

Assessment of Land Tenure and Management Challenges of Reducing Climate Change Impacts in the Southern Highlands of Tanzania

Gwambene, N. B., and Liwenga E. T.
University of Dar es Salaam

Abstract

Producing more food for a growing population in the context of changing climate, while at the same time combating poverty and food insecurity, is among the enormous challenge facing Sub-Saharan African. Such factors affect land which forms the most important resource that forms the main part of the mode of production among farm households. The climate change risks, reduce arable land and pose environmental degradation that increases vulnerability to climate change and variability impacts. To reduce climate change impacts and growing land shortage, smallholder farmers in the southern highlands of Tanzania have been shifting to farming systems that are restoring exhausted soils and are increasing food crop yields, household food security, and incomes. However, some of these activities have implication on long-term adaptation and mitigation strategies. This paper reviews land tenure challenges of land use management and development of adaptation and mitigation strategies. The aim is to assess land tenure and management strategies for reducing climate change challenges and increasing food security and environmental resilience. To acquire accurate and detailed information, combinations of both qualitative and quantitative approaches were used. The use of two approaches facilitated the triangulation and validation of information collected through various methods. The main focus was on the land tenure challenges in relation to climate variability and adaptation and mitigation measures. Quantitative data compiled and analyzed by using Statistical Package for Social Sciences (SPSS) and Microsoft Excel software while qualitative data analyzed during and after data collection using content analysis. The results indicate land fragmentation and high land pressure in the area. This affected crop diversification and implementation of adaptation and mitigation measures, especially for that involve utilization of the large size of land. Also the small size of land resulted in the substance farming with less incentive for commercial farming. The results from Pearson Chi-Square signify the size of owned land value 65.816 with df 44 and Asymp. Sig. (2-sided) .018. And borrowed value 17.355, with df of 14 and Asymp. Sig. (2-sided) .238. The frequency of the small size of land is higher than the large size forming leaner distribution as divergent to the normal distribution curve. It was further revealed that land acquisition through inherited, redistributed by household heads with few buying have implication on land management and changes on land uses and affects development of mitigation measures. The absence of policy incentives for good land management, high population density and land shortage places excessive pressure on land that increases challenges on management strategies. Also land ownership has an influence on land management for example rented land receive less management incentive, while the owned land can have a long term management measures. A measure that enhances land management and carbon storage both above ground and below ground and induce more effective conservation of above and below-ground biodiversity are essential.

Key words: *Land tenure, climate change challenges, land use practices and agriculture*

1.0 Introduction

1.1 Background of the study

Land is the key asset of the rural poor and forms important part of the production system. Its use is a primary determinant of local and regional climate change adaptation capacity and mitigation measures (Morris *et al.*, 201;

EPA, 2011).

Climate change and variability increase challenge on the landscapes and land management in farming societies in sub-Saharan Africa. It is apparent that human activities are compromising sustainability of important resource and natural processes and this dynamic is being further amplified by

increasing climate variability (TerrAfrica, 2009). Farmers have been observing the changes in the land and knowledge of land uses and management for several decades and have been developing coping and adaptation strategies (Tauli-Corpuz & Lyng, 2008). The developed strategies have implication on adaptation and mitigation strategies to climate change and variability impacts and improving livelihood and food security. Sustainable land management strategies and practices are becoming an important factor in reducing the challenge of climate change and variability impacts. It enables farmers and communities to become more resilient to climate change by increasing food production, conserving soil and water, enhancing food security and restoring productive natural resources (TerrAfrica, 2009). It was evidenced that sustainable land management practices not only contribute to restoring ecosystem functions, but also contributes significantly to adaptation to and mitigation of climate change in the context of Sub-Saharan Africa.

Proven land management practices that allow farmers to better adapt to climate change contribute to mitigate climate change and can produce win-win-win outcomes in Sub-Saharan Africa (Rosenzweig & Tubiello, 2007). According to TerrAfrica (2009) a wide variety of pressures have led to the adoption of unsustainable land management practices in Sub-Saharan Africa. Such pressures include continuous cropping (with reductions in fallow and rotations), repetitive tillage and soil nutrient mining, overstocking, overgrazing, frequent rangeland burning, and over-use or clearance of woodlands and forest. The impacts of these practices include loss of soil and other natural resources, changes in natural habitats and ecosystems, reduced ecosystem services such as water infiltration and loss of agro-biodiversity and wild biodiversity as well as decreases in land productivity leading to poor harvests and food shortages (Morris *et al.*, 2010). Climate change is now further exacerbating these problems. To increase the

resilience of agricultural and natural resource management systems need to have land management practices that offer opportunities to have adaptation to climate change.

Climate change adaptation strategies that do not involve sustainable land management, such as land expansion into forest areas or excessive crop input applications, including pesticides, might exacerbate land degradation and contribute to GHG emissions (UNCCD, 2009). For instance, in most part of Tanzania, environmental degradation has increased as a result of farmers' responses to droughts and other environmental stresses, which have involved agricultural intensification and extensification, livelihood diversification and migration (TerrAfrica, 2009). While these strategies have been instrumental for survival, they have also contributed to increased deforestation, soil nutrient depletion, soil erosion and reduced water retention (Tubiello & Van der Velde, 2014). Therefore, by increasing environmental degradation, short-term adaptation strategies adopted to cope with current climate changes might increase the vulnerability of the population to the future impacts of climate change.

1.2 Statement of the problem

Land use management problems expressed as soil or forest loss, reduced water availability, or poor yields, such impoverishment of the land is being driven by inefficient or unsustainable land management practices and inappropriate or competing land uses (TerrAfrica, 2009). The problem exaggerated by climate change and variability impacts that manifested in decreased crop yields, livestock production and deforestation that proceed at the highest rate. This affects the effort of reducing climate change impacts in small holder farmers in sub-Saharan Africa. Among the perceived and observed climate change and variability implication on land management include a decrease in production that resulted in competing land uses and fail to adhere to sustainable land management strategies among the users. It has undermined

the sustainable management efforts of agricultural land in southern highland and altered the rainfall patterns, augmented the drought cycle, and increased the agricultural pests and diseases (Ngigi, 2009; Chifamba & Mashavira, 2011). Such situation increased conflicts over resource and more extraction of resources that increase challenges in reducing climate change impacts. Consequently inadequate land management or technical skills, socio-political issues, inadequate maintenance incentives for land management – systems initiated by smallholders farmers frequently fall into mismanagement. The maladaptation to climatic changes have increased, with the impact of climate change devastating community's efforts to sustainably manage agricultural land. Combined factors such as variable rainfall, high temperatures, and poor soil fertility management have shaped the vulnerability of farmers to hardships from extreme climatic conditions. It is important to promote land management strategies that increase productivity and contribute to adaptation and mitigation of climate change impacts.

1.3 Objectives

The main objective of this paper is to assess the challenges of land tenure and management to reducing climate change and variability impacts in the farming community in the southern highlands of Tanzania. Specifically the paper aims to assess land tenure and management in southern highlands, identify land tenure and management challenges on sustainable land use management and development of adaptation and mitigation strategies. The aim is to assess land tenure and management strategies for reducing climate change challenges and increasing food security and environmental resilience.

2.0 Research Methodology

The study was undertaken in three villages of Rungwe District each representing the agro-ecological zone. The District is located in the southern part of the Mbeya region in the

Southern highlands of Tanzania. The district was selected due to its agricultural potential within its vertical landscape gradient with diverse characteristics, which allow the production of a number of crops. For a long time, the district has been a basket of food supply in the country. The District is also acknowledged on climate change and variability that had effects on crop production and land management. In order to have efficient and representative sample, the study covered three selected villages of the district to cover highland zone, middle land zone and lowland land. Random and purposeful sampling techniques were used in the selection of wards and villages for study. The selection was based on the agro-ecological zones, social services, accessibility, and economic activities that characterize the biophysical environment and economic activities. Basing on these criteria, Mbeye 1 (highland), Kikota (middle land) and Kapulampunguti (low land) villages were selected for this study.

The study used both qualitative and quantitative research methodologies. Basing on the nature of the study and its objectives, quantitative method was employed at a household level whereby a closed and open-ended questionnaire administered to sample households, with face-to-face interview being the main approach within study villages. Consequently, the qualitative design involved key informant interviews, and Focus Group Discussions (FGD) coupled with field observations. Key informant interview and FGD were guided by semistructured questionnaires. The qualitative methods established the knowledge and experience with the implication of climate variability on livelihood; spatial and temporal changes in land use and management challenges and response strategies to climate change and variability while the quantitative method provided the percentages and statistical information. Purposive and random sampling was used in sample selection of 14 key informants for interview. The selected persons for key informant interviews include Village

Government 6, Elderly people 3, Extension workers 3, Agricultural and Officers 1, and Natural resources Officers

1. Purposive and random sampling was used in sample selection of household for interview. In all total 147 household randomly selected among farming households were interviewed. Consequently, one FGD of 12 to 18 participants was conducted in each village making a total of three FGD. These FGD involves different groups, basing on gender, age, and socioeconomic standing in the selected villages.

The choice of research method depends on the type and quality of information required, socioeconomic setting, time frame and resource available for the type of research work. Information collected was biophysical, weather and socioeconomic and cultural. In order to enhance the smooth running of the study secondary information were reviewed from various documents on what others have done and form a basis for discussion and background of the study. The questionnaire was the main quantitative data collecting tool utilized and, in the qualitative methodologies, a number of methods were used, which included focus group discussions and semi-structured interviews with key informants, such as district council officials, ward and local committee members, and aged people. Rapid Rural Appraisal (RRA) was also utilized to assess the general environmental conditions. Participants were selected on the basis of the vulnerability to climate change, community responsibility, age, gender and livelihood diversification.

The research also utilized observations where the administration of questionnaires was concurrently carried with observing the condition of the environment. Field observations were undertaken to check and validate some of the information. This method assisted in soliciting biophysical information and proving information gathered from interviews, focus group discussions and

household survey. Through this method characteristic of farm and farming management system across the agro-ecological zones were observed and studied. Social services development, the use of agricultural implements and inputs was also observed and studies. The data collected from different source and methods were edited, coded, tabulated, compiled, processed and analysis using different techniques. Quantitative data compiled and analyzed by using Statistical Package for Social Sciences (SPSS) and Microsoft Excel software while qualitative data analyzed using content analysis. Cross tabulation allows a comparison of different study parameters among villages and across agro-ecological zone. The results displayed in the form of percentages, Tables and Figures. Qualitative information presented in the form of descriptions. The Chi-square² (X^2) test was used to test the significance.

3. Findings and Discussion

3.1 Household asset and livelihood characteristics

It was also appearing that households decide on what to produce, how to produce, and how much to produce. These choices will have environmental consequences, and determine the quantities and quality of the products offered on the market. General farmers' income in agricultural production may be influenced by a number of factors include education level, means of accessing, market information, household size, gender, marital status, production costs, land size and farming experience. In broad-spectrum the household characteristics include factors such as labour and land availability, consumption needs and food preferences, capital assets, knowledge base (literacy/traditional knowledge), religion, off-farm income, and willingness to take risk are all important factors which will influence household decision making. At the household level the choice of the suitable adaptation measure depends on factor endowments. Such factors, for example, include access to land and the size of the land owned / utilized and capital resources at the disposal of farming

households. Better access to farm assets and inputs such as improved implements and inputs found to promote the use of improved agronomic practices and increase household adaptability capacity. The similar results discussed by Hassan and Nhemachena, (2008) were the size of household, land and capital resources at a farm level considered to be a production determinant.

Small size of land characterizes the farming activities in all study villages that limits further expansion of farming activities. In these lands a mixed livestock with cropping activities are practiced. As in other area larger farm sizes are associated with rain-fed farming systems, scarcer land resources are within irrigated agriculture. It was revealed that land

1

shortage are experienced in both rain-fed and irrigation farming systems, although in irrigated farming the problem is more experienced. In the study area most of the farmers own small size of land, especially in the middle land zone as indicated in Figure 1. Such factors have an influence on agricultural production and on developing adaptation and mitigation measures to climate change and variability since farmers have less land for mechanization and crop diversification. The result indicates that most farmers own small size of land, for example, 36% in the lowland, and in the midlands 43% own to 0.25 to 1 acres, in lowland, 44% in the midlands and 38% in highland owned 1.25 to 3 acres and by all villages farmers own not more than ten acres.

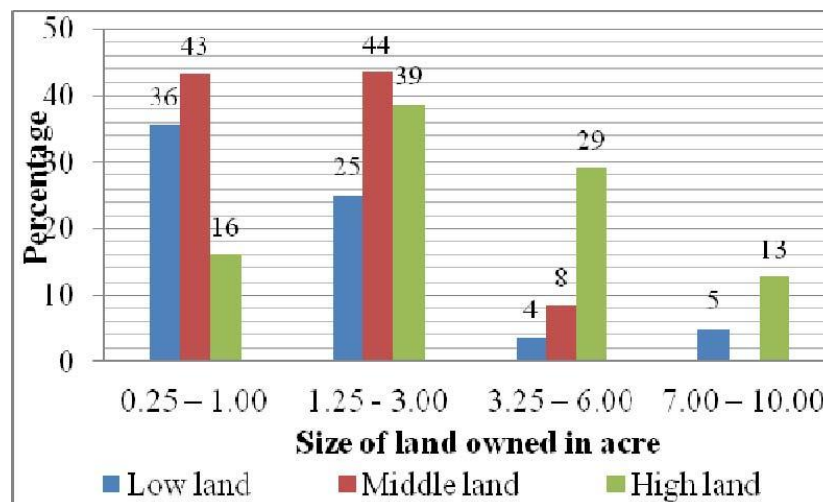


Figure 1 Total land size owned in the villages in acres

The importance of livestock production is growing in the area, it account on average for 35 % of the household income in the middle and lowland areas of the study villages. It serves diversified functions such as income generating, improving diets, providing draft power, utilizing land, which is not suited for cultivation, as an asset, and insurance during difficult times. Interaction between crop and livestock is increasing in the study area that often

benefit both, for example, crop production, enhanced through the availability of manure, draft animals for cultivation and transportation of harvest and agricultural inputs. On the other hand, livestock production benefit from crop residues that constitute an important fodder resource. Land shortages in the area favour the integration of crop and livestock production especially in the midlands.

Livestock was reported to be a reliable source of income, especially in middle land where the farming activities characterize by small size plots. The major livestock types being kept in the surveyed villages are cattle, sheep, goats, chicken and pigs. It was noted that the major population of livestock is the local breeds in low land, with significant populations of livestock, which are exotic breeds, while in the midland area improved cattle are dominant.

3.2 An overview of the impact of climate change

Climate change exacerbates existing vulnerabilities to land degradation (TerrAfrica, 2009), for instance, floods and drought challenge farmers and communities to make changes to production systems and protect natural resources. Worsening drought conditions and land degradation affect land use and subsistence agriculture and bring about a serious loss of biodiversity (Kousky *et al.*, 2011). Soil erosion exacerbated by unreliable rainfall; stronger winds and storm lead to loss of land, crops and local vegetation species. Such situation increase food shortage due to the difficulty of maintaining viable land productivity.

Climate change and variability contribute to land degradation by making current land use practices unsustainable and inducing more rapid conversion of land to unsustainable uses. Land degradation is mainly caused by conversion of forests, woodlands and rangelands to crop production and unsustainable agricultural practices on croplands. In all zone land degradation was reported to be among the factors influencing agricultural production and farming systems. Also, it was reported that land degradation is the cause of climate variability, especially in highland and lowland zones. Land degradation increases the vulnerability of rural people. Climate variability as exhibited by the

occurrence of more intense and drastic changes in rainfall patterns which, threatens agricultural productivity and sustainability of food production. It affects food production and water resources that are critical for livelihoods in farming activities in rural area where much of the population, especially the poor, rely on local supply systems that are sensitive to climate variation. Such effect also was revealed by Hassan and Nhemachena, (2008).

Changing in rainfall patterns and higher temperatures have forced farmers to shorten the growing season and switch to more expensive with high production and weather Open pollinated varieties (OPV) or hybrid crops. Frequency droughts and floods are eroding assets and knowledge, leaving people more vulnerable to extreme events. In all zones in the study area changes in aspects of climate such as minimum and maximum daily temperature, occurrence and distribution of rainfall, decrease in the number of wet and increase of dry spell days was revealed. These changes reported to have posed significant impacts on crop production. For example, rainfall fluctuation during the growing season has affected the growing season and cropping patterns/ calendar. For example the aged man in Kikota village (Midlands zone) said:

'Farming activities are becoming more difficult and unreliable as a result of the unpredictability of rainfall and increased soil degradation. In the past, we never had to apply fertilizer and rainfall was reliable to produce more crops, but now rains is affecting everything, We are learning to grow different crops varieties and apply manure/ fertilizer, but it's not enough and still we do not get as much from our crops as we used to.'

In addition, changes in climate affected the agro-ecological zones that resulted in a general shift in the agro-ecological zones and change in the cropping. Such changes will need farmers to adhere to improved agronomic practices and better crop management. For example less and erratic rainfall received in lowland and middle land areas, irrigation and drought resistant varieties is required to substitute for moisture losses due to increased evapotranspiration. The main farming constraints in the highland zone include heavy rainfall, fogs, ice and crop pest and diseases. Soil exhaustion also affects farming production in the area that has resulted in the use of inorganic fertilizer especially in round potato production. Likewise, in the middle zone the main farming constraints include land exhaustion, the high price of inputs, rainfall fluctuation, pest and diseases, unreliable market. In the lowland areas the farming system is affected by climate variability (mainly drought, unpredictable rainfall and an increase of temperature), water shortage for irrigation, pest and diseases, land exhaustion and high price of inputs.

It is becoming more challenging to plan agricultural activities due to climate variability and population increase. In the past farmers used to harvest more crops, land was available with high fertility; the climate was good with rainfall coming on time. The rainy season in the middle land area for example, was known to start in mid-October through May but now the rainfall pattern has become unpredictable and unreliable it can start in November or December. The remarkable changes in rainfall have been observed in the last two decades, which affects crop production, especially in lowland and middle land zone. Understanding the effects and impacts of climate variability on agriculture is critical in formulating

strategies and adaptation options to minimize adverse consequences.

Climate change exacerbates existing vulnerabilities to land degradation, for instance, floods and drought challenge farmers and communities to make changes to production systems and protect natural resources. The results indicated that more frequent and severe extreme climatic events, especially drought are the challenge of agricultural production and on ensuring food security in smallholder farmers (Gwambene 2011). The production and productivity of main crop significantly decreased, and the area suitable for agriculture, length of growing season, yield potential and yields from rain-fed agriculture have been decreased and the local food supplies negatively affected. In addition, small farm sizes, low technology, low capital/adaptive capacity and diverse non climate stress, increase vulnerability to the impacts of climate change and variability.

Climate change and variability also can offer new opportunities for sustainable land management, by increasing temperature and rainfall in some environments, through CO₂ fertilization effects. Development of sustainable land management measures provides major opportunities to mitigate climate change by sequestering carbon or reducing greenhouse gas emissions (TerrAfrica, 2009). Sustainable land management can reduce vulnerability to climate change and increase people's ability to adapt and in many cases can contribute to climate change mitigation through improved carbon sequestration and reduced greenhouse gas emissions.

3.3 Land tenure and management strategies

Land is the most important resource among farm households; fragmentation of land ownership is a challenge in improving production, ecological management, and development of adaptation and mitigation measures. A better access to land resources with good condition increase crop productivity as it forms the main part of the mode of production. In the study area access to land is limited as most of the farmers own or rent small size of land that are less than 2 acres. For example the average farm size in the lowlands was about 2 acres, while in the middle zone and the highlands had an average farm size of 1 and 3 acres, respectively. In the highland there is more land than in low and middle land since the population density was still low. The small size of land resulted in the substance farming with less incentive for commercial farming. The minimum size of land owned within the village is .0.5 acres in lowland, 0.25 acres in midlands and 0.5 acres in the highland, while the maximum size is 9 acres of low land with a range of 8.5, mean of 2.05 with a Std of 1.98. In the midlands the maximum total size of land owned is 6 acres with a range of 5.75 at a mean of 1.65 with Std of 1.59. In the highland zone maximum a size of total land owned is 10 acres with a range of 9.5 at a mean of 3.67 with Std 2.45. Such results indicate land fragmentation and high land pressure in the area. This affect crop diversification and implementation of adaptation measures, especially that involve utilization of the large size of land.

To complement this small size of land farmers own land outside the village or borrow the land. The size of land owned outside the village or borrowed also is small. It ranges from 1 -6 acres for owned and 0.25 – 3 acres for borrowing in lowland, 0.25-4.00 acres of owned and 0.50 -2.00 acres borrowed in middle land

while in highland it ranges from 1-4 acres for owned and 0.5 – 3 acres for borrowing land with a mean of 2.33 , 1.17 and Std of 1.52 and 0.98. The statistical test on land ownership and land use in the study area indicates the high fragmentation of land size used for agriculture as indicated by χ^2 test. The results from Pearson Chi-Square signify that the total size of owning land within the village has a value 65.816 with df 44 and Asymp. Sig. (2-sided) .018, total land borrowed has a value 17.355, with df of 14 and Asymp. Sig. (2-sided) .238, while the total size owned outside has a value 15.905 with df 14 and Asymp. Sig. (2-sided) .319. Such result verifies the null hypothesis assuming that land ownership and land use are not normal distributed. The frequency of the small size of land is higher than the large size forming leaner distribution as divergent to the normal distribution curve.

With regards to land acquisition, the land owned in the study area is usually acquired through inherited, redistributed by household heads for family land to other family members who need it, buying, and also are given as a gift for close relatives or friends. Land sales are uncommon in the area because of its shortage whereby most farmers own less than three acres. However, due to decrease in crop productivity in the area, land exhaustion, changes in weather pattern and low income some farmers sell their land. The results indicate that most of the respondents acquired land through inherited by 32% (n=18) in lowland, 58% (n=35) in middle lands and 87% (n=27) in the highland zones. Such results imply the high fragmentations of land as each family/ household has to distribute land among the family members. Land has become increasingly scarce in the area because of population pressure. In all study zones, farmers own small size of land.

Small holder farmers used to own many small size fields within and outside the village as the way to reduce the risk and also due to land shortage in the area. This study revealed that most of the farmers own land or rent outside the village because they have access to land either through inherited land from their relative or buying land because of fertility and conducive climate for crop production in the area and few buy land as an asset (this was especially for those employed in different sectors including business). Farmers own 1-3 plots in the lowlands, 1-3 in the middle zone, and 1-5 plots in the highlands. There is a difference between the number of plots in the lowlands and in the middle zone and highland zones. Across the three zones, farmers own many plots with large size in the highland zone as compared with fewer plots owned in middle land. This may be attributed with limited access to agricultural land in the middle land zone, which characterizes by growing a diverse types of crops including tea that either owned by tea estates, village or individual. Tea as a pure stand crop is not used for inter-cropping with any other crops, which reduces chances of using the land for other crop production. Although in the individual farms some farmers uprooted the tea for gaining the land for other crop production and or for settlement uses.

The results show that most of the respondents own one plot with few owning up to three plots in the lowland and middle land while in the highland zone respondents owned up to five plots. It was further revealed that farmers owned more than one plot as the way of diversification to avoid loss during the extreme events. It is common practice for farmers to have many plots in the area. However land shortage has affected the size of the land and land ownership that reduced crop diversification and affects land management strategies. To increase production in the midland zone farmers used to set aside a plot or plots for producing other crops. In their home steady most

farmers in this zone used to grow bananas and other crops are produced in adjacent areas. This type of land use helps farmers to have a range of crop type and varieties in a small size of land. However, most of the crops produced are mainly subsistence. It is difficult to involve in commercial production and management strategies that require a large area from a small size of land.

Agricultural production among smallholder farmers and landless people provides a livelihood for people, allowing them the opportunity to stay in their communities. In many areas of the world, productive land is not available for agricultural production, thus, people who want or need to farm and make a living have little incentive to improve the land (FAO, 2012). In the study area the landless people and those who own small land size than what they need to borrow land for agriculture. Land are borrowed either for free or rented in cash or kind. The amount paid for renting land range from Tsh 2,000/= to 170,000/= in the lowland zone, in the high land it ranges between Tsh 70,000/= to 100,000/=. The price for renting land depends on the location and productivity of the land. For example, in the lowland the price of renting land for rice production under irrigation was higher due to availability of water that increased security in production and enabled farmers to produce twice a year compared with land in another area. In highland also because of booming of round potatoes and the zone has enough moisture to support crop production, renting price has increased. However round potatoes need high capital for management, especially Agrochemicals since the area affected by low temperature, frost, fog and heavy rainfall that increase the use of agrochemical hence production cost.

There is a significantly higher average acreage owned than those borrowing/renting. Most of farmers borrow/ rent 0.25 to 3 acres in lowland and 0.25 to 6 acres in highland and Midlands areas. Number of

plots borrowed in highland are 1 to 3, while in the lowland and middle land zone borrow 1 plot. The borrowed land is used for producing food and cash crop. The main crops grown on borrowed/ rented land in low land include rice, maize, and groundnuts; in middle land include african eggplant, tomatoes, maize, beans, garden crops are grown in the borrowed land, while in the highland zone the borrowed land is used to produce round potatoes and maize. In terms of management, there is less incentive for land management, especially for long-term measures and those needs for high capital.

Land management has a greater greenhouse gas mitigation potential in agricultural lands. This can prevent land degradation, restore degraded lands, and reduce the need for further conversion of natural forests and grasslands. Land users can reduce GHG emissions, and maintain carbon stocks in soil and vegetation at relatively low cost, while also improving food production and securing diverse livelihoods as discussed also by TerrAfrica (2009). Sustainable land management practices contribute to restoring ecosystem functions and forms a basis for adaptation to and mitigation of climate change.

3.4 Land tenure and management challenges

Changing in land management practices has reduced the capacity of the soil to produce (Morris *et al.*, 2010). For Sub-Saharan Africa, land degradation, deforestation, and extractive farming practices are the practical upfront issues in addressing climate change (AU-NEPAD, 2010). Agriculture occupies a large proportion of the landscape and has an important role to play in both climate change mitigation and adaptation. It is a major source of greenhouse gases to the atmosphere in sub-Saharan Africa, it is contributing to climate change (Rosenzweig & Tubiello, 2007). It was revealed that clearing and management of land for food and livestock production

contributes to cumulative carbon emissions. Generally, agriculture and associated land use changes emit about a quarter of the carbon dioxide (through deforestation and soil organic carbon depletion, machine and fertilizer use), half of the methane (via livestock and rice cultivation), and three-fourths of the nitrous oxide (through fertilizer applications and manure management) annually released into the atmosphere by human activities (Rosenzweig & Tubiello, 2007; TerrAfrica, 2009).

Land ownership has an influence on land management for example rented land receive less management incentive, while the owned land can have a long term management measures. The average farm¹⁶ area in all study zones is very fragmented and the affected land due to land degradation is increasing, especially in the highland zone and the causes are complex. There are many aspects of land degradation; including soil erosion, soil compaction, reduced soil organic matter, declining soil fertility and soil biodiversity. Although land degradation is evident in a majority of farming systems, it is particularly notable in those such as the highland area where in the absence of policy incentives for good land management, high population density and land shortage places excessive pressure on land in middle lands and lowland zones. Climate change and variability affect agricultural systems substantially, this requiring farmers to adapt at the same time they are called on to reduce emissions at the farm level. Choosing effective adaptation and mitigation strategies will represent a key challenge for farmers. Optimization strategies are those that, via careful management of land, maintain or

¹⁶Farm area, defined as the area that the farmers are currently cultivating and forest land (forest in this paper is defined as the area where pine, eucalyptus or other tree species is planted)

increase the resilience and stability of production systems, while also sequestering soil carbon and/or reducing fluxes from farm activities (Rosenzweig & Tubiello, 2007). Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions (IFRC, 2009).

Farming systems characteristics and classification take into consideration of both average farm size and the quality of available natural resources. Both existing livelihood levels and the potential for future improvement depend upon the technological development and the quality and availability of natural resources. The resource base of a farming system is best conceptualized as the average resource endowment of typical farm households, measured according to their productive potential when using existing technologies. Such factors differentiate the farming systems in low potential areas and those in the high potential areas.

Farming systems in the high potential areas depend on diversification and off-farm income. Intensification makes a substantial contribution, but it's constrained by land fragmentation in most cases. The high potential systems offer the most important anticipation for expanded food production in future. While in the low potential areas, farming systems characterized by low or erratic rainfall and poor soil fertility that tend to have relatively few agricultural development opportunities, and farmers may be more concerned with minimizing risk than maximizing food production and income or profit (Gwambene, 2011). Low potential areas tend to face higher risks, particularly in the distribution and amount of water available for farming needs. In this area the range of options open livelihood improvement from off-farm also is more

restricted than in high potential areas. In this area most of adaptation strategies depend upon seasonal or permanent migration to seek employment as labourers in wealthier group, or to urban areas.

Pressure to cultivate marginal land, or adopt unsustainable cultivation practices as yields, reduce, may increase land degradation and endanger the biodiversity of both wild and domestic species, possibly jeopardizing future ability to respond to increasing climate risk. In particular, several autonomous response strategies may place extra stress on water and other environmental resources as warming increases. Planned adaptation, including changes in policies, institutions and dedicated infrastructure, will therefore be needed to facilitate and maximize the long-term benefits of adaptation responses to climate change (Tubiello & Van der Velde, 2014). The adaptation activities, leading to the increased resilience of systems and improved rural incomes include forestry management and agroforestry techniques.

Agriculture as a sector offers several opportunities to mitigate the portion of global greenhouse gas emissions that are directly dependent upon land use, land-use change, and land-management techniques. Adaptation strategies will vary with agricultural systems, location, and scenarios of climate change considered (Rosenzweig & Tubiello, 2007). To reduce the potential negative effects of climate change, key synergies need to be identified, as mitigation practices may compete with modifications to local agricultural practices aimed at maintaining production and income. Under future climate and socio-economic pressures, land managers and farmers will be faced with challenges in regard to selecting those mitigation and adaptation strategies that together meet food security and improve livelihood.

3.5 Adaptation and mitigation challenges allied land tenure and management

Climate change and variability are one of the greatest challenges to land management and agricultural production. The situation has been aggravated by limited mitigation and adaptation measures thus threatening agricultural production and land management. There is the need to develop technologies and innovations that are geared towards increased food production and at the same time reducing impacts of climate change. These include development of fast growing crops, drought tolerant crops, early maturing crops. Other areas of focus include; irrigation, conservation agriculture and sustainable land management practices (NEMA, 2013).

Land management has a greater greenhouse gas mitigation potential in agricultural lands. This can prevent land degradation, restore degraded lands, and reduce the need for further conversion of natural forests and grasslands. Land users can reduce GHG emissions, and maintain carbon stocks in soil and vegetation at relatively low cost, while also improving food production and securing diverse livelihoods (TerrAfrica, 2009; AU-NEPAD, 2010). Sustainable land management practices contribute to restoring ecosystem functions and forms a basis for adaptation to and mitigation of climate change. The mitigation measure includes, but not limited to agronomic practices, nutrient management, tillage and residue management, water management, agroforestry, pasture management, restoration of organic soils, restoration of degraded land and manure application. Climate change undermined efforts in the sustainable management of agricultural land. The results indicated that climate change affects sustainable land management efforts through altering soil function, watershed hydrology, vegetation patterns and also stimulates changes in land use practices. Adaptation and mitigation strategies form the basis for elucidation risk. Proper Land

management strategies reduce climate change challenges and increasing food security and environmental resilience. Sustainable land management is crucial to minimize land degradation, rehabilitating degraded land and ensuring the optimal use of land resources for the benefit of the present and future generations. Among the important adaptation and mitigation strategies as described in TerrAfrica (2009) includes: Improved crop/plant/livestock management

Crop rotations can reduce competition from weeds and pest impacts and possibly reduce mining of specific nutrients Agroforestry systems mixed with crops / pasture increases water infiltration, slow soil drying and can provide nutrients through the leaves. Use of more resource efficient crops, livestock and trees increases water use or nutrient use efficiency under current or future climate shifts, Reduces need for nutrients and possible N₂O emission reductions Fire protection of vegetation Preservation of vegetation and important species Prevention of GHG emissions

Improved soil management

Cover cropping Helps to reduce soil erosion, reduce weed growth, and contributes to soil carbon build up Use of mulch and compost Reduces soil erosion and helps to maintain/improve soil moisture, nutrients, and organic matter and Soil carbon improvement Manuring Enhances soil organic matter Soil carbon improvement Crop residue incorporation; Adds nutrient and soil organic matter into soils Soil carbon improvement Intercropping with legumes; Helps to improve infiltration, soil carbon, and soil nutrients (through nitrogen fixation) and Enhances soil carbon but possible NO₂ emission increases Soil improving agroforestry; helps to reduce weed growth, improve infiltration, soil carbon, and soil nutrients (through nitrogen fixation). Some soil carbon impacts, but also provide woody biomass; possible N₂O emission increases with legumes Vegetative strips Prevents soil

erosion Terracing/bunding Prevents soil erosion Minimum tillage Increases soil moisture and builds soil carbon, Soil carbon improvement Windbreaks and shelterbelts; Reduces erosion due to high winds and rains, Improved above ground carbon storage with trees

Improved water management

Rainwater harvesting Storage of water from rooftop or ground into tanks/ponds – offset prolonged droughts on high value enterprises Earth catchments In-situ entrapment of rainwater, minimizes loss of valuable rainwater and erosive runoff localized improvement of soil structure through activity of soil organisms Soil carbon improvement Tied ridges; In-situ entrapment of rainwater minimizes loss of valuable rainwater and erosive runoff localized improvement of soil structure through the activity of soil organisms Soil carbon improvement Contour ridging / planting Evenly distributes water on sloping areas and enables infiltration Reduces runoff Soil carbon improvement in selected niches Formal irrigation systems Offsets effects of drought periods Also can prevent the fields from accumulating excess water Watershed management Effective management of rainwater, surface, and ground waters need to be implemented at scales above the household Landscape level improvement in soil carbon and possibly in woody vegetation

Sustainable land management measures are among the important approaches that households can use to adapt to climate change and vulnerability. Land management measures help to mitigate GHG emissions and climate change by sequestering carbon in the soil and vegetation, or by reducing emissions of carbon dioxide, nitrous oxide or methane caused by poor land management practices (Rosenzweig & Tubiello, 2007; Smith, 2009 & TerrAfrica, 2009). It is evidence that cropland expansion is a source of GHG emissions, and strongly argued that raising global average productivity leads to

smaller rates of cropland conversion. In all study area climate change was the most important contributor to degradation, followed by poor agricultural practices and overexploitation and Unsustainable agricultural practices (e.g., farming on steep slopes without sufficient use of soil and water conservation measures, excessive tillage, continuous land cultivation without application of soil nutrients).

Farm-level adaptation involves more than adopting new agricultural technologies such as improved water storage facilities, additional irrigation, and new crop varieties. It also needs to take into consideration knowledge, the capacity of the farmers to adapt the strategies and marketing facility and improvement of infrastructure bases. Building on the knowledge acquired over the past seasons will also help in reducing risk by tucking spatial temporal changes. It is recognized that agriculture and forestry offer significant cost-effective mitigation options, since many management techniques, are required to strengthen production systems, sequester carbon either above or below ground and reduce direct greenhouse gas emissions.

Adaptation in agriculture and forestry should be concurrent with mitigation: reducing greenhouse gas emissions and increasing carbon sequestration through sustainable agricultural and forestry practices including conservation of soil and ecosystems. Agriculture, and associated deforestation activities, is responsible for one-third of total anthropogenic greenhouse gas emissions (Tubiello & Van der Velde, 2014). Adaptation strategies in agriculture involve reduction of non-CO₂ gases through improved crop and livestock management and agroforestry practices, enhanced soil carbon sequestration in agricultural soils through reduced tillage and land restoration, and production of bio-energy from biomass. Conservation practices, no-till farming, implementation of cover crops and

agroforestry are likely to both improve adaptive capacity through increasing the resilience of the agricultural system, as well as increasing carbon storage in agricultural soil. It was further suggested that increasing the organic matter and soil carbon content of degraded cropland would also increase crop yields (Tubiello & Van der Velde, 2014).

In general, land degradation is both a source and a result of climate change as well as a constraint to adapting production to climate variability. Sustainable land management strategies help to combat the effects of adaptation and mitigation, climate change in the southern highland area. Sustainable land management through changes in land cover and tillage management could promote both mitigation and adaptation. A mix of horticulture crops with optimal crop rotations would promote carbon sequestration and productivity (Smith, 2009; Tubiello & Van der Velde, 2014). Land management best practices, tillage and residue management, improve agro-ecosystem function and enhanced community well-being. It suggested that improving land resource resilience and productivity within the context of the devastating effects of climate change require maintains of long term productivity and ecosystem functions at the same time increase productivity (quality, quantity and diversity) of goods and services (TerrAfrica, 2009).

4.0 Conclusions

Agricultural land plays an important role in mitigation and adaptation strategies for reducing climate change and variability. Management of natural resources and agricultural land, are likely to offer the best long term adaptation and mitigation measures and increase food security and ecological management. This can be implemented together with regulation and compliance with good farming and land management practices is imperative for reduce climate change and variability risk in farming community.

The relative economic and environmental advantage of sustainable land management as a mechanism to reduce climate change and variability impact depends on local site-specific conditions. In some situation land management strategies can make a significant contribution in adaptation and mitigation measures and contribute to improvement, household income and sustain food security and the environment. Land fragmentations, use of poor technology and inadequate information to inform best adaptation measures and opportunities to increase production affect the crop production and pose a challenge in reducing climate change and variability impacts in the small holder farming. Size of land is among the main constraints in crop diversification and practicing adaptation and mitigation measures that require large area, especially in places where farmers own small size of land. Larger farm sizes were found to encourage the use of multiple cropping and integration of a livestock component, especially under drought conditions. Large farm sizes allow farmers to diversify their crop and livestock options and help spread the risks of loss associated with changes in climate.

The implementation of the policy, plan, strategies and by-law is still a challenge to smallholder farming, especially at a local level. The government and local authority have a well planned and explanatory guidance, policy, strategies and bylaws on land management and adaptation to climate change. However the problem is on the awareness of such documents to the target group expected to implement them and in most cases lack enforcements. This will need a well developed and planed sensitization and awareness creation of the target group as well as improvement of enforcement mechanism. Maintaining and improving the capacity of the higher potential agricultural lands to support an expanding population and rehabilitating the resources on lower potential lands is an important option in

reducing climate change and variability impacts. Intensification of agriculture production by diversifying the production systems for maximizing efficiency in the utilization of local resources, while minimizing environmental and economic risks are important in sustaining future demands. Where intensification of farming systems is not possible, other on-farm and off-farm employment opportunities should be identified and developed to reduce vulnerability and avoid further expansion onto marginal lands and encroachment on fragile ecosystems.

References

- Anley, Y, Bogale, A & Haile-Gabriel, A. (2007) *Adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers in Dedo district, Western Ethiopia*. Land Degradation and Development 18, 289–302.
- Antle, J.M. (2009) *Agriculture and the Food System: Adaptation to Climate Change*. An Initiative of the Climate Policy Program at RFF report available from http://www.rff.org/rff/documents/rff-rpt_adaptation-antle.pdf Accessed on June 23, 2011
- AU-NEPAD. 2010. The AU-NEPAD Agriculture-Climate change Adaptation-Mitigation Framework. <http://tinyurl.com/nl4cqoe>
- Bisanda S & Mwangi W. (1996) *Adoption of recommended maize in of the southern highlands of Tanzania*. Addis Ababa: CIMMYT/the United of Tanzania, Ministry of Agriculture.
- Chifamba E. & Mashavira N. 2011. Adaption and mitigation strategies in sustainable land resource management to combat the effects of climate change in chipinge, zimbabwe. *Journal of Sustainable Development in Africa* .Volume 13, No.2. <http://tinyurl.com/njoqxs4> Accessed on March 21, 2014
- Environmental Protection Agency (EPA). 2011. How should hazard mitigation and other community planning programs respond to climate change? Iowa Climate Change Adaptation & Resilience Report. Retrieved from http://www.epa.gov/dced/pdf/iowa_climate_adaptation_report.pdf Accessed on March 20, 2014
- FAO (2009). Food security and agriculture mitigation in developing countries: Options for Capturing Synergies. Available from <ftp://ftp.fao.org/docrep/fao/012/ak596e/ak596e00.pdf> Accessed on June 23, 2012
- Gwambene B. (2011). Climate Change and Variability Adaptation Strategies: Implication of adaptation strategies on land resources in Rungwe District. Tanzania LAP LAMBERT, Saarbrucken Deutschland.
- Hassan R & Nhemachena C. (2008). *Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis*, AfJARE Vol 2 No 1 p 83-104
- International Federation of Red Cross and Red Crescent Societies (IFRC). 2009. Climate Change Adaptation Strategies for Local Impact Key Messages for UNFCCC Negotiators. Technical Paper for the IASC Task Force on Climate Change. <http://tinyurl.com/pwpxnb8>
- Kangalawe R. (2012). Food security and health in the southern highlands of Tanzania: A multidisciplinary approach to evaluate the impact of climate change and other stress factors. *African Journal of Environmental Science and Technology* Vol. 6(1), pp. 50-66.
- Kousky C., Olmstead S., Walls M., Stern A, & Macauley M. 2011. The role of land use in adaptation to increased precipitation and flooding: a case study in wisconsin's lower fox river basin. Resources for the Future, Washington, DC.

- [http://www.rff.org/RFF/Documents/RFF-Kousky%20etal%20GreatLakes%20\(2\).pdf](http://www.rff.org/RFF/Documents/RFF-Kousky%20etal%20GreatLakes%20(2).pdf) Accessed on March 20, 2014
- Morris J. Hess T. & Posthumus H. 2010. Agriculture's role in flood adaptation and mitigation: policy issues and approaches. <http://www.fanrpan.org/documents/d00871>
- Morton J. F. (2007). The impact of climate change on smallholder and subsistence agriculture <http://www.pnas.org/content/104/50/19680.full> Accessed on May 24, 2013
- National Environment Management Authority (NEMA) 2013. Effect Of Climate Change in Kenya Kenya: Adaptation and Mitigation Measures. <http://tinyurl.com/q7uhsgw>
- National Environment Management Authority (NEMA) 2013. Effect Of Climate Change in Kenya Kenya: Adaptation and Mitigation Measures. <http://tinyurl.com/q7uhsgw>
- Ngigi, S.N. 2009. Climate Change Adaptation Strategies: Water Resources Management Options for Smallholder Farming Systems in Sub-Saharan Africa. The MDG Centre for East and Southern Africa, The Earth Institute at Columbia University, New York. 189p. <http://tinyurl.com/cqwnbpb> Accessed on March 20, 2014
- Rosenzweig, C. & Tubiello, F. N. 2007. Adaptation and mitigation strategies in agriculture: an analysis of potential synergies. NASA Publications. Paper 25. <http://digitalcommons.unl.edu/nasapub/25>
- Smith P. 2009. Agriculture and Climate Change: An Agenda for Negotiation in Copenhagen. Synergies Among Mitigation, Adaptation, and Sustainable Development For Food, Agriculture, and the Environment. http://www.ifpri.org/sites/default/files/publications/focus16_09.pdf
- Tauli-Corpuz V. & Lynge A. 2008. Impact of climate change mitigation measures on indigenous peoples and on their territories and lands; Climate Change, bio-cultural diversity and livelihoods: the stewardship role of indigenous peoples and new challenges. Permanent Forum on Indigenous Issues, Seventh session. New York. <http://tinyurl.com/nl4cqoe> Accessed on March 20, 2014.
- TerrAfrica. 2009. Using sustainable land management practices to adapt to and mitigate climate change in sub-saharan africa. Resource guide version 1. <http://tinyurl.com/op4dyeb> Accessed on March 21, 2014
- Tubiello F. N. and van der Velde M. 2014. Land and water use options for climate change adaptation and mitigation in agriculture. SOLAW Background Thematic Report -TR04A. GET-Carbon, New York, USA . <http://tinyurl.com/qe6bcym>
- United Nations Convention to Combat Desertification (U N C C D). 2009. Land a tool for climate change adaptation. Policy brief based on the outcomes of LAND DAY, 6 June 2009, Bonn, Germany. <http://tinyurl.com/q9vnvaq>