terms of livelihood alternatives (URT, 2012). The majority of the population employed by the sector are smallholder farmers living in rural settings engaged in subsistence farming for household consumption using family labour as the main capital investment.

The agricultural sector in Tanzania has been reported to maintain a steady growth rate of over 3% which is greater than the total population growth rate of 2.9%, which is small but rather steady increase in annual per capita agricultural output (URT, 2003; 2006b; 2012). Besides the crucial role played by the sector, it is still challenged by several bottlenecks like crop pests, unreliable rainfall and markets for its products, depletion of soil fertility, just to mention a few (URT, 2012). All these

have led to a dilemma to the livelihoods of the majority of smallholder farmers and the national economy at large. The issue of ensuring food security status to majority of smallholder farmers in most developing countries like Tanzania has been emphasized as a critical agenda within poor households as compared to other livelihood needs (Maxwell and Smith, 1992).

However, nature does not exist in isolation rather, it interacts with social life that is integrated within culture of the society (Irwin 2001:23 cited by Barrow, 2003). In response to the needs of obtaining food, resource poor smallholder farmers who are characterised by growing different crops in small plots have invented indigenous practices to cope with situations in the face of a changing socio-cultural, socioeconomic and environmental conditions primarily using human labour and other available resources for their own food security (Netting, 1993; Todaro and Smith, 2006). The indigenous (knowledge) is rather unique to a particular culture and/or society and contrasts with the international knowledge system generated by universities, research institutions and private firms (Warren, 1991).

This indigenous knowledge system is also the basis for local-level decision making in agriculture, natural resource management, food preparation, education, health, and a host of other activities in rural communities. Indigenous knowledge is considered an integral part of the local ecosystem and a key element for the social capital of the poor; the main asset to invest in the struggle for survival to produce food, to provide for shelter or to achieve control over their own lives. The evolution of these indigenous practices has played a crucial role in sustaining the livelihoods of the

resource poor farming communities by enhancing their food security through crop production, post-harvest handling of crops, including food processing, etc. However, these indigenous technologies have received little attention in terms of intervention deemed to promote their use under this changing world to curb the food insecurity stress (Agea *et al.*, 2008).

Tanzania has over 120 ethnic groups engaged largely in farming, agro-pastoralism and nomadic pastoralism with diverse indigenous knowledge systems (Kajembe and Rutatora, 1999). Among others, the Matengo people, living in the south western highlands of Tanzania have evolved their unique farming system, the Matengo pits farming system (locally known as *ngolo*¹). The Matengo pits farming system is characterised by combination of indigenous anti-erosion techniques of pits and ridges constructed on steep slopes which have supported their livelihoods for over 200 years (MWARP, 1998; Malley *et al.*, 2004). This Matengo pits farming system is essentially an indigenous knowledge system geared towards managing or conserving soil and water to support crop production on steep slopes.

Historically the Matengo pits farming system dates back even before 1890 when German colonialists found people practising it in Litembo village in Matengo highlands (Allan, 1965; Mbago, 1997, cited by Nindi, 1999). Despite being a labour intensive activity, this particular system has been practiced by over 75% of farmers in the highlands except those in Mbinga Division (MWARP, 1998). Matengo pits

¹ A vernacular terminology of Matengo Pits which will be used interchangeably throughout this document connoting an indigenous anti-erosion technique consisting of pits and ridges uniquely practiced in the Matengo Highlands

farming system has served multi-functional roles including: improving underground drainage, conserving soil moisture (by harvesting water in pits for crop plant use), checking soil erosion (by trapping soil sediments within pits), and fertilizing the soil through decomposition of plant/crop residues incorporated into the soil, as well as in-situ crop rotation between beans and maize/wheat and fallowing. This indigenous soil-management practice has supported the livelihoods of the Matengo highland communities through production of staple food crops like beans, maize, cassava and wheat.

Coffee, which is the mainstay of the Matengos' economy, is grown around homesteads in terraces or flat cultivated farm plots (Nindi, 2004). Therefore, the basic component of household food security to Matengo farming communities has been their own food production from Matengo pits farming system, supplemented by access through purchases from markets or sharing in reciprocity. With this regard, it was of vital importance to study the dynamics of Matengo pits farming system under the current changing socio-economic, cultural and environmental conditions, and find out the implications of such changes on household food security.

1.2 Problem Statement and Study Justification

1.2.1 Problem statement

Despite the Matengo pits farming system being technically feasible and viable in sustaining the Matengo people's livelihoods through providing them with food and surplus to sell by controlling soil erosion, improving soil fertility and soil moisture retention, this indigenous technology has started losing its popularity (Msanya *et al.*,

1996; MWARP, 1998). Construction of shallow *ngolo* and conventional ridges aligned either along (locally known as *malonga*²) or across (locally known as *mitumbila*³) the slope has now started replacing the traditional *ngolo* in Mbinga District. The body of local or indigenous knowledge system is not static rather it is liable to change due to the influence of various factors. Douglas (1992), cited by Chinene *et al.* (1994) commented that decisions as to what the land is actually used for and management practices to be followed will primarily be influenced by socio-economic circumstances in which individual farm households operate. Also climate change, shift in ethnic composition or social relationships, alteration of gender roles, etc, may lead to new conditions that greatly influence the direction of change (Reenberg, 2001).

At the same time in Matengo highlands there has been an increase in population from new generations and in-migrants/intermarriages. Mbinga District is estimated to have an average population density of 48 persons per km² while in the Matengo highlands it has reached approximately 120 persons per km² which was higher than the national population density (Rutatora and Nindi 2008; Mbinga District Council, 2009). Altogether, deterioration of the coffee economy in the area due to trade liberalisation policy (Mhando and Itani, 2007) have apparently placed great pressure on scarce agricultural land and forest resources leading to other negative socioeconomic impacts. In addition, agronomic and environmental factors revolving around the Matengo smallholder farmers are critical issues that need to be studied as well to

² Among traditional tillage methods, which involves constructing conventional ridges running down the slope mostly used along Lake Nyasa shores serving for planting sweet potatoes.

³ Conventional ridges constructed across the slope.

ensure that the struggle for attaining food security or pulling out of poverty is not done at the expense of the environment.

This indigenous farming system, however, has also received a great scholarly attention on its contribution to livelihoods of the people in the district, particularly on the aspect of supporting household food security. However, there have been a few empirical studies done from the household level to identify and quantify pertinent issues leading to changes of the indigenous *ngolo* cultivation practices. Besides, the substantive information on how households have been exposed to food insecurity vulnerability following changes taking place in Matengo pits farming system and emerging practices is still missing. In this context, the study aimed at acquiring such an in-depth understanding of the forces and the rationale behind the changes of the indigenous *ngolo* farming system.

1.2.2 Justification of the study

The study is in line with Tanzania Development Vision of 2025 (attaining high quality livelihood through devising strategies that will realize food self-sufficiency and food security), as well as the Millennium Development Goals, i.e. goal number one of eradicating poverty and hunger, and goal number seven of ensuring environmental sustainability (URT, 2006a; 2006c). Poverty, food insecurity and environmental degradation are among the major issues of concern in Tanzania. Escaping from this trap calls for stakeholders' willingness to prepare jointly an exit strategy that will ensure human and environmental well-being. The past experience has shown that many development programmes and strategies fail to yield significant

results due to insufficient understanding of realities on the ground, inadequate participation of local people as well as overlooking their indigenous knowledge and skills (Gombe, 1988 as cited by Rutatora *et. al.*, 1996). Additionally, other workers have continued to emphasize that researchers should build upon the existing local knowledge in order to come up with timely and sustainable solutions to agricultural research question or problems experienced by farmers (Bentley and Thiele, 1999; Sinclair and Walker, 1999 as cited by Grossman, 2003). Apparently this calls for researchers to assume a new role as facilitators, focused on studying the knowledge, preferences, and problems of local men and women (instead of their usual role as experts and providers of solutions and services).

On a similar basis, a smooth implementation of any development intervention in Tanzania geared to achieve goals as spelt out in cluster one of the National Strategy for Growth and Reduction of Poverty (NSGRP) (URT, 2006a; 2006c), calls for establishment of the farmers' or target community's knowledge in early stages to ensure sustainable fruitful results. Documenting such information would contribute to formulating and implementing sound and well-informed policies and strategies for ensuring sustainable livelihood and natural resource management. It will also bring the issue to the agenda of various development stakeholders and decision/policy makers, including the Ministry of Agriculture Food Security and Cooperatives and local communities, to come up with sustainable agricultural practices in fragile landscapes through bridging existing information gap between the indigenous and technical knowledge.

1.4 Objectives of the Study

1.4.1 General objective

The main objective of the study was to determine the emerging changes in the indigenous practices on soil-water management (Matengo pits farming system) and the implications for household food security.

1.4.2 Specific objectives

The study specifically aimed to:

- i. Identify changes in cultivation practice, and other emerging practices and the factors influencing such changes;
- ii. Determine changes in gender roles of household members on agricultural practices;
- iii. Determine the implications of changes in cultivation practices/emerging technologies on household food security

1.5 Research Questions

1.5.1 Central question of the research

What are the current changes of the Matengo pits farming system and their implication for household food security?

1.5.2 Specific questions

- i. What changes have taken place within Matengo Pits farming system, and which are the driving forces?

- ii. What are existing soil-water management (cultivation) practices, and where are they situated within the Matengo landscape?
- iii. What are farmers' perceptions over the environmental challenges (rainfall variability), and how do they cope with them?
- iv. What is the current status of gender division of labour within this indigenous farming system?
- v. What are the contributions of emerged new/borrowed soil and water management practices (together with modifications made to Matengo pits farming system) to household food security and income status?

1.6 Conceptual Framework

The study rests on the conceptual framework depicted in Fig. 1. This conceptual framework provides a highlight of potential driving forces that push the Matengo pits farming system to change, and ultimately influence household food security status. Matengo households are continually confronted by day to day challenges posed by changing environmental, socio-economic, socio-political, sociocultural and demographic factors; As such the households respond by devoting new strategies. Demographic factors include: age of the household head and members, sex, intermarriages, and household size. Age is regarded as one of factors determining labour supply potential within farming households, as well as upon which decisions and efficiency of carrying out farm activities rely on. Young farmers may have little experience on Matengo pits cultivation practices and are likewise risk takers by adopting new technologies. The number of members within a household regarding

their ability to work determines availability of labour. Similarly, intermarriages can trigger a change in socio-cultural settings and technical knowledge of societies.

Socio-economic factors entailed: educational level of household head and members, financial resources availability, farm location and size. Education level of the head or household members has a role to play in decisions over which activity or what technology to use, apart from making an individual being vibrant to take a risk or innovate. Also education has a chance of increasing farmers' eagerness to seek for relevant information to improve production. Financial resources availability (savings, remittances or credits) provides options to farmers to make decisions on agricultural activities. However, food security is the most critical aspect to establish from smallholder farmers because there is a chance to influence the human capital (ability to work, skills and knowledge and health status) which enables them to undertake different activities. Access to, and control over, resources like land as well as the size and location of the farm plot (could be selected strategically either in upland or lowland) can influence farmers to decide over which farming technology to invest in.

Regarding the environmental factors, the study focused on: rainfall unreliability, which is likely to influence farmer's decisions on allocating the available resources (e.g. labour, seed input, capital) within a given timeframe. Measuring farmers' perceptions over rainfall pattern variations enables to find out how they have adapted to or mitigated the vulnerability. Similarly, establishing crop yields would shade some light on changes in biophysical factors that set terms for decisions to farmers with reference to resources at their disposal.

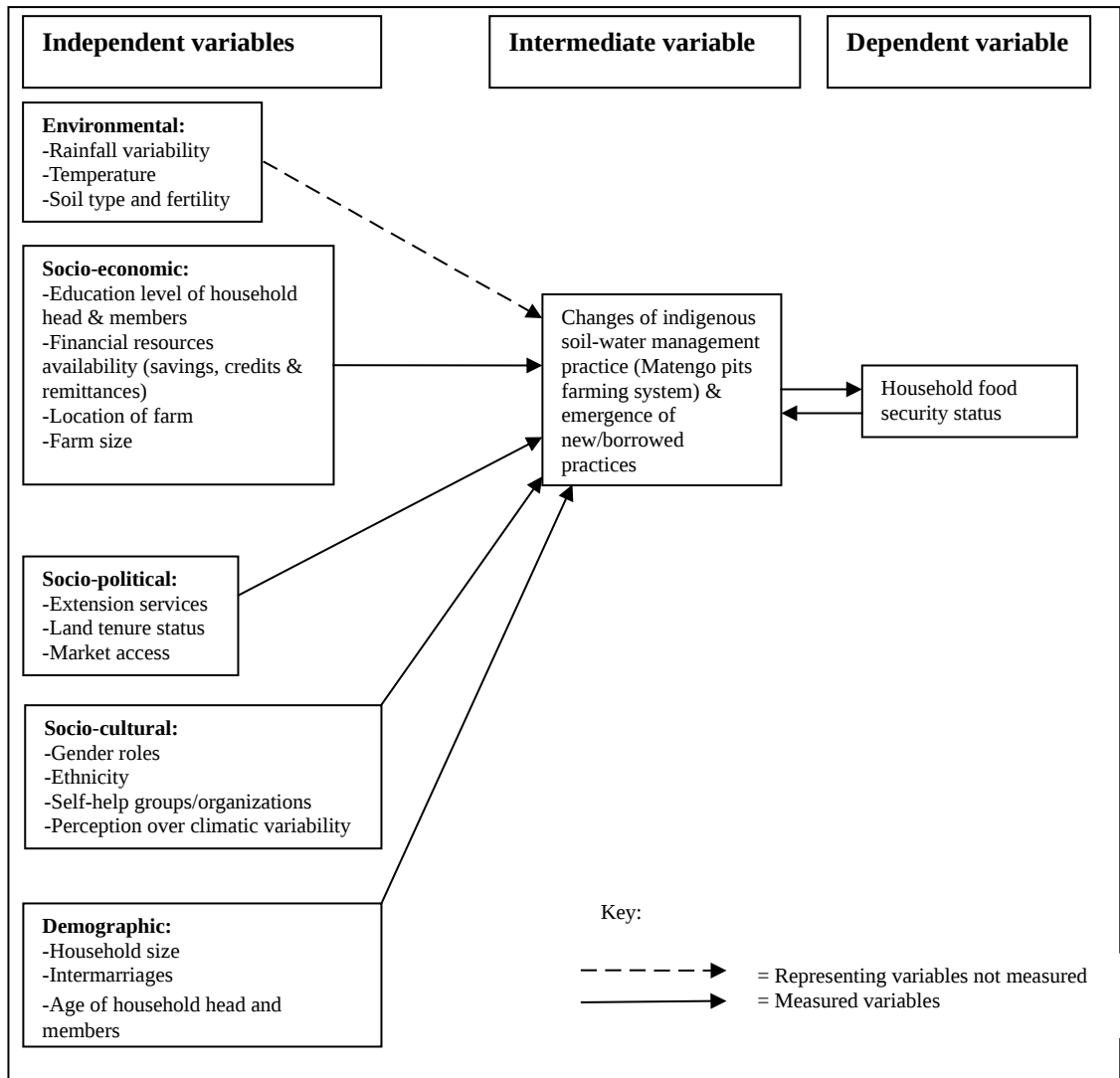


Figure 1: Conceptual Framework

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

This chapter aims to build a theoretical foundation upon which this research study was based. The chapter shows the linkage between the research problem as described previously (Chapter One) and the wider body of knowledge. The chapter consists of five sections organised as follows: the first section is defining the concepts of indigenous knowledge and food security, including analysing their linkages; second section highlights on indigenous soil-water management practices and challenges; the third section describes factors on changes in indigenous soil–water management practices; fourth section is analysing the research status on indigenous soil-water management practices in Tanzania; and the fifth section focuses attention on the Government initiatives towards addressing food insecurity.

2.2 Definition of Concepts

2.2.1 The concept of indigenous knowledge

A number of authors have defined indigenous knowledge as referring to “local practices” (Scoones *et al.*, 1996); and as “culturally specific self-contained knowledge comprised of skills and acquired intelligence, responding to constantly changing social and natural environments” (Antweiler, 2004). According to Kelbessa (2007), “the word indigenous and traditional even sometimes ‘local’ have been used interchangeably to connote something that was created and preserved by previous

generations, and has been inherited wholly or partially and further developed by successive generations”. Indigenous knowledge base has been subjected to intense debate with its rival western or global scientific knowledge. The western knowledge is regarded as systematic and objective centred on rationality and intelligence developed from formal institutions, schools, research stations (Warren, 1991) in contrast to indigenous knowledge which is perceived by other authors as primitive, un-intellectual, emotional, part of residual, traditional, backward way of life and developed by local communities through interacting with changing environment (Agrawal, 1995; Ellen and Harris, 2000 cited by Briggs, 2005).

The dispute has been aggravated by romanticising the western knowledge as the panacea in development agenda, while the indigenous knowledge is taken as a scapegoat to observed failures. Being culturally embedded and specific to a particular society, indigenous knowledge is underscored as irrelevant or harmful piece of knowledge by other societies. However, this is not a sufficient conclusion since there are reports of farmers’ and healers’ knowledge practices transferring and sharing among similar communities within and even beyond Africa through cross-country relations (World Bank, 2002). Giving an example on divergence of the two knowledge systems, Neimeijer (1995) cited by Briggs (2005) referred to soil classification and management aspects that the western system tends to explore further deep into soil horizons while the indigenous system considers soil properties from surface to the crop plant rooting zone, which is relevant to their own context.

However, other workers have noted some limitations to the universal knowledge in coming up with solutions to certain encountered problems (Thomas and Middleton, 1994; Fairhead and Leach, 1996; Thomas, 1996 cited by Stringer and Reed, 2007). Failure of considering knowledge base of targeted beneficiaries has ended up with unsatisfactory results. Until recently, many of development stakeholders have become aware of indigenous knowledge as a resource that remains untapped that could serve for providing insights of how local communities have survived in their ever changing socio-economic and environmental conditions (Odhiambo 1993 cited from MWARP, 1998; Bicker *et al.*, 2004). The two knowledge bases are complementary to each other in an endeavour to bring up promising sustainable development.

2.3 The Concept of Food Security

The concept of food security is very broad and dynamic and has received a considerable scholarly attention since its inception in 1970s in an endeavour to bring clarity to development stakeholders (Maxwell and Frankenberger, 1992). A number of definitions have been put forward by researchers and development stakeholders. According to Hoddinott (1999) there are approximately 200 definitions and 450 indicators of food security. Attention to the concept of food security has shifted from regional, national and global perspectives into household and individual food supply and accessibility (Maxwell, 1996; Hoddinott, 1999). The World Food Summit held in Rome in 1996 defined the concept of food security as “a state where all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences”. Similarly, FAO defines food security as “assuring to all

human beings the physical and economic access to the basic foods they need” (FAO, 1997). However, this definition has even been further refined to incorporate the concept of vulnerability to reduce disparities in food intake by different social groups. Hence, Maxwell (1996) argues that food security consists of related concepts like access, sufficiency, security (or vulnerability), and sustainability. However, this definition overlooks the issue of food availability which is very important. In view to this, the study focused on food security status experienced at the household level, since it is the unit responsible with the final distribution of the resource or food whether from own production or accessed through buying.

2.3.1 Indigenous practices and food security linkages

Much of scientific attention has focused on relationships between indigenous knowledge and the biodiversity with much emphasis on sustaining plants with medicinal and traditional healing roles. The valuable traditional gardening knowledge owned by Ghanaian farmers is reported to have potential contribution in attainment of household’s food security and health needs (Yiridoe and Anchirinah, 2005). These farmers have developed their inherent knowledge in selecting what garden crops and fruit trees to plant while considering socio-economic, agronomic, medicinal rationality as well as ecological factors for improved garden productivity.

Similarly, traditional irrigation systems in Tanzania have been well acknowledged for their role in enhancing agricultural production and reducing food insecurity and poverty (Sokoni and Shechambo, 2005). According to scholarly materials reviewed,

Matengo pits cultivation system has also made a remarkable contribution to support food production by farmers in Mbinga District for over the past 200 years (Temu, 1996; MWARP, 1998). This farming system has served to improve soil drainage, maintaining soil fertility through a short grass fallow and in-situ composting, and crop rotation of beans and maize/wheat, which have influenced agricultural productivity, hence food security and livelihoods well-being. However, there might be some knowledge systems changes, which are of concern to be addressed before they are lost due to various socio-economic and environmental/ecological factors.

2.4 Indigenous Soil and Water Management Practices

Indigenous soil and water management practices are regarded to have evolved over time through resource poor farmers' gradual learning process entailing observation, trial and error experimentation and evaluation, hence passing down to descendants the attained experience and wisdom (Shetto, 1999). It includes a diversity of practices ranging from agro forestry, agronomic (traditional crop rotations, mixed cropping, trash lines, etc.) to tillage methods essentially centred on soil-nutrient and soil moisture managements to attain multiple needs of the farmers (Reij, 1991 cited by Scoones *et al.*, 1996). For instance, farmers in Burkina Faso have developed a traditional technique called *zai* for rehabilitating a degraded land, which involves opening planting pits to be supplied with manure before sowing maize, sorghum or millet (Oedragogo and Kabore, 1996, Olokesusi, 2006). Similarly, the mounds cultivation locally referred to as *intuumba* of Wafipa in Tanzania, and *fundikila* of Kenya have existed ever since as an in-situ traditional soil composting technique for soil fertility management used by our forefathers to produce beans and cowpeas in

the first season followed by maize and millet crops in the second season (Mbegu, 1996; Shetto, 1999). However, it has been reported that this particular indigenous technology is challenged by increased use of animal drawn ploughs done by farmers such that it has threatened its sustainability (Mbegu, 1996).

Traditional stone bunds and lines built perpendicular to the sloping land used in Harerge highlands of Ethiopia and Ader Douchi Maggia of Republic of Niger have been used for harvesting surface run-off water and protecting soil erosion with intention of improving land productivity (Olokesusi, 2006). Similar practices have been found in Ukara Islands along Lake Victoria, while ladder terraces in Uluguru Mountains have been used to conserve soil and improve its moisture content. Among the practices, there are also traditional irrigation systems, for instance Shaduf or Shadouf found around River Nile in Egypt (Olokesusi 2006), as well as *ndiwa* of the west Usambara Mountains in Tanzania which essentially is an overnight farm pond reserving water from springs for irrigation purposes (Sokoni and Shechambo, 2005). The latter system is reported to have improved the livelihoods of farmers despite experiencing some environmental challenges (particularly constrained by rainfall shortages). In the southern highlands of Tanzania (Districts of Njombe, Mufindi, Ludewa and Iringa) there have been traditional valley bottom cultivation practices involving digging raised broad ridges to grow vegetables during off-seasons for supplementing household food security and income earnings (Lema, 1996; Mkavindanda and Kaswamila, 2001).

The Matengo pits farming system has been regarded as the most spectacular indigenous farming system in the country characterized by indigenous combination of anti-erosion techniques of pits and ridges on the steep slopes of approximately 10-60% (Rutatora, *et. al.*, 1995; MWARP, 1998, Kayombo *et. al.*, 2001). Through checking the soil erosion by trapping run-off and rain water into pits, improving soil moisture content and soil fertility has played a crucial role in supporting food production (Temu and Bisanda, 1996; MWARP, 1998; Kayombo *et. al.*, 2001). Traditionally, this cultivation system was strictly gender based, whereas adult men were accustomed to slashing grasses and crop remains using billhook or *nyengo* in the field. Slashed grasses are supposed to be left for at least two weeks to dry before collecting and organising them (*kubunga*) into grid/lattice forms. The two primary steps of preparations involve adult men. However, the original dimensions for grids were approximately 2m x 2m. The third step involves adult women who are responsible for digging (from the mid of grids) and covering grasses laid down in grids with shallow layer of soil (locally known as *kujalila*) before broadcasting seeds (bean/wheat). Similarly, broadcasting seeds is assigned to women. After seed broadcasting, the women finalize the Matengo pits preparation by covering the seeds with more soil excavated from the pit i.e. *kukulila*.

Preparation of these Matengo pits normally started in February -March when there are light showers (end of rainfall season) which cannot impair the activity. The first crop planted during this period is harvested in June-July, meanwhile the *ngolo* (pits and ridges) are left intact until November (same year) when the new rain season starts. At this particular time, cleaning of this crop field is done by removing crop

remains/weeds and putting them into excavated pits. Thereafter, making furrows (*makeni*) on ridges i.e. across the slope is done ready for planting maize. However, making of furrows is the responsibility of men. After harvesting maize (second crop) in July of the following year, a crop field is subjected to a short fallow until late February-March of the next year (at least seven months) before being cultivated again. Actually, during this new cropping season the pits and ridges are demolished by turning over the soil banks into a new position (i.e. alternating positions with pits), while crop debris is ploughed under. It is essentially a two crop rotation (involving bean, green pea or wheat and maize crop plants) and a short fallow farming system (Rutatora, *et. al.*, 1995; MWARP, 1998). Such artwork of constructing *ngolo* has significantly contributed to the production of food crops through trapping rainfall water into pits to improve soil moisture, ameliorating the soil fertility by incorporating organic matter (crop remains and weeds) and controlling soil erosion. Basically, *ngolo* has served as the cornerstone for household food security.

The above mentioned indigenous soil and water management practices have been found in a wide range of fragile landscapes, as from mountainous to valley bottoms. These indigenous practices have been developed for multi-functional purposes like controlling soil erosion, improving soil nutrient availability to crops and moisture content by water harvesting, spreading the risk of crop failure and maximizing household labour utilization (Reij, 1996).

2.5 Factors of Changes in Indigenous Soil and Water Management Practices

Previous scholars, like Warren (1991) have suggested that indigenous knowledge is subject to change since “it is neither static nor uniform and that it cannot be documented once and for all” rather it is always under continual negotiation among smallholder farmers. Ecological anthropologists claim that human beings have capacities of interacting among themselves and to the changing environment by adapting and adjusting themselves to fit for survival (Moran, 2000). Smallholder farmers who are the main actors in soil and water resource management have experienced different rapidly changing socio-economic, cultural and environmental stresses driving them either towards or away from investing into a particular indigenous practice. There are several biophysical and socio-economic factors that subject smallholder farmers to the pressure of mobilizing agricultural labour, managing productive resources and organizing consumption under the context of changing climate, resources availability and markets (Netting, 1993).

2.5.1 Biophysical factors

The change in biophysical factors like population increase, rainfall change calamities, soil type and landscape, vegetation, among others, have been linked with to complexity of indigenous agricultural practices dynamics.

2.5.1.1 Population dynamics

Population increase has widely been considered as one of the factors posing a great challenge to many of indigenous practices, including of soil and water management (Boserup, 1965). The Boserup’s theory has been about the existing relationship

between population densities and land use pattern, i.e. increase in number of people per unit of land has led into agricultural intensification. Some practices like slash and burn and bush fallowing have either been reduced or replaced by other agricultural practices due to land size shrinkage (Reij, 1996; Shetto, 1999). Indeed, extensive slash and burn (shifting cultivation) in many places in Africa, including southern highlands of Tanzania (MWARP, 1998) and *chitemene* (a form of long fallowing) in Zambia (Johnson, 1994) have been modified or abandoned by local communities. The issue of out-migration has similarly created a different scenario to farmers to decide which particular indigenous practice to invest in response to shortage of labour.

2.5.1.2 Soil characteristics

The nature of the land or soil type variability has a role in influencing type of farming system to be employed by farmers, particularly those who have poor resource endowment. Tengberg *et al.* (1998) studying the application of agro-diversity concept to indigenous soil and water conservation practices in Kenya observed that soil fertility had significant influence on farmers' choices of cropping system and land management practices. The experimenting farmers in Ouhigouya, Burkina Faso were also found integrating their traditional planting pits "*zai*" with organic matter application to counteract the crop yield decline and reclaiming the denuded land into production (Reij *et al.*, 2005). A decline in crop yields due to environmental changes (e.g. drought and soil fertility decline) can trigger farming communities to experiment with new or borrowed technologies.

2.5.1.3 Climatic variation and changes

Climate change has recently been a major agenda at local and global levels. Studies have shown indication of global warming (due to both human and natural induced processes) and different societies experience the situation differently depending on locality (Salick and Byg, 2007; Lagos, 2007). Smallholder farming which is also referred to as subsistence farming depends largely on family labour, highly risky and uncertain to venture in due to, among others, rainfall uncertainties, price fluctuations, and lack of insurance (Todaro and Smith, 2006). It has been projected that approximately 75-250 million people in African countries will be trapped into livelihood tragedies due to climatic change by year 2020, whereas rain-fed agricultural production will record up to 50% decline (IPCC, 2007). Climatic change in Tanzania is also thought to have resulted into the decrease of the Mt. Kilimanjaro's snow cap, which is currently 85% less than that of 1912 (World Bank, 2006). Also recent encroachment and degradation of wetlands by crop growers and pastoralists in Usangu, Ugalla game reserve, Ihefu, and Kilombero basin have been witnessed even prompting the government to intervene.

Under a rain-fed agricultural production system variability of onset and ending of rain season happen to conflict with smallholder farmers' decisions on allocating family labour to different household activities. Farmers have adjusted themselves through centuries of experience and experimentation by opting for less labour intensive agricultural practices that ensure substantial returns (Ruthenberg, 1980). Seo and Mendelsohn (2007) observed that changes in temperature and precipitation had implications for choices of Latin American farmers on which animal species to

keep, whether beef or dairy cattle. Pastoralists in African countries have been migrating from dry to wet areas searching for water and pastures, while some have shifted from keeping cattle to small ruminants like sheep and goats.

Sahelian farmers for example in drought prone area in Africa reported to have developed intricate systems of gathering, prediction, interpretation and decision making in relation to weather variability and change (Nyong *et al*, 2007). Sokoni and Shechambo (2005) also noted that prolonged dry seasons in west Usambara Mountains was among factors that led to the disappearance of some structures of traditional irrigation system, resulting into emergence of new forms (shortened *ndiwa* furrows, small sized *ndiwa*, use of manure and introduction of terraces in cropping fields) to cope with decreasing water quantity.

Climatic changes have also been projected to have chances of leading into more disease incidences like malaria, tuberculosis, diarrhoea/cholera, pneumonia etc. to human beings which will have direct or indirect implications to households in terms of income, human capital (ability to provide labour), and food security status. Furthermore, farmers might substitute their family labour for hired labour input provided household's situation allows (availability of extra resources), which no wonder will lead to farm activities' imperfections. Such scenario is likely to affect *ngolo* cultivation practices as well since it is a labour intensive and tedious activity undertaken by Matengo people.

Nyong *et al.* (2007), however, criticise the tendency of western researchers to blame indigenous land use practices on climatic and environmental degradation without taking into consideration the positive role played by such methods for years. These scholars commend the inhabitants of Sahel to have over the years, adapted to the climatic extremes that exceed those predicted by some of the IPCC models following the wisdom of the accumulated knowledge over their environment.

2.5.2 Socio-economic and policy change factors

Several developing countries, including Tanzania from 1980s-1990s embarked on structural adjustment policies in response to macro-economic policies imposed by the World Bank and International Monetary Fund (IMF). This discourse centred on market led economic development. Structural adjustment policies in Tanzania included liberalization of agricultural markets and removal of state monopolies, withdrawal of government from production projects, decentralization of agricultural extension services to respective district councils and local government authorities (URT, 2003). Tagseth (2002), and Limbu (1995) cited by Sokoni and Shechambo (2005), commented on such structural adjustments that have influenced the operating environment under which traditional irrigation systems are prevailing. Since such policies advocated free market economic development, apparently have implications to farmers' decisions on what to produce, where (e.g. upland or bottomland) and what technology to invest which in return has effect on soil and water conservation systems.

Changes in governing policy frameworks may cause shifts in socio-economic roles. Lema (1996), in his study noted a shift of men in the southern Tanzania towards valley bottom cultivations (for vegetable gardening) an activity which was formerly done by women. This shift may result into new garden preparation or planting patterns. Similarly, the out-migration/emigration of men to urban centres and mining sites for employment opportunities which is among the results of macro-economic policies have led women to assume new roles as de facto heads of households to make decisions. An example was noted by Igbokwe (1996) in Nigeria where the indigenous terracing system “*ishi-mgboko*” was under the threat of disappearing due to out-migration of males to suburban centres for wage labour in large opened plantations leaving women short of important resource for repairing the system. Similarly, Kangalawe and Lyimo (2008) have observed the deterioration of *ngolo* in terms of size which has increasingly become small due to less labour availability in Matengo highlands following out-migration to mining sites.

Government programmes may bring a change into particular resource management practices. This was evidently revealed by the implications from the Ujamaa villagisation programme which took place in 1973-6 in Tanzania. The programme is regarded as “one of the greatest social experiments in postcolonial Africa” (Lawi, 2007). Several societies lost their specific resource management knowledge nurtured and developed over years of experimentation as a result of shifting residence from well-established former homesteads into new concentrated settlements. For example, the “*ngitiri*” system of setting aside a forested land for future use by Sukuma (Kikula, 1997, Ylhaisi, 2006), and the intensive land use system of integrating cattle

grazing/pasture land-home gardening (*tlarang'w*) around homesteads practised by Iraqw (Lawi, 2007) were devastated. Indigenous institutions i.e. “established local systems of authority and phenomena derived from social cultural and historical processes of a given society” have also been caught in a trap of political and economic changes taking place in developing countries (Appiah-Opoku and Hyma, 1999).

Repercussions of such changes include erosion of cultural heritage and loss of site specific soil-water management knowledge too. It was similarly observed by Watson (2003) that customary institutions which served for natural resource management in Borara, Ethiopia assumed new roles in influencing people’s access to and control over resource and arbitrates resource as a result of policy changes. The change of roles ultimately had implications on the use and management pattern of resources. Also intentional government interventions can drive farmers to abandon their indigenous knowledge if an innovation meets the local demands. Over 80% of interviewed farmers in Ufipa plateau claimed that their well known indigenous soil composting technique alias mounds cultivation “*intuumba*” was dwindling in status following the adoption of animal drawn plough (Mbegu, 1996).

These policy changes or intentional government interventions in the country may also have implications for the Matengo pit system which has gone undocumented to a large extent. All the same, it has not been backed up with enough empirical evidence as to whether policy changes have been sensitive or not to indigenous

practices (Matengo pits cultivation). It is unknown as to what features have undergone changes and what are their implications to the communities.

2.5.3 Other contributing factors

A body of literature has documented the effect of land tenure security on farmers' confidence to invest on resource management and conservation. Maxwell and Wiebe (1999), cited from Saidou *et al.* (2007), hypothesized that "tenure security increases the supply of formal credit through creation of tradable collaterals, which could result into greater short term investment in inputs and greater long term investment in land conserving technologies".

A shift of gender roles or division of labour is also found to have influence on indigenous soil and water management practices. The knowledge and skills accumulated through experiences and experimentation across different social groups is reportedly different. According to the World Bank (2003) over half of the world's population is women who are mostly engaged in ensuring household food security activities, collecting forest products through which they have harvested a vast indigenous knowledge and skills different from that of men. Global changes which are currently taking place might have impacted them differently. Likewise their fellow women in Matengo highlands who are craftsmen behind Matengo pits cultivations, "*ngolo*" making (digging and turning up the soil), which is a labour intensive activity ought to be studied for sustainability of people's livelihood and environmental well-being.

2.6 Research Status on Indigenous Soil and Water Management Practices in

Tanzania

Tanzania has a diversity of ethnic groups engaging in different livelihood options and strategies, mainly being agricultural related activities. Clearly, each ethnic group in particular has a stock of different indigenous knowledge and skills for survival strategies. Mascarenhas (2004), however, has contended that little has been done to document these indigenous knowledge and skills in the country until recently, as much of the attention has been paid to scientific knowledge system. The government has currently taken initiatives of mainstreaming some of indigenous knowledge systems into national policies and programs, for instance traditional healers and birth attendants into the health sector (Shemdoe, undated). Also formulation of Traditional Irrigation and Environmental Development Program (TIP), though not by the government, reveals further recognition of the role demonstrated by traditional irrigation systems in the country in supporting agricultural production (Sokoni and Shechambo, 2005).

However, ever since the colonial rule (i.e. before 1961), several studies have been done seeking to understand different indigenous soil and water management or conservation practices developed voluntarily by resource poor farmers. To mention a few, include studies on mounds cultivations in Rukwa (Mbegu, 1996), pitting systems of the Matengo people in south western highlands of Tanzania (MWARP, 1998; Allan, 1965; Mbago, 1997 cited by Nindi, 1999; Kayombo *et. al.*, 2001; Malley *et. al.*, 2004), water harvesting techniques called “*majaruba*” or earth bunds

invented by farmers in paddy growing areas e.g. Mwanza, Shinyanga, Tabora, Dodoma and Singida (Shaka *et al.*, 1996, Kayombo *et al.*, 1999), and use of tied ridges in Mwanza and Shinyanga (Prentice, 1946 and Kayombo, 1993 cited from Kayombo *et al.*, 1999). Also, there have been studies on the role of traditional irrigation systems such as *ndiwa* used in Usambara Mountains, which has served for ensuring household food security (Sokoni and Sechambo, 2005).

Despite such considerable research efforts, however, many of the studies have taken a static perspective and not acknowledged the dynamic nature of the indigenous knowledge systems. Secondly, studies have not examined the implications of changes on food security. The reviewed body of literature has well acknowledged the role which the pitting system (*ngolo*) has played to the livelihood of the people of Mbinga and the agricultural sector in the country. However, the existing literature has remained speculative based on generalized perceptions and scant anecdotal evidence, as to whether the practice will withstand fast pacing environmental, economic, political and cultural changes currently taking place from local to global levels, and its ultimate implication to the household food security status. A few workers have indulged to establish empirical evidence of the situation, which this study was seeking to understand.

2.7 Theoretical Perspectives

There are a number of scholarly theses that have tried to put some propositions with regards to agricultural technology changes, including farmers' behaviours. This study reviews some of the theories which provided guidance on the subject matter of

tracing changes in Matengo pits cultivations and their implications for food security. It covers theories of change, including agricultural change theory and behavioural change theories.

2.7.1 Agricultural change theory

This theory comprises of two dominant schools of thought: Malthusian theory (1798) and Boserup theory (1965) which both argue about population and agricultural change. The assumption of agricultural change theory is that changes in agriculture occur on daily basis i.e. farmers all over the world make decisions about what, where and how to cultivate.

Malthusian theory conceives that “the power of population growth is indefinitely greater than the power of land to produce subsistence for man ...” (Netting, 1993; Mendola, 2007). The thesis argues over intrinsic imbalance between rates of population increase and food production. Furthermore, it contends that “unchecked population increases in geometrical ratio while subsistence increases in an arithmetical ratio”. Therefore such increase in population leads into land scarcity and prompting farmers to expand their agricultural activities into marginal lands. He emphasized over bringing more land into tillage (extensive farming) in order to increase production.

However, Boserupian perspective (Boserup, 1965) counteracted Malthus theory by contending that it is the population which determines agricultural technological change/inventions rather than the opposite. It emphasizes more faith in technological

development by stating that “shorter fallow will induce labour intensification and technological innovation”. That is agricultural development is dependent on population growth. The rising population density calls for production concentration (i.e. agricultural productivity in terms of output per unit of land per unit of time) to rise and shortening of land fallowing time. Population increase has led into reduced period of land fallowing or its abandonment which prompted into continual cultivations of existing crop fields (agricultural intensification) ultimately leads to soil productivity decline. Such continual cultivation and productivity decline have called for expanded efforts at land preparations, fertiliser applications, irrigation, weeding etc. Empirical evidence has similarly been noted in different areas including in Matengo highlands (MWARP, 1998). Similarly, the Matengo pits system is among the forms of intensive farming systems resulting from population increase.

The Boserup theory further highlighted that such changes have induced agricultural innovations though have implications to the farmer since they lead into increase in marginal labour cost with increase in population density. However, the Boserupian model is challenged by other scholars that it is basically ideal to industrialised agriculture with well-developed infrastructures, capital investments, access to inputs, markets, etc. in contrast to resource poor countries. Also the Boserup argument of “intensification as a universal process cross cutting environment” received a challenge from Ecological variation model that “the use of fire and fallow” are not universal. All the same, Brookfield (1987) compared the Boserup model to the toothpaste tube “that population growth applies pressure on tube and squeezes out agricultural innovation at the end”, which sometimes brings very different patterns of

agricultural technology changes due to different farmers' abilities to invest, withstand risk and attract subsidy. Therefore such changes may lead into land degradation rather than innovation, which were also noted in Matengo highland farmers opting for environmental unfriendly field preparation technologies.

Chayanov (1925), cited by Thorner *et al.*, (1966) analysed the peasant farming based on energy optimization, with change in agricultural technology driven mainly by demographic make-up of the household. Chayanov theory of peasant theory argued that the drudgery of labour in peasant production was such that farm household did not seek to produce as much as possible in profit maximization but sought a more restrained and less elastic goal.

2.7.2 Cognitive behavioural change theories

Behavioural change theories are adapted to explain resource management decisions and degradation. Farming families are primarily regarded as individuals and in many aspects will tend to behave very much like other individual decision makers. As such, Behaviour change theories still had an opportunity of providing guidance to this study along with other robust theories which consider other issues that impact on decisions. Farmers like many other individuals have different motivations/needs which all aim at survival and personal growth. Similarly, this is what motivates the behaviour of individuals.

Among many of behavioural change theories; there is Trans-theoretical model of behaviour change (TTM) put forward by Procheska *et al.* (1970) and later modified

by Procheska *et al.* (1994). This theory provides some basis for explanations of situations which motivate an individual/farmer to undertake particular behavioural change. It is assumed by TTM that a behavioural change is a process rather than a single event through which an individual undergoes different stages of change, which include: pre-contemplation (individual has no idea/intention to change); contemplation –an individual is making a survey with eyes or mind; preparation; action; maintenance. Each stage of change describes a person's emotional or motivation readiness to change or progress towards changing the problem behaviour.

However, TTM contends further that stages are not linear in that a person can start at any stage of change, and still people can revert back to an earlier stage or skip forward based on both internal and external factors. Similarly, Matengo farming communities tend to use conventional ridges when constrained by time following a number of factors (timing unreliable rainfalls, being overwhelmed by the number of farm and non-farm activities) but could still bounce back to Matengo pits farming system in the following season.

2.8 Summary of the Literature Review

Reviewed scholarly materials indicated that the Sub Sahara African countries, including Tanzania have a diversity of indigenous soil and water management practices. To mention a few, Tanzania consists of a range of indigenous practices like stone bunds in Ukara Islands along Lake Victoria, ladder terraces in Uluguru Mountains, traditional irrigation systems e.g. *ndiwa* in Usambara Mountains, *intuumba* of the Wafipa, Matengo pits farming system. However, most of these

indigenous knowledge systems have been challenged by a number of factors, including socio-economic, demographic and environmental factors.

Referring to the Matengo pits farming system as the focus of this study, the reviewed body of literature has acknowledged the role which this system has played to the livelihood of the people of Mbinga and the agricultural sector in the country. Despite such considerable research efforts, however, many of studies have taken a static perspective and not acknowledged the dynamic nature of the indigenous knowledge systems. Much of the existing literature has remained speculative based on generalized perceptions and scant anecdotal evidence, as to whether the system will withstand fast paced environmental, economic, political and cultural changes currently taking place. That there is little empirical evidence from the micro-levels of individual households (regarded as centres/units for decision making), as to what extent this indigenous farming system has changed since its invention. Few workers have endeavoured to establish such empirical evidences of the situation.

Nevertheless, most of the reviewed research studies were more inclined to a single qualitative approach rather than being integrated with quantitative research methodology for collecting field data. Neither of the two approaches could independently bring an exhaustive picture of the situation rather they need to be integrated, since they are complimentary. In view of this, there was a need for further research by integrating the two approaches in order to adequately explain the situation of the current Matengo pits farming system and its implications to household food security to bridge existing knowledge gap.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Overview

This chapter describes the research design and methods adopted to provide data to answer the objectives and research questions presented in chapter one. The chapter is largely organised around several major topics, including study area, design and justification, sampling procedure and sample size determination, data collection and data processing. This chapter describes further how the data were collected and dealt with in terms of processing and analysis in order to generate the study information.

3.2 Description of the Study Area and Justification for its Selection

This study was undertaken in Mbinga District in Ruvuma Region, which lies between longitudes 34° 24' E and 35 28' E and latitudes 10° 15'S and 11° 34'S i.e. in the south western part of Tanzania. The district covers about 11,935 km² and is dominated by four distinct agro-ecological zones namely: mountainous highlands, rolling hills of northern and southern parts, the Hagati plateau and the coastal strip along Lake Nyasa (MWARP, 1998). Climatically, the area has a unimodal rainfall pattern, starting in November to May with an average annual rainfall of 1224 mm varying from 1000 mm to over 1600 mm (Kayombo *et al.*, 2001). Coffee, tobacco and cashew nuts are grown mainly as cash crops, whereas maize, beans and cassava are staple food crops. The district was purposely selected because of the existence of Matengo pits that are suited to hilly areas and is believed to be one of the most spectacular indigenous farming systems found in Tanzania, currently facing socio-

economic and environmental challenges prompting farmers to adjust accordingly (Rutatora *et. al.*, 1996).

3.3 Research Design

A cross-sectional research design was adopted for this particular study which involved “collection of data on more than one case and at a single point in time in order to collect a body of qualitative or quantifiable data in connection with two or more variables, which are then examined to detect patterns of association” as it was suggested by Bryman (2004). Choice of the research design, however, was also appropriate given the limited resources (time and money) availed to the researcher, while maintaining the reliability of the collected data.

3.4 Sampling Procedures

The study covered a total of four villages. Selection was based on the fact that, villages are located in two different landscape scenarios i.e. from mountainous (Kindimba and Litembo) to rolling hills areas (Myangayanga and Tukuzi) characterised by existence of *ngolo* to be studied. The sampling unit was the household, since it is the basic unit of analysis for understanding farm management and decision making (Chinene *et. al.*, 1994). The sampling procedures were divided into two phases i.e. for selecting the participants for undertaking PRA exercises and selecting farming households which were subjected to the household interview using the questionnaires.

3.4.1 Selection of participants for PRA exercise

The study used focus group discussion (FGD) as the main tool of PRA to serve as the benchmark for comparing the current situation of the Matengo pits system of farming with that of the past, including the overall situation of the respective village. The participants for the FGD were purposely selected from their respective study villages by emphasizing representation of different gender groups (young/old generation; men and women, etc.) from all sub-villages to capture the diversity of the community views. Groups of participants differed from not less than 10 to 15 people aged between 30 to 70 years old. As a challenge to the study, this FGD exercise sometimes created a lot of interest to the rest of the village community members preferring to take part in the discussion but it was not possible to accommodate all of them. Also purposive sampling procedure was used to obtain district government officials, village leaders and key informants (village elders/influential people) for undertaking the key informant interviews.

3.4.2 Selection procedures for household interviews

Households were obtained from the sampling frame which was the list of all households within respective villages. The farming households were all stratified according to their socio-economic well-being differences following wealth ranking exercise during Participatory Rural Appraisal (PRA), after which the stratified random sampling technique was used to select households for interviews. A total of 180 farming households were used as the sample size, which was at least 5% of the total households in the study area (see Appendix I) as proposed by Boyd *et. al.* (1981).

However, this final sample of the study was reached by randomly selecting 15 households from a total of three identified sub-villages (i.e. five households from each sub-village) from every study village. These summed up to 45 households from every village. Out of these 180 sampled households, a total of 898 people including household heads were found as household members, whereas their personal information was subjected to the study analysis. Such sample size of 180 households was manageable based on the nature of the study which banked on memories of farming communities.

3.5 Data Collection Procedures

3.5.1 Primary data

The study employed both qualitative and quantitative research methodologies to meet the above mentioned objectives (see Appendix II and III). The first stage involved the use of different Participatory Rural Appraisal (PRA) tools (Focus Group Discussions, wealth ranking, timeline analysis, crop/work calendar, resource mapping, etc.) to facilitate a two way process of information exchange between local communities and outsiders (Warburton and Martin, 1999). Focus Group Discussions were carried out in order to analyse socioeconomic characteristics of the study communities as well as capturing institutional and policy changes. Due to scepticism of farming households on reckoning the use of un-recommended practices in their fields, the use of PRA served the purpose of grasping the reality regarding changes within Matengo pits farming system from a different dimension. PRA involved the use of key informants and opinion leaders, including other social group categories (regarding to sex, age groups, etc.). The PRAs were conducted in each study village,

whereby the researcher introduced the subject matter (Appendix VI) and left it to the participants to discuss freely.

The second stage entailed administering questionnaires with closed and open ended questions (quantitative survey) to households identified and selected randomly during the PRA exercise according to their differences in socio-economic status (refer to section 3.4.2). The socio-economic differences comprised of three strata that is: wealthy households, better-off households, and poor households which were grouped according to their own perceived criteria as indicated in Appendix VII. The questionnaire used for household survey is as attached in Appendix IV. This stage surveyed the study sampled communities over the socio-economic, social and environmental issues subjecting them to changes of the Matengo pits system and emerging of new cultivation practices, and how these practices have impacted on food security.

3.5.2 Secondary data

Other sources were consulted to obtain secondary data from related studies done by previous workers to supplement the current study. It included obtaining the Mbinga District socio-economic profile, District environmental by-laws, different research reports and literature.

3.6 Data Management Procedures

3.6.1 Data processing and analysis

Collected data were coded, cleaned and subjected to the computer based programme of SPSS (Statistical Package for Social Science) for statistical analysis. Descriptive statistical analysis was undertaken; include running frequencies, means and standard variations to explain the distribution of study variables. In addition, Chi-square analyses were also done to explore the relationship between dependent and independent variables i.e. explaining the best predictor of undergoing changes taking place in indigenous soil-water management practices. However, content analysis was employed for qualitative data analysis. The information from Focus Group Discussions was scrutinised into meaningful units based on the research objectives/research question to supplement the quantitative data/information.

3.6.2 Relationship between variables

The collected data were subjected to two analytical processes to find the relationship among different variables. Firstly, Chi-square analysis was used to determine the relationship between different factors (socio-economic, demographic, environmental and socio-cultural) as independent variables and the changes in Matengo pits farming system (emerging/ new forms of cultivations) as a dependent variable.

Secondly, the analysis involved cross tabulations using Chi-square test in order to determine the association between different factors (like crop field landscape, tillage method used and the location of the particular field) and household food production (measured in kilogram yields per hectare). The analysis was undertaken by

comparing means of crop yields obtained from different landscapes, tillage methods and field locations to determine their influence on physical food production. Feeding rate to children less than five years during food shortages, and number of months the household is food secure were also analysed.

However, the analysis was further supported by running the binary logistic regression model for predicting which type of changes in Matengo pits farming system had an influence on the household food security status. The selection for this model was based on the fact that is well suited for describing the relationship between categorical outcome variable and one or more categorical or continuous explanatory variables. The outcome of the binary logistic model was whether food shortage occurred or did not due to changes in Matengo pits system of farming (change of time used for drying grasses, modification of grasses alignment pattern, size and depth of Matengo pits) as independent variables. The outcome variable is denoted as Y (dichotomous variable) with the values either 0 or 1 (where 0= food shortage did not occur and 1= food shortage occurred). If X_1, \dots, X_n are explanatory variables behind the occurrence of the outcome (food shortage).

However, the logistic regression model applies the logit transformation (natural logarithm) to the dependent variable i.e. it predicts the logit of Y from X based on the conditional probability for the event occurrence (event to occur $Y=1$) given the values of X_1, \dots, X_p as described below:

$$P(Y) = 1 / [1 + \exp - (\alpha - \sum \beta_i X_i)] \quad \text{Equation (1)}$$

Therefore the natural logarithm of the Equation (1) is as follows below:

$$\text{Logit } P(Y) = \alpha + \sum \beta_i X_i + \varepsilon \quad \text{Equation (2)}$$

Whereas:

Y = probability of the outcome (Y =1 if food shortage occurs; and Y = 0 if food shortage do not occur)

α = constant term

X = Independent variables [Time used for drying grasses (At least two weeks = 0, Less than two weeks = 1); Grass alignment pattern (Grid form=0, Parallel lines = 1); *Ngolo* size (Large size = 0, reduced size= 1); Depth of *ngolo* (Deep = 0, shallow =1); Accessed extension services (No = 0, Yes = 1); Accessed credit services (No = 0, Yes = 1); Household size; Total acreage owned; Income earned from coffee]

ε = Error term

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Overview

This chapter presents the findings obtained by this study, including discussion in line with the study objectives. It presents the results under five main sections. In first section, the chapter provides an overview of household based information including demographic, socio-economic and socio-cultural characteristics of both household heads and members. The second section presents a summary of the findings related to the dynamics of Matengo pits farming system and their associated factors. This particular section summarizes some empirical evidence in an endeavour to unravel the future of the farming system and the livelihoods of the Matengo people. The third section has focused on different sources of labour and gender dimensions within this particular farming system. The emphasis has been on gender analysis because of the farming system is strictly gendered.

The fourth section of the chapter summarises the external factors (institutional and agro-ecological variability) which directly or indirectly have played significant role behind changes in Matengo pits farming system. The fifth section of this chapter discusses the status of crop production and household food security as influenced by changes in land husbandry and agro-ecological differences. All these findings enhance the understanding of the various options which have been undertaken by the farming communities in response to the social, economic and environmental

changes. It also highlights some possible options to assist the farmers to reduce their vulnerability by increasing the resilience of the Matengo farming system which supports their livelihoods.

4.2 Household Structure

This section summarizes key characteristics of the farming households which is the centre of analysis on determining production and consumption decisions. Netting (1993) defined a farming household as the major corporate social unit for mobilizing agricultural labour, managing productive resources, and organizing consumptions. It is also a centre of decisions which pre-determine the uptake of any development interventions as guided by choices made by household heads and respective members. This section has two sub-sections, firstly on the findings related to heads of households with respect to their demographic (sex and age structure distribution, household composition i.e. household size, marital status), socio-cultural (ethnicity) and socio-economic profiles (literacy level, wealth status, main occupation). Establishing the status of the head of household is particularly important since he/she is largely involved with major decisions concerning resource use and operational management within the household.

The second sub-section provides an analysis of the characteristics of the general population (excluding heads of households). This sub-section includes the description of demographic, socio-economic and socio-cultural aspects related to household members and how they interact with the Matengo farming system.

4.2.1 Demographic characteristics of household heads

4.2.1.1 Sex and age structure

A total of 180 households were surveyed, 32 (17.8%) of which constituted female headed households. This is slightly higher than the average 14.0% of female headed households recorded in the Tanzania Agriculture Sample Census –National Gender Report for Ruvuma Region (URT, 2007). Table 1 summarises the age structure distribution according to their respective sex categories.

Table 1: Age groups distribution of household heads (n=180)

Characteristic	Sex of household heads				Total	
	Male		Female			
	Freq.	%	Freq.	%	Freq.	%
Age groups (years):						
25-34	17	9.5	2	1.2	19	10.5
35-64	97	53.9	26	14.4	123	58.3
65+	34	18.9	4	2.3	38	21.2
Total	148	82.2	32	17.8	180	100
Mean						51.8
Minimum						25
Maximum						87
Std error						1.1

The average age was 51.8 years, while the minimum and maximum ages were 25 and 87 years, respectively. A large group of household heads from sample population was aged between 35-64 years. This particular age group was the most active and productive age group, which is potentially vibrant to make innovative decisions particularly on high labour demanding activities, including Matengo pits preparations.

The average age of sampled population was slightly below the life expectancy of 53 years for men and 56 years for women as projected by the National Bureau of Statistics in 2008 (NBS, 2009). Despite the fact that the compared mean ages were from two different samples, yet they provided a highlight of life expectancy of the Matengo communities. The drop in the life expectancy could be accompanied by a number of factors. Mbinga District ranks the sixth in HIV infection prevalence rate (11.1%) in Tanzania, according to blood donors' surveillance statistics of 2005 (Ministry of Health, 2007). Also, among others, current prevalence of malaria in Matengo highlands due to climatic changes and dual residence of farmers (from uplands to lowlands for agricultural land), poor health services, etc apparently have labour availability repercussions to such labour intensive indigenous farming system.

4.2.1.2 Marital status

Establishing facts on the marital status of household heads allows an understanding of whether there are intermarriages which can influence what and which technology to use during farming activities. Similarly, the factor of marital status determines the quality of *ngolo* workmanship. This is particularly true since the Matengo farming system is strict on gender division of labour or specialization of activities. Results from this study as shown in Table 2, revealed that 77.8% of the sample were married (only represented by male household heads), and while 50.0% of all female-headed households were widows and 28.1% divorced. The rate of widowhood to female household heads was at higher levels than male headed households, which was only 4.1% of their respective total counts. This is probably highly accompanied by a tendency of males to re-marry after death of their spouses, which is not commonly

done by females. These findings also coincide with what was reported by previous researchers from other areas within the Tanzania (Isinika and Mdoe, 2001; Kirway, 2009). In view of the above, these heads of household lacking spouses were assumed to fall under the group of those constructing poor Matengo pits (e.g. with shallow depth, aligning grasses in parallel form, reduced size, etc.). This was revealed during focus group discussions and household survey.

Table 2: The marital status of household heads

Marital status	Sex		Total (n=180)
	Male (Counts=148)	Female (Counts=32)	
Single (never married)	0 (0.0%)	7 (21.9%)	7 (3.9%)
Married	140 (94.6%)	0 (0.0%)	140 (77.8%)
Widower/widow	6 (4.1%)	16 (50.0%)	22 (12.2%)
Divorced	2 (1.4%)	9 (28.1%)	11 (6.1%)

4.2.2 Socio-economic and socio-cultural attributes of household heads

4.2.2.1 Education level

The literacy level of household heads is believed to influence accessibility, control and utilization of resources. It may also influence access to new information regarding knowledge and skills from different sources, including extension services, which apparently could have impact(s) on environmental management, and more specifically on Matengo pits farming system as well.

Table 3 shows that majority of the sample population (88.9%) had primary school education, and only 4.4% had never obtained formal education most of whom were female household heads. The literacy rate is higher than the national statistics which is 72.5% according to Household Budget Survey of 2007 (PHDR, 2009). It goes hand in hand with a well-established history of Roman Catholic Church in the Matengo highlands which altogether introduced missionary schools before independence. Also according to the socio-economic profile, Mbinga District has recorded the highest number of primary schools compared to other districts in Ruvuma Region. The maximum level of education was post-secondary represented by only 1.7% of the sample population of which none of female household heads had attained. On the other side, the illiteracy level of heads of households is relatively lower than 21.0% and 51.0% for both males and females, respectively as was established by the Tanzania Agriculture Sample Census statistics (URT, 2007).

Table 3: Education level of household heads (n=180)

Characteristics	Sex				Total	
	Male		Female			
Education level:	Freq.	%	Freq.	%	Freq.	%
No formal education	5	2.8	3	1.7	8	4.4
Primary	138	73.3	28	15.6	160	88.9
Secondary	8	4.4	1	0.6	9	5.0
Post-secondary	3	1.7	0	0.0	3	1.7

Existence of a small percentage of household heads who attained post-secondary education is probably due to the lack of opportunities for further studies or justifies the fact that majority of educated people migrate to urban areas seeking for better-paid jobs other than farming activities.

4.2.2.2 Economic activities and wealth status

Most rural communities in developing countries like Tanzania tend to engage themselves in a number of activities for a living. However, despite all these activities still there are main economic ones which bread winners (i.e. household heads) greatly depend on. Majority (96.1%) of household heads reported to rely on 'farming' as their main economic activity providing them with food and income (Table 4). The study findings, revealed further that all female household heads were in this category. This still explains that women are highly engaged in farming activities probably due to lack of other livelihood alternatives at their disposal. According to this study, the aspect of farming refers to both crop farming and livestock keeping activities. Among the sampled households, explicitly 2.8% and 1.1% reported respectively as civil servants and self-employed. These civil servants were working as teachers and court clerks within rural communities, while the self-employed group was composed of wood workers and tailors.

Wealth ranking was done by the farming communities based on their own identified criteria during focus group discussions. Among others, criteria which were pointed out included: amount of coffee harvested and sold, food security status, house types, ability to send children to secondary schools, etc. (Appendix VII). Table 4 shows that

8.9% of female-headed households (about 50% of their respective total count) were categorised as poor farming families compared to only 24.4% of male-headed households. Male-headed households were the dominant group in the rich people ranking.

Table 4: Main occupation and wealth status of household heads

Characteristics		Sex				Total (n=180)	
		Male		Female			
		Freq.	%	Freq.	%	Freq.	%
Main occupation:	Farmer	141	78.3	32	17.8	173	96.1
	Civil servant	5	2.8	0	0.0	5	2.8
	Self-employed	2	1.1	0	0.0	2	1.1
Wealth status:	Rich	53	29.4	7	3.9	60	33.3
	Better-off	51	28.3	9	5.0	60	33.3
	Poor	44	24.4	16	8.9	60	33.3

4.2.2.3 Ethnicity status

The question of ethnicity is also considered among factors which can influence the type and nature of farming practice the household could decide to venture in. According to MWARP (1998), Mbinga District is dominated by three main ethnic groups, namely the Ngoni, Nyasa and Matengo people. In this study, ethnicity was established since this particular farming system is highly accustomed to the Matengo ethnic group as the only custodians of making Matengo pits along mountainous areas, which is different from their counterparts residing in lowlands employing different practices.

It was found that only 1.7% out of the total sample population constituted a group of in-migrant people who moved into the Matengo highlands. These were largely civil servants (primary school teacher and court clerk) who also engage themselves in farming activities, as well. This group of in-migrants was basically the Ndendeule originating from Namtumbo District in Ruvuma Region.

However, this does not exclude the chances of existing intermarriages since there might be non-ethnic spouses, which is examined in the following sections under the general population characteristics (i.e. other household members).

4.2.3 General characteristics of the household members

Focusing only on characteristics of household heads may not explicitly exhaust the potentials which other household members possess and their contribution to production and consumption decisions. Based on the objectives of this study, multiple observations and analyses were imperative in order to have best explanation of the farming households and how they interact with soil and water resources to attain their livelihoods. A total of 718 people (excluding heads of households) formed the rest of farming population subjected to this particular analysis.

This section presents the results of household members' characteristics. It pays attention to demographic characteristics like sex categories and age distribution. In addition, results on main occupation and literacy level of household members as far as socio-economic profile is concerned are also presented.

4.2.3.1 Demographic profiles of household members

Age structure

The results from Table 5 show that 43.2% of household members were below 14 years old, while 11.2% of the total household members were children below five years. Cumulatively, 52.5% of household members were between 15-64 years old, which is referred to as the active age in agricultural production activities (URT, 2007). Out of this percentage, however, females were more (33.9%) than males. This further confirms the fact that rural women are highly engaged in farming activities. Similarly, women still accounted 59.6% of the total household members.

Table 5: Age distribution of household members (n=718)

Characteristic	Sex of members (%)		Total (%)
	Males	Females	
Age groups (years):			
00 - 04	5.4	5.7	11.2
05 - 14	15.5	16.5	32.0
15 - 64	19.3	33.4	52.5
65 years & above	0.2	4.1	4.3
Total	40.6	59.4	100

The population pyramid (Fig. 2), shows a bulging structure in ages of five to 19 years old, which is relatively more in terms of percentages as compared to the national population census statistics as shown in Fig. 3. It probably indicates that this particular population is growing despite having relatively low birth rate (shrinkage of the population pyramid at the base i.e. age group of (00-04 years). It also reflects that such children/youth age bulging could serve as a potential labour force supply to

farming households for another 45 to 59 years provided working conditions (e.g. policies, climate, social services, etc.) suites/motivates them to remain in rural settings and engage in the farming.

However, the number of males within households tended to decline steadily beyond 19 years and none were between 55-74 years in contrast to females who were relatively well distributed across all age groups (Table 5 and Fig. 2). However, the population pyramid in 2002 as indicated in Figure 3 was shrinking fairly particularly from the age of 55-70, which was in contrast to the study findings. This might be contributed by out-migration of adult males to urban centres and mining areas seeking for better-paid off-farm activities where they sometimes become exposed to high mortality rates due to dangerous environments.

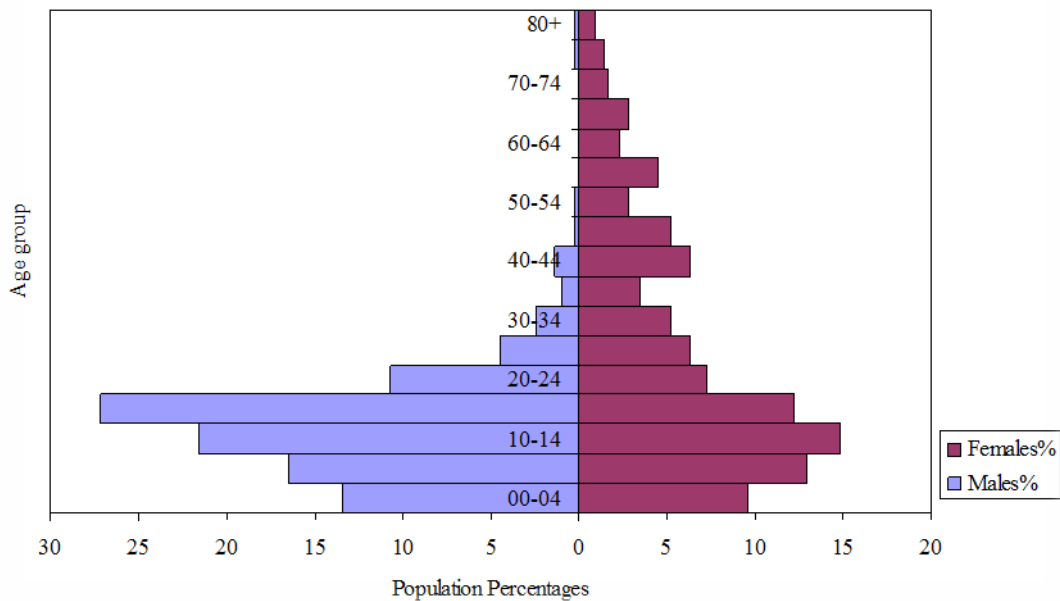


Figure 2: Population pyramid (According to study results)

Apart from the Matengo people practising dual residence between upland and lowland agro-ecological zones in endeavour to seek for arable land, still some have moved and settled permanently outside their native places, which might have contributed to low male population in the study area. Moreover, polygamy is commonly practiced by Matengo people despite this being against their Roman Catholic faith, which in turn increases the number of females from outside the study area. It might also subject into death risks due to household conflicts and HIV/AIDS infections. This has an implication for the *ngolo* being constructed poorly (with parallel lines of grasses) due to male labour shortages.

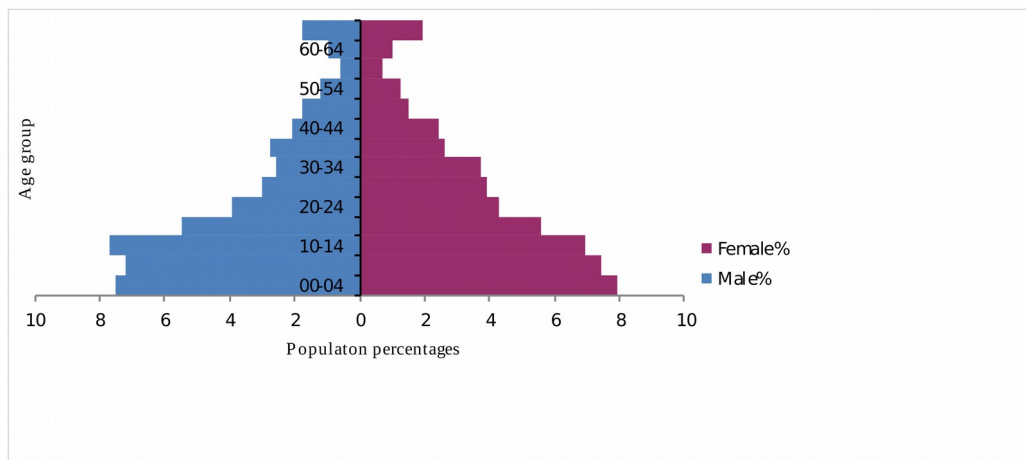


Figure 3: Population pyramid of the study area (According to the 2002 National Population Census)

However, the graphical differences of these two population pyramids (Fig. 2 & 3) are based from the fact that they were developed from two different samples despite being from the same population target. The number of people within different age categories shown in Fig. 3 was still in small percentages in contrast to the later

population sample (Fig. 2) indicating the population was still growing. It calls for investment in schools and health services provision to the study area.

Household size

Establishing the number of persons within farming households highlights the potential labour supply capacity of the household that could be organized to invest in Matengo pits farming system. A household is classified as “either a one person or a group of people who eat and share some common living arrangements” (UN, 1998). Table 6 shows the results regarding the number of persons within households, which included the household heads, as well. At most 42.2% of all sampled households had four to five people as household members. However, it was also observed that 43.8% of female-headed households had this number of members, followed by two to three people (34.4%) of their respective total counts.

Large household sizes potentially could serve as labour supply back-up particularly during peak labour demands to most of rural farming communities. This could also be truly reflected within the Matengo society, as well. The maximum number was ten household members while only one person was the minimum number (which respectively was represented by 0.6% and 1.7% of total households). However, 4.9 persons was the average number of members within the interviewed farming households being less than an average of 5.1 people which was recorded during 1988 population census (RALDO, 1997).

However, existence of a large household may not always guarantee the availability of family labour as might be compromised by several factors, like out-migration for better-paid non-farm employment opportunities in urban areas, attending school, illness, disabilities, old age or immaturity, just to mention a few. Similarly, the Matengo farming communities may not be immune to these challenges. This was observed by key informants during PRA that as of recent there has been an increase of “pull factors” in urban (serving as maids in houses and restaurants) and mining areas which attract a number of young males and females from rural communities. All these population dynamics have implications for the well-being of the agriculture sector by depleting the labour force.

Table 6: Household size

Household size	Sex of Household head		Total (n=180)
	Male	Female	
0-1 person	2 (1.4*)	1 (3.1)	3 (1.7)
2-3 persons	26 (17.6)	11 (34.4)	37 (20.6)
4-5 persons	62 (41.9)	14 (43.8)	76 (42.2)
6-7 persons	39 (26.4)	5 (15.6)	44 (24.4)
8-9 persons	18 (12.2)	1 (3.1)	19 (10.6)
10 and above persons	1 (0.7)	0 (0.0)	1 (0.6)
Mean			4.9
Std Error of Mean			0.14
Minimum			1
Maximum			10

(*)= all figures within brackets are %

It is more likely small sized households opting for either hiring-in labour (in exchange for: cash, seeds, food produce to eat) or relying on social networks (such as “*chama*” or “*ngokela*”) which depends on financial capabilities and social relations

with the rest of the farming communities, respectively. However, the quality of work in terms of Matengo pits constructions from above mentioned groups has remained questionable. *Ngolo* were claimed to be prepared from poorly organised grasses (aligned in parallel, ploughed under the soil even before drying (sun dried for at least two weeks), and consist of reduced dimensions and shallow depth. Reportedly, the more cultivated Matengo pits means more money to the casual labourer. It is very similar to the invited members of the *chama* who normally are ambitious to make more pits (regardless of the quality) to their hosting fellow members' fields in return for the same counts of pits to be repaid in their respective fields. Under this premise, the quality of work from both sources of labour (*chama* and casual labourers) becomes compromised.

Marital status and relationship to household heads

This variable has a potential to show whether there are existing intermarriages between the Matengo and other ethnic groups, which can also influence the skill of making Matengo pits. Altogether, the study went further to establish the relationships of the members to their household heads in order to identify the burden which the latter experiences.

Different ethnic groups within the country have a stock of different indigenous soil and water management practices, which are liable to change due to cultural interactions. Table 7 shows that out of 718 of the household members (excluding household heads), 51.5% were still too young to get married. As it has been reported earlier in Figure 2 that the age structure of this population is supported by a relatively

wide base, which implies that the study communities had a large number of children. Of all household members, however, 23.7% were married and 20.8% were mostly wives of male household heads, while one fifth had never married. The rate of divorce and widowhood was relatively low for household members as 3.2% and 1.5% respectively were noted. Intermarriages were also not very common, which accounted for 1.7%, implying little influence on changes of Matengo pit cultivations.

Table 7: Marital status and relationship of members to household head

Characteristics		Frequency	Percentages (%)
Marital status:	Single (never married)	144	20.0
	Married	170	23.7
	Widow/widower	11	1.5
	Divorced	23	3.2
	Too young to get married	370	51.5
Relationship to head:	Wife	149	20.8
	Child	440	61.3
	Grandchild	92	12.8
	Parent	12	1.7
	In-law	11	1.5
	Relative (sister/brother)	14	1.9

Nevertheless, more than half of household members were still below the officially recognised marriage age of 18 years. Although this may not be decisive criteria to most of rural communities rather it depends on whether the expected couples have reached adolescence to be married traditionally. As far as relationship matters are concerned, 61.3% of household members were children of household heads. Meanwhile, others were grandchildren (12.8%), parents (1.7%), in-laws (1.5%) and relatives like brothers and sisters (1.9%) of all household members (Table 7). None

of interviewed household heads had non-relative members' like casual labourers commonly found in tobacco growing areas. It simply implies that still most of interviewed farming communities maintain their extended families. It also means there were minimal chances for diffusion of new farming technology from other societies.

4.2.3.2 Socio-economic profiles of the household members

Literacy and employment status

Education level of the household members has a contribution to household production decisions, which this particular study measured. Similarly, employment status whether in the on-farm or off-farm enterprises has implications on household labour, time or income to invest in farming activities. The results in the Table 8 indicate that 61.7% of household members (excluding heads of household) had either accomplished primary education or were still in school. It largely, included children of 05-12 years (18.2%), young adults of 18-35 years (16.5%), and adolescents (13-17 years), which constituted 12.0%. However, 24.1% were illiterate and could not read and write, out of which 11.2% were still children. A small group of members represented by 1.1% (18-35 years old) were still undertaking post-secondary education.

Employment opportunities have implications on production decisions as well. Availability of off-farm employment opportunities might influence labour availability for households as some members could forego farming activities to

undertake wage labour assignments which have higher returns. However, accumulated resources (financial capital) from off-farm employments could also be invested in accessing farming technologies like hiring-in labour, buying or renting-in land, buying inputs, etc.

From the results, a large group of household members were still engaged in farming activities (42.7%). The dominant group was that of the working age (15-64 years), while a few old aged people (3.1%) were involved in farming activities. Interestingly, however, the school age children represented by 1.0% were employed full time in agricultural activities. Presumably, these were children who missed the opportunity to go to school and instead were absorbed into farming as the only alternative available at their disposal. Similarly, many of pupils within farming households assumed dual responsibilities i.e. as pupils and farm workers by supplying their family labour to agricultural activities on part time basis depending on their availability after school hours.

As far as non-farm employments are concerned, it was noted that very few were civil servants (0.1%) and self-employed particularly as tailors and lumberpersons (0.6%). Students formed relatively a large group constituting 35.6% of the total household members, meanwhile 20.6% constituted a group of sick persons, old aged and children who cannot work. All these have cost implications connected to child bearing and rearing, taking care of old aged, sick persons and children. It also includes sending children to school and meeting hospital costs when they fall sick which can influence some decisions on farming practices and type of crops to grow.

Involvement of school age children in Matengo pits preparation activities have been reported to have negative implications on the overall workmanship of the particular farm activity. This was particularly a matter of concern to majority of PRA participants in all contacted villages. Under this premise, the emphasis of the study was to establish which particular age group of the children assumes responsibilities as students or farmers.

Table 8: Education and employment status of members across age groups (n=180)

Characteristics	Age groups (years)				Total
	Pre-school age (0-6)	School age (7-14)	Working age (15-64)	Old age (65+)	
Education (%):					
No schooling	117(16.3*)	9(1.3)	29(4.0)	17(2.4)	172(24.0)
Primary	6(0.8)	171(23.8)	251(35.0)	14(2.0)	442(61.6)
Secondary	0(0.0)	7(1.0)	87(12.1)	0(0.0)	94(13.1)
Post-secondary	0(0.0)	0(0.0)	9(1.3)	0(0.0)	9(1.3)
Occupation (%):					
Farmer	0(0.0)	7(1.0)	277(38.6)	22(3.1)	306(42.7)
Civil servant	0(0.0)	0(0.0)	1(0.1)	0(0.0)	1(0.1)
Self-employed	0(0.0)	0(0.0)	4(0.6)	0(0.0)	4(0.6)
Student	4(0.6)	172(24.0)	79(11.0)	0(0.0)	255(35.6)
Not working	119(16.6)	8(1.1)	12(1.7)	9(1.3)	148(20.6)
Temporal (janitor)	0(0.0)	0(0.0)	3(0.4)	0(0.0)	3(0.4)

(*)= all figures within brackets are % out of total responses; 177 valid cases and 3 missing cases

Ethnicity of household members

Describing the ethnicity of the household members was of interest to this particular study as it has also been explained in previous sections that different ethnic groups have different stocks of knowledge. It was found that most of household members (98.2%) were the Matengo, and only 1.8% were in-migrants from other ethnic groups.

The study results suggest that the rate of in-migration in Matengo highlands was very low apparently contributed by the shortage of land. It further reflects that intermarriages were less common in the area, which might have been contributed by the decline of existing social interactions involving different ethnic groups sharing a common traditional dancing ground. Similarly, this might have been contributed by increasing food insecurity pressure. Therefore the aspect of ethnicity as the result of in-migration and intermarriages had little influence on the type of farming practices, though it could not be totally ignored.

4.3 Dynamics of Matengo Pits Farming System and Emerging Practices

This section provides some highlights on the changes which have taken place within the Matengo pits farming system, and what other borrowed soil-water management practices have emerged from outside the study area, including their accompanying reasons. According to the research results, these changes have resulted due to many factors revolving within and around farming families (socio-economic, demographic, environmental-climatic changes etc.). The study results are presented in two different sub-sections i.e. firstly, providing an overview of changes reported within particular Matengo pits farming system itself and secondly, highlighting on other newly introduced soil and water management technologies.

4.3.1 Changes within Matengo pits farming system

Matengo pits preparation is composed of a number of stages which are based on gender labour division/specialization. Among others, the following were some of the changes reported by the farmers from the study area. Reported modifications varied

from preliminary stages of land preparations to final stages of Matengo pits constructions. Among these modifications, include: time spent (number of days) for freshly slashed grasses left to dry before being ploughed under the soil during digging of Matengo pits; organisation or alignment pattern (within crop field) of collected dry grasses which serves as a sketch map to show where the pits will be constructed; the dimensions (size) of the pits, and depth of the pit excavated during constructing *ngolo*.

4.3.2. Time allowed for slashed grasses to dry

Table 9 depicts the results on the average time used by farming households to allow the grasses slashed by a billhook to dry before being aligned in a square or lattice form. After which, covering of aligned grasses with soil scooped from the centre follows to make tied soil bunds. Traditionally, at least two weeks is regarded as an optimal range of time for slashed grasses to be allowed to dry up before being incorporated into the soil (MWARP, 1998). However, from the study findings, over fifty per cent of farmers left the slashed grasses for at least two weeks to dry. This was regarded as an optimal time for grasses to dry. However, some of the farmers left slashed grasses for a week (26.0%), one to two weeks (18.1%) and others even less than a week (2.8%) before being ploughed under. Timing of activities was mentioned as the main push for the farming households (12.4%) to embark on incorporating grasses under the soil even before the optimal traditional time is attained. It indicates that time has become a scarce resource in Matengo highlands compelled by climatic changes and increase in livelihood activities.

Table 9: Time options and their associated reasons/factors

Time options	Reasons for time options selection (%)				Total (%)
	Few grasses in fields	Timing of activities	Optimal time	Avoid grasses regeneration	
Less than a week	0.6	2.3	0.6	0.0	2.8
A week	10.7	12.4	6.8	2.3	26.0
One to two weeks	6.2	9.0	4.5	3.4	18.1
At least two weeks	4.0	4.5	44.6	4.0	53.1
Total (%)	21.5	28.2	56.5	9.6	100

NB: Percentages are based on respondents (177 valid cases; 3 missing cases)

The majority of farming households were engaged in different farming and non-farm activities undertaken from the bottomland to upland fields all year round. The coffee industry, among other enterprises undertaken in the study area competes stiffly with food production sub-sector particularly for time and labour resources. Peak demands for such resources is particularly during February-March in the year when weeding and tilling to increase water infiltration in coffee fields coincides with preparation of new Matengo pits. These findings were in line with what was observed by Clayton (1968), cited by Barlett (1980). Also due to climatic changes, farmers have been “chasing” rainfall calendar which has become uncertain (refer section 4.5.4). The shift of rainfall calendar has impaired some of the activities as most of them starts when the rainfall season begins. This underscores the fact that bio-physical factors have a critical role to play in explaining the decisions over what type and why such crop husbandry was undertaken during that particular time/area.

Presence of few grasses during land clearing (slashing) also tends to convince farmers that they should incorporate these grasses timely into the soil to avoid losses of compost ingredients. Low availability of weeds/grasses to incorporate into the soil during Matengo pits preparations is mostly contributed by allowing cattle to graze in their fields after crop harvesting. Altogether, erratic rains experienced and soil productivity decline have contributed to less weeds growth during short fallowing period, hence less organic matter to incorporate. Yet some of the farmers in Myangayanga and Litembo claimed that they were incorporating grasses timely (within less than two weeks) to avoid regeneration of new grasses after slashing. All the same, such decision might be influenced by several other factors which prompt a farmer to undertake a particular behavioural or technological change (Prochaska *et al.*, 1994). For instance, timing of farming activities or rainfall season might drive changes. The findings similarly were in line with agricultural change theorists (Boserup, 1965), that land shortages in Matengo highlands have led to shortening of fallowing periods such that soil productivity has declined.

The implications of time modifications (i.e. opting for less than two weeks) might be associated with poor crop seeds germination following more heat generated during decomposition of fresh weeds/grasses. However, still time modifications might be in line with current climatic changes since farmers are probably experiencing longer sunny days enough to dry up all grasses in a shorter time.

4.3.3 Alignment pattern of dried grasses

Table 10 presents the results on grass alignment modifications. Traditionally dried grasses were aligned in a lattice form/square boxes where the ridges or soil bunds will be aligned to cover them (MWARP, 1998). From Table 10, 14.0% of the interviewed households reported aligning the dried grasses in parallel lines running down the field slope (refer Plates 1 and 2), while less than five per cent used both grid forms and parallel lines interchangeably. Reasons behind such emerging technology options were to simplify field work (12.3%) and the use of hired or communal labour mobilized either through *chama* or *ngokela* (4.5%). However, very few farmers (1.7%) reported this being contributed by existence of little amounts of grasses/crop remains within croplands such that they cannot make grids/lattice forms. Yet despite all above mentioned changes, still over eighty per cent of farming households were aligning grasses in grid or lattice form, since that is the traditional practice which has maintained soil productivity through composting and controlling soil erosion.

As it has been explained above, people opt for simple technologies to serve time and labour to invest in other activities for instance in coffee fields or sometimes due to the shrinkage of human capital (ability to work depending on age, health status). Meanwhile, other people have been rushing to “*pombe* shops” which have reportedly increased in number compared to previous years. Based on participant observations, these emerging practices were relatively more common in Litembo village (the upland side within Matengo highlands) which is regarded as the origin of this particular farming system.

Table 10: Alignment pattern of dried grasses with accompanying reasons

Grass Alignment Pattern	Reasons behind technology selection (%)				Total (%)
	For simplicity	Using communal/hired labour	Traditional practice	Few grasses	
Parallel lines down slope	11.2	4.5	0.0	0.6	14.0
Grid form	0.0	0.0	83.8	0.0	83.8
Either grids/ parallel lines	1.1	0.0	0.0	1.1	2.2
Total (%)	12.3	4.5	83.8	1.7	100

NB: Percentages are based on respondents (177 valid cases; 3 missing cases)



Plate 1: Parallel alignment of dried grasses on a steep sloped landscape



Plate 2: Women aligning grasses (parallel lines) and digging by hand hoes

According to FGD, farmers reported to have increased the use of hired labour since 2000 influenced by money economy of rural communities accrued from coffee. The quality of work either done by hired or communal labour (*chama/ ngokela*) has remained questionable since most of invited people are claimed to be in a hurry to make more *ngolo* pits to earn more cash/in-kind (food or labour) repayments. Use of casual labourers in Matengo farming system has similarly received serious attention by previous scholars (Mattee, 2000) in that it has led to poorly constructed *ngolo* which has contributed to declining productivity in Matengo highlands.

Such changes have repercussions to the overall strength of constructed *ngolo* pits as they have poor productivity especially the part which had no grasses underneath. Although these were relatively small percentages of change in grass alignment pattern but still have great potential to influence other farmers to adopt this practice.

Unless timely actions are undertaken by stakeholders to halt the process, the sustainability of *ngolo* farming system will remain in jeopardy. Nevertheless, the results were also contributed by farmers being sceptical to commit themselves during household interviews that were undertaking modified *ngolo* practices, which are not only restricted by cultural norms and traditions, but also are against administrative regulations.

4.3.4 Matengo pits size and depth modifications

4.3.4.1 Depth of Matengo pits

Regarding the Matengo pits farming system, farmers acknowledged to have modified both size and depth of the pit. Table 11 depicts the results on Matengo pit depth modifications including their accompanying reasons as reported by farmers. According to farmers' perceptions, pit depths were referred to as shallow, medium and deep. Discussions during PRA served as platforms for reaching consensus on different depth categories, which were also roughly ascertained by field measurements of a representative pits sample. Shallow pits referred to those less than 20 centimetres; medium depth referred to between one foot (30 cm) and 20 centimetres; a deep pit was 30 centimetres or more. However, the use of words like "shallow" or "deep" could still be just relative. Traditionally, a standard depth was estimated to be around 60-75 cm deep such that a kid of two-three years sitting in the pit may not be seen clearly from a distance.

Table 11: Excavated pit-depths and accompanying reasons

Depth of pits	Accompanying reasons (%)				Total (%)
	Avoid red soil (subsoil)	Communal/ hired labour use	Saving energy/ Labour	Control of soil erosion	
Shallow	21.4	25.0	10.7	0.0	51.8
Medium	8.9	12.5	10.7	1.8	30.4
Deep	0.0	0.0	0.0	17.9	17.9
Total (%)	30.4	37.5	21.4	19.6	100

Over fifty per cent of farming households reported constructing Matengo pits with shallow depth mainly due to use of communal labour or hiring casual labourers who normally rush to accomplish assigned field tasks at the expense of the quality of work; and avoid coming into contact with the red subsoil “*luhumbi lukeli*” which is deficient in plant nutrients (Plate 3). Existing land pressure in highlands has driven farmers into continued field cultivations without leaving fallows, which has ultimately subjected soils into erosion and excessive nutrient mining. These were similarly evidenced by Derpsch and Moriya (1998), cited by Arshad (1999). On the other hand, still 17.9% of farming households reported maintaining the traditional pit-depth with the reason that it controls soil erosion. These households also claimed that deep *ngolo* provides more soil to cover crop remains/grasses for enhancing in-situ composting activity and for soil erosion control (Plate 4).



Plate 3: A field plot with shallow Matengo pits left unplanted (foreground)

In addition, the FGD revealed that the slope of the seedbed has an influence not only on the depth of *ngolo* but also on its overall size. In croplands which are gently sloping, deeply excavated Matengo pits were highly preferable. This is due to existence of deep soils in contrast with steep sloping fields where most of the topsoil has been eroded.



Plate 4: Among the multiple roles of well-constructed Matengo pits (water harvesting and erosion control)

4.3.4.2 Size of Matengo pits

The results on size modifications are shown in Table 12. Over three quarters of the interviewed farmers reported constructing medium sized Matengo pits, and only 11.7% maintained the traditional large size dimensions (1.0m x 1.0m) with the reason that they provide more yields. A very small proportion of farming communities used either small (3.4%) or a combination of small and medium sized (9.5%) pits. The problem of land shortage in Matengo highlands has provided the impetus for changes in *ngolo* size. Reducing dimensions of Matengo pits into a medium size (approximately 0.75m x 0.75m) was highly associated with maximizing the available field space (31.8%) simply by spacing them more closely (means high plant populations per unit area) rather than using large sized pits. Large sized Matengo pits

leave more open spaces unutilised. This is also reflected in Table 14 as 23.5% of respondents reported seeking for more yields with the use of medium sized pits.

However, labour shortage was mentioned by 23.5% of the sample as among constraints impairing the use of the recommended large sized pits. Several factors like human health, age, number of able bodied persons within households and conflicting crop calendars determined the family labour supply potential.

Table 12: Different sizes of cultivated *ngolo* and reasons behind

<i>Ngolo</i> size	Reasons behind size options (%)					Total (%)
	Easy digging	Labour shortage	Maximizing space	More yields	Use of communal/hired labour	
Large (traditional)	0.0	0.6	0.0	11.7	0.0	11.7
Medium	12.3	23.5	31.8	23.5	14.0	75.4
Small	0.0	1.7	1.1	1.7	0.6	3.4
Small to medium	2.2	5.6	1.1	0.0	6.7	9.5
Total (%)	15.1	31.3	34.1	36.9	21.2	100

NB: Percentages are based on respondents (179 valid cases; 1 missing case)

Selling of labour for cash income, food or obtaining crop seeds to plant has also reduced availability of family labour. It was further deduced by farmers that medium sized *ngolo* pits were highly preferred in steep slopes since they could be closely spaced to control soil erosion by reducing the amount and speed of surface runoff. Also constructing large sized pits along steep sloped cropland was claimed to be

difficult. In addition, the amount of grasses collected during laying down the sketch of *ngolo* also determines the final *ngolo* size. Those who preferred small sized pits also claimed they were avoiding too much water collection within pits which exerts more erosion pressure on bunds of large sized *ngolo* pits. Existence of stones within the field also impairs construction of deep and large sized pits.

Based on these findings, confirms the contention by Boserup (1965) that land shortages could lead into evolution of new farming technologies. Land husbandry practices in Matengo highlands are still shaped by a number of factors, including land shortage pressure.

4.3.5 Prevalence of unplanted Matengo pits system

Participant observations revealed an increased proportion of people constructing new *ngolo* without planting seeds (beans/wheat as a primary crop) due to several interlinked reasons. Prevalence of food insecurity, need for cash income and rainfall unreliability in Matengo highlands have led to a shortage of seeds to plant. It was reported that people have been consuming seeds or selling the stock because of the attractive price (TAS 2,000 to 4,000 per “dumla⁴”). Some even taint bean seeds with paraffin to make them inedible. Unreliable rainfall has also brought interference with timing of activities and have rendered the crop to perform poorly due to either excessive or shortage of rains. Periods for relatively low intensity rains (February-March) have changed as they currently experience either thunderstorms destroying

⁴ A vernacular terminology referring to a plastic container of four litres capacity which originally was used for colour paints

crop stands or sometimes the season ends prematurely before a crop has reached maturity.

Existence of unplanted Matengo pits has some repercussions to the livelihoods of the Matengo communities because they would miss a primary crop. Traditionally, bean crop is used as the first crop to most of households except where people use wheat (mostly in Tukuzi and Litembo). Therefore, the system will fail to take advantage of nitrogen fixation by the bean crop due to incomplete crop rotation cycle (i.e. beans-maize-beans).

4.3.6 Emerging cultivation practices and their distribution

This sub-section summarizes different soil and water management practices (tillage methods) currently undertaken within the study area with regards to field location, terrain and type of crops grown as main driving forces to their selection. These indigenous soil-water management practices are likely to be lost based on several factors, including socio-economic, physical and biological factors. However, terminologies like tillage methods and cultivation practices would be used interchangeably.

Soil is generally regarded as an integral part of the natural functions of an ecosystem as it provides significant services to mankind including food through cropland, water, protection against diseases, climate change regulation through carbon sequestration, etc. The study surveyed both traditional and emerged or borrowed farming technologies employed by farmers, which significantly differed across all villages as

per Table 13 indicates. Table 13 below which summaries the tillage methods undertaken by farmers within their respective villages.

A total of five tillage methods were identified in the study area, namely: *ngolo*, *sesa* (flat cultivation), *mitumbila* (conventional ridges), *malonga* (ridges running down slope) and terraces. The prevalence of these cultivation practices differed significantly within respective villages, *ngolo* being the most common practice. In Kindimba, 56.7% of total village responses acknowledged using Matengo pits cultivation, which was the highest record compared to other surveyed villages. It was even higher than what was reported in Litembo village (47.8%) the area which is regarded as the origin of the Matengo pits.

Table 13: Response percentages of existing tillage methods

Tillage methods	Villages			
	Kindimba	Tukuzi	Litembo	Myangayanga
Ngolo	136 (56.7)	99 (44.0)	121 (47.8)	98 (46.4)
Mitumbila	19 (7.9)	22 (9.8)	16 (6.3)	32 (15.2)
Malonga	1 (0.4)	8 (3.6)	24 (9.5)	0 (0.0)
Sesa (flat cultivation)	57 (23.8)	95 (42.2)	85 (33.6)	77 (36.5)
Terraces	27 (11.3)	1 (0.4)	7 (2.8)	4 (1.9)
Total	240 (100)	225 (100)	253 (100)	211 (100)
Statistics: χ^2	259.8	443.9	358.8	339.9
p-value	0.001	0.001	0.001	0.001

NB: In brackets are total response percentages of respective tillage method within villages

Kindimba village has received a number of collaborative research and outreach interventions from Sokoine University of Agriculture compared to other villages in the Matengo highlands. Such field interventions should have raised awareness to

farmers on the rationale of undertaking proper agricultural practices like use of *ngolo* for producing food crops and terraces in coffee fields.

Presently, there are soil-water management practices which have emerged as newly introduced or borrowed technologies, which include conventional ridges (*mitumbila*), *malonga* (ridges running down the slope) and flat cultivations (*sesa*). Conventional ridges which were very common in lowlands/rolling hills have recently been introduced in Matengo highlands. Myangayanga had the highest response (15.2%) followed by Tukuzi (9.8%), Kindimba (7.9%) and Litembo (6.3%). However, not all of the reported *mitumbila* were practised in the study area rather some were used outside their respective villages in lowland areas like Kigonsera, Mkako, etc. However, this does not deny the fact some *mitumbila* for instance in Tukuzi were located in upland field plots within the village for growing maize and sweet potatoes.

Due to existing demographic pressure in the highlands, people have shifted from Matengo highlands to the rolling hills which are still sparsely populated seeking for arable land and some have settled there permanently while others maintain dual residence. Such dual residence has facilitated copying of some technologies both ways which ultimately ended up into the introduction of *mitumbila* in the highlands. Policy changes have also influenced penetration of this technology. Advocating self-reliance to school children, incoming of new societies into the study areas as civil servants (teachers, health workers, extension officers, etc.) have also provided avenues to local communities to learn about these conventional ridges. Similarly in one of Focus Group Discussions in Tukuzi it was reported that this technology was

the result of government intervention of introducing conventional ridges in Matengo highlands during 1980s. This was intended for the control of soil erosion and discouraging *ngolo* practices, which was rather an oversight instead of creating sustainable marriage between the two knowledge disciplines.

Another emergent practice is the use of conventional ridges constructed parallel to the slope of the field, namely *malonga* (Plate 5). This practice was fairly common in Litembo village covering approximately ten per cent of the village's cultivated land, but none were reported in Myangayanga village (Table 13). The practice was copied from Litembo neighbouring villages along the shores of Lake Nyasa commonly used for growing sweet potatoes. Farmers' interest on the technology is based on obtaining more yields since it provides chances for deep rooting of the crop. But why conventional ridges are constructed running down the slope? It is believed that it is done to avoid settling of surface run-off within ridge furrows which could deteriorate tubers, while others mentioned simplicity of constructing them.

Other practices, like *sesa* were very common in Tukuzi (42.2%) which is located in the lower side of the Matengo highlands compared to Litembo and Kindimba situated in the uplands. Essentially this practice largely used in coffee fields (65.3%) and valley bottom cultivation during off-season for producing crops like maize, beans, vegetables, sugarcane. Although the main focus of the study was on soil-water management practices revolving around the farming communities with emphasis on food crops, coffee fields were also studied. The use of terraces which were introduced in the area along with the coffee crop has steadily declined. Table 13

summarizes the results. Most of terraces have remained in coffee plots in Kindimba village (11.3%) and the least in Tukuzi (0.4%). The decline of this practice is due to the difficulties in manoeuvring during weeding and also most of terraces have been destroyed by digging or ploughing of the land to increase water percolation and aeration around the rooting zone.



Plate 5: Field plot with *malonga* planted with sweet potatoes running down the slope (right hand)

4.3.7 Field location and type of soil-water management practice

Like in many other smallholder farmers, land fragmentation is very common in Matengo farming communities. Farmers have a number of field plots scattered within or outside their respective villages. Field locations under this study referred to those situated around homesteads, within *ntambo* (a mountain ridge separated by river valley and where settlement and other livelihood activities are undertaken), outside *ntambo* but within the same village, and outside the village. The assumption

of the study was that different locations influenced differently field cultivation methods. Different locations differ in terms of land agro-ecological potentials (soil fertility, erodibility, micro-climate, topography, etc.) which dictate its suitability for growing a particular type of crop under particular soil tillage methods. Accessible fields around homesteads are more likely to have the recommended soil-water management practices as compared to those outside the proximity. Table 14 shows where different tillage methods were undertaken within or outside the study area.

Results analysis as presented in Table 14 show that tillage methods and field locations had statistically significant relationships ($\chi^2 (12) = 199.8, p < 0.001$). Flat cultivation was very dominant in homestead fields (57.9%) where most of the coffee fields exist. It also accounts for valley bottomland cultivations, as well. *Ngolo* cultivation was mostly reported outside farmers' respective *ntambos* but within their villages (63.4%), and around homesteads (27.3%). Most of the responses (28.9%) indicated that *mitumbila* were largely practised by farmers outside their respective villages, while few respondents indicated that *mitumbila* (5.2%) were practised around homesteads. In both these locations, maize and sweet potatoes were planted. Over three per cent of *malonga* were practised within either their respective homesteads or *ntambos*, which still indicates that there was evident change of tillage methods taking place within Matengo highlands.

Food shortages within households and increasing market demands of food products might have influenced the increased use of *malonga* and *mitumbila* practices. This has been done without considering potential threats posed by these practices on soil

degradation rather only focusing on producing food crops like sweet potatoes. Similarly, most of farmers claimed that the use of these types of ridges (*malonga* and *mitumbila*) was associated with saving labour and time since were constructed after returning from main field plots. School children were mostly associated particularly with the use of *mitumbila* through learning from school.

Table 14: Distribution of tillage methods across different field locations

Tillage methods	Field locations (%)				Total
	Homestead	Within <i>Ntambo</i>	Outside <i>Ntambo</i> - same village	Outside village	
Ngolo	27.3	52.3	63.4	61.5	49.2
Mitumbila	5.2	8.7	4.3	28.9	9.5
Malonga	3.3	3.4	5.1	1.5	3.5
Sesa/flat cultivation	57.9	31.9	23.4	6.7	33.7
Terraces	6.3	3.7	3.8	1.5	4.2
Statistics: χ^2	199.8				
p-value	0.001				

4.3.8 Crop field's topography and cultivation practice

Topographical position (landscape) of the crop field potentially has a role on decisions over what kind of cultivation method to be employed. With reference to this particular study, crop field landscape were basically categorised according to the perceptions/experiences of the interviewed farmers on general topographical positions of their respective fields. Field plots were generally categorised into four slope groups, namely: upland field-steep sloped, upland field-moderately sloped, upland field with flat terrain, and valley bottomland. Table 15 summarises the results with regards to the type of cultivation method in relation to field landscapes. It was

noted that Matengo pits was suited to all field landscapes, including in valley bottomlands for supporting maize production (11.6%).

Interestingly, however, newly introduced practices like *mitumbila* were even cultivated in steep sloped croplands (11.9%), although mostly were located in moderately sloped croplands (57.1%) serving mainly for maize (11.9%) and sweet potatoes (30.6%), as it was previously noted. In the case of *malonga*, these were constructed in upland field plots with relatively moderate slopes with high percentage found in sweet potatoes fields (61.3%). Similarly, despite being found in moderately sloped lands, it does not exclude them from experiencing severe soil erosion. This is highly associated with the fact that *malonga* are simply constructed parallel to the slope which encourages scouring of soil by running surface water. Flat cultivation is commonly practised in coffee fields and valley bottomland cultivations used in Matengo highlands. Study findings indicated that in upland fields this particular tillage method was found in flat terrains (1.4%) and moderately sloped landscapes (5.5%). Valley bottomlands were under flat cultivation by 93.2% as per responses of interviewed farmers capitalising on residual moisture for off-season food crop production and storing of seeds (beans and sweet potatoes as planting materials) to be planted during rain seasons (October–November).

Steepness of the landscape is among the factors determining vulnerability of the crop field to soil erosion. No wonder these crop fields with inappropriate tillage methods or incompatible with the nature of the soil and landscape pose potential threats to soil erosion and fertility declines. Also some of the farmers were using fire for land

preparation before constructing either *mitumbila* or *malonga* which releases sequestered carbon off the soil, meanwhile depleting what would have been incorporated as straws/crop remains during cultivation. Also the type of crops which were commonly grown in upland flat cropland (locally called *liheba*) and in valley bottomlands, include maize and sugarcane which cannot provide the soil cover nor capable of protecting the soil against erosion.

Table 15: Tillage methods under different field landscapes

Tillage methods:	Field landscapes				Total
	Upland steeply sloped	Upland moderately sloped	Upland with flat slope (<i>Liheba</i>)	Valley bottomland	
Ngolo	57 (30.0)	101 (53.2)	11 (5.4)	12 (11.6)	190 (100)
Mitumbila	5 (11.9)	24 (57.1)	11 (26.2)	2 (4.8)	42 (100)
Sesa/flat cultivation	0 (0.0)	4 (5.5)	1 (1.4)	68 (93.2)	73 (100)
Terraces	0 (0.0)	0 (0.0)	0 (0.0)	2 (100)	2 (100)

NB: Figures in brackets are percentages

4.4 Farming Labour and Gender Dimensions in Matengo Farming System

This section is structured around intra-household gender roles toward labour access and investments in Matengo pits farming system. Gender is defined as the social construct explaining the existing relationship between men and women within particular society. It is further concerned with the relationship among other social groups (e.g. age groups, ethnicity, race, rich and poor, etc.). Apart from household family labour (i.e. adult men and women, children), the study has also covered other alternative sources of labour invested in farming activities including hired labour (paid in cash/food) and use of communal labour/social networks i.e. *ngokela* and

chama. Children as a social group were not further segregated into boys and girls, the same applied to members of *chama* and *ngokela* whether were males or females due to difficulties of recalling.

Despite a farming household being regarded as a single unit of production, it is also comprised of different types and numbers of members differing in power positions, technical know-how, roles and responsibilities, just to mention a few (Quisumbing and Maluccio, 2006). On this basis, different members are tasked with different responsibilities. Similarly, labour investments in Matengo farming system are strictly based on gender.

The pits cultivation system encompasses a number of stages before and after construction of pits, whereas men were traditionally responsible in preliminary field preparation stages (slashing and aligning grasses/crop remains into grid forms), before digging and sowing of seeds which predominantly is done by women especially for beans and wheat crops. Matengo farming communities have traditionally banked on family labour, including the use of communal or local labour exchange groups locally known as *chama* and *ngokela*, and hired labour. Among other study objectives, it was found pertinent to disaggregate these gender roles and responsibilities within Matengo Pits farming system which may not have remained consistent under the current changing socio-economic and environmental factors.

4.4.1 Labour for land clearing and field aligning of dried grasses

The results in Table 16 show that statistically, the type of labour involved in land preparation differed significantly across villages of Myangayanga ($\chi^2(18) = 35.651$, $p < 0.008$) and Tukuzi ($\chi^2(24) = 42.866$, $p < 0.010$). Men's labour still formed the central component of the task of land clearing (*kukyesa*) and aligning grass grids (*kubunga*), whereby they were found to work individually in majority of surveyed villages. They were mostly reported in Myangayanga (35.2%), despite the fact that there were also women participating in the activity working as single members or alongside male family members.

Over 17% of responses from Litembo and Tukuzi, respectively indicated that women had recently assumed a full responsibility of land clearing (*kukyesa*) and organizing grass grids. Similarly, children provided a substantial labour backup to their respective families in clearing and aligning grasses. Their invested labour ranged from 11.8% to 23.5% across all villages, but mostly reported in Tukuzi (23.5%) as indicated in the Table 16. This particular gender group is actually formed by school children whose labour was subject to availability just after classes or during holidays. That is probably why the majority of rural communities tend to argue that the introduction of schools in rural settings has contributed to family labour shortages.

Rural-urban migration of males for wage labour, and poor human capital (due to unhealthy condition or aging of adult generation) might have influenced females and children to assume new responsibilities. However, the participation of these groups into this particular activity had received mixed feelings from the FGD participants. The majority of participants argued that this has led to poor land clearing (shallower

slashing) and arrangement of grasses, and probably emerging of parallel lines of grasses running up and down the slope instead of forming grids. Prevalence of HIV/AIDS also aggravates pressure on farming households, and is projected to lead to a labour force decline by 2020 by about 12.7% in the country (FAO, 2001). This has also contributed to the Matengo women becoming overwhelmed by both production and household chores which apparently have instigated the use of simple techniques to save time and labour.

Table 16: Labour used for land clearing and grass alignment in villages (%)

Type of labour used	Agro-ecological locations			
	Kindimba	Tukuzi	Litembo	Myangayanga
Family:				
-Adult males	18.4	27.9	20.0	35.2
-Adult females	14.3	17.6	17.6	5.6
-Jointly (male & female adults)	7.1	8.8	10.6	8.5
-Children	17.3	23.5	11.8	15.5
Hired labour	29.6	13.2	20.0	21.1
Ngokela	12.2	5.9	17.6	12.7
Chama	1.0	2.9	2.4	1.4
χ^2	20.497	42.866	24.693	35.651
df	24	24	24	18
P-value	0.668	0.010	0.423	0.008

However, there have been significant changes in the use of alternative sources of labour supplementing the family labour. More recently, the use of hired labour has overtaken the traditional labour exchange arrangements, which have significantly declined. Table 16 justifies that hired labour has mostly served on field preparations. The use of hired labour services was reported in Kindimba village (29.6%) compared to other communities. Land clearing and aligning of grass grids were reportedly

costing TAS 25,000 per hectare. The penetration of money economy into the rural community has resulted into the emergence of new forms of social relations among rural communities. Also from FGD it was revealed that the incoming of the Bena people in the Matengo highlands (1980s) seeking for livelihoods opportunities, including selling labour had influenced the change of labour supply arrangements. Consequently, all these factors have influenced the dissolution of local arrangements for communal labour sharing. The sharing of labour in reciprocity (visiting members in successions (*chama*) or eating food together (*ngokela*) has become almost obsolete under the current era. Every resource including food produce has been converted into a monetary commodity. Under this context, the concept of “food for work” has even proved unsustainable following the increase in food insecurity within rural households. Also it was claimed that working in *chama* takes more time of the member being outside his/her respective field before returning back while rainfall has become unreliable. Therefore people opt for casual labourers to serve time.

4.4.2 Access of labour in cultivating Matengo pits

According to the results in Table 17 labour invested in constructing Matengo pits was noted to have a statistically significant ($\chi^2 (18) = 44.239, p < 0.001$) relationship to the agro-ecological location/villages. The results indicate that men have gone against their traditions by taking part in constructing *ngolo*. Most men in Tukuzi (27.8%) and Litembo (24.0%) worked collaboratively with their spouses in constructing *ngolo*. Nevertheless, men as individuals particularly in Kindimba (4.9%) and Tukuzi (4.6%) were also constructing Matengo pits in their respective fields. They might be those who were either living as single members (widowers/un-married) or decided to

assume the responsibilities simply because their spouses were incapacitated or not available during that particular time. It is a relatively small percentage but has significant implications for the overall artwork of *ngolo* making. The participation of males in digging *ngolo* and seed sowing activities was formerly stigmatised. In the past, it was regarded as being against cultural norms for men to assume such women's field responsibilities, but this has shown signs of changing. Similarly, such changes have also been contributed by the Bena people who moved into the study area and started selling labour. These findings conform to what was previously reported by Lema (1996) that the shift of men into valley bottom cultivation had implications on soil management practices.

Table 17: Labour distribution in *ngolo* construction across villages (%)

Type of labour used	Agro-ecological locations			
	Kindimba	Tukuzi	Liteambo	Myangayanga
Family:				
-Adult men	4.9	4.6	2.3	0.7
-Adult women	31.9	31.5	36.4	40.6
-Jointly (adult men & women)	14.6	27.8	24.0	15.4
-Children	11.8	19.4	8.5	18.2
Hired labour	19.4	13.9	10.9	15.4
<i>Ngokela</i>	16.7	1.9	17.8	9.8
<i>Chama</i>	0.7	0.9	0.0	0.0
χ^2	44.239			
df	18			
P-value	0.001			

However, women have remained responsible for performing the difficult work of constructing *ngolo*, which was mostly evident in Myangayanga (40.6%) in comparison to other villages. Moreover, children have also been confirmed to play a

big role in family labour provision. Children were mostly performing this activity in villages of Tukuzi (19.4%) and Myangayanga (18.2%), while fewer responses were noted from Litembo village (8.5%).

The use of *chama* was much lower than other alternative labour sources which farming households depended on during family labour shortages. No responses were recorded from the two distantly separated villages of Litembo and Myangayanga on use of *chama*. However, the use of hired labour and *ngokela* were more reported in Kindimba (19.4%) and Litembo (17.8%). It indicated that penetration of money economy into every aspect of social life has influenced the change in family economy, ultimately challenging existing social relations. It has contributed to dissolution of social ties due to the need of having cash for meeting household needs which subjected men and women to seeking for paid labour or concentrating on cash crop production.

The whole concept of social capital among rural communities has taken a new form. *Ngokela* for instance, has now been organised through cash payable to middle-man/woman instead of eating food together after work. Similarly, *chama* has taken a new direction i.e. from agricultural related activities to social functions, including non-farm activities. Other forms of *chama* have emerged among local brewers and drinkers/customers aimed at mobilising more customers of the prepared alcohol. Also, it has concentrated much on social activities like wedding ceremonies known as “T-Party”, celebrations for newly born babies, and during baptism of children

(both known as *matula*). Under this arrangement, invited members bring food items like maize grains or cassava packed in traditional containers, namely *majamanda*.

Other accompanying gifts to the host include chicken, household utensils, soap, *khanga*, to mention a few. But in pursuing agricultural activities, *chama* has mostly remained at family level (i.e. parents and children). All these are based on the same principle of sharing material support in reciprocity, which is reported to have become more vivid in 2000s. These changes are the responses of the rural communities to the current pressure from globalization, demographic and socio-economic changes. Such results on decline of social networks were similarly reported by Rutatora *et al.* (1996). The increased use of hired labour has been one of the reasons for poorly constructed Matengo pits as it was explained in previous sections, which was similarly noted by Rutatora *et al.* (1996).

4.4.3 Labour access during crops planting

The data on labour used for sowing seeds is presented with respect to type of crop grown and agro-ecological distribution/villages separately. The idea to present the results according to crop types was to find out whether there is a shift in division of labour especially for crops like beans and wheat which are strictly gendered. Women throughout the developing world are well acknowledged to have detailed knowledge and strong preferences for specific crop traits, and which makes them to be regarded as crop breeders (Aubron *et al.*, 2009). Therefore grasping such information would be important for policy makers and other rural development stakeholders in determining how men and women would be affected by the intended interventions

(Doss, 2002). Labour availability is still among major technical determinants for technology adoption and adaptation within different farming systems which ought to be established.

Table 18 presents some observed changes in division of labour during sowing of seeds, which had highly significant relationship with the type of crop established ($\chi^2(72) = 165.361, p < 0.001$), but were not closely related to agro-ecological locations/villages. Of all surveyed villages, Kindimba had relatively higher number of adult men (4.8%) who moved into women's field chores of seed sowing responsibilities (Fig. 4). These adult family men were found engaged in sowing bean crop (5.1%) which formerly was strictly limited to women as their main domain, including a wheat crop. Normally sowing of bean seeds into Matengo pits is done through controlled broadcasting method locally called *kulekalela* in contrast to wheat seeds which are widely broadcasted (alias *kukweta*), both highly specialised for Matengo women. As from the results, the Matengo women who are well accustomed to this activity constituted 35.6 – 44.8% of their individual labour input in surveyed villages (Fig. 4).

Moreover, the largest share of household labour was provided jointly by adult men and women particularly in planting sweet potatoes (80.0%) and cassava (71.4%), despite some invested in beans and wheat, as indicated in Table 20. A large number was observed in Litembo and Tukuzi villages, whereas joint labour input was commonly used (Fig. 4). The preference for men to this activity is based on belief that they have “a good hand” particularly to cassava crop which could bring more

yields. In Matengo highlands, roots and tubers are culturally referred to as women's crops, which conform to what was reported by Sachs (1996) and Aubron *et al.* (2009).

Table 18: Labour investment in planting different crops (%)

Type of labour used	Type of crop				
	Maize	Cassava	Beans	Wheat	Sweet potatoes
Family:					
-Adult men	2.2	0.0	5.1	0.0	0.0
-Adult women	36.5	0.0	59.5	78.7	2.9
-Jointly (adult men & women)	28.7	71.4	17.7	17.0	80.0
-Children	19.7	14.3	5.1	2.1	8.6
Hired labour	11.8	14.3	7.6	2.1	5.7
<i>Ngokela</i>	0.6	0.0	2.5	0.0	2.9
<i>Chama</i>	0.6	0.0	2.5	0.0	0.0
χ^2	165.361				
df	72				
p-value	0.001				

Probably, such changes in men's responsibilities could be associated with women being preoccupied by current increasing farm and household reproductive activities, which propel them to seek for a hand from male household members. It also indicates a change of social cultural values which apparently could not remain static under the current pressure from globalization influences.

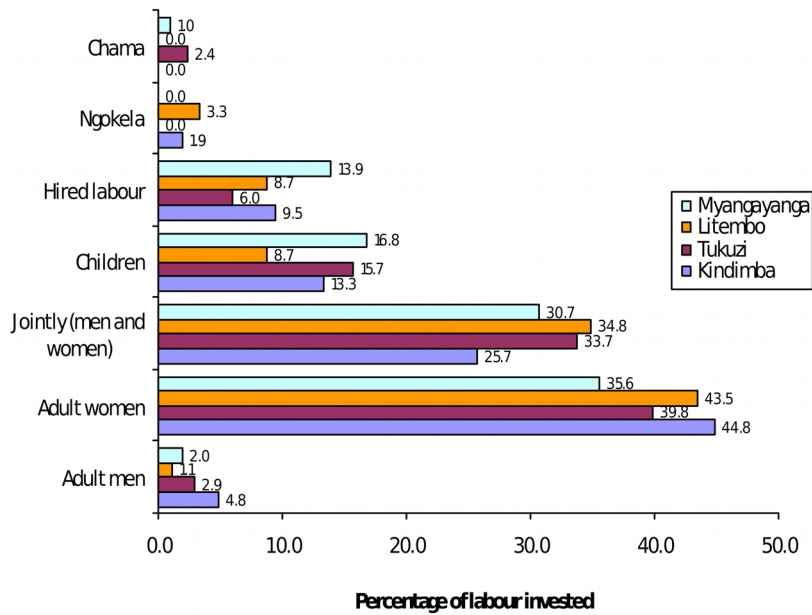


Figure 4: Sources of labour used by farmers during crop planting across villages

School aged children within farming households played a significant role as active household members in performing different field activities, which include planting maize (19.7%) and cassava (14.3%) as per Table 18. Notably, Tukuzi (15.7%) and Myangayanga (16.8%) had relatively more involvement of family children in planting activities (Fig. 4). However, very few of school children took part in planting bean and wheat crops. The results coincide with what was reported under previous section deduced over labour allocation to land clearing and organizing dried grasses in the fields. Furthermore, these findings cement the argument put forward by Kongstad (1980) that family labour is still the basic source of the agricultural labour force.

Table 18 further presents the analysis of other sources of labour which were opted by farmers during peak labour demands. Farmers continued to refrain from relying on either communal or hired labour during planting of crop seeds. However, the use of casual labourers was slightly higher in Myangayanga (13.9%) as compared to other surveyed villages. The hired labour input was largely invested in planting cassava (14.3%). Similarly, *ngokela* and *chama* communal labour was not commonly used in planting different crops, despite existence of few responses from Litembo (3.3%) and Tukuzi (2.4%), as shown in Fig. 4. Food insecurity and shortage of seeds within farming households were quoted as among the factors which have influenced farmers to refrain from investing on communal or hired labour. Farmers were trying to avoid losing of planting seeds through either theft done by invited community members or being obliged to pay them in-kind (i.e. paying them crop seeds instead of cash/food) for participating in the exercise.

4.4.4 Labour invested in weeding different crops

Weeding, like other crop husbandry practices, also calls for substantial labour investment to avail a competitive advantage to the established crop for enough light, soil nutrients, water, etc. Table 19 shows the gender disparities in performing the weeding work with respect to villages and crop types grown. Ideally, segregating the data according to the type of crop was to find out who is more engaged either in each crop, whereas coffee normally competes for the available labour particularly during weeding period (January-March) with food crops. Statistically, sources of labour differed significantly ($\chi^2(90) = 232.620, p < 0.001$) with crop type (Table 19). Participation of individual adult men was found to be extremely low compared to

other household members. Fig. 5 shows that most of interviewed farmers were working jointly (i.e. adult men and women) particularly in Tukuzi (40.5%) and Myangayanga (39.5%). Yet they invested most of their labour in weeding sweet potatoes (77.8%) and cassava (68.4%) as food crops, and just 18.6% spent time in coffee fields. Probably there are no cultural barriers or gender biased work skills needed for weeding which could restrict some of gender categories to participate.

Table 19: Labour invested in weeding different crops (%)

Type of labour invested	Crop types				
	Maize	Cassava	Beans	Coffee	Sweet potatoes
Family labour:					
-Adult men	4.4	0.0	5.6	5.1	3.7
-Adult women	14.5	5.3	33.3	24.1	2.8
-Jointly (adult men & women)	31.5	68.4	27.8	18.6	77.8
-Children	25.7	7.9	16.7	30.2	6.5
Hired labour	14.3	13.2	11.1	15.3	0.9
Ngokela	8.2	5.3	5.6	6.8	0.9
Chama	1.4	0.0	0.0	0.0	0.9
χ^2	232.62				
Df	90				
p-value	0.001				

Again, children continued to provide their contribution, mostly working in coffee (30.2%) and maize (25.7%) crop fields (Table 19; Fig. 5). Although coffee crop which is considered as a men's crop, still women and children were found highly engaged. However, it seemed that the wheat crop did not attract any labour investment in weeding probably due to the planting space i.e. being closely spaced which brings difficulties in hand hoeing unless hand pulling is used, and which gives the crop an added advantage to compete with weeds.

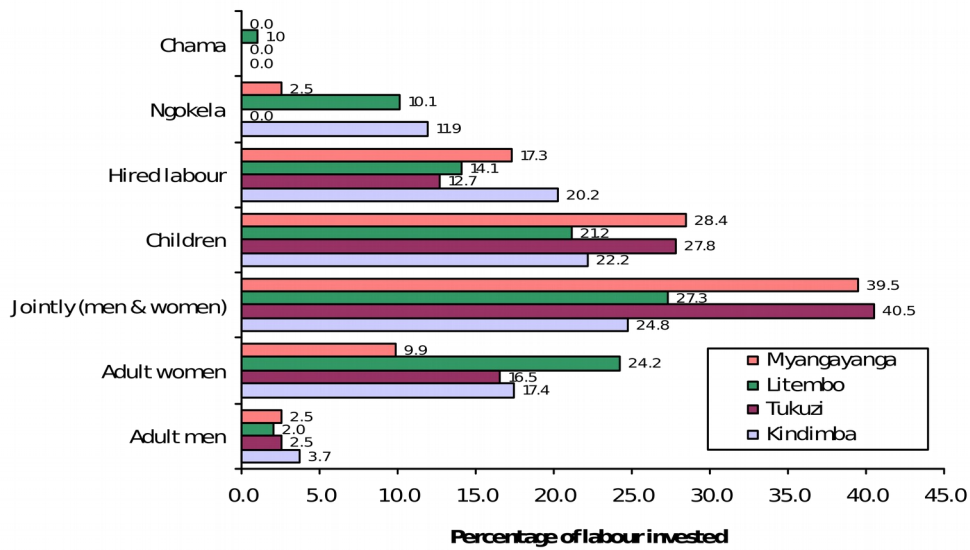


Figure 5: Distribution of labour invested in weeding crops from different villages

On the other side, hired labour in Kindimba village accounted for 20.2% as the highest contribution of all other forms of labour input out-sourced by farming households when constrained by family labour. Apparently, it is still a question of differences in household economies which have influenced the choice for such arrangement. Nevertheless, social ties among farming rural communities is dwindling, and most striking result was on the use of *chama*. It was one of the social networks bound by reciprocity working spirit which was found to have disappeared in most of the surveyed village communities. However, in contrast, *ngokela* was slightly reported in Kindimba (11.9%) and Litembo (10.1%) being used in maize and coffee fields. Village communities might be operating under different economic spheres which ultimately had subjected them to different positions of accessing particular labour services.

In summary, Tukuzi and Myangayanga households were noted as being highly dependent on family labour which is regarded as among the most valuable assets owned by rural households. However, some farmers opted for herbicides to control weeds in coffee fields to save labour for investing into other field activities. It obviously reflects the existence of a stiff competition for labour services in the rural areas such that its value has appreciated continuously especially during peak demand periods.

Despite focusing on the labour invested in Matengo farming system, the study also noted other labour demanding activities from household to community levels, including household chores, marketing, participation in community activities like funerals and weddings, just to mention a few.

4.4.5 Labour invested in crop harvesting

Under this aspect the study concentrated on division of labour with regard to crop type, since these are closely related. Coffee crop which fiercely competes for labour with food crops also continued to be given a consideration regardless of being grown outside Matengo pits farming system. Table 20 sets out the results indicating the existence of significant association ($\chi^2(90) = 489.75, p < 0.001$) between the type of labour invested and the crop harvested. Working as individual family members, adult men invested their labour in cassava harvesting (11.8%). The adult men were reported working jointly with adult women and most preferably in harvesting sweet potatoes (65.1%) and cassava (52.9%).

Table 20: Type of labour invested in harvesting different crops (%)

Type of labour used	Crops					
	Maize	Cassava	Beans	Wheat	Coffee	Sweet potatoes
Family:						
-Adult men	3.2	11.8	3.9	1.0	2.4	4.7
-Adult women	20.3	5.9	35.3	39.2	4.1	3.1
-Jointly (adult men & women)	33.6	52.9	29.4	25.5	15.2	65.1
-Children	20.3	11.8	15.7	21.6	31.6	7.0
Hired labour	14.2	11.8	9.8	6.9	21.9	20.2
Ngokela	3.8	5.9	5.2	3.9	22.9	0.0
Chama	4.5	0.0	0.7	2.0	1.4	0.0
χ^2	439.75					
df	90					
p-value	0.001					

Women concentrated more in harvesting wheat (39.2%) and beans (35.3%) in contrast to root crops which were given less attention. This might be associated with the higher value attached to the bean and wheat crops than to root crops that can easily be harvested by anyone. Therefore, much of the associated burden of harvesting, shredding and winnowing rested on women. However, the labour provided by children in the family largely served in harvesting wheat (21.6%) and maize (20.3%) as food crops. Thirty per cent of children's labour spent in coffee harvesting which was the largest share of the family labour (Table 20). This indicates that over seventy percentage of labour invested in the activity came from respective farming families and the remainder was obtained from hired and communal labour (*ngokela* and *chama*). Generally speaking, the paid labour had replaced the use of communal labour in a number of food crops, and mostly invested in harvesting sweet potatoes (20.2%) and maize (14.2%). Similarly, the use of *ngokela* had also surpassed that of *chama* from all surveyed crops, including coffee cash crop by 21.9%. The reasons behind are similar to what has been discussed above.

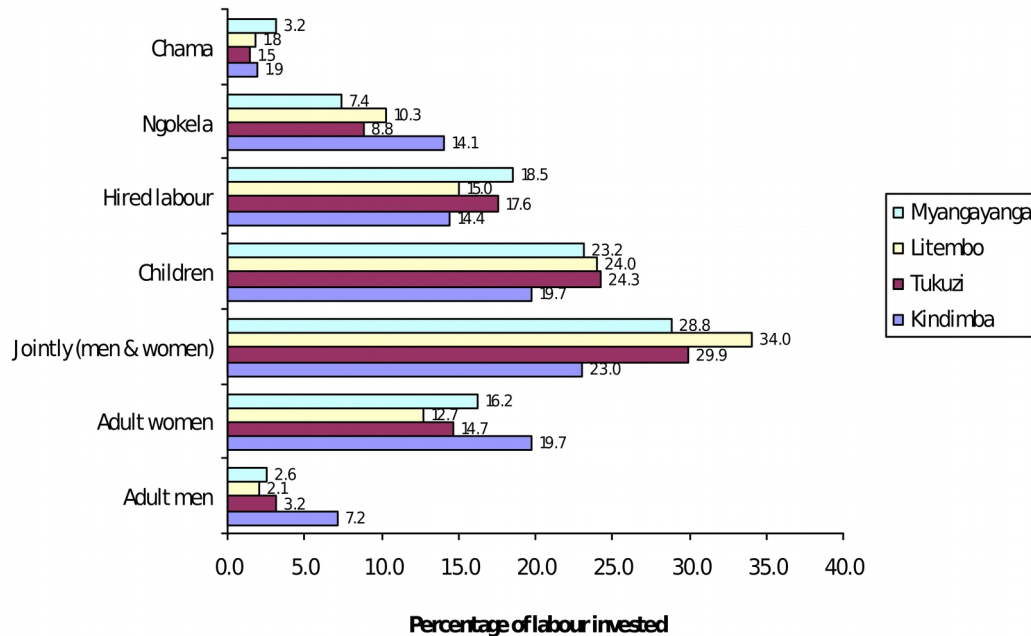


Figure 6: Distribution of labour during crop harvesting across villages

Farmers in Myangayanga hired relatively more labour (18.5%) compared to other study areas (Fig. 6). Probably the farmers had enough income accrued from off-farm activities because the two villages are close to Mbinga town compared to the rest of surveyed villages. Closeness to Mbinga town might have created family labour shortages as some household members would opt for better-paid jobs in the urban centre to meet the growing household needs.

4.5 Other Factors Influencing Changes of Matengo Pits Farming System

This section discusses the traditional institutions which served to supervise the traditional by-laws and cultural ethics regarding societal mode of operation which was under clan head leadership. *Sengu* particularly refers to the traditional institution which among its responsibilities was to ensure Matengo pits farming system was

maintained through enforcement of cultural norms behind the practice. Apart from that it was historically responsible to harmonise disputes among Matengo people encouraging social cohesion and hardworking spirit. Therefore, analysing the rise and fall of *sengu* was found imperative since it has a close relationship to the well-being of the Matengo farming system. Moreover, the section presents the results on farmers' perceptions on climatic variability which is the overriding factor determining the start of agricultural activities. Also men and women are exposed to different levels of climatic risks and opportunities particularly to gendered activities (Nelson and Tanya, 2009). It therefore calls for undertaking an analysis of possible impacts of rainfall variability on Matengo pits farming system.

4.5.1 *Sengu* as a traditional institution

This traditional institution was structured around customary laws and norms of the Matengo people under clan head for managing their common pool property i.e. regulating accessibility and utilization of natural resources like arable land, grazing areas, forests, etc. by individuals or communities. Eating food together was claimed by PRA participants to be the main characteristic feature of this social institution whereby descendants of the same clan gathered under a big tree or traditional shelter to share a word, eat food together and plan future activities. Over 96 per cent of interviewed farmers (not shown in Fig. 7) reported being aware of the local institution called *sengu* which historically served a number of community issues, as presented in Fig. 7. According to the results, *sengu* was reported primarily being a social organization which was responsible in shaping people who were not committed to work, including imparting some technical knowledge and skills to

children on how to construct Matengo pits (38.8%). Also it was involved in resolving family disputes (31.1%), and eating food together (30.0%).

It was generally commented that *sengu* was the main social arrangement which supervised rules and regulations abiding to the quality of constructed Matengo pits. It was from this institution where children from farming families had an opportunity to emulate their parents' technical skills of constructing Matengo pits. To date, however, such institutional arrangement is reported to have lost its popularity in the area due to several factors.

The penetration of western living style so called 'modern life' into the Matengo rural farming communities was quoted as the main reason behind the collapse of the institution, as mentioned by over 46 per cent of respondents (Fig. 8). Similarly, other 21.7% of respondents claimed that the decline of *sengu* was closely associated with food shortages/poor yields currently experienced among farming households, bearing in mind that availability of food served for maintaining social ties. Also death of the founders (elderly people the pioneers/clan heads) was also among the push factors leading to the dissolution of this institutional arrangement as mentioned by 16.8% of the respondents.

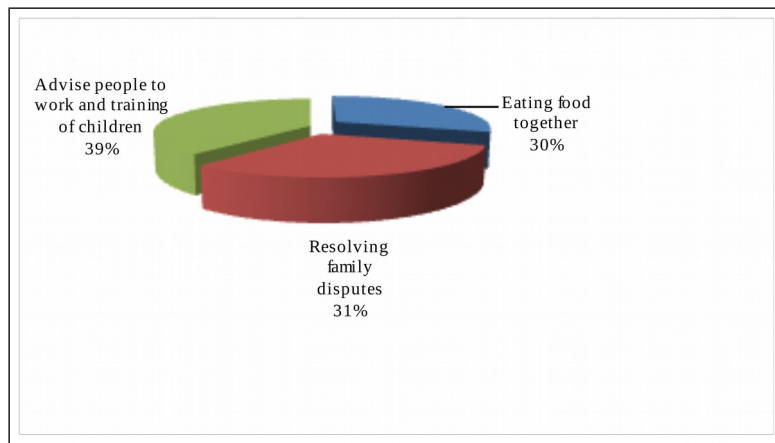


Figure 7: Roles and responsibilities of *sengu* as traditional institution

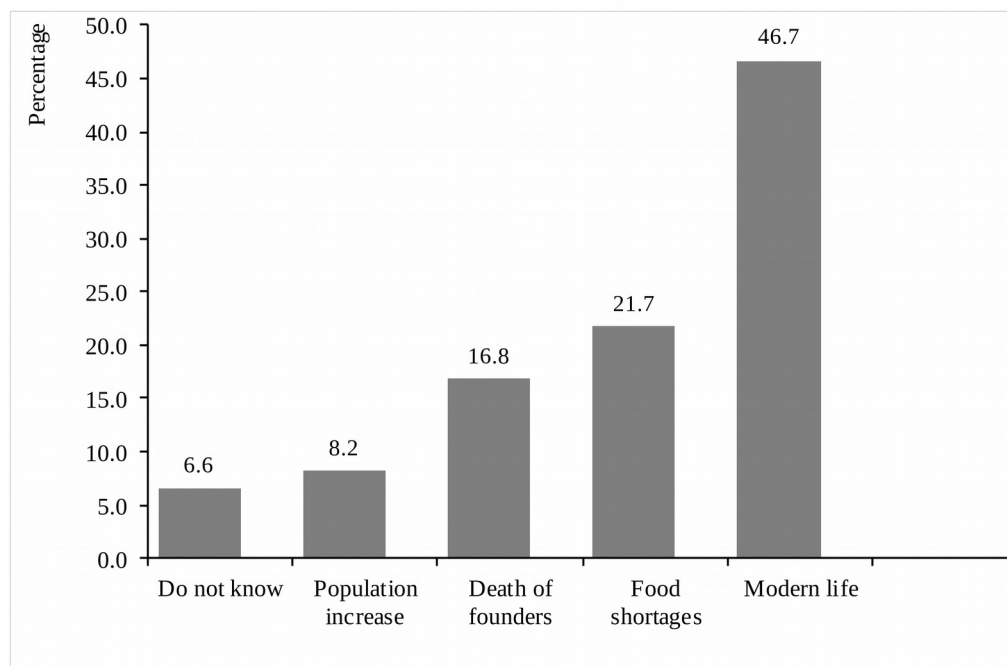


Figure 8: Factors behind the decline of *sengu*

Under farmers' context, modern life actually referred to new set-up of households imitating western style of life. People have built modern houses with sitting rooms, furnished with tables and chairs which have failed to accommodate a large number of

clan members for sharing food. They also referred to their connectivity to the outside world through radio, television, telecommunications and road infrastructure improvements in rural areas which exposed them to new ways of life. During earlier periods (before 1970s), travelling outside the village required to have consent from the clan head, and took many walking days to reach Mbinga town which is not the case currently. The increase in mobility has led to changes in household structures since some family members have opted to live permanently outside their native places which is difficult to assemble for discussion or eating together. Above all, some of the roles and responsibilities of *sengu* like resolving disputes have been replaced by western based legal systems like ward councils (*Mabaraza ya Kata*), primary courts, ten-cell leadership, etc. A study by Vatn (2007) provides further highlights on how state interventions could have pros and cons over traditional institutions sustainability. Similarly, the findings of the present study coincide with those by Appiah-Opuku and Hyma (1999) and Watson (2003).

All these results conform to globalisation and structural adjustment impacts as explained by culture and development scholars (Bryceson, 2000), who contended that peasant institutions have been caught in cross-roads following the implementation of the structural adjustment policies which have catalysed cultural transformation, changing of food produce into market commodities. Consistent with this, Trask (2010) contended further that “globalization is the critical driving force restructuring the social order around the world, and families are the centre of this change”. Also shortage of food in the Matengo highlands which was the strong institutional binder has contributed to the dissolution of *sengu* as a local institution.

Apart from climatic variability and crop pests, also food crops have attained higher monetary values due to penetration of the money economy into rural areas consequently sharing of food has become expensive if not unaffordable.

According to PRA results, however, it shows that *sengu* has not completely disappeared from the Matengo society rather has undertaken a shift from clan level to household or family level. That is, it has still remained in the family involving parent(s) and children within a household as core members in making production and consumption decisions. Furthermore, it was claimed to have remained in funeral ceremonies whereby clan descendants come together. During this particular time men become responsible for preparing the meat sauce and distributing to female members. This was strongly argued as being among the shortfalls of *sengu* which fuelled its disintegration due to segregation between males and females and even more between young and old generations. Based on these deductions, still *sengu* exists though it has changed the format of operation and skewed the level of activities as it does not invest much time in monitoring ethical matters guiding the overall quality of Matengo pits. No wonder the quality of Matengo pits has been questionable to some extent.

4.5.2 Land legislation and soil water management practices

Many of smallholder farmers face a number of challenges among which are land tenure security problems. Land tenure security according to Flintan (2010), is attained “when community or individual rights over land are publicly recognised and where rights to holders are protected against arbitrary deprivation and enjoy

economic benefits attached to their land rights”. Like other African countries, Tanzanian government has continued with dual system of land tenure and authority i.e. based on western culture (land registration and titling) and that of customary tenure system. In the country, the latter system has continued dominating in rural areas, despite the fact that the whole land is under state ownership. The issue of land ownership and access is critical to decisions over which type of crop to be established and what particular technology or management practice to invest which also affects productivity. The study also found it very important to describe existing land access and ownership arrangements in the study area which might have also influenced decisions of farming communities.

The results are as presented in Table 21. The Matengo farming communities had a number of scattered field plots which were accessed through different arrangements. According to Table 21, there were several forms of land tenure systems which defined a household’s right of access to land. Owning land in perpetuity was obtained either by inheriting from parents, purchasing, or being given by the village government. But there were also other forms of land access under certain tenancy agreements (not owning land permanently) which included renting-in, borrowing and share-cropping. A much larger proportion of plots were obtained through inheritance from parents (over 70.0%) and mostly found in Myangayanga. The Matengo are patrilineal society whereas land is commonly inherited only by males, while women have remained victims owning land by virtual of their male relatives. The other relatively common form of land accessibility was purchasing of land which ranged from 13.0 - 20.3% of all arrangements, and was mostly reported by Kindimba

farmers (Table 21). Village governments were facing land pressure such that they have failed to apportion land to substantial number of individuals especially the young generation to venture into farming. All the same, other forms of land access through tenancy agreements were not very common in the area, despite the fact that they have served for cushioning land shortage pressure to landless individuals. Crop sharing was practised at less than 1.5%, and Tukuzi farmers were leading. They commonly used this practice for seed multiplication and storage in the form of a crop stand (especially wheat, beans and green peas).

Table 21: Different land tenure forms within respective villages (%)

Land tenure forms	Villages				Total
	Kindimba	Tukuzi	Litembo	Myangayanga	
Inherited	71.6 ^a	65.8	73.7	76.0	71.8 ^b
Purchased	20.3	13.2	14.8	13.6	15.5
Borrowed	4.1	9.2	6.1	5.4	6.2
Rented-in	2.2	9.2	3.0	3.9	4.6
Given by village	1.1	0.4	1.0	0.4	0.7
Others	0.7	2.2	1.3	0.8	1.3
Statistics:	x ²	36.585			
	df	15			
	p-value	0.001			

NB: a: figures are % within villages;

b: figures are total % across villages and within mode of land access

4.5.2.1 Land tenure implications for Matengo pits farming system

Land tenure status of the farming household is of particular interest, since it has direct influence on type of crop to be established and which soil management is practised. Having legitimacy to the land resource increases confidence of the household to invest not only to modern soil water management practices but even indigenous soil-water management practices like Matengo pits cultivation which is

labour intensive. Therefore this sub-section is intended to describe the different forms of land ownership and type of land management practices undertaken by the Matengo people.

Table 22: Tillage methods under different land tenure forms (%)

Tillage method	Land tenure forms						Total
	Inherited	Purchased	Borrowed	Rented -in	Given by village	Other	
Ngolo	36.0	7.7	3.4	2.8	0.0	0.9	50.8
Mitumbila	4.2	2.3	0.9	1.4	0.2	0.0	9.1
Malonga	1.9	0.5	0.5	0.2	0.0	0.0	3.1
Sesa	25.7	4.6	1.1	0.6	0.5	0.2	32.7
Terraces	3.3	0.8	0.0	0.1	0.1	0.0	4.4
Total	71.2	15.8	6.0	5.0	0.8	1.1	100
Statistics:	χ^2	62.533					
	df	20					
	P-value	0.001					

According to the study results, over 79.0% of the cropland was under ownership of the farming households and the rest was seasonally accessed through different arrangements (renting-in, borrowing and sharing for crop growing). It is generally perceived that land ownership determines the farmer's decision over which type of land husbandry technology/tillage method to use in crop field(s). The Chi-square value as presented in Table 22 indicates that there was a significant relationship ($\chi^2(20) = 62.533, p < 0.001$) between the forms of land tenure and type of farming technology opted by the farmers. Approximately 43.7% of the owned crop fields (i.e. obtained through inheriting, purchasing and given by village government) were

under Matengo pits, while 30.8% were under *sesa* cultivation in valley bottoms for growing food crops, homestead fields for planting coffee, and outside village fields (rolling hills) used for maize. Newly introduced practices i.e. *mitumbila* and *malonga* were used more in owned crop fields, although in small percentages.

This implies that farmers had much confidence in their own croplands to decide which cultivation technology to use, including new technologies. Yet of all practices, *ngolo* was dominantly practised under all forms of land tenure system. Furthermore, it proved wrong the assumption that farmers do not normally use conservation measures in crop fields which do not belong to them.

4.5.3 Implications of agricultural extension services for Matengo pits farming system

According to URT (2003), the general purpose of agricultural service is to “improve the productivity of agricultural systems, to raise incomes of farm families and improve quality of life of rural farm households”. To achieve this, the government has embarked on several reforms with intention of improving extension service delivery to subsistence farmers with more commercial and improved technology packages. Delivering services is one thing, and use of such technology is another, which is subject to a number of factors prompting households to make choice of to use or not to use the services. Therefore this sub-section summarises the information regarding whether agricultural extension services were reaching the Matengo farming communities, and what particular technologies were delivered. Establishing

this information would help to understand potential impacts and help to expand the use of promising technologies that appeal more to the well-being of the farmers and to ensure sustainability of the Matengo pits farming system.

The findings from this study revealed that 62.2% of interviewed households had access to agricultural extension services particularly during 2007-2009 (Table 23). The remaining farmers did not have access to extension services due to different reasons, with majority not being aware. Most of households which had access to extension services, reported to have received technical services on matters pertaining to crop production (67.3%), with 24.5% being related to livestock treatment. However, much of extension services delivered to farmers centred on monoculture i.e. improving particularly coffee production (focused on coffee husbandry practices like fertiliser and pesticide applications, weeding, pruning, use of cuttings as planting materials, etc.), while little emphasis was given to food crops. All the same, it indicates that *ngolo* sustainability was given a little attention. Existence of Tanzania Coffee Research Institute (TaCRI), including NGOs like Techno-Serve⁵ and KILICAFE⁶ providing complementary services on the ground has much influenced dominance of coffee related extension services to farmers. Additionally, village based extension officers have been used by the same NGOs under certain arrangements (allowances/working gears) to ensure a close technical back-up to farmers. All these still emphasise the promotion of export crops, which most of developing countries' economies are largely dependent.

⁵ The International non-profit organization providing technical and business solutions to coffee farmers

⁶ An association of small-scale coffee farmers that provides marketing and export services to its members, include helping its member in accessing financial supports for improving coffee quality

According to URT (2003), the national extension service has continued to be based on Training and Visit system, which has also been backed up by the Farmer Field School (FFS) approach. The FFS groups have equally gained popularity in the study area delivering extension services by training clients to become experts in solving their own agricultural problems. According to the District Agricultural and Livestock Development Office (DALDO), there were 206 FFS groups in the District during 2008. Among technology packages delivered to farmers, include integration of Matengo pits farming system with contour bunds, “*fanya chini*” and “*fanya juu*” in Mayangayanga village. However, still no convincing results have been observed.

Table 23: Access of farmers to agricultural extension services

Did you have access to extension services? (N=180)			
Response	%	Response	%
Accessed the services	62.2	Did not access the services	37.2
Type of services obtained:		Reasons for not accessing:	
-Livestock treatment	24.5	-Not available	25.8
-Crop production	67.3	-Use own knowledge	12.1
-Both on livestock & crop production	8.2	-Not aware	60.6
		-Having low income	1.5

Despite all efforts invested by the government in reforming the agricultural service delivery system, still there have been reported controversies. Farmers reported their concerns over controversial decisions made by government officials through change agents during 1980’s those advocated among other technologies, the use of conventional ridges instead of the Matengo pits in steep slopes. Such decisions were later found by the district government not practically sustainable, though new

practices (conventional ridges/*mitumbila*) were already introduced. This scenario was similarly reported by Chuma *et al.* (2000) that the government of Zimbabwe also intervened to discourage traditional practices. This indicates that the potential of traditional practices is still not appreciated in agricultural development plans or projects.

Nevertheless, government interventions may also have pros and cons, if decisions would be taken solely as bible truths without proper supervision, monitoring and evaluation. This also refers to current introduction of power tillers to every district in response to *Kilimo Kwanza* initiative, which poses a potential threat to the sustainability of Matengo pits farming system unless there is a close supervision. Proper recommendations and supervision have to be strictly attached to the introduced power tillers otherwise due to the convenience of the technology farmers would wish to try them even in steep slopes of the Matengo highlands. If that would be the case, *ngolo* could more likely be replaced by flat cultivations and *mitumbila* constructed easily by power tillers.

4.5.4 Rainfall variability and its effects on Matengo pits farming system

Decisions over land management practices by the farming households are also influenced by factors like climate, soils, topography, infrastructure, water, vegetation etc. Above all these factors, this study focused on the influence of changing climate on soil-water management decisions in particular Matengo pits cultivations. Rainfall also determines what type of crop to produce and how to produce (which technology to use), and how much to produce by taking into account availability of resources.

The world has currently witnessed the global climate change which is predicted to be experienced differently by people as regards to temporal and spatial dynamics (IPCC, 2007). Similarly, the Matengo farming communities cannot be excluded from the vulnerable group since their farming activities are highly dependent on rainfall.

Table 24 reports on farmers' observations on climatic changes, with particular emphasis on rainfall variability (intensities, distributions and starting and ending of seasons). Nearly 97% of the sampled population acknowledged to have witnessed climatic changes in Matengo highlands since the 1980's to date. Rainfall variability was cited as the main climatic element which has changed such that is impairing their farming activities. The Matengo farming communities are like many other farmers in Sub-Sahara African countries largely depending on rain-fed agriculture as the best livelihood alternative, which has been trapped by the changing climate.

Farmers reported experiencing heavy rains (51.7%) in contrast to 1980-1990's seasons. Heavy rains have increased the susceptibility of crop fields to soil erosion. It was also reported to impair wheat tussling due to continued heavy rains. Moreover, the starting and ending of rainfall season was reported to be increasingly unreliable. It was reported that the rainfall season was starting late (27.2%), and ending earlier even before April (38.3%). It therefore reflects that the rain season has shortened. Singing of birds like the one locally known as *sonunkoku* (*dudumizi*) in September-October coincided with starting of rainfall season, which has shifted into November-December and sometimes to January. The onset and cessation of rainfall season is

quoted by many of subsistence farmers in SSA as among issues of concern interfering with farming activities (Kihupi *et al.*, 2007).

Similarly, these changes have great impacts on Matengo pits preparation calendar and quality. Starting of *ngolo* preparations is commonly regulated by rainfall season (starting and ending of rains). A shorter rainfall season subjected farmers to a scramble for labour in order to accomplish timely field activities. The change in rainfall patterns has made farmers to hire casual labourers who have also been blamed for poor work, as previously discussed.

Table 24: Farmers' perception on rainfall variability in Matengo highlands

Rainfall patterns	Agro-ecological locations (%)				Total
	Kindimba	Tukuzi	Litembo	Myangayanga	
Rains start late	7(14.3)	7(14.3)	14(28.6)	21(42.9)	49(27.2)
Rains start timely	4(44.4)	1(11.1)	1(11.1)	3(33.3)	9(5.0)
Rains end earlier	17(24.6)	13(18.8)	18(26.1)	21(30.4)	69(38.3)
Experiencing heavy rains	23(24.7)	30(32.3)	22(23.7)	18(19.4)	93(51.7)
Uncertain season start/ ending	7(21.9)	14(43.8)	4(12.5)	7(21.9)	32(17.8)

NB: Percentages are within brackets and were presented according to responses across villages

Table 25 presents the associated effects of rainfall variability on Matengo pits farming system. Changes in rainfall patterns have posed great difficulties to farmers, as 42.7% of responses indicated missing the calendar of making *ngolo*. It has driven some of the farmers to forego preparing *ngolo* completely or to dig *ngolo* without planting seeds to avoid crop losses, but still composting the incorporated organic matter to release nutrients for crop to be established in the following season (November). Such a shift of rainfall calendar has caused collision of time tables for different field activities, for instance weeding of maize and coffee done in January to

February, which similarly is the period for preparing fields ready for *ngolo* cultivation. As a result, it has subjected farming communities to stiff competition for labour in order to make proper timing of rainfall. Ultimately, some have switched to simple technologies like using conventional ridges and poorly constructed *ngolo* Pits (e.g. using parallel lines of dried grasses down slope, shallowly excavated *ngolo*, etc.) to save time and labour.

Table 25: Effects of rainfall variability on Matengo pits farming system

Effects	Kindimba	Tukuzi	Liteambo	Myangayanga	Total
Soil erosion	14(20.9)	22(32.8)	18(26.9)	13(19.4)	68(37.8)
Poor crop yields	21(25.3)	26(31.3)	11(13.3)	25(30.1)	83(46.1)
Confusing <i>ngolo</i> making calendar	26(33.8)	19(24.7)	13(16.9)	19(24.7)	77(42.8)

NB: Percentages are within brackets presented according to responses across villages

As a result of high rainfall intensities, soil erosion has also increased in the study area. Relatively, Tukuzi farmers reported most cases (32.8%), of fertile topsoil being washed away together with crops (Table 25). As per results from PRA, soil erosion has rendered croplands to have shallow soil depth, which has consequently resulted in construction of shallow and small sized Matengo pits. The remaining sub-soil (red coloured), locally known as *luhumbi lukeli* is claimed to be very hard and tedious to work on, hence opting for simple technologies. Erratic rainfalls have also led to seed shortages for most farmers following poor crop yields contributed by pest infestation like “*kimangu*” (aphids) attacking the bean crop, drying of crops or physical damages. As a coping strategy, farmers have been opting for planting beans in small plots of newly constructed *ngolo* (locally known as *kukajulila*) during the first rains

in November (which is not the actual time for making *ngolo*) to multiply seeds to plant in February-March.

In concluding, changing climate has a negative implication to the Matengo pits cultivation as far as its sustainability is concerned. Likewise, farming families have been struggling with limited resources at their disposal to overcome the negative effects of climate change to sustain their livelihoods. It obviously calls for consideration in devising adaptation policies.

4.6 Crop Production

4.6.1 Crop yields in different tillage methods and landscapes

In measuring the food security status of farming communities, the study primarily directed its attention on physical production (availability) of major staple food crops like maize, beans and wheat which are very critical to the majority of Matengo people for their daily caloric requirement. Based on results from previous sections, it was observed that tillage methods were also influenced by nature of the topography, which together has influence on crop yields. The landscape/topography of the particular field plot is closely related to the type of soil catena, water holding capacity, including soil depth and erodibility status. Topography categories were based on farmers' perceptions with reference to their respective crop fields.

The results are as shown in Table 26. Yields were based on farmers' recall reported in traditional units (like number of *dumla* per bag per plot) which were converted into standard units (kg/ha or tonnage/ha). From the results, it was justified that the use of

particular tillage method under particular cropland topography had significant effect on crop yields. Higher yields of maize were recorded from upland field plots with flat to moderate slopes, whereas *ngolo* produced an average of 2.3 tons/ha, exceeding the conventional ridges i.e. *mitumbila*. However, terraces occasionally used by farmers and mostly referred to broad ridges had surprising results of an average maize yield of 5.8 tons/ha. All yield results were relatively higher than 1.3 tons/ha which were reported as the average yield of maize from Ruvuma Region during 2002/2003 National Sample Census of Agriculture (URT, 2006).

Beans and wheat crops were mostly grown in Matengo pits which occupied between 72.0% to 99.0% of the cultivated land in the study area, of which Matengo pits produced an average of 0.34 tons/ha of beans and 0.61 tons/ha of wheat. Valley bottomland cultivation yielded more wheat under flat cultivation (1.8 tons/ha) despite the fact that this technology was rarely used for growing such a crop. Similarly, yields differed significantly according to the interaction of tillage method and cropland topography, whereas higher yields of beans were recorded from upland flat landscape (1.3 tons/ha) which surpassed the national average of around 0.45 tons/ha (URT, 2006). These findings may imply that different croplands with varying micro-topography characteristics would call for specific soil management practices and not relying on a blanket recommendation. Therefore, such a coping strategy of growing crops under different landscapes takes the advantage of deep soils with relatively good fertility status and moisture contents, particularly in upland flatlands (locally known as *liheba*) and valley bottoms to have more yields.

Table 26: Influence of cropland topography and tillage methods on crop yields (average yields)

Cropland topography	Tillage method	Maize			Beans			Wheat		
		N	(%)	Yield* (kg/ha)	N	(%)	Yield (kg/ha)	N	(%)	Yield (kg/ha)
Upland steep sloped	Ngolo	55	18.3	1985.7	68	25.0	275.5	25	32.5	625.0
	Mitumbila	5	1.7	1072.1	4	1.5	240.8	-	-	-
	Malonga	1	0.3	160.0	-	-	-	-	-	-
	Sesa	1	0.3	50.0	1	0.4	31.9	-	-	-
	Terrace	1	0.3	300.0	-	-	-	-	-	-
Upland moderate sloped	Ngolo	98	32.6	2328.0	105	38.6	290.9	49	63.6	627.5
	Mitumbila	24	8.0	2060.1	9	3.3	215.8	-	-	-
	Sesa	5	1.7	1293.6	5	1.8	612.9	-	-	-
	Terrace	2	0.7	5850.0	-	-	-	-	-	-
Upland flat	Ngolo	11	3.7	2359.8	10	3.7	1472.4	2	2.6	150.0
	Mitumbila	11	3.7	1908.8	2	0.7	572.4	-	-	-
	Sesa	2	0.7	3900.0	1	0.4	1278.0	-	-	-
Valley bottomland	Ngolo	19	6.3	1094.1	15	5.5	289.1	-	-	-
	Mitumbila	1	0.3	3600	-	-	-	-	-	-
	Sesa	62	20.6	1272.0	51	18.8	292.8	1	1.3	1800.0
	Terrace	3	1.0	2100.0	1	0.4	213.0	-	-	-
	Df			3			3			3
	df _R			297			268			73
	F-value (p < 0.05)			3.850**			18.490**			2.830**

NB: *=Average yields were based on farmers' recall from different plots under different tillage methods which were converted from traditional units into kg/ha

F-values followed by the sign (**) denotes that mean yields of such particular crop are significantly different at P < 0.05

4.6.2 Effect of land fragmentation on crop yields

Land fragmentation is described mainly as the result of population increase in Sub-Saharan African countries, which have forced people to abandon particular soil management practices. All the same, increase in population pressure in Matengo highlands has caused out-migration of farmers to the rolling hills in villages of Kitanda, Lupilo, Utiri, Kigonsera, Mkako, etc. seeking for new arable lands (Rutatora *et al.*, 1996). People in the highlands have either abandoned or shortened land fallowing periods to their croplands due to land shortage. Average landholdings of the surveyed households was 1.8 acres (approximately 0.72 ha), while 45.2% of the majority had below one acre i.e. 0.4 ha. Field plots were scattered within (i.e. close to homesteads, within or outside “*ntambo*”) or outside their respective villages. Farmers tend to use different technologies depending on field locations. Conventional ridges as *mitumbila* and flat cultivations commonly found in the rolling hills where farmers with dual residence (with seasonal movement) have been transferred to the highlands. However, scattering of crop fields diversifies the risk of crop failure by capitalising on agro-ecological potentials of different locations which this study found pertinent to establish.

Study findings indicated that crop fields around homesteads had relatively higher maize productivity than other locations, despite the fact that was not statistically significant (Table 27). An average yield of 2.3 tons of maize/ha was recorded from homestead based fields in contrast to 1.7 tons/ha from other fields within respective farmers’ *ntambos* which had the lowest yield. It was similarly noted from wheat crop grown around

homestead fields that produced an average yield of 691.7 kg/ha (0.7 tons/ha). About 47 per cent of wheat plots were outside farmers' respective *ntambo* within same village, and only 5.1% of plots were close to homesteads. For the bean crop, however, it was a different case. Homestead based field plots (12.8%) had the least productivity potentials producing an average of 305.3 kg/ha and most of production came far from homesteads.

Table 27: Mean crop yields (kg/ha) from different field locations

Field location		Maize	Beans	Wheat
Homestead	Count	35	36	4
	(%)	11.3	12.8	5.1
	Mean yield	2289.0	305.3	691.7
Within <i>ntambo</i>	Count	113	111	24
	(%)	36.6	39.5	30.7
	Mean yield	1744.7	320.3	690.0
Outside <i>ntambo</i> (within village)	Count	91	89	37
	(%)	29.4	31.7	47.4
	Mean yield	1880.7	321.3	598.1
Outside village	Count	70	45	13
	(%)	22.6	16.0	16.7
	Mean yield	1930.2	525.5	562.8

The linkage between crop field location and crop yields was not very evident, but probably the good performance of some of crops grown around homesteads was associated with good crop husbandry practices like use of organic/industrial fertilisers, timely weeding, to mention a few because they are within farmers proximities. In other words, crop yields were not solely explained by the type of seedbed preparation, rather an interaction of tillage method with a number of factors like micro-topography

conditions and spatial location of cropland. Landscape has played a significant role not only influencing type of tillage method but also crop yields. Upland fields with moderate slopes attracted most of *ngolo* cultivations. At the same time, low bean crop yields have been contributed by a set of complex factors, including erratic rainfalls which also created favourable conditions for pest infestations (*kimango*/aphids), poor soil fertility especially low levels of available phosphorus in steep sloped areas (Msanya, *et al.*, 1998 cited in Mattee *at al.*, 1998).

4.7 Matengo Pits Farming System and Household Food Security

Apart from physical production of food produced, this study also focused on other associated indicators which prevailed among the farming households. It included measuring the number of meals for children who were under five (infants) and establishing the periods (months) and longevity of the duration/number of months the interviewed households had food shortages.

4.7.1 Perception of farmers on food security status

According to the study results, a total of 110 surveyed households (62.9%) reported experiencing food insecurity. The concept of food security differs among different communities. In Matengo communities, the concept of food security is largely related to availability of food within household throughout the year (82.6%), which actually refers to the existence of maize stock (Fig. 9). Lack of maize within a particular household was considered a disaster despite the fact that farmers have other food crops like cassava,

sweet potatoes, banana, etc. This implies that such crops (cassava, banana, and sweet potatoes) have low social value compared to maize and beans. The results on preferences of particular food crops were found similarly presented by Mwaseba (2005) with regards to rice availability to Kyela and Kilombero rural communities as the main food security indicator.

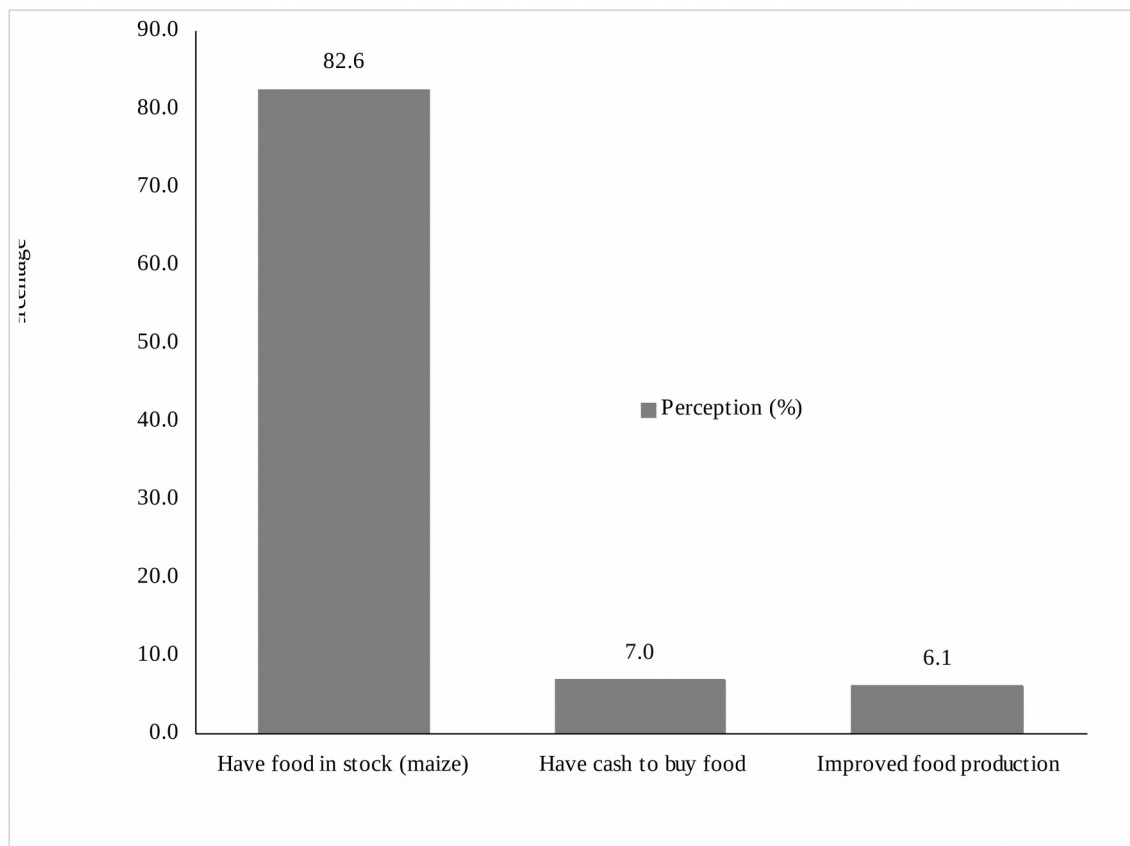


Figure 9: Household food security perception

Having cash income to buy food seemed to have relatively little attention (7.0%) as an indicator of being food secured. Nevertheless, coffee economy in Matengo highlands

still has remained dependable by majority of farming communities to have income access to meet household obligations like purchasing food during shortages.

4.7.2 Other study indicators of food insecurity

4.7.2.1 Frequency of eating to infants during food shortages

The study also analysed the implications of food insecurity to vulnerable groups, particularly the children who were under the age of five years within interviewed households. According to the study results, 34.5% of the households could only afford giving their five year old children one or two meals per day due to food insecurity (Fig. 10). It might imply that the children were not meeting their nutritional requirements in terms of daily protein, vitamins, and calorie intake. However, these statistics were based on a small number of children who were under five years (11.2%) in the study area, as per household structure reported before. Yet the information shades some light on the level of food insecurity the farmers are experiencing under the current situation.

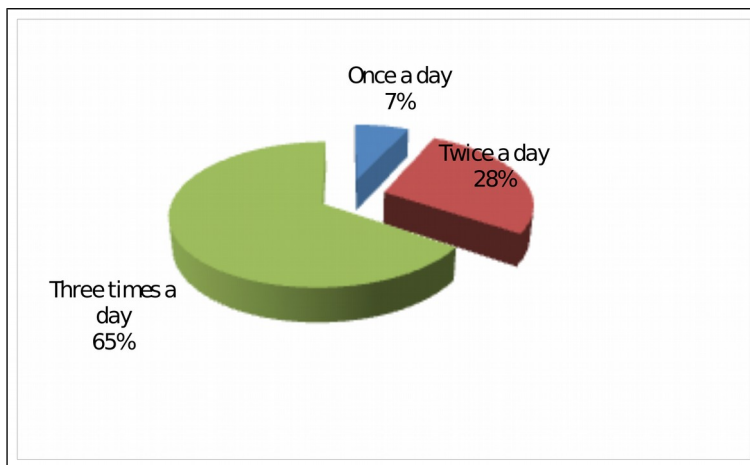


Figure 10: Feeding rate to children who are under five years

4.7.2.2 Longevity and particular months of food insecurity

The analysis results are as shown in Table 28. About half (49.1%) of interviewed households had food shortages for a period ranging from one to four months, and mostly were within two months. Yet, there were about 4.0% of all households which experienced food insecurity for as long as nine to twelve months of the year.

Table 28: Longevity of food insecurity period (n=180)

Number of months experiencing food insecurity	Frequency	Percentage
None	76	42.9
One	25	14.1
Two	31	17.5
Three	20	11.3
Four	11	6.2
Five	4	2.3
Six	3	1.7
Seven	3	1.7
Nine	2	1.1
Ten	1	0.6
Twelve	1	0.6

4.7.2.3 Particular months of food shortages

As per Fig. 11, over 70.0% of responses showed that the most critical months of food shortages were from February to May, and mostly in March (25.8%). This particular period of February to May coincides with the time which also farmers are trapped into a number of field activities like weeding coffee and food crops, spraying pesticides to coffee fields, as well as preparation of new *ngolo* and planting of seeds. The findings indicated that the trend of food shortage stress tended to decline sharply after May towards July and thereafter becoming fairly low until the month of November. In December, food shortage stress increasingly continue rising until March of the following year. Therefore, all year round different households were under different periods of food shortage crisis (Fig. 11).

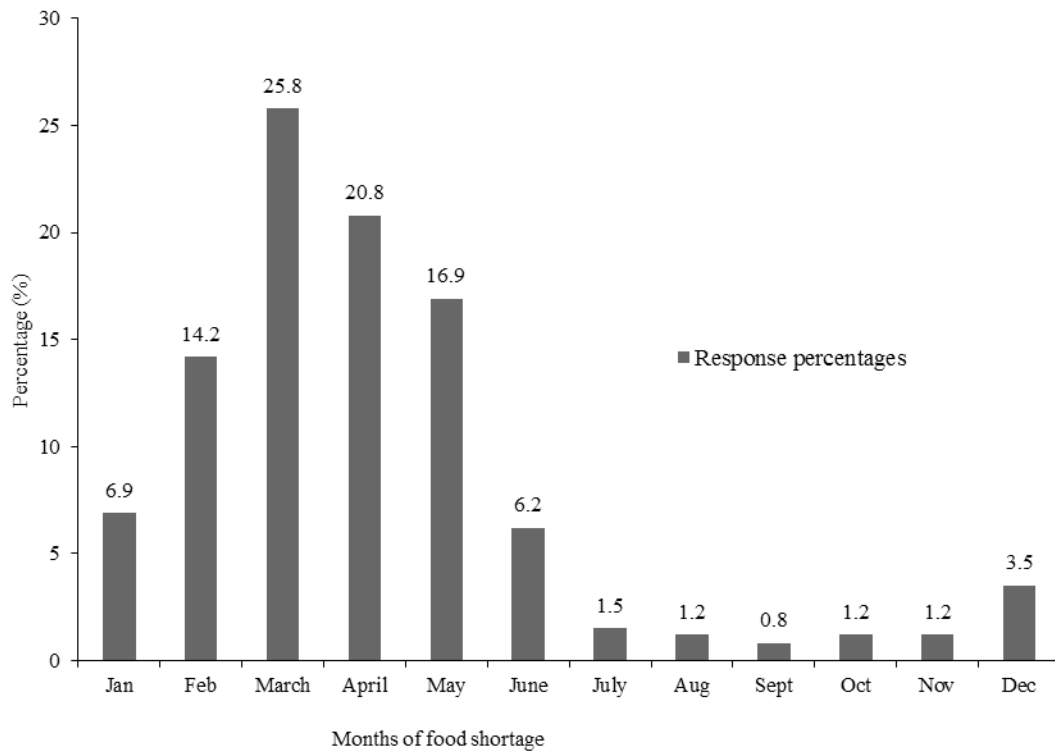


Figure 11: Farmers' responses on food shortage months

4.7.3 The implication of changes in Matengo pits farming system on food security

For many years, the Matengo pits farming system has played a significant role in supporting a number of farming families in the Matengo highlands by enabling them to produce staple food crops like maize, beans and wheat for own consumption and selling the surplus. Therefore, changes which have been taking place within this particular farming system have either direct or indirect implications to household food security.

Food production is the function of a number of factors, which include the use of improved crop varieties, weeds and pests control, use of fertilisers, soil and water

management, and rainfall variability. *Ngolo* has played a significant multifunctional role in maintaining soil fertility (through in-situ composting of incorporated grasses and crop rotation), improving soil moisture by rainwater harvesting and controlling soil erosion.

Based on results as indicated in the Table 29, it has been found that there is no statistically significant relationship between changes in Matengo pits farming system (explanatory variables) and household food security as an outcome. However, the study findings indicate that there have been some non-significant associations/relationships between the changes in Matengo pits farming (as independent variables) and the food insecurity status (outcome variable). Some of the predicting variables like *ngolo* size and time period allowed for grasses to dry (before being incorporated) had non-significant negative relationship with the outcome (household food shortage). The unit increase of one the explanatory variables (change in *ngolo* size/time modification) leads to the decreased relative chances of facing food shortage. The probability Wald statistics for the *ngolo* size variable was $0.096 > 0.05$ significance level, while its Exp (B) was 0.327. It means that those farming households which changed the size of Matengo pits (i.e. reduced the size from the traditional large to medium or relatively small size) were 67.3% less likely to experience food shortage. This finding was previously noted by the study that farmers were opting for medium sized Matengo pits in order to have more crop yield. It also implies that land is increasingly becoming a scarce resource in Matengo highlands.

Table 29: The implication of changes in Matengo pits farming system on food security

Parameter	β	SE β	Wald's χ^2	df	p	Odds ratio [Ex(β)]
Constant	2.087	0.868	5.780	1	0.016	8.063
Size of <i>ngolo</i> (1)	-1.118	0.671	2.777	1	0.096	0.327
Time used to dry grass (1)	-0.128	0.334	0.146	1	0.703	0.880
Depth of <i>ngolo</i> (1)	0.350	0.506	0.480	1	0.489	1.420
Grass alignment pattern (1)	0.507	0.490	1.072	1	0.301	1.661
Access to extension services (1)	0.636	0.363	3.062	1	0.080	1.889
Access to credit services (1)	-0.223	0.354	0.396	1	0.529	0.800
Household size	0.032	0.095	0.113	1	0.736	1.032
Acreage	-0.182	0.063	8.293	1	0.004	0.833
Income from coffee	0.000	0.001	0.029	1	0.865	1.000
Test	χ^2	df	P			
Overall model evaluation						
- Likelihood ration test	20.093	9	0.017			
- Goodness of fit test	16.339	8	0.038			

Also the study has found that for a unit change of time as an independent variable (i.e. reducing time allowed for grasses to dry) was associated with 0.128 decreases of log odds of facing food shortage by likely 0.880 times more (Table 29). It implies that farmers who decided to incorporate the slashed grasses/crop remains less than two weeks were 12.0% less likely to face food shortages. Leaving slashed grasses/crop remains for less than two weeks was regarded as un-traditional practice. It probably indicates that farmers are capitalising on climatic change advantages that there are currently longer sunny and hot days which could dry fresh grasses faster. By saving time, farmers could also engage into other livelihood activities contributing to food security improvement. Other *ngolo* modifications like change in grass alignment pattern and depth of excavated pits had positive associations with the outcome (food shortage).

Regarding other contributing factors to food security status, total number of acreage owned by the farming household had a statistically significant negative relationship with household food shortage (Table 29). The Exp (B) for acreage was 0.833 which implies that the decrease in the odds of 16.7% i.e. $(0.833-1 = - 16.7)$. The results suggest that those farming households which increased the size of their arable land were 16.7% less likely to experience food shortages. It probably implies that accessing more land by the farming household maximized chances for growing a variety of food crops if not obtaining more yields. However, this finding signifies the fact that changes in Matengo pits farming system may not be singled out solely as the only determinant of household food security status rather there are many other contributing factors.

4.7.4 Food security trends (production and availability) during 1998-2008

On measuring the trend of food security, the study largely focused on physical availability of food from own production as well as the capacity of farmers in accessing through purchasing, being given by relatives, governments, etc. Traditionally, the Matengo have not only depended on own-produced food rather also relied on coffee, including other farm and non-farm activities for earning cash to buy food.

According to Fig. 12 approximately more than half of interviewed households reported a declining trend of their food production over the past ten years (1998-2008) due to several constrains, which include: unreliable weather, declining soil fertility, lack of cash

for purchasing farm inputs and hiring in labour, and unavailability of inputs (inorganic fertilizers) considered as main issue of concern (Fig. 14).

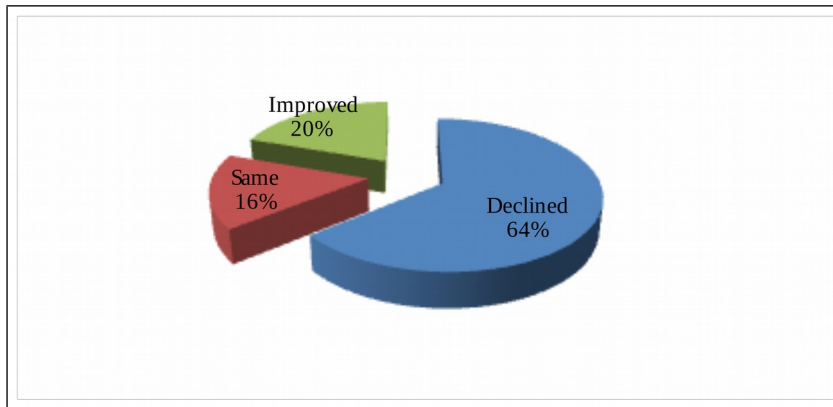


Figure 12: Food production trends since 1998-2008

However, still some of the farmers (24.0%) claimed to have improved their food production, while one fifth had not changed their food production status. Improvement in food production reported to have been obtained mainly through use of industrial fertilizers (Fig. 13) and expansion of cultivated land (outside their respective villages to the rolling hills in Mkako, Kigonsera, Utiri, Kitanda, etc).

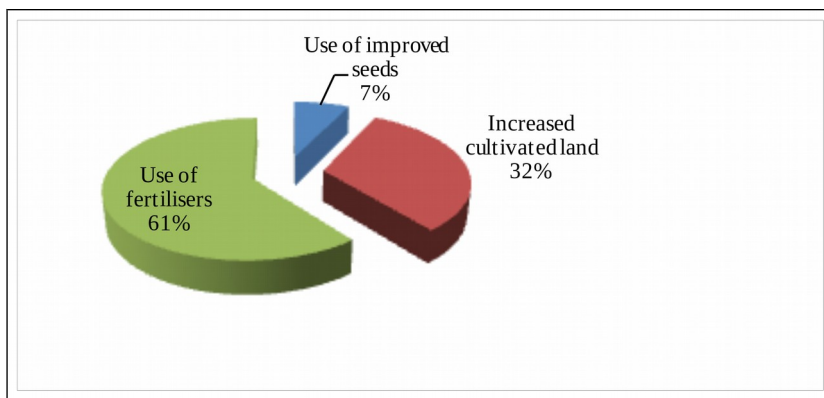


Figure 13: Contributing factors to improvement of food production trend

The use of improved maize seed variety has received a negative attention by the farmers as the majority have kept maintaining their local genetic landrace of maize crop namely *Lusewa* because it withstands pests and diseases infestation. Improved maize varieties were reported to be highly vulnerable to different pests and diseases even before being harvested especially under the current climatic change and variability.

The deterioration of food production in Matengo highlands was similarly noted by Kangalawe and Lyimo (2008) that soil fertility declines, labour shortages, and change in cultivation technologies particularly on the size of *ngolo* were among the causative factors. On the other hand, it was contrary to what farmers had argued before within this study that reducing the size of the Matengo pits had the advantage of improving crop yields. Basically reducing pit size provides more crop planting space, though might also bring competition for light, nutrients and water. However, despite all experimentations indulged in by farmers, yet food production trend has not improved. It probably justifies that attaining improved food production is not a question of a single technological option rather a function of different factors.

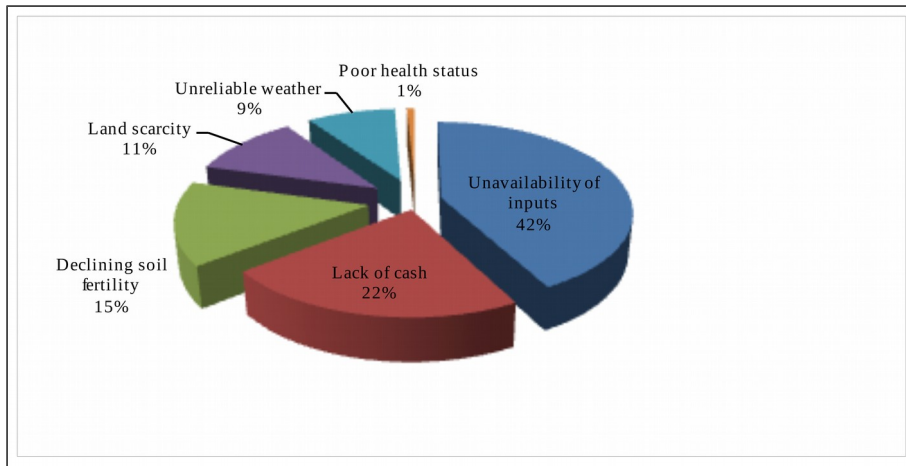


Figure 14: Associated factors for declining food production trend

Regarding food availability, the majority of farmers acknowledged experiencing difficulties when compared to the past ten years back. As the study results indicate in Fig. 15, about 44.3% of the farming households reported declining food accessibility mainly contributed by poor yields and lack of enough cash to buy food during shortages. But some of the farmers (34.1%) claimed to have improved their situation because of increased crop yields and appropriate budgeting (for consumption and exchange for labour), and have attained purchasing power from coffee income and livestock to buy food. Similarly, switching to other food products like banana, taro, cassava and sweet potatoes as energy sources apart from maize and beans (staple food crops) has improved the situation.

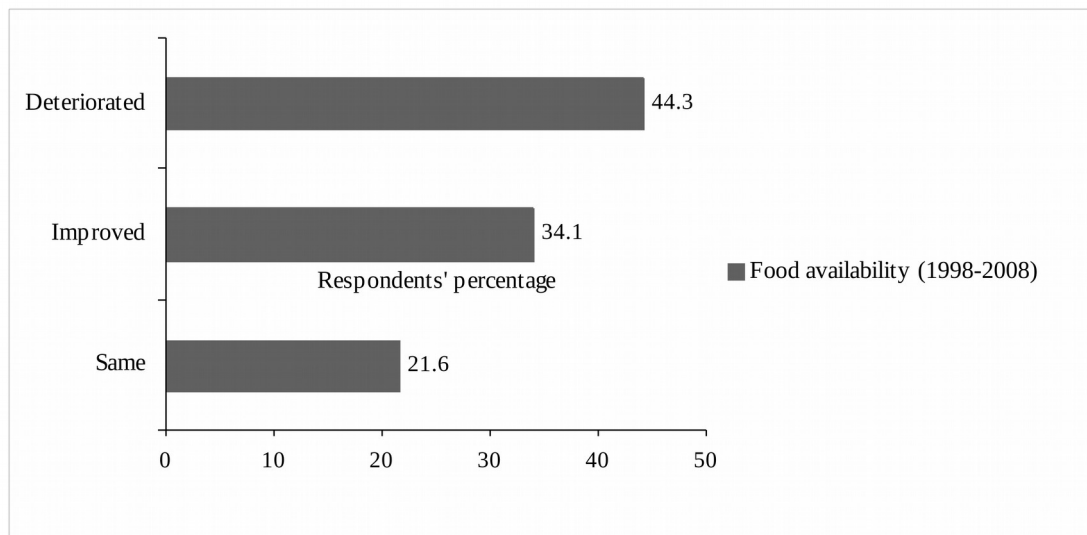


Figure 15: Food availability since 1998-2008

4.7.5 Contributing factors to household food insecurity

Majority of interviewed households reported experiencing food insecurity due to poor yields realised from their croplands (60.2%), while female-headed households were mostly affected (Table 30). Apart from agronomic reasons, also farming households confessed to poor budgeting of produced food stocks (26.9%), which included participation in social functions like *matula* and traditional dances like *mganda*, *chioda*, and *muwambo*. *Matula* involves taking food (especially maize, dried cassava, sometimes beans) to the household hosting the ceremony (Plate 6), as previously described. Similarly, those belonging to traditional dancing groups are mandated by group norms to host and entertain their fellow visiting dancers with good meals over the whole period of their stay. Apparently, all these social functions have food security implications to the

farming communities. Kauzeni (2000) also documented the same in his study in Kibaha that prolonged traditional festivals consumed large amounts of harvested food.

Other sources of food losses among Matengo communities were through local brewing and selling food stock during emergencies. Preparing local brew contributes to depletion of cereals especially maize which is the main input although this did not feature during the household survey. This was differently perceived by women involved in local brewing that it served as a coping strategy for earning more cash to meet household basic needs, including buying food. In other words, local brewing was regarded as a way of adding value to the crop, hence fetched more money within the household. Yet this area needs to be further scrutinised.

Table 30: Contributing factors to food shortages as per household-head's sex (%)

Accompanying reasons/factors	Male headed	Female headed	Total
Low crop production	47.3 (57.9)*	12.9 (70.6)	60.2
Land shortages	3.2 (3.9)	0.0 (0.0)	3.2
Poor food budgeting	23.7 (28.9)	3.2 (17.6)	26.9
Large family size	7.5 (9.2)	2.2 (11.8)	9.7
Total (column %)	81.7	18.3	100

*= denotes that figures in brackets are percentages within respective columns (sex)



Plate 6: Women with *majamanda* on their heads for a party - *matula*

4.7.6 Coping strategies for improving food availability

A number of coping strategies were employed by farmers in curbing the food insecurity i.e. improving food availability within their households, as illustrated in Fig. 16. Of all the coping strategies, majority of farmers in the study area largely depended on cash earned from coffee (28.9%) to buy food during shortages. It was also noted that still some of the farmers were practising *magoma*⁷ in order solve immediate problems. However, diversifying food sources was ranked the second (18.6%) after coffee income. Farmers reported switching to different food crops which previously had little social value like banana, cassava, sweet potatoes, taro etc. to reduce the level of hunger within households.

⁷ An informal arrangement of the Matengo people for accessing soft loans from their fellows/traders and pay back in terms of coffee after harvesting or by mortgaging a coffee cherries still in the field

However, under the farmers' context, local brewing is generally considered among the reliable livelihood alternatives which convert a form of cereal food products (like maize and simsim) into alcohol which in return fetches money to meet household needs including buying food. Farmers were also depending on other sources of income like wages, lumbering, masonry, handcraft, tailoring activities, etc. for earning cash to buy food. Selling labour was undertaken more by female headed households in exchange for food products or cash income. Most of these coping strategies centred on obtaining cash income to have the food purchasing power rather than depending on food sharing. This implies that people need cash to bargain for food even outside their respective villages, including Mbinga town where informal arrangements e.g. sharing food for labour are limited.

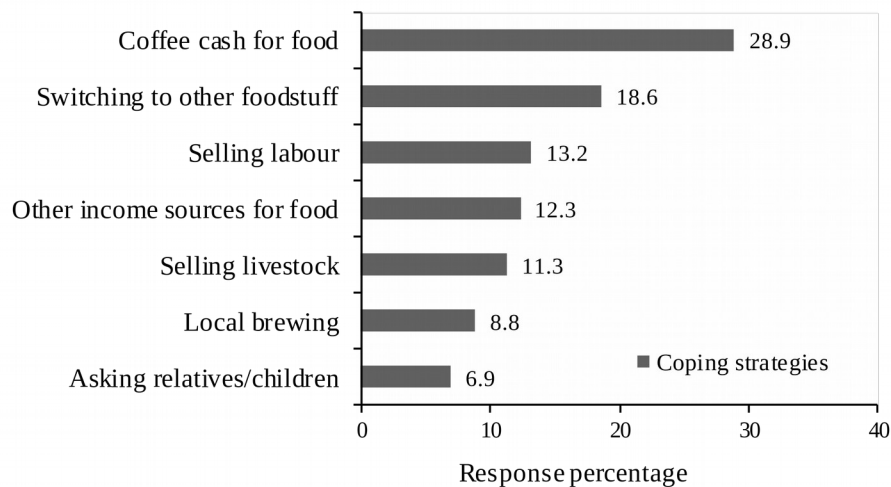


Figure 16: Coping strategies opted by farming households during food shortages

The coping strategies of farming households tend to differ, but valley bottom cultivation is the most common for the majority as a long term strategy. This particular activity provides variety of food crops to people mostly from February to April depending on the timing of their establishments. Crop harvests like maize, beans and taro, just to mention a few, are normally obtained from valley bottoms.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter summarises the results based on the empirical evidence obtained by this study. It gives some answers to the research problem and research questions which were investigated and provides further recommendations based on the conclusions.

5.2 Conclusions

Based on the study findings, it is generally concluded that the Matengo pits farming system has not remained resilient to changes rather has started losing some of the key components/characteristics, which have sustained it for hundreds of years. This follows the observed evidence related to modifications/changes of the overall time spent for drying grasses, organization pattern of grasses/crop remains, size and depth of the *ngolo* pits. A wide range of factors (socio-economic, social cultural, demographic including environmental conditions) were found to have significantly contributed to shaping of this particular farming system. It reveals that time and labour availability in Matengo highlands has become among the scarce resources which has compelled the increased use of casual labourers and simpler farming practices.

Similarly, the bio-physical factors (e.g. rainfall season variability, land shortages, etc.) have played a great role in influencing the decisions of what farming activity to

undertake and which technology to use. The Matengo highlands like many other smallholder communities in the country, have not remained immune to the impacts of climatic change and variability. The issue of rainfall intensity and variability (starting and ending of the season) have imposed a great challenge to the Matengo pits farming system. Rainfall variability has subjected farmers into a stiff competition for time and labour, which have sometimes compromised the quality of work performed. Also land shortage has been among the driving forces behind agricultural intensification and reduction of *ngolo* sizes in order to maximise the crop planting space.

In addition, the social changes currently taking place within the Matengo highlands (change in gender dimensions and decline of long standing cultural pillars like *sengu*) due to global influences have exposed this farming system to the threat of disappearing. The implication for such changes if left unchecked would subject the Matengo highlands into land degradation, and ultimately compromising households' food production situation.

Moreover, the present study suggests that the reviewed agricultural change theories (Malthusian Theory-1798; Boserup Theory-1965) were relatively narrow focused on change of technology and production (population pressure and agricultural technology change), in contrast to the present study findings. The study findings further suggested that agricultural related technological changes are influenced by multiple factors including environmental, socio-economic, social cultural and social political factors

rather than population pressure being the only driving factor. The study findings have also further stretched our understanding by taking the indigenous knowledge (conceptually) on board instead of only focusing on scientific knowledge changes. In addition, these study findings could serve as the cornerstone for developing well-informed decisions and future practical interventions aimed at building resilience of the farming system.

The implication of changes in Matengo pits farming system on household food security was statistically non-significant. Yet this demonstrates that changes in Matengo pits farming system may not be singled out solely as the only driving factor of household food security status, rather there are other determinant factors. Apart from physical food production, also farming households might access food through purchasing, support from relatives/government and non-governmental organizations or in-kind food payments for work. Similarly, poor food budgeting was an issue of concern to the majority of farmers in Matengo highlands, which also compromised food security status within households.

5.3 Recommendations

The following recommendations were drawn based on the study results. Among other findings, the study established the fact that there have been some contradictory decisions imposed by district officials particularly during 1980s which advocated replacement of the Matengo pits with conventional ridges in steep slopes. Yet the study has found that

most of extension services/packages were targeting the promotion of coffee production (i.e. monoculture), and none specifically aimed at improving Matengo pits. This indicates that this particular indigenous farming system has not yet received maximum attention from the government and other rural development stakeholders despite playing a significant role in supporting the livelihoods of the Matengo people. In view to this, the study is recommending to have collective and well informed decisions built on research findings and existing experiences from that particular community.

The study is further recommending formulation of joint initiatives which could raise awareness and promote the supremacy of the Matengo farming system over the other farming systems. It could be through putting more emphasis on participatory action research and training with farmers, organizing farmers' competitions and demonstration plots accessible to the wider community to trigger the moral/ spirit of sustaining this indigenous farming system. Also primary and secondary schools could still serve as training venues to equip and instil the children with basic principles of constructing *ngolo* with the best standards.

Furthermore, existing district environmental by-laws have remained silent on promoting the use and sustainability of Matengo pits in the highlands. Thus there is a need for having strict measures if not by-laws enforcement mechanisms in the study area to promote the sustainability of the *ngolo* and the land resource at large which is the key physical asset to the rural communities.

A close monitoring is also recommended to the introduced technological packages not only in Matengo highlands but also elsewhere in the country, unless otherwise the intended goals of the Kilimo Kwanza initiatives may not be realistic. It is based on the fact that introduction of some of technologies like power tillers in the district poses a potential threat to the future of the Matengo pits farming system if the farmers and the technology itself will respectively not be well advised and monitored. Timely delivery of the technical knowhow is recommended before introduction of the particular technology.

As far as areas for future research are concerned, the study is calling for further research to determine the impacts of climate change on Matengo pits farming system, particularly on gender related aspects as well as identifying the potential of the system on mitigation of the emerging calamity. Moreover, the study is proposing for an assessment of whether there is an existing relationship between type of land husbandry practices, soil tillage method in particular undertaken by farmers and the nature of soil (soil physical and chemical properties), which was not covered due to financial resource limitations. Undertaking these will contribute to more information for more focused interventions aimed at promoting and sustaining this indigenous technology.

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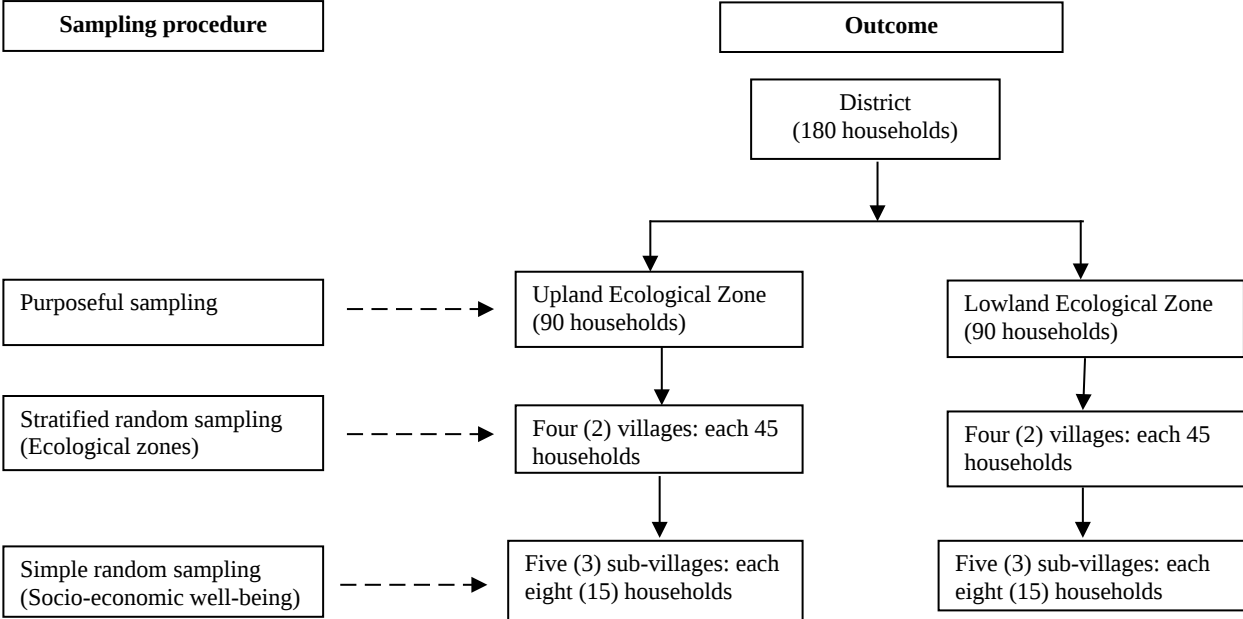
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APPENDICES

Appendix I: Sampling procedure



Appendix II: Operationalization of research objectives and data collection

Objective	Type of data	Method of collection	Method of analysis
i. Identifying changes in cultivation practices, and emerging technologies and; Factors impelling changes in cultivation practices	<ul style="list-style-type: none"> • Disappearing or emerging forms/components of Matengo pits preparation and constructions • Other emerging cultivation practices 	Focus group discussion, Transect walk, and household interviews (administering questionnaires)	Descriptive statistics and cross tabulation (chi-square test)
	<ul style="list-style-type: none"> • Establishing changes in gender based labour division in households • Household demographic information (age, sex of household head, education level, household size, etc) • Land size, location and ownership status • Measuring income status and source (savings, remittances, credits etc) • Market availability (distance to selling point and price) • Ethnicity of household members • Access to extension services (how many and what kind of technology a household have accessed from extension agent) • Marital status • Involvement/membership to local self-help groups/organizations (<i>ngokela</i>) 	Focus group discussion and household interviews/administering questionnaires	Descriptive statistics and cross tabulation (chi-square test)
iii. Determine environmental (climatic variability) driving	<ul style="list-style-type: none"> • Farmers perceptions on rainfall variability (onset and ending of 	Focus group discussion and household interviews by	Descriptive statistics and cross tabulation (chi-

the changes in cultivation practices	season) and how it affects construction of Matengo pits <ul style="list-style-type: none"> • Annual rainfall and temperature distribution recordings from available sources (weather stations) 	administering questionnaires Secondary data collection	square test)
iv. Determine changes in gender roles of household members on agricultural practices	❖ Establishing who is responsible with/taking part in: <ul style="list-style-type: none"> - Household chores (home making, taking care of children, old and sick people etc) - Production activities (agricultural food/cash crop production; marketing); non-farm income generating activities; off-farm income generating activities - Community activities - Village meetings (village decision making issues) 	Focus group discussions and household interviews	Descriptive statistics and cross tabulation (chi-square test)
v. Determine the implications of changes in cultivation practices/emerging technologies on household food security	<ul style="list-style-type: none"> • Yields of food crops produced (100 kg bag) • Amount of food crop(s) that was produced and consumed in household (kg); given out to relatives, friends or doing in-kind payments, etc. • Amount of food or cash crop sold (kg) 	Focus group discussions and household interviews	Descriptive statistics and cross tabulation (chi-square test)

Appendix III: Operational definitions of variables

Socio-economic/social-cultural/demographic characteristics/Variables

Variable		Indicator
Category 1:	Dependent: Changes of Matengo pits farming system	Disappearing of some practices of Matengo pits construction or preparations; emerging of new forms of cultivation systems/Matengo pits construction/changes in components of Matengo pits farming system
	Independent: Demographic and Socio-economic Data/characteristics	
	Age	Age of household (Hh) head and household members (number of years), which will be categorised to understand active contribution of different age groups in farming and non-farming activities (labour supply potential).
	Sex	Sex of the Hh-head (male =1/female=0) for sex category differentials.
	Household size	Number of members living within the same household
	Education	Education level attained (including number of years spent in school) i.e. whether in primary, secondary or highest level attained; or none
	Farm size	Size measured in terms of acres then converted into hectares (ha) equivalents
	Farm/field location within the landscape	Nature of the terrain in which the field is located (upland: steep sloped land, gentle sloped or lowland: flatland/valley bottomland)
	Distance to the farm/field	Number of kilometres (km) to the field
	Financial resources availability	Measured in terms of amount of Hh- head savings, remittances obtained by Hh- head, and credit access (availability and accessibility of soft loans to Hh- head, including members)
	Input use	Labour supply (man-days/ha) i.e. sum of family and hired labour; seeding rate (kg/ha); fertilizer rate (kg/ha) etc.
	Independent: Socio-political	
	Extension services access	Visited/contacted by the extension agent or service provider (visited=1;not visited=0)
	Market access	Selling point of crop products (farm gate, village, outside market and their attached prices)
	Land tenure/ownership	Access and control of land can determine type of crop and technology to invest. Measured by observing whether: self-owned, rented in or borrowed from a relative, friend, village government etc.
	Independent: Socio-cultural	

	Intermarriages	Measured by observing to which ethnic group the Hh-head is married to (if it is different to Hh-head). Or determining the ethnicity of the spouse
	Gender roles	Measured by observing division of labour among household members across household chore/reproductive and production activities, and community relations /works (i.e. who takes part in village meetings, functions/funerals, dances etc) with regards to their social categories (sex and age of Hh-members)
	Self-help groups/informal organizations/ social networks	Membership of Hh- head or Hh- members to any traditional mutual help groups/ social networks (namely: <i>ngokela</i> , <i>chama</i> , conventional groups)
	Ethnicity	Recording the tribe/origin /ethnic group of the Hh-head
	Perception to rainfall variability	Changes of on-set and ending of rainfall seasons/times as determined by Hh-head/members
Category 2:	Dependent: Household food security status	The amount of food crops (kg/ha) produced and consumed; Number of months the household took to exhaust its own produced food crop, including the number of meals taken per day. OR (food secure=0; food insecure=1)
	Independent: Changes in Matengo pits farming system	
	Emerging cultivation practices	Use of new/ borrowed tillage methods (e.g. flat cultivations, conventional ridges running across the slope (<i>mitumbila</i>), ridges running parallel to the slope (<i>malonga</i>), etc
	Current Matengo pits modifications	Existence of new structures/components of constructing Matengo pits, including a change in pattern of aligning dried-grass debris before covering with soil (grid form=0; parallel=1); modifications of ridge construction style i.e. depth of pits (cm), width (cm) (i.e. deep=0; shallow=1); size of <i>ngolo</i> (traditional large size=0; reduced size=1); change of time for drying grasses (normal time =0; reduced time=1)

Appendix IV: Household survey questionnaire

A: Household identification:

Name of respondent:Village: Ward

Sub-village:Ntambo:

Interviewer: Date:

A-1: Household Demographic and Socio-economic characteristics

HH member	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
Sex														
Age														
Education														
Marital status														
Ethnicity														
Main occupation														
Work on farm														
Household head														
Relation to H/head														

Sex:	Education	Marital status	Ethnicity	Main occupation	Work on farm	Household head	Relation to H/head
1. Male	1. None	1. Single	1. Ethnic	1. Farmer	1.Full time	1. yes	
2. Female	2. Primary	2. Married	2. In-migrant (specify)	2. Civil servant	2. Part time	2.No	
	3. secondary	3. Widow		3. Self-employed	3.None		
	4. Post-secondary	4. Widower		4. Unemployed	4. Other (specify)		
	5. Other (specify)	5. Divorced		5. Student			
		6. Immature		6. Housework			
		7. Other (specify)		7. Sick, Old, Child, Disabled			
				8. Other (specify)			

B-1: Number of livestock owned

Type of livestock	Number Now	Number last year	Number eaten	Number sold	Income earned
Pigs					
Cattle					
Chicken					
Ducks					
Goats					
Sheep					
Other (specify)					

B-2: Income sources

1. What are the major sources of income in your household?

Source of income	Rank	Source of income	Rank
Sale of food crop		Employment (civil servant)	
Sale of coffee		Self-employment (mention)	
Sale of livestock		Remittances	
Other (mention)			

B-3: Remittance

1. Did you give/get any remittance to/from someone who is not living together in 2006/2007? (1. Yes 2. No), if Yes

To/From whom (Name)	Relation to Hh-head	Amount of cash (TShs)/ in kind (specify)	
		Give	Receive

Code: For relation to Hh-head

- 1. Wife 2. Husband 3. Child 4. Parent(s) 5. Brother
- 6. Sister 7. NGO 8. Other (specify)

2. What was the main use of the remittance obtained? (Mention key issues):

.....

C: Savings and Credit accessibility

C-1: Credit

1. Did you receive any credit/loan during the year 2006/07? (Yes/ No), if yes go to next Qn

From	Amount (cash/in-kind)	Purpose	Purpose accomplished? (Remarks)

3. Did anyone in your household receive any loan/credit in 2006/07? (Yes/No), If yes, (mention last amount borrowed: cash/in-kind).

4. If yes (above), what was the purpose/use of the loan? (Mention key issue):

.....

C-2: Savings

1. Do you have any income savings? (Yes/No), if 'yes' please, mention a balance to date: (TShs).

D: Socio-political information

D-1: Market Access/Availability

1. Where do you sell your farm products:
 - (a) Food crops (1. at farm gate/on the spot 2. local market/within village 3. neighbouring village market 4. other market (specify)
 - (b) Cash crops (1. farm gate/household level 2. local market/ within village 3. neighbouring village market 4. Other market (specify))
2. Mention type of cash/food crops sold at respective above mentioned markets during last season (2007/08).

D-2: Extension services accessibility

1. Have you ever had access to extension service? (Yes/ No), if 'Yes' go to next question below/ if 'No' respond to question No. 4 below

2. When was your last time, and who offered services?
.....
.....

3. List type of services you were offered in your last contacts?
.....
.....
.....

4. If 'No', please give reasons
.....
.....

E-1: Household land ownership and utilization (2008/2009)

Field ID	Plot-1	Plot-2	Plot-3	Plot-4	Plot-5	Plot-6
Field size (acreage)						
Ownership (1= Own 2= Not own)						
Acquisition of plot (1= inherited 2= purchased 3= borrowed 4= rented in 5= given by village government 6= Other (specify))						
Location (1. homestead 2= within ntambo 3=outside ntambo-within same village 4=outside village – please mention)						
Field landscape (1.= upland steep sloped 2= upland with moderate slope 3= upland flat 4= valley bottom)						
Cropping system (1= sole cropping 2= mixed cropping 3= re-lay cropping 4=tree planted-mention 5= fallow)						
Primary crop grown						
Type of seeds used (1= local 2= improved 3= other -specify)						
Secondary crop grown						
Type of seeds used (1= local 2= improved 3= other -specify)						
Third crop grown						
Type of seeds used (1= local 2= improved 3= other -specify)						
Tillage method used (1= Ngolo 2= mitumbila 3= malonga 4= sesa 5= other (specify))						
Land prepared by (1= Family adult men 2= Family adult women 3= Both adults 4= Children 5= Hired labour –mention cost 6= Other-mention)						
Pattern of grass/crop debris arrangement (1= Grid/lattice form; 2= single lines down slope; 3= single lines across slope)						
Digging by (1= Family adult men 2= Family adult women 3= Both adults 4= Children 5= Hired labour-mention cost 6= Other-mention)						
Sowing done by (1= Family adult men 2= Family adult women 3= Both adults 4= Children 5= Hired labour 6= Other-mention)						
Weeding by (1= Family adult men 2= Family adult women 3= Both adults 4= Children 5= Hired labour 6= Other-mention)						
Used fertilizer? (1= Yes; 2= No)						

Type of fertilizer						
Did you use pesticide (1=Yes; 2= No)						
Type of pesticide						
Harvesting done by (1= Family adult men 2= Family adult women 3= Both adults 4= Children 5= Hired labour 6= Other-mention)						

B-2: Household land ownership and utilization (2008/2009)

Field ID	Plot-1	Plot-2	Plot-3	Plot-4	Plot-5	Plot-6
Field size (acreage)						
Ownership (1= Own 2= Not own)						
Acquisition of plot (1= inherited 2= purchased 3= borrowed 4= rented in 5= given by village government 6= Other (specify)						
Location (1. homestead 2= within ntambo 3=outside ntambo-within same village 4=outside village – please mention)						
Field landscape (1.= upland steep sloped 2= upland with moderate slope 3= upland flat 4= valley bottom)						
Cropping system (1= sole cropping 2= mixed cropping 3= re-lay cropping 4=tree planted-mention 5= fallow)						
Primary crop grown						
Type of seeds used (1= local 2= improved 3= other -specify)						
Secondary crop grown						
Type of seeds used (1= local 2= improved 3= other -specify)						
Third crop grown						
Type of seeds used (1= local 2= improved 3= other -specify)						
Tillage method used (1= Ngolo 2= mitumbila 3= malonga 4= sesa 5= other (specify)						
Land prepared by (1= Family adult men 2= Family adult women 3= Both adults 4=						

Children 5= Hired labour –mention cost 6= Other-mention)						
Pattern of grass/crop debris arrangement (1= Grid/lattice form; 2= single lines down slope; 3= single lines across slope)						
Digging by (1= Family adult men 2= Family adult women 3= Both adults 4= Children 5= Hired labour-mention cost 6= Other-mention)						
Sowing done by (1= Family adult men 2= Family adult women 3= Both adults 4= Children 5= Hired labour 6= Other-mention)						
Weeding by (1= Family adult men 2= Family adult women 3= Both adults 4= Children 5= Hired labour 6= Other-mention)						
Used fertilizer? (1= Yes; 2= No)						
Type of fertilizer						
Did you use pesticide (1=Yes; 2= No)						
Type of pesticide						
Harvesting done by (1= Family adult men 2= Family adult women 3= Both adults 4= Children 5= Hired labour 6= Other-mention)						

2. If is 'No' (above), at which period does this shortage mostly occur, and WHY?

Critical Period	Accompanying reason

3. What strategies do you take to cope with this situation?

- (a) hiring-in labour
- (b) relying on *ngokela* (self-help social networks)
- (c) asking assistance from relatives/neighbours (without any kind of payments-cash/in-kind)
- (d) Other: specify:

.....

F-2: General Household Division of Labour (at the current situation)

Activity	Wet season (days/month)			Dry season (days/month)		
	Male	Female	Both	Male	Female	Both
A. Production						
1. Land preparation/clearing						
2. Aligning grasses (dried) in grid						
3. Digging						
4. Planting/sowing						
5. Weeding						
6. Harvesting						
7. Marketing						
8. Collecting forage for livestock						
9. Herding/tethering						
10. Milking						
11. Other production activities						
B. Reproduction Roles						
1. Cooking						
2. Fetching water						
3. Fetching fuel						
4. Child, sick and old people's care						
5. Housekeeping						
6. Other activities						
C. Participating to Community Issues						
1. Village meetings						
2. Community works						
3. Funerals/functions						

Code:

- 1. Male adult
- 2. Female adult
- 3. Male child
- 4. Female child
- 5. Hired labour (male)
- 6. Hired labour (female)
- 7. Other (specify)

G-1: Voluntary association

1. Are you or any of household members involved in any social group (Yes/No)?

Group category	Who is involved	Main activities	Name of group	When joined and why?
Farming group				
Non-farm income production group				
Other (specify)				

2. If “Yes” (above), what benefits have you realized being a member to such group(s)?

3. If the answer is “No”, what are the accompanying reasons?

H-1: Food security (Availability and Accessibility)

1. When do you consider the household is food secured?
 (a) Eating three meals per day (adults)
 (b) Food available in the household throughout the year (January to December)
 (c) Improved food crop production
 (d) Improved income to buy food
 (e) Other (specify)
2. How many meals do your children (under five years old) take when the household is food secured? Mention number of times:

3. Do you experience food shortages in your household? (Yes/No)?
4. If “Yes”, specify which particular months, and reasons as to WHY?

5. What are your coping strategies during food shortages? (Mention three)

6. Referring to 1990s; 2000 and currently (2007) has the food availability in your household (1. increased 2. remained the same 3. decreased), and why?

7. Compared to 1990s; 2000 and current/last (2006/07) cropping season, own food production has (1. increased 2. remained the same 3. decreased), and what are contributing factors/associated

reasons?

8. Referring to your last cropping season (2006/2007), did you do any of the following?

Event	Type and Amount (kg)	Value (TShs)	To/From
Buy food			
Give-out (in-kind) food			
Receive food assistance			

I-1: Matengo pits (*ngolo*) sustainability

1. What type of tillage methods you have been using to grow cash and food crops under different time periods (since 1980s to date)?

Period	Crop type	Tillage method	Reason(s)
1980s	Food crop(s): Cash crop(s):		
1990s	Food crop(s): Cash crop(s):		
2000 to date	Food crop(s): Cash crop(s):		

2. Do you find any constraints in cultivating *ngolo* in your fields? (Yes/ No), if 'Yes' please mention them (rank):

3. How do you cope with above mentioned constraints? (by ranking)

.....
 4. How do you compare the past (1990s) and the current experiences (2000s) in terms of constraints (1. increased 2. same 3. decreased), and WHY?

.....
 5. Is the mode of *ngolo* cultivation (preparations, cultivating pits and ridges, seed sowing pattern, etc) has still remained the same as that used by your grandparents? (Yes/No).

6. If “No”, what type of changes or modifications have been made, and WHY such changes/modifications have taken place?

Activity	Modifications	Reasons
i. Land preparation: <ul style="list-style-type: none"> • Clearing • Time for grasses left to dry • Alignment pattern of dried grasses • Other (specify) 		
ii. Ngolo cultivations/ridging		
iii. Sowing pattern		
iv. Weeding practice & frequency		
v. Other (specify)		

7. How do these changes/modifications in *ngolo* making have influenced household food sufficiency? Explain:

8. Do you think this *ngolo* farming system will be sustained in the area? (Yes/ No), Explain:

J-1: Local institutions and By-laws:

1. Are there any by-laws enforcing sustainability of *ngolo* within the village? (Yes/No). If yes, please answer the Qn below.

2. What are these by-laws? Mention

3. How do you find them in terms of efficiency (rank)?

-
-
4. Are you aware of the traditional institution called *sengu*? (Yes/No). If yes, explain its roles/activities:

 5. Does this *Sengu* still exist in your society? (Yes/No). If answer is “No” explain WHY?

K-1: Environmental changes (Farmers’ perceptions on rainfall variability)

1. Are there any signs of climatic changes/variability currently in your village as compared to 1980s and 1990s (Yes/No).
2. If “YES”, what changes have taken place and their accompanying signs/indicators?

Climatic (rainfall) changes	Indicators/signs

3. How do these climatic changes affect your farming activities?

Activity	Effects
<i>Ngolo</i> cultivations/making	
Cropping pattern	

4. What is your view on the rainfall pattern during the last 2006/2007 cropping season? (1. started timely, i.e. on set and ending of season 2. rainfall delayed to start 3. rainfall season ended shortly 4. other)
5. How was the rainfall distribution across the cropping season of 2006/2007? (1. Evenly distributed 2. not well distributed)
6. Did it have any effect on *ngolo* cultivation practices? (Yes/No), explain:

Appendix V: Checklist for district extension officers

- i. What are available institutional frameworks/by-laws guiding the Matengo pits farming system?
- ii. How are farmers being equipped or facilitated with production knowledge and skills in terms of improved farming technologies? How do these technologies fair with Matengo pits cultivation system?
- iii. What are potential challenges to households' socio-economic status, particularly focusing on: land, food security, labour availability, rainfall variability, etc?
- iv. What changes/innovations (endogenous) have taken place in Matengo pits farming system and their associated factors?
- v. In your understanding, what do you think about the sustainability of *ngolo*/Matengo pits farming system in Matengo highlands?

Appendix VI: Focus Group Discussion checklist

- i. What major changes have taken place since 1980's, 1990's, 2000-05, 2006 to date in terms of the following and their associated reasons?
 - Types of crops cultivated and livestock kept
 - Tillage methods
 - Input use (fertilizer, pesticide, etc) with regards to their respective crop types and fields
 - Environmental conditions, including rainfall variability in terms of starting (on-set) and ending of seasons, distribution over the season and intensity
 - Use of self-help networks or groups (*ngokela*, *chama*, conventional farmers' groups, etc)
 - Crops production trends and food security status
 - Market accessibility (which selling points have been used by people to dispose their farm products including the attached value offered to main crops)
 - Extension services accessibility
- ii. What has happened to Matengo pits farming system? Do people still cultivating *ngolo* the same way used to be done by their parents or ancestors?
- iii. What changes or modifications have taken place in the above mentioned farming system, and WHY?
- iv. What is the current status of division of labour with reference to the following, and WHY so?
 - Production activities, with much emphasis on *ngolo* making (as from farm preparation to harvesting) etc.
 - Reproduction roles
 - Community works
- v. How does work done by men differ from that of women or young and old, hired labour and family labour during *ngolo* making?
- vi. Which cultural or traditional institutions used to be in place for safeguarding the *ngolo* farming system?
- vii. What constraints do you currently face during cropping season/*Ngolo* making and how do people cope with?
- viii. How does climatic change (rainfall) affect *ngolo* cultivation system, and how do farmers cope with the situation?

Appendix VII: Socio-economic status of the targeted population

Category	Kindimba	Litembo	Tukuzi	Myangayanga
A: Wealthy	Characterised by having modern houses with corrugated iron sheet as the roof, plastered and painted; Food secured for twelve months; Have also assets (livestock and improved means of transport like motorbike, bicycle, motorcars, and milling machines). Can afford to meet health and education service costs; Have at least 3 acres of coffee fields; Harvesting coffee to an average of 2000 kg (approx. 40 bags of 50 kg capacity); Have bank deposits; Majority are middle aged people.	These households were reported to have high food crop production particularly for crops like maize, wheat and beans; They also keep livestock, mostly cattle, goats and pigs; They are leading in terms of coffee production and cash earnings.	The villagers with large coffee fields with around 3000- 4000 trees (approx. 6-8 acres). Under ideal condition, a well-managed coffee tree could produce an average of 3kg of coffee cherries; Also have financial capacity, and food secured. Likewise, could have assets like transport facilities, a modern house (roofed with corrugated iron sheets, cemented floor and painted walls), and cattle. Also have children attending to secondary schools.	With well managed coffee fields (2-4 acres), producing a max. of 60 bags of coffee; Keeping livestock (for either meat/milk or farmyard manure); Food stock coincides with newly harvested stock; With transport facilities enabling them to manage distant crop fields; Have well maintained modern houses (burnt brick walls and corrugated iron roofs); Sending children to better schools; Can afford better health services; Dominated by male headed households, even of young generation;
B: Better-off	With a modern house furnished with doors and windows; Have food stock covering about 5-8 months before it elapses; To some extent can afford to meet the costs pertaining to health and education services; Have approximately 2 acres of coffee crop producing an average of 1000 kg of parchment coffee; Might have a milling machine inherited from parents but not working; With 2 wives and about 6 children; Mostly dominated by old people.	They are obtaining an average yield from food crops which could at least take them through July/August up March in the following year; Some have livestock; They are getting an average of 5-6 bags (50kg size) of parchment coffee.	These were claimed to have modern houses (with iron sheet roof, without cemented floor) and do not face hunger crises. Capable to meet their daily needs as they also keep livestock like goats, pigs and chicken. Have 1000-2000 coffee trees.	Mostly practice crop mortgaging (e.g. 3-4 bags of crops for a bag of fertilizer), particularly coffee cherries; They experience food insecurity as most of harvests serve for credit repayments; A few sells labour for cash/ food; Sometimes out-migrates to escape their debts. Cultivates ≤ 2 acres of food crops, all the same have coffee fields (≤ 2 acres); Obtaining an average of 2-3 bags of coffee; Incapable of sending children to better secondary schools; Depends on cheap health services; Comprised of male and female headed households (all age groups even < 60 years).
C: Poor	Are not food secured as the stock lasts for about 3 months since harvesting; As a result, opts for selling labour to earn food; Have poor houses (thatch roofed with burnt brick walls); Have no assets like livestock/means of transport; Harvesting not more than 500 kg of coffee which mostly is mortgaged still in the field (<i>magoma</i>). Have formal education, with 3 wives and about 10 children. Spend more time drinking local brew (<i>ngelenge</i>); Comprised of elderly male headed households.	Have unreliable food security status because of very little harvests they get such that are forced to move out to neighbouring villages (e.g. Maguu village -cassava producing area) to buy food after selling labour; Normally sell labour to other households for cash or food; Majority do not keep livestock; Have poor coffee yields as due to poor management.	Own poorly managed coffee fields with approximate 300-500 trees; These people cannot afford not only meeting pesticides costs but also health services; Some do not even have land to cultivate; They also do not have a good house to stay and keeping no livestock; Tend to spend most of time selling labour to their fellow village community members for earning a living as they mostly experiencing food insecurity in their households.	Mostly food insecure simply their food stock elapses just two months since harvesting; Very few have an average of 1.5 acres of coffee, and majority have just 100-200 coffee trees; Group dominated by secondary school dropouts aging 20-45 years; Lazy to work; Few opt selling labour to other groups. Have poorly maintained modern houses; Also cannot afford paying for improved health services or sending children to school.