INTERACTION BETWEEN INDIGENOUS AND EXTERNAL KNOWLEDGE IN INFLUENCING ADAPTATION TO CLIMATE CHANGE IMPACTS AMONG COMMUNITIES OF NORTH PARE MOUNTAINS, TANZANIA

BY

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ABSTRACT

This study aimed at assessing the interaction between indigenous and external knowledge in influencing adaptation to climate change among communities in North Pare Mountains. Specifically, the objectives of the study were to: (i) assess the local knowledge on climate change, indigenous and externally influenced practices for adapting to climate change (ii) assess the effects of interaction between indigenous and external knowledge systems for adapting to climate change; and (iii) determine socio-economic factors influencing adoption of external practices for adapting to climate change. Information was obtained by using structured household questionnaire administered to 103 sampled households, PRA (focus group discussion and key informant interviews) and participant observations. Qualitative information was analyzed using content analysis which is a set of methods for analyzing symbolic content of any communication. Quantitative data were processed and analysed using Statistical Package for Social Sciences (SPSS) while logistic regression analysis was used to establish the relationship between the extent of adoption of external practices and socio-economic/demographic factors. Results show that 52.2% of respondents see drought as an indicator of climate change. Other indicators mentioned were seasonal variation in rainfall, increasing air temperature and floods. Communities use externally influenced practices such as planting exotic tree species and crops, and modern water storage systems. Majority of the community use externally influenced practices and a combination of indigenous and externally influenced practices. Age, education level and income significantly influenced adoption of externally introduced practices. It is concluded that local adaptation to climate change will continue being influenced by both indigenous and externally driven knowledge. Harnessing the potential of indigenous knowledge and its interaction with external (professional) knowledge is paramount in building a climate resilient community in the north Pare Mountains. Therefore measures to enhance the indigenous adaptive capacity and its interactions with external knowledge are necessary.

Further education on climate change and its impacts is necessary so as to increase the communities' resilience to climate change impacts.

DECLARATION

I, SCOLA KEVIN PONERA do hereby declare to the Senate of the Sokoine University of Agriculture that this dissertation presented here is my own original work done within the period of registration, and that it has neither been submitted for a degree award nor concurrently submitted for a degree award at any other institution.

.... 21/11/2013

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(MSc MNRSA candidate)

The above declaration is confirmed by

.... 21 - 11 - 2013

Prof. P K T Munishi Date

(Supervisor)

.... 21/11/2013

Dr. L.P. Lusambo Date

(Supervisor)

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DEDICATION

This dissertation is dedicated to my father Mr Kevin A. Ponera, my mother Ms Anusiatha Y. Moyo and my late brother Mr. Samuel Ponera, who contributed substantially towards my education.

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LIST OF ABBREVIATIONS

CC & V	Climate change and Vulnerability
FAO	Food and Agriculture Organization
FIVIMS	Food Insecurity and Vulnerability Information Mapping System
GDP	Gross Domestic Product
HIV	Human Immune Virus
INCR	Initial National Communication Report
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LRM	Logistic Regression Model
MNRT	Ministry of Natural Resources and Tourism
NAPA	National Adaptation Programme of Action
URT	United Republic of Tanzania
UNFCCC	United Nations Convention Framework on Climate Change
V.A.R	Vulnerability Assessment Report

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Climate change is now a global issue posing challenges to the very survival of mankind and sustainable development. The adverse impacts of climate change include reduced crop yields due to droughts and floods, and reduced water availability. Shifting of seasonal rainfall, one of the predicted outcomes of climate change, include too much rain when and where it is not required, which may damage crops. In addition, dramatically rising temperatures are responsible for increased evapo-transpiration in the soil and may keep crops from maturing due to lack of enough moisture in the soil, and thus result in a shortage of food (Boko, 2007).

The reality of climate change and its effects is becoming even apparent as exemplified by more frequent and severe droughts, hurricanes, floods and storms. These changes are increasingly threatening the livelihoods of especially people in the developing world including Tanzania (Kajembe *et al.,* 2010).

Indigenous knowledge is defined as localized knowledge unique to particular ethnic groups or societies. It is believed to be consistent and coherent set of cognitions and techniques that have slowly evolved through trial and error of generations of farmers who had to live by the results (Titilola (1991); Richard (1989) and Warrren (1989) in Kajembe *et al.* (2010)). Other terms which are used synonymously with indigenous knowledge are local knowledge, rural peoples' knowledge, ethno science, and farmer's knowledge.

Some of indigenous knowledge includes some traditional way of collecting and storing rain water in big barrels placed under the roofs of houses and planting traditional drought resistant crops.

Although it may have other definitions, “External knowledge” in this study will be used to mean the scientific knowledge, professional knowledge, expert knowledge, and all other knowledge which are not locally originated. Some of the external knowledge practiced in the area are planting of exotic tree species and the introduced water storage systems example wells and bore holes.

According to FAO (2000), adapting to climate change involves reducing exposure and sensitivity. This may be done by modifying a traditional approach that is practicing indigenous practices or by taking a new approach which is the external knowledge. Thus is to say the two knowledge systems have an influence to one another in adapting to climate change. But these interactions remains poorly understood and are the focus of this research. The word interaction will be used to mean a kind of action that occurs as two or more objects have an effect upon one another. The idea of a two-way effect is essential in the concept of interaction, as opposed to a one-way causal effect.

1.2 Objectives of the Study

1.2.1 Main objective

The main objective of this study was to assess the interaction between indigenous and external knowledge in influencing adaptation to climate change among communities in North Pare Mountains.

1.2.2 Specific objectives

The specific objectives of the study were to:

(i) assess the local knowledge on climate change, indigenous and externally influenced practices for adapting to climate change in the study area.

(ii) assess the effects of interaction between indigenous and external knowledge systems for adapting to climate change in the study area.

(iii) determine socio-economic factors influencing adoption of external practices for adapting to climate change in the study area.

1.3 Research Questions

The following were the research questions;

(i) What is the communities' local knowledge on climate change in the study area?

(ii) What are indigenous and externally influenced practices for adapting to climate change in the study area?

(iii) What are the effects of interactions between indigenous and external knowledge systems for adapting to climate change in the study area?

(iv) What are the socio-economic factors influencing adoption of external practices in the study area?

1.4 Conceptual Framework

Conceptual framework acts as a basis for discussing the relationships between different groups, individuals or issues and can always be progressively revisited as further information becomes available (Linda (1999) in Lusambo, 2009). Climate change impacts such as droughts, floods, and seasonal rainfall cause the local communities to create some strategies for adapting to them. They can use indigenous knowledge systems or/and external knowledge systems which have an influence on one another.

The adoption of either indigenous or/and external knowledge systems depends on the socio-economic factors, climatic factors, location and topography. The adoption of adaptation strategies for climate change impacts also has an influence on the livelihood of the local communities as it shown in Fig. 1.

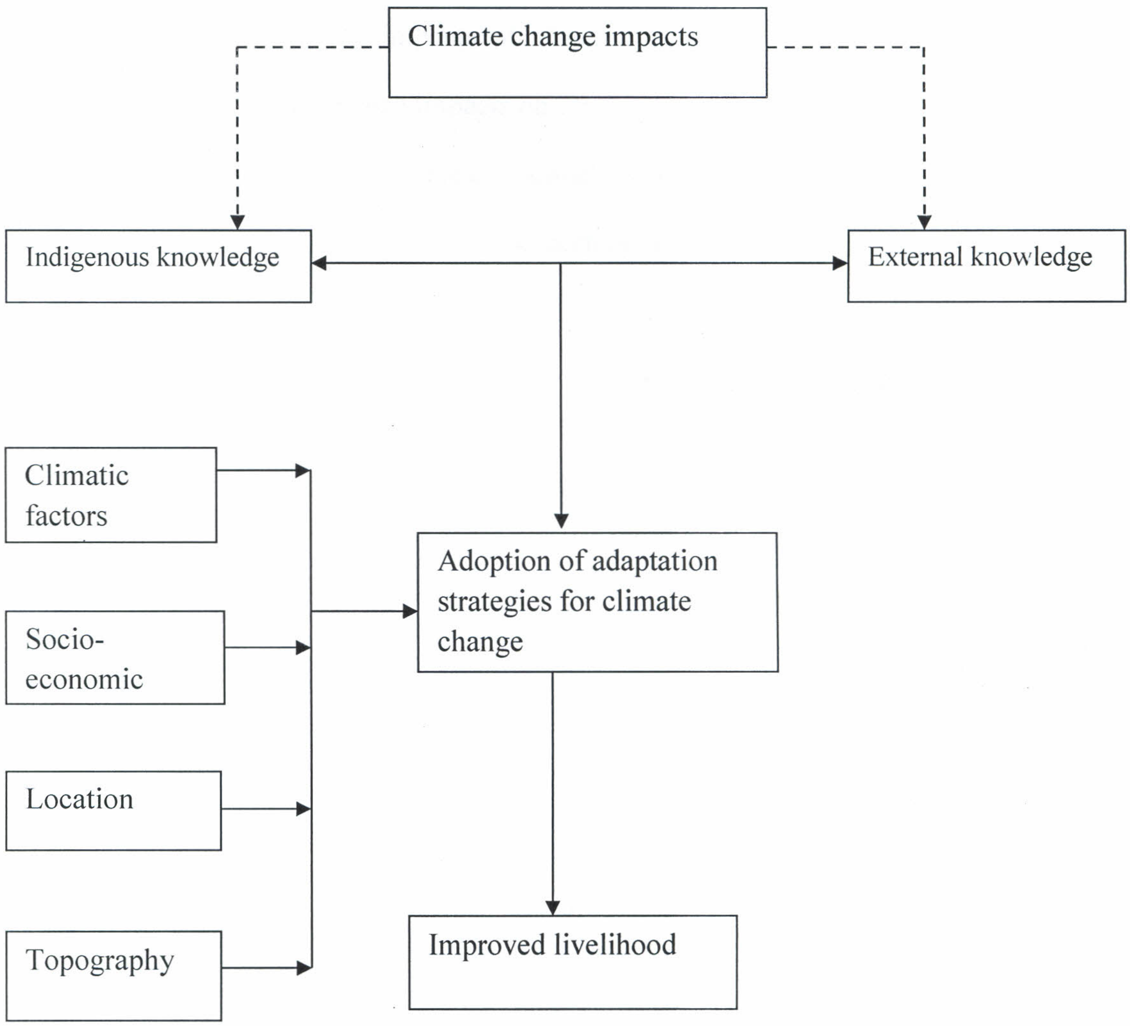

Figure 1: Conceptual Framework

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Climate Change Impacts

According to URT (2006), agriculture has been identified to be the second most vulnerable sector to the impacts of climate change. A study on vulnerability and adaptation to climate change impacts on other sectors in Tanzania clearly indicated that forestry, water, coastal resources, livestock and human health are also likely to be vulnerable to climate change. These sectors are closely linked to agriculture and therefore effects of climate change and vulnerability on such sectors will further negatively affect both crops and livestock production systems. The impacts of climate variability are manifested by floods, droughts, erratic rains and extreme events. URT (2005) revealed that famine resulting from either floods or drought has become increasingly common since the mid-1990s and is undermining food security. According to IPCC (2005), Africa is the most vulnerable region to climate change, due to the extreme poverty of many Africans, frequent natural disasters such as droughts and floods, while agricultural systems heavily depend on rainfall. Agriculture and natural resources provide the livelihood for 70% to 80% of the population, and account for 30% of GDP and 40% of export revenue in Sub-Saharan Africa (Toulmin and Huq, 2006).

Droughts have mainly affected the Sahel, the Horn of Africa and Southern Africa particularly since the end of the 1960s. One third of the people in Africa live in drought prone areas. At the opposite side of the spectrum, floods are recurrent in some countries (William 2004). Besides the physical environment, much of the continent is grappling with other crises arising from overdependence on natural resources, structural adjustment policies, trade liberalization, globalization, conflicts, poor governance, malnutrition, poverty and a high disease burden, particularly malaria and HIV/AIDS (William, 2004).

According to Boko *et al.* (2007), the effects of climate change and climate variability will continue to challenge vulnerable people. Droughts and dry spells will be more frequent, rain more inconsistent, and torrential downpours heavier, all phenomena that increase the risk of soil erosion and vegetation damage through runoff. Higher temperatures will increase the evaporation of soil moisture. Climate change will aggravate water stress, which the continent has already experienced, putting more people at risk of water stress.

According to Nkomo *et al.* (2006), the most viable option that is open to Africa to manage the impacts of climate change is through adaptation. However, the continent's low adaptive capacity serves as a major constraint to her ability to adapt. This limited adaptive capacity results from the region's poor financial resources, low technical and technological capabilities, weak institutions and limited awareness of the devastating impacts of climate change. However, despite this limited adaptive capacity, several adaptation strategies are currently being practised to cope with present climate variability in the region. For instances, within the agricultural sector, these strategies range from the development and deployment of early warning systems, better agricultural management systems, improved crop cultivars, better and more efficient irrigation systems and good grain storage systems. Strategies used in other sectors include the construction of sea retaining walls to stop coastal erosion and storm surges, the use of insecticide-treated nets to reduce the incidences of malaria, etc. Efforts should be made by the more developed countries who contribute the bulk of the greenhouse gas responsible for the global warming to cut down on their emissions to acceptable limits as well as provide funds and technical capability to enable Africa adapt to climate change.

2.2 Climate Change and Vulnerability

Climate change and vulnerability are likely to intensify drought and increase potential vulnerability of the communities to future climate change especially in the semi-arid regions (Rosenzweig *et al*., 2002), where crop production and livestock keeping are critically important to food security and rural livelihoods. A number of studies conducted recently in Tanzania have recognized that climate change and vulnerability are happening and are coupled with significant impact on various natural resources including agriculture which is the main source of livelihood in rural areas (Majule *et al*., 2008). Various climate-related impacts such as floods and droughts regularly have substantial effects on economic performance and livelihood of communities in rural areas that depend on rain-fed agriculture.

A study by Ngana (1993) on drought and famine in Dodoma District indicated that the presence of dry spells in critical periods for most crops contributed considerably to crop failure and famine. Given the over-dependence on rain-fed agriculture by the majority of people living in rural areas, climate change and vulnerability have been some of the major limiting factors in agricultural production thus resulting in food insecurity and low-income generation. For example, droughts and floods have been reported to cause failure and damage to crop and livestock leading to chronic food shortages in Manyoni district, Tanzania (Liwenga *et al*., 2007).

Studies conducted by Rosenzweig *et al*. (2002) revealed that changes in rainfall patterns and amounts have led to loss of crops and reduced livestock production.

Increasing impacts of Climate change and Vulnerability in particular drought and floods on agriculture have been associated with various adaptation and coping mechanisms (Gwambene, 2007). These are based mainly on traditional knowledge also referred to as indigenous knowledge which embodies a wide variety of skills developed outside the formal education system (UNFCCC, 2003). Such adaptation and coping mechanisms include increased exploitation of non wood forest products and increased wetland cultivation (Majule *et al.,* 2008), indicating clearly how rural people adapt to climate change. Indigenous knowledge arises out of continuous experimentation, innovation and adaptation and blending many knowledge systems to solve local problems (UNFCCC, 2003). Climate change is a global phenomenon while adaptation is largely site-specific. A common disadvantage for local coping strategies is that they are often not documented, but rather handed down through oral history and local expertise. As site-specific issues require site-specific knowledge, experience has shown that identified adaptation measures do not necessarily translate into changes because there are context-specific social, financial, cultural, psychological and physiological barriers to adaptation (IPCC, 2007). It is very important to clearly understand what is happening at community level, because farmers are the most climate-vulnerable group.

2.3 Indigenous Knowledge and Adaptation to Climate Hazards

Indigenous people hold unique cultural, experiential and ecological knowledge of their landscapes. They have passed down information about changing landscapes through hundreds of generations. Indigenous knowledge about the relationship between human communities and the environment can offer valuable insight into how to address the causes and the consequences of climate change. With increased recognition and use of Indigenous ecological knowledge, the literature on the subject has grown steadily over the last few decades (Bonny and Berkes, 2008).

Traditional adaptation measures is very crucial when dealing with climate change impacts, these may include planting drought resistant crops, constructing water wells for irrigation, building elevated enclosures for livestock, increasing the household's food stock and increasing feedstock for animals. Eighty one percent of households interviewed suffered from water shortages for agricultural uses, while 54% suffered from water shortages for personal uses (URT, 2006).

Although villagers have traditionally coped with drought in a variety of ways, there appear to be serious limits to the extent to which people may adapt. For stance, 24% of villagers interviewed simply organise religious ceremonies in the hope that these will bring rain, about 16% of the surveyed respondents' plant crops as usual, again hoping that there will be enough rain for agriculture. Some 17% of households reduce water consumption by limiting bathing to a few times a week; or just wiping oneself with a wet cloth instead of taking a full bath (URT, 2006).

Indigenous knowledge to climate change and to climate extremes should not be equated to preparedness and adaptation. People may be used to yearly losses of lives, damages to property and agricultural fields, but a habit of acceptance does not imply successful adaptation. For large proportions of the population, coping mechanisms simply consist of praying for rain or planting as usual (URT, 2006).

2.4 General Perspective of Indigenous Knowledge and Adaptation

Kajembe (1997) in Katani (1999) discussed three perspectives of local knowledge. The first perspective is Instrumental perspective which is mainly based on ecological or technical point of view, in which the use of indigenous knowledge can be seen as contributing to a better assessment, management and conservation of natural resources and forming a basis for new (ecological) scientific knowledge. The second perspective is Interpretative or "Farmer first" perspective. This perspective calls for reversal in the relation between farmers and external experts. It is argued that it is the farmers who should formulate research agenda and experiment and innovate, based on their own locally specific situation and external experts should act as facilitators. The third perspective is the Actor-orientated or Beyond "Farmer first" perspective, which moves beyond the "Farmer first" perspective, not only by rejecting its basic goals, namely; active participation of all actors, empowerment of the local people and poverty relief, but by deepening the concepts of knowledge and power in the analysis of natural resource management and by adopting a more actor-oriented approach. The actor oriented approach, allows for the recognition of institutional incorporation or bureaucratization as a basic trend in contemporary rural development history.

According to Katani (1999), indigenous knowledge is being used by local people to develop coping strategies against deforestation impacts is influenced by socio-economic factors. Coping strategies include retention of trees in farms, eating raw foods, pre-soaking of certain foods like beans to reduce cooking time and use of animals dung and crop residues as source of energy.

Indigenous knowledge has over the years played significant roles in solving problems, including adapting to climate change. It has played a significant role in Africa's adaptation efforts, in the face of low technology but still the knowledge is usually neglected in academic, policy and public discourses on climate change and adaptation (Gyampoh *et al.*, 2008). Farmers and other natural resource dependent communities in Ghana have been coping quite well with changes in climate through indigenous knowledge and practices although the country has no climate change adaptation policy.

In Tanzania, local farmers have developed several adaptation measures such as planting drought resistant crops, switch from upland cultivation to valley bottoms, crop diversification in valley bottom cultivation and construction of shallow wells that have enabled them to reduce their vulnerability to climate variability and extremes (NAPA, 2007).

One important step in reducing the vulnerability of a climatic hazard is the development of an early warning system for the prediction or forecast of the event (Ajibade, 2003). There is a wealth of local knowledge based on predicting weather and climate. A study of weather knowledge in various parts of Tanzania reveals the wealth of knowledge that farmers possess. These farmers have developed complicated systems of gathering, prediction, interpretation and decision-making in relation to weather. To a large extent, these systems of climate forecasts have been very helpful to the farmers in managing vulnerability. Farmers are known to make decisions on cropping patterns based on local predictions of climate, and decisions on planting dates based on complex cultural models of weather (Ajibade, 2003).

2.5 External Knowledge and Adaptation Practices

Till *et al.,* (2010) classified adaptation practices based on external knowledge into five categories (which are not mutually exclusive) namely: farm management and technology, farm financial management, diversification on and beyond the farm, government interventions in rural infrastructure, the rural health care services, risk reduction for the rural population, knowledge management, networks, and governance . Changes in farm management include a wide range of adjustments in land use and livelihood strategies that go beyond the usual agricultural practices available for coping with constantly varying biophysical and socioeconomic conditions. According to Till *et al.* (2010), farmers may reassess the crops and varieties they grow, and they may consider shifting from farming to raising livestock which may serve as a marketable insurance in times of hardship. They may also introduce different livestock breeds that are more resistant to drought. Changes in technology include for example, the development of new crop varieties or improved climate information systems.

In a case study covering villages in three South African provinces, Thomas *et al.* (2007) found that during dry spells farmers tended to reduce their investment in crops or even stop planting and focus instead on livestock management. Since climate change scenarios predict an increase in climate variability in many parts of Africa, farmers probably will turn to this temporary coping strategy more frequently and thus turn it into adaptation. Another finding based on the study by Thomas *et al.* (2007) is that farmers are increasingly trying to exploit the spatial diversity of their landscape. The villagers studied by Thomas and colleagues tried to gain access to land that gives good yields during times of drought because there is a water source for irrigation reachable at plot level (Thomas *et al.,* 2007). In Tanzania, farmers use cover crops to enhance seedling survival. On the other hand, controlling erosion by using contour planting, mulching, and the construction of cut-off drains and sluices was popular only in the Mbulu highlands in Tanzania, where the fields are on a slope (Tengö and Belfrage, 2004).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location and Description of the Study Area

The study was conducted in the North Pare Mountains Mwanga District which is one of 7 districts of Kilimanjaro Region. The District is located at 3° 45' 0 S and 37° 40' 0 E and borders Same District to the South, Moshi district to the North, Simanjiro District to the West and Republic of Kenya to the North East.

The District has a total surface area of about 2641 km^2 and has 5 divisions and 16 wards. There are 60 villages comprising of 24,326 hamlets. The land is divided into two distinct agro ecological zones: the Highlands (Ugweno, part of Lembeni and Usangi divisions – about 808 km^2) with an elevation of 1200 – 2000 meters above sea level and the lowlands covering an area of about 1833 km^2, between 700 – 800 meters above sea level, which again are divided into two division, the Eastern depicted as receiving a higher precipitation than the Western division (MNRT, 2004).

3.2 Population and Socio-Economic Activities

The District has a population of 115,145 (URT 2002) which is now estimated by Mwanga district council to be 132,033 people, of whom 55,327 are males, and 59,815 are females. Average household size is 4.5 and proportion of population with disability is 1.9%, while the proportion of child orphans is 1.0%.

The main socio-economic activities in Mwanga District are agriculture and livestock keeping. Fishing is also practised in the Nyumba ya Mungu dam. There are also other small business activities where employment in Agriculture is 60%, Business Operations 18% Elementary Occupation 10%, Office work 9%, and Fishing 3%.

3.3 Climate and Soil Characteristics

The climate of Mwanga District is generally semi-arid which makes the district experience predominantly easterly winds which cause more (700-1000 mm/year) precipitation in the mountains and at the Eastern slopes because they are on the windward side of the highlands. In contrast, the Eastern and Western Lowlands are on the leeward side and receive less (500-650 mm) annual rainfall with occurrences of severe droughts. On average, precipitation is relatively low, with about 60 % of the yearly rainfall in less than three months (period mid-March to May in Eatern and Western lowlands). September is the driest month with, on average, less than 10 mm of rainfall (FAO, 1986 in Soil Appraisal, 1992). Temperatures range from a minimum of 16°C, between July and August, and 32°C between January and February (MNRT, 2004).

The northern and eastern parts have predominantly red soils and have very high potential for agriculture. The central western part of the district is covered by soils classified as very stony and moderately deep, not suitable for agriculture but marginally suitable for grazing because they contain alluvial and clay soils. In the eastern side of the North Pare Mountains the soils are characterized by loamy and clay alluvial deposits, whereas the Lake Jipe plains are built up by thick layer of calcareous lacustrine deposits of clay and heavy clays (MNRT, 2004).

In the highlands, the soils consist of well-drained deep yellowish or reddish clay with moderate organic matter, and shallow undifferentiated soils. Water logged and poorly drained soils are found in some valley bottoms and riverbanks (MNRT, 2004).

3.4 Vegetation

The land area is covered by shrubs of *Acacia* type especially in both Eastern and Western lowlands. Short grass exists in the highlands and forests around the mountains. Some of these forests have been preserved by the people long time ago for ritual ceremonies.

3.5 Sampling Procedure and Sample Size Determination

3.5.1 Sampling procedure

Mwanga District was purposively selected because it is experiencing climate change impacts highly such as drought and floods. The District was stratified into highland and lowland, in order to capture highland lowland data on the interaction between indigenous and external knowledge systems in influencing adaptation to climate change impacts. Then two villages (one from lowland) which is about 700 metres above sea level and the other from highland which is about 1500 metres above sea level were randomly selected.

3.5.2 Household sample size determination

The sample size for the study was computed using the formula recommended by Bartlett *et al.,* (2001) in Lusambo (2009).

$$n = \frac{n_o}{(1 + n_o / N)} \qquad \text{.....(1)}$$

Where n= the required sample size (or sample size from finite population)

N= the population size

$$n_o = \frac{t^2 * pq}{d^2} = \text{Sample size for infinite population} \ldots\ldots(2)$$

Where: *p* is the proportion of respondent that will give you information of interest (the proportion *confirming*), *q* viz (1-*p*) is the proportion not giving information of interest (proportion *defective)*, and *p* q* is the estimate of variance (*which is maximum when p = 0.50 and q=0.50)*. The maximum population variance of 0.25 gives the maximum sample size.

Using the formula, the required sample size of 54 respondents/households was selected for the interview in Mangulai (a lowland village) while 49 respondents were selected randomly for interview in Mangio (a highland village). A village register was used to select respondents/households.

3.6 Data Collection

Primary data which is created for the first time and there is no previous source available and secondary data which are those data readily available like from trade directories, were collected in this study. In collecting primary data standard social methods were employed. These included in-depth interview using questionnaire administration, participatory rural appraisal (PRA), key informants interview, focus group discussion (FGD) and participant observation.

3.6.1 Primary data

3.6.1.1 Questionnaire administration

Semi-structured questionnaire which include both open and closed-ended questions was administered to collect information from households. The information collected included socio economic factors for adoption of external and local knowledge on climate change, the indigenous and externally influenced practices for adapting to drought, floods, rainfall variability, and the interaction between indigenous and external knowledge systems for adapting to climate change impacts.

3.6.1.2 Participatory rural appraisal (PRA)

This study employed a pair-wise ranking tool of PRA. A pair-wise ranking assisted in problem identification, identifying local knowledge on climate change impacts and the adaptation strategies adopted in coping with drought, floods, rainfall variability and temperature change. It also identified the effects of interaction between the indigenous and external knowledge systems and socio-economic factors influencing adoption of external knowledge for adapting to climate change. Techniques such as mapping, timeline, seasonal calendars, historical profile and trend analysis were employed to get relevant information. The participants include elders, middle aged and youths male and female from each village to make a PRA discussion group.

3.6.1.3 Key informants interview

These were individuals who were approached to give their views on the climate change issues using a semi-structured list of questions. Key informants included extension officers, forest officers, Community Development officers, elders and influential people in the village. Questions were asked on local knowledge with respect to climate change, effects of interactions between indigenous and external knowledge and the socio-economic factors influencing adoption of external knowledge for adaptation to climate change.

3.6.1.4 Focus group discussion

This was conducted with groups of people in the village water, environmental and food and security, men, women and young people committees. Two meetings each comprised 20 participants per group were conducted in each study village making total of four meetings. All groups had a mixture of sex and age classes. The type of information obtained in the focus group discussion was on local knowledge on climate change impacts, indigenous and externally influenced practices for adapting to climate change, effects of interaction between these two knowledge systems and the socio-economic factors influencing the adoption of external knowledge for adaptation to climate change.

3.6.1.5 Participant observation

Participant observer is described as the one who seeks to go beyond outward appearance and probe the perception, motives, belief, values and attitudes of the people studied (Lusambo, 2009). For the whole period of fieldwork, the researcher was keenly observing various aspects related to the interaction between indigenous and external knowledge systems practices.

3.6.2 Secondary data

Secondary data on the interaction between external and indigenous knowledge in adapting to climate change, the effects of the interaction, indigenous and external practices for adapting to climate change was collected from relevant offices, villages and wards management, relevant government and non-governmental offices. Other documents and publications were obtained through grey literature, literature search using Internet and libraries.

3.6.3 Data Analysis

The data from semi-structured questionnaire survey were coded, assigned variables and analysed using Statistical Package for Social Sciences (SPSS 12.0). Information from focus group discussion, key informant interview and participant observation was subjected to descriptive statistics, which provided information on measure of central tendencies such as frequencies, means, minimum, maximum and cross tabulation. The data collected using PRA tools were analysed by triangulation (analyzing using more than one perspective) and with the help of the local community members who were regarded as partners and not client or beneficiaries (Kajembe and Kessy,2000).

3.6.3.1 Socio – economic data

(a) Descriptive and inferential statistical analyses

Quantitative data from household surveys were processed and analysed using Statistical Package for Social Sciences (SPSS). Most of the analysis under quantitative data falls under the domain of "descriptive statistical analysis". Descriptive statistical analysis (statistical data about the distribution, central tendency and dispersion of responses) were summarized and presented as figures, frequency tables and cross-tabulations. Cross tabulation is both a powerful way of communicating information and the commonest form of data presentation (Casley and Kumar, 1988). The function of the second domain "inferential statistical analysis" was to provide an idea about whether the patterns described in the samples were likely to apply in the population from which the samples were drawn (de Vaus, 1986, as cited by Mbwambo, 2000) by developing a logistical regression model. Thus, in this study, the logistic regression analysis was used to establish a relationship (Whitehead, 1998; Pampel, 2000) between dependent variable i.e. adoption of external practices and independent variables i.e. socio-economic and demographic factors (i.e. age, education, gender, marital status, main occupation, income and household size). Logistic regression is useful for situations in which one wants to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables. It is similar to a linear regression model but is suited to models where the dependent variable is dichotomous, while the independent variables can be interval level or categorical. The logistical regression coefficients can be used to estimate odd ratios for each of the independent variable in the model. The following model was used:

Logistic (Y) = $\ln \pi / 1 - \pi = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_n X_n$..(3)

Where:

Y_i = the ith probability of event to occur for the dependent variable (adoption of external knowledge a binary/dichotomous variable with value of 1 if there is adoption of external practices and 0 if other wise),

α = constant term of the model without the independent variables (intercept),

β_1 to β_n = independent variables coefficients estimates from the data,

e = is a natural logarithm base approximately equal to 2.718,

i = 1, 2… n; where n is the total number of variables,

X_1 to X_n = independent variables (socio-economic and demographic factors),

X_1 = age of respondents in years,

X_2 = gender (male vs. female) – (*dummy variable*),

X_3 = marital status (married vs. not married) – (*dummy variable*),

X_4 = income ($\leq$10,000 Tshs. vs. > 50,000 TZS) – (*dummy variable*),

X_5 = education level (formal vs. non formal) – (*dummy variable*),

X_6 = main occupation – (*dummy variable*).

The probability of an event not to occur was estimated as:

Prob (No event) = 1- Prob (Event).

The hypotheses tested were:

Ho: $ß_1 = ß_2 = ß_3 = ß_4 = \ldots\ldots ß_n = 0$ (implying that the regression coefficients are equal to zero and thus there is no correlation between adoption of external practices (dependent variable) and socio-economic and demographic factors (independent variables)); against

H_1: at least one of the $ß_s \neq 0$ (and thus there is either a positive or a negative correlation between adoption of external practices and the socio-economic and demographic factors).

H_o: was rejected only where $p<0.05$.

To test whether the regression coefficients are significantly different from zero, the Wald statistic (equivalent to t-value) that asymptotically follows a Chi-squared distribution in large samples (Gujarati, 1995) was used. The Wald statistic is distributed as Chi-square with degree of freedom (df) equal to the number of constrained parameters (r). With single parameter, the Wald statistic is simply the square of the ratio. The odds ratios represented by Exp (ß) from logistic regression analysis were used in explaining the likelihood of adoption of external practices under specified socio-economic and demographic factors.

To assess the goodness of fit of the regression model to the data, the Chi-square model as suggested by Pampel (2000) was used and was tested at 5% probability level. Chi-square measures how well the independent variables affect the outcome of dependent variable. Also, -2 log likelihood (-2LL) which indicates that the model fits the data reasonably well, and the overall percentage of correct predictions where the bigger the percentage the better the model were used.

Proper interpretation of logistic regression results involved looking at Wald statistic (t-value) to see whether the effect of a particular independent variable was statistically significant, to see whether the increase in independent variable increased or decreased the probability of success (in this case adoption of external practices), magnitudes of the similarly measured variables to determine which of the independent variables seemed to have a greater impact on the adoption of external knowledge, and the Exp(ß) to see how much a 1- unit increase in Xi changes the odds of success (this is because the odds of success is not the same as probability of success).

(b) Content and structural – functional analysis from Household survey, key informant interview and focus group discussion

The qualitative data and information was analysed using the content and structural-functional analysis techniques. Content analysis method was used to analyse in detail the components of verbal discussions held with key informants, focus group discussion and open-ended questions whereby recorded dialogue with respondents broken was down into smallest meaningful units of information or themes and tendencies. This as explained in Kajembe (1994) in helps the researcher in ascertaining values and attitudes of the respondents. Since most of the data were categorical, interpretation was done using frequencies, cross tabulations and percentages. Structural functional analysis was used to explain the way social factors relate to each other within a social system and to the physical surrounding. This type of analysis helps the researcher to distinguish between manifest and latent functions. Manifest functions are “those consequences which are intended and recognised by actors in a system”. Latent functions are “those consequences which are neither intended nor recognized (Thomlinson, 1965 as cited by Kajembe and Luoga, 1996).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio Economic Characteristics of Respondents

4.1.1 Age distribution of respondents

Interviews were conducted based on different age classes (Fig.1).The first class comprised the young ones aging less than 20 years; middle age comprised those ranging from 31 to 59 years of age and old ones aging more than 60 years. This reduced the chances of obtaining biased results by considering certain age group and excluding others. Similarly, it was assumed that awareness on climate change effects differs from one age class to another. The middle class formed the majority of the respondents possibly due to the fact that young people are immigrating to urban areas. Old people formed the minority of the respondents, probably due to short life expectancy and those alive were sick or too weak to participate in any socio-economic activities. The most active group in adaptation activities was the middle age and they were highly engaged in the construction of wells, tree plantations, agriculture activities as well as being employed in labour works during drought and other climate change disasters as a coping strategy to climate change impacts. However, the old group had more indigenous knowledge in adapting to climate change. The results are supported by the findings of the study conducted in Ethiopia by Deressa *et al.*, (2009), the study shows that age of the household head, which captures farming experience influences awareness of, and adaptation to, climate change.

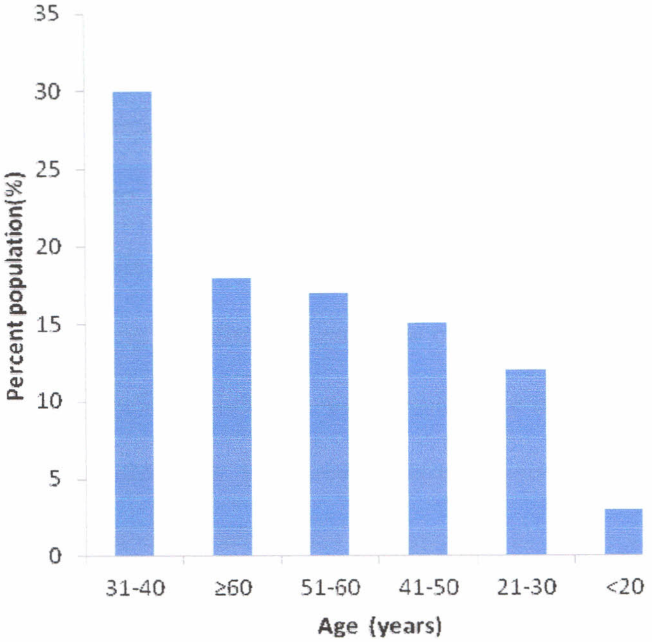

Figure 1: Age distribution (years) of respondents in Mangio and Mangulai villages.

4.1.2 Gender composition of the respondents

Gender distribution of respondents was effectively considered during data collection so as to reduce chances of obtaining results which are not gender sensitive. Majority (53.4%) of the respondents were males. This is because most of women were carrying out farming activities during the interview and therefore could not show up, and the fact that most societies are patrilineal and therefore women found themselves inferior to appear and express themselves before people. In the study conducted in Italy by FAO (2002) 'The report of Gender and Development Plan of Action' indicated that men and women have different access to resources, including physical resources like land, social resources like networks, and financial resources like income-generating activities and credit. In times of change, they will have different options and 'safety nets' for coping with climate change. Also, men are found to be more likely to adapt to climate change. This is because men do much of the agricultural work and are more likely to obtain information and have access to new technologies, and to take greater risks than females

4.1.3 Level of education of the respondents

Most (55%) of the respondents have primary education while others as indicated in Fig 2 have never gone to school, some have secondary education and others have adult education. This implies that the majority of the people have some education that is useful in understanding the effects of and how can they adapt to climate change impacts. The group with secondary education was found to be more active in practicing climate change adaptation strategies like tree planting, water harvesting, planting drought resistant crops and other related issues perhaps due to the fact that education provided them with sufficient reasoning capacity on the causes and effects of climate change. The illiterates were seen to be less aware of the causes of climate change, although they had an idea of the impacts of climate change. However, considerable efforts are done by agricultural extension officers to change people's attitude or facilitate their understanding on the causes and impacts of climate change and what the short and long term adaptation strategies are.

The study conducted in Ethiopia by Deressa *et al.* (2009) indicated that education increases climate change awareness and the likelihood of soil conservation and changing planting dates as an adaptation method, the households with high level of education were mostly able to adapt to climate change impacts.

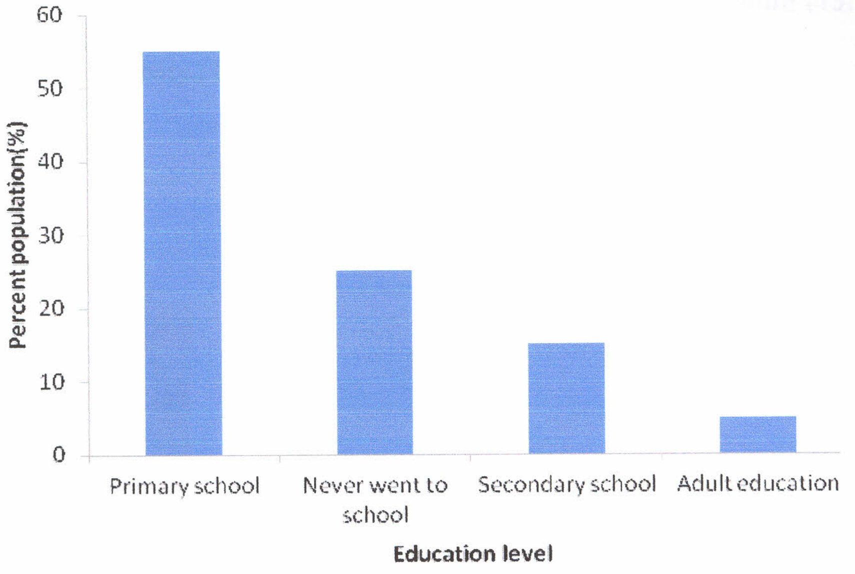

Figure 2: Education level of the respondents of Mangulai and Mangio villages

4.2 Communities' Local knowledge on Adaptation to Climate Change

According to IPCC (2007), local knowledge is variously referred to among others as folk knowledge, traditional knowledge, traditional environmental knowledge, indigenous traditional knowledge, indigenous agricultural knowledge, farmers' knowledge, rural people's knowledge, peasants' knowledge, ethno-science. It is based on experience, often tested over centuries of use, and entails many insights, perceptions and intuitions relating to local culture and the environment. It is both dynamic and complex, and is not confined to knowledge about uses and products but also about processes.

4.2.1 Local knowledge on climate change impacts

Results from this study show that about 52% of the respondents from Mangio and Mangulai villages experienced severe droughts which led to severe loss of agricultural production. They are now producing less than before but also some crops are no longer cultivated because of severe drought. Other indicators of climate change mentioned were seasonal rainfall variation (18%), increasing air temperature (13.1%), increasing sunshine intensity (12.9%) and floods (3.8%) (Fig.3).

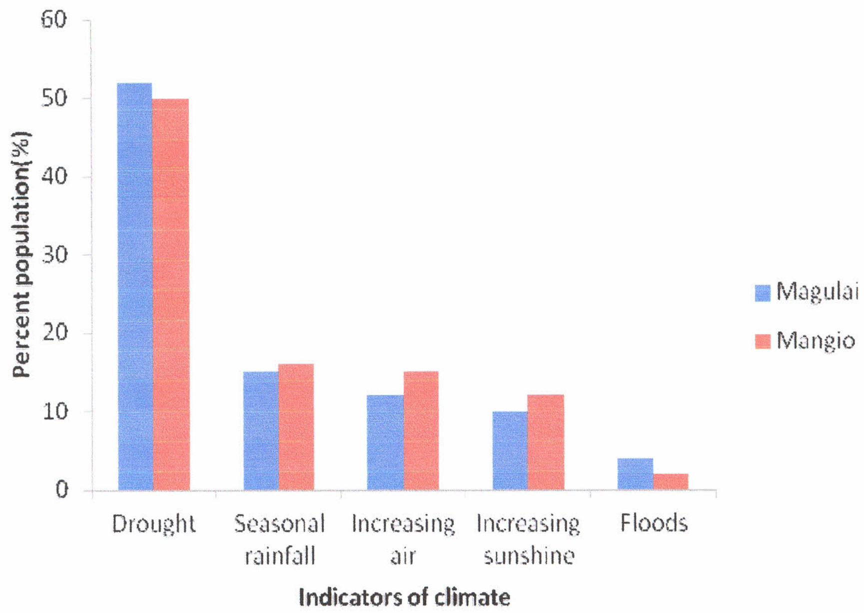

Figure 3: Responses on indicators of climate change based on local knowledge in Mwanga District

Drought affects livestock production in the study area. About 40% of the respondents mentioned that there was high loss of livestock and livestock grazing areas especially in 2009 due to drought (Fig. 3). The study villages were among the most affected ones by drought since they showed high number of livestock loss whereby Mangulai lost 125 livestock, and Mangio lost 90 livestock. The results are in line with those of Sherpard *et al,* (2010) in Kenya and Tanzania which indicated that there was increase in frequency of droughts since 1990s that has caused catastrophic losses in livestock combined with failure of agricultural crops leading to increased food insecurity.

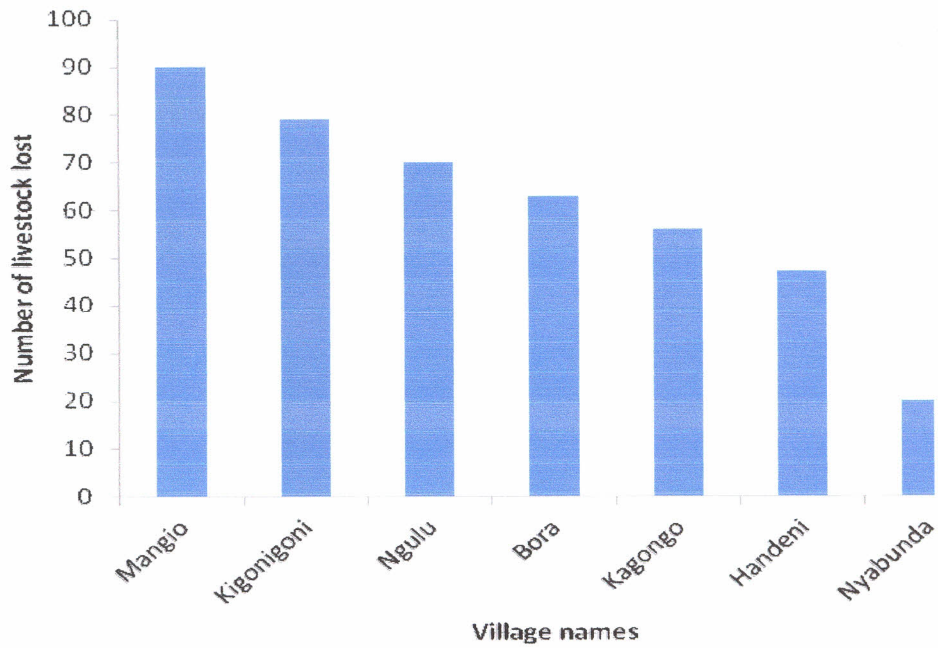

Figure 4: Number of livestock lost due to drought in 2009 in seven villages of Mwanga District

These findings also are in agreement with an analysis conducted by Hatibu *et al.* (2000) which revealed that more than 33% of disasters in Tanzania over a period of 100 years were related to drought, which is a major pre-cursor of agro-hydrological problems in the semi-arid regions. Empirical evidence showed that Tanzania had recorded 37 occurrences of drought between 1872 and 1990 (URT, 1998a). Such a situation has serious impact on food security and people's livelihood. When asked to state what they saw as the causes of the mentioned changes, 64% of the respondents mentioned deforestation as the major cause of changes observed in the area. Some (20.4%) of them did not know what were the exact causes of climate change (Figure 5). Cutting trees was mostly practised due to poverty because people were cutting trees for charcoal making and fuel wood and some for expansion of their farms for cultivation. Most of the respondents in the study area clearly believed that deforestation is a huge cause of climate change (Fig. 5).

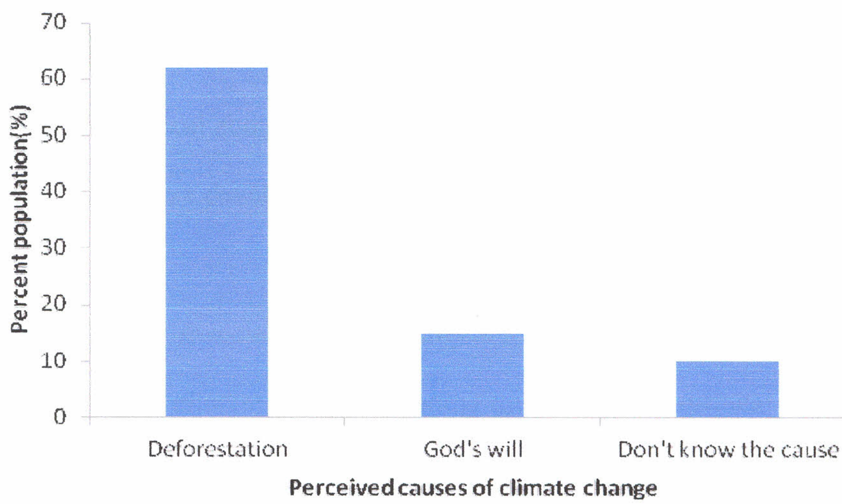

Figure 5: Local Perceptions on Causes of climate change in Mangio and Emangulai

Plate 1: Deforested area in Manguali village

4.2.2 Indigenous practices for adapting to climate change.

IPCC (2007) described indigenous practice for adapting to climate change as a practice unique to a given culture or society, acquired through accumulation of experiences of local people (farmers, landless labourers, women, rural artisans, herders, etc.) through informal experiments and intimate understanding of the natural systems stressed by climate change and socio-economic development. Climate change impacts affect the natural systems. Since local communities have historically and continue to be guardians of these systems, they have developed novel ways of adapting to such stresses.

Results from this study revealed several indigenous practices in the area which are potential for adapting to climate change including the use of a traditional water storage system ‘ndiva’. It was reported that such system were previously used for domestic water but overtime the system has been developing into irrigation systems due to increasing dry spells and drought. Other adaptation strategies reported were switching from cultivation in upland to valley bottoms known as “vitivo” where the moisture levels are higher and persistent while using the uplands for tree planting to increase the supply of fuel wood and other forest products. Moreover use of drought resistant crop varieties, crop diversification in valley bottom cultivation and construction of shallow wells to augment the ‘ndiva’ have been developing as responses to increasing water scarcity due to frequent droughts and changing rainfall patterns.

4.3.2.1 Use of traditional water storage system ‘ndiva’ for adapting to climate change

Results show that about 86% of the respondents use ‘ndiva’ water for irrigation while 13.7% use ‘ndiva’ water for domestic purposes. It was reported by the local communities in the study area during focus group discussions that traditionally they had been conserving water by using “ndiva systems” which are the storage structures common in the upstream villages. These ‘ndiva’ structures have high water runoff rate which then requires controlled structures before they can easily be managed and utilized by farmers in their fields. They were constructed purposefully for conserving water for domestic purpose, but now due to drought almost all traditional wells are used for irrigation purposes.

Plate 2: An almost disappearing ‘Ndiva’ due to drought in Mangio village

A similar study in other district of Kilimanjaro region conducted by Stigter *et al.* (2005) shows information on traditional adaptation strategies including traditional water storage structures locally called ‘Ndiva’ which aimed at improving water availability for crop production.

4.2.2.2 Switch from upland cultivation to valley bottoms as the way of adapting to climate change

The results indicate that about 84.3% of the respondents owned small land parcels of farms for cultivation on valley bottoms where the condition is favourable for agricultural activities and planting of different types of crops. The study further showed that some still have small areas in uplands (Figure 6) although they are mostly using them for growing fruit trees and other tree species. It was reported that planting of trees was the major adaptation strategy in responding to climate change impacts where individuals were required to plant trees whenever they cut one for land and water conservation as well as reduction of pressure on the existing natural forests. Results from this study revealed that reasons for switching from upland cultivation to valley bottoms known as "kitivo" where the moisture levels are higher and persistent, and using the uplands for tree planting to increase the supply of fuel wood and other forest products was that in the valley bottoms there is enough water, fertile soil and the geographical condition favouring growing of various crops such as banana, beans, maize, rice, cocoyam, onion, sweet potatoes, tomatoes, cabbage, and spinach.

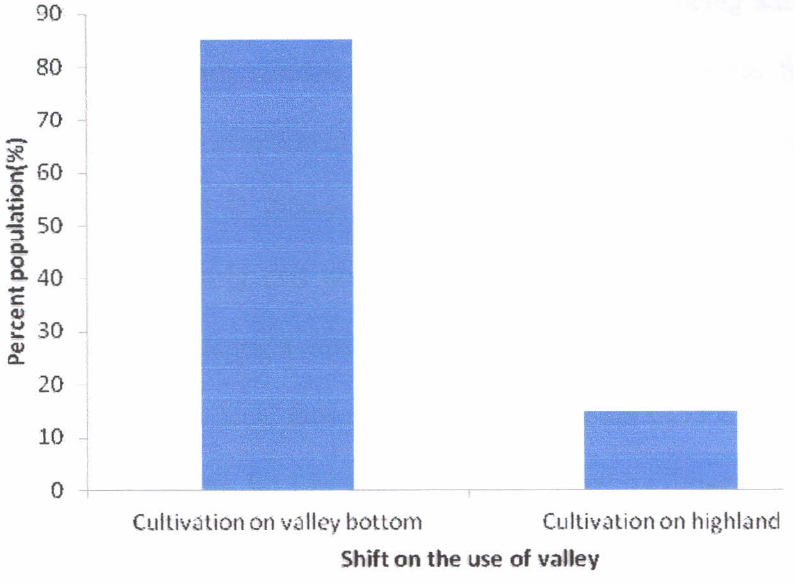

Figure 6: Percent Population cultivating in valley Bottoms and Highlands in Mangio and Mangulai Villages Mwanga District.

These results are supported by study conducted in Same district by Agrawalia (2003) which showed that highland valleys were traditionally planted with various kinds of crops but now farmers have shifted from upland cultivation to valley bottoms known as "vitivo".

4.2.3 Externally influenced practices for adapting to climate change

Use of drought resistant crop varieties, crop diversification in valley bottom cultivation and construction of shallow wells to augment the 'ndiva' has been developed as a response to increasing water scarcity due to frequent droughts and changing rainfall patterns.

4.2.3.1 Use of drought resistant crop varieties

Majority (92%) of respondents used drought resistant crops while only (7.6%) in 1990s were reported to plant sorghum and millet in Kilimanjaro region (Fig. 7). This study found out that the improved sorghum and millet varieties are being adopted by local farmers differently in both villages in Mwanga district. Responses from the local farmers indicated that the adoption in terms of area under improved sorghum and millet seeds in Mwanga district is increasing from 1990s. Despite the fact that improved sorghum seeds mature early and are suitable for the conditions in Mwanga district especially in the study villages, availability of the improved seeds seem to be limited by supply as reported by the local farmers (Fig 7). This could have contributed into low adoption rate. Other reasons for low adoption as explained by farmers seem to be pests especially birds which attack the crop as it matures earlier than the local varieties. This therefore implies that adoption of external practices especially improved seeds as a response to impacts of climate change may not be a straightforward process.

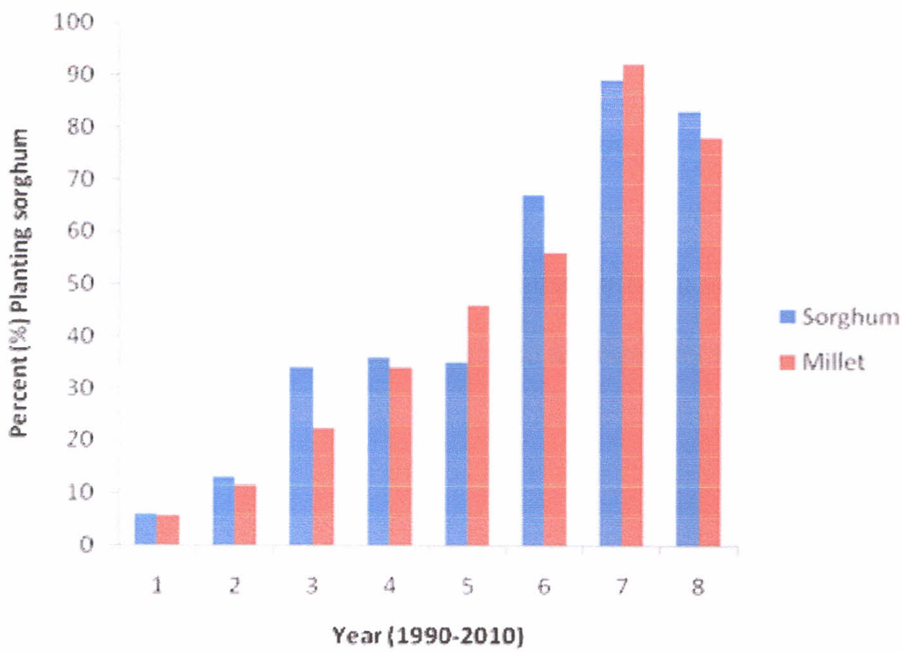

Figure 7: Trends in adoption of drought resistant millet and sorghum varieties in Mwanga district (Year 1 = 1990)

A similar study conducted by Rohrabacher *et al.* (1999) identified three critical conditions for the adoption of new varieties. These conditions include but not limited to early involvement of farmers in crop variety selection, rapid release in response to farmer preferences and government commitment to rapid multiplication and dissemination of high-quality seed.

Farmers' inability to access seeds is a chronic problem in Mwanga district and this can be due to lack of information and incentives (poor links to output markets) or means to purchase them. As a general rule, most of the private seed companies target the large commercial farmers. Thus there is a strong need to design solutions to the seed problem among the smallholder farming communities especially in response to climate change impacts.

4.2.3.2 Crop diversification and intercropping

Results indicate that about 70% of the population grows banana and maize in all the two villages. Also sorghum and sunflower are grown by more than 64% of the same population (Fig. 8) this implies that diversification by increasing the number of crops per unit area was a common practice adopted as shown by the diverse number of crops grown (Fig 8).

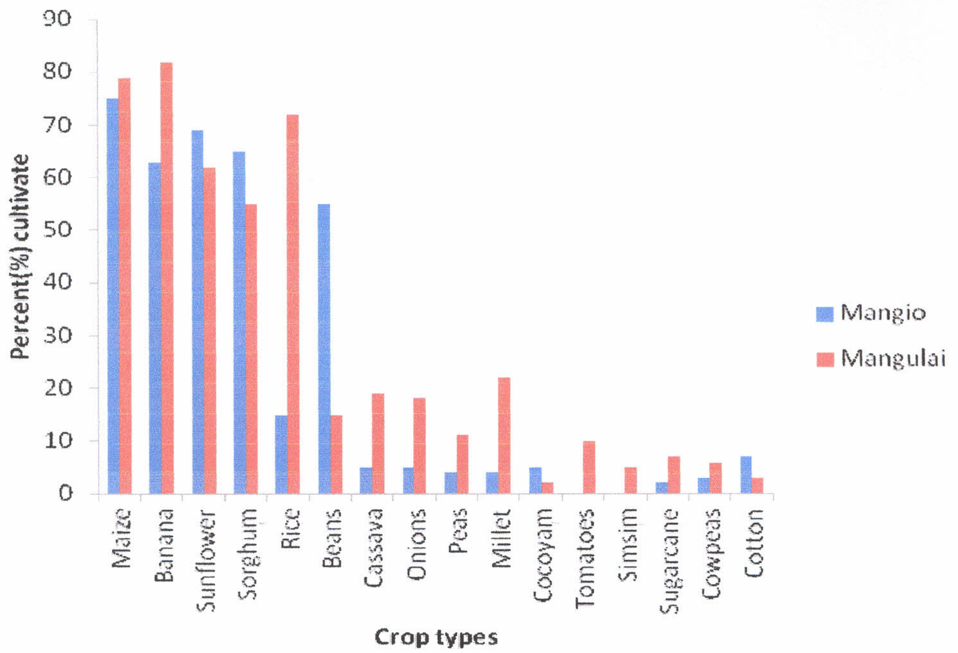

Figure 8: Types of Crops grown Mwanga district

Results from this study revealed that majority of farmers (62.3%) grow a range of 4 to 7 different crops on their land (Fig. 9). Furthermore it was revealed that horticultural crops are grown by less than 50% of the farmers in both villages. Other crops grown in attempt to diversify crops are legumes, cassava, cocoyam, rice, cowpea and simsim.

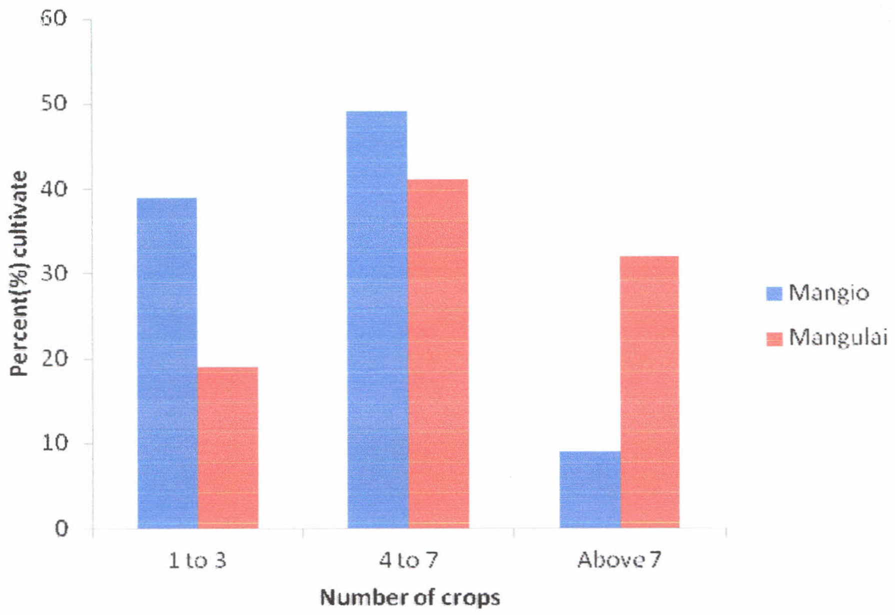

Figure 9: Number of crops grown by individual farmer

Intercropping of annual and perennial crops such as beans, banana, pigeon pea and maize were other practices adopted by farmers in the study area (Fig. 10). This kind of crop diversification aims at avoiding risk of crop failure under climatic variation. Occasional crop failure especially maize and cotton as cash crop has been reported to occur due to prolonged period of drought as stipulated by Mwanga District Agricultural and Livestock District Officer.

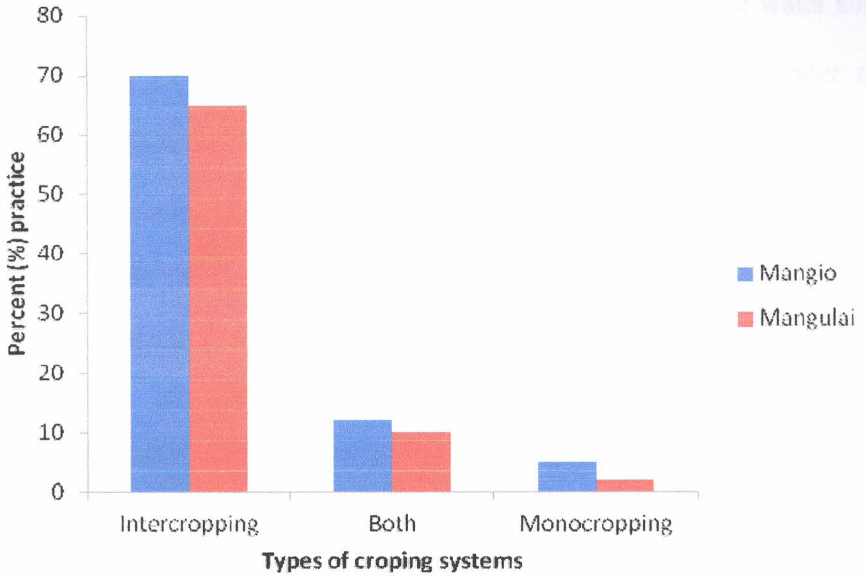

Figure 10: Cropping systems in Mangio and Mangulai villages

4.2.3.3 Development of shallow wells

Results indicate that about 78.2% of respondents use shallow wells which are the common water supply strategies adopted by the local farmers. Shallow wells are locally established by digging up 1.5m to 2m pit. Shallow well serves as water sources for domestic uses and for livestock.

The results from this study reveal that village shallow wells are commonly adopted by local farmers to cope with water stress mainly during the dry season. During rains seasonal rivers streams and water dams serves as major source of water supply for livestock and domestic use.

The study shows that dams are also used to cope with reduced water supply and water stress during periods of drought or during the dry season. Under climate change scenarios with increasing temperature open dams may not be adequate due to increased evaporation from open water dams making this approach inappropriate to sustain adequate water for long time. This result implies that water supply in Mwanga district is a chronic problem which has resulted due to climate change.

Plate 3: (a) Shallow wells in Emangulai village (b) Seasonal dam in Mangio village

4.3 The Interaction between Indigenous and External Knowledge in Influencing Local Adaptation to Climate Change Impacts

4.3.1 Role of indigenous knowledge in influencing adaptation to climate change

The study revealed a variety of indigenous agronomic strategies that suggest that indigenous knowledge could provide the basis for development of more effective strategies. About 55.6% of respondents use monoculture followed by plain ridge cultivation (40.2%) and only 12.3% of respondents use terraces due to the nature of the area especially in the highlands. Other agronomic practices mentioned were shifting cultivation, intercropping and sensor (Fig.11).

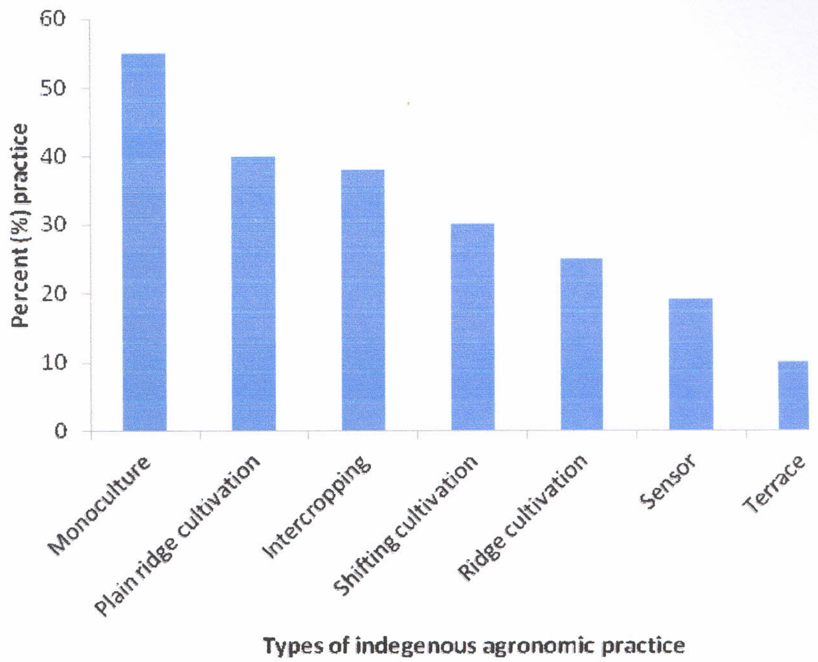

Figure 11: Indigenous agronomic practices in Mangio and Mangulai villages

Results from this study revealed several indigenous crops which are grown in order to adapt with the changing climate. About 41.7% of respondents grow maize which is a crop they have been cultivating for a long time for ensuring food security. The results also indicate that 20.2% of respondents grow paddy variety which is indigenous to the area, followed by 19.5% who grow bananas. Other crops mentioned were cassava, sweet potatoes and cocoyam (Fig 12). People grow cassava, sweet potatoes and cocoyam due to the fact that they are drought tolerant crops so this implies that they are using indigenous crops to adapt to climate change impacts.

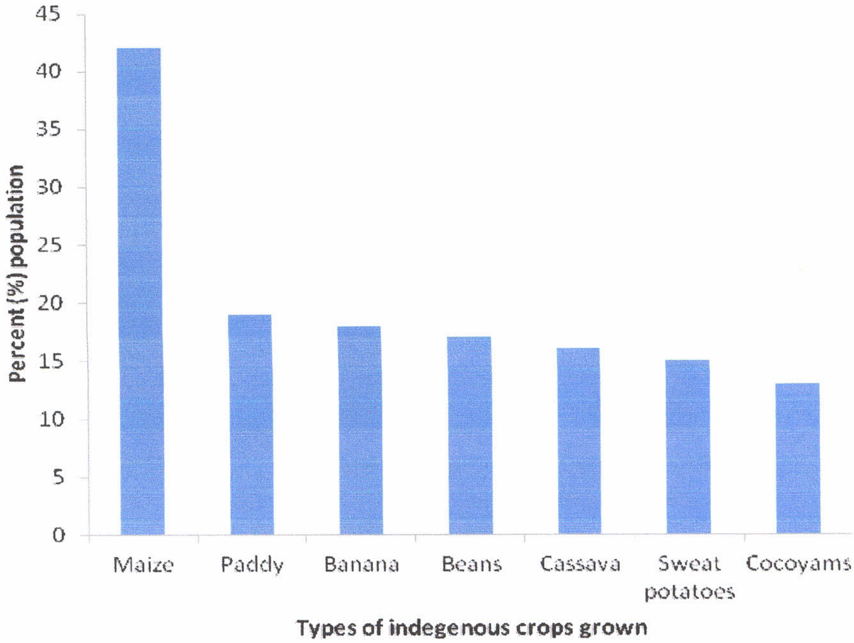

Figure 12: Indigenous crops grown in the Mangulai villages

Results from this study are similar to the study conducted in semi arid regions of Tanzania by FAO (2005) on the adaptation to climate change in agriculture which indicated that farmers used their indigenous knowledge to adapt with climate change through using indigeneous agronomic practice such as monoculture, and planting indigenous trees and crops.

4.3.2 Role of external knowledge in influencing adaptation to climate change

The study show that most (44.7%) of the respondents use improved ridges and intercropping (30.1%) whilea good proportion (25.8%) use fertilizers in order to improve crop yields as a strategy of adapting to climate change (Fig. 13). These results imply that despite the fact that communities use indegeneous knowledge in adapting to climate change they also use external/ proffessional knowledege in the process of adaptation.

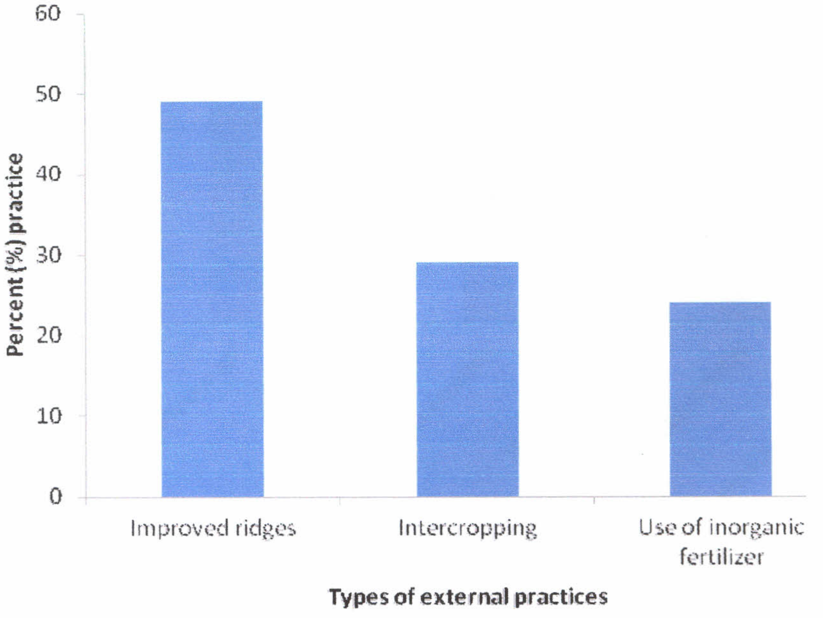

Figure 13: The introduced agronomic practices in Mangio village

The study found several reasons for the introduction of agronomic pratices (Fig.14) present a summary of what the respondents perceived as the reasons for the introduction of the agronomic practices. Majority (68.1%) of the respondents mention climate change, followed by drought (50.5%) and only 1.9% mentioned soil erosion prenvetion to be the reason for the introduction of agronomic practice. Others mentioned soil water conservation, shortage of ranfall, increased yield and renew soil fertility (Fig. 14).

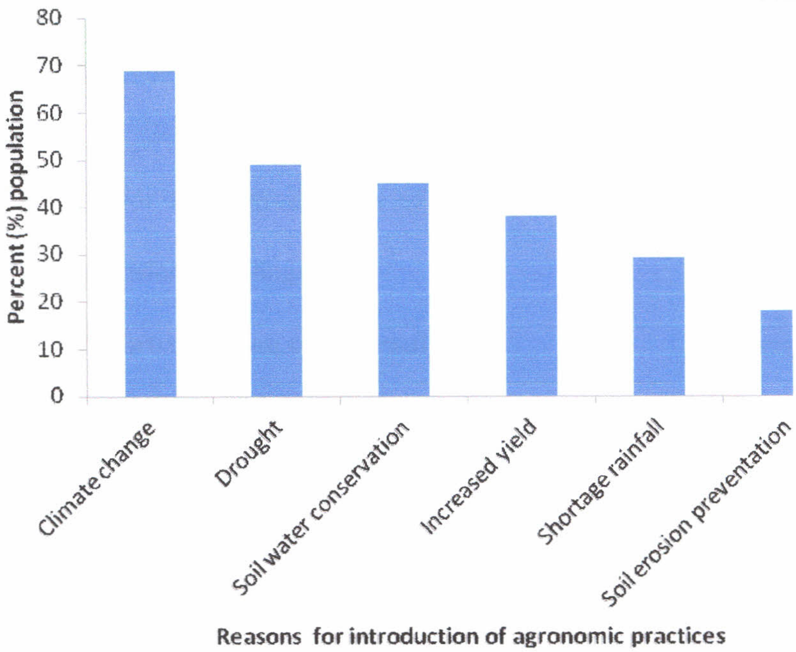

Figure 14: Reasons for the introduction of agronomic practices in Mangio and Mangulai villages

Results from this study revealed that several crops have been introduced to the area in order to adapt with the changing climate. Most of the respondents 30.8% mentioned horticultural crops and sorghum (30.4%). Other crops introduced in the area are maize hybrid variety and coco yams. Crops introduced depended on their contribution to the improving food security by providing higher yields, contribution to the income as they are cash crops and their ability to resist drought condition or water shortage. Results further indicated that crops such as watermelon, sorghum, cocoyam and sunflower although they were planted as cash crops they were also mainly chosen due to climatic condition that favours them to grow in drought areas or water shortage areas.

The study found several reasons for the introduction of external crops. Most (34%) of the respondents said it was due to the shortage of rainfall, followed by those who said it was introduced as an alternative crop (26.2%) and about (24.3%) said as a cash crop and others (15.5%) said the crops were introduced due to drought (Table 1).

Table 1: Reasons for the introduction of external crops in adapting to climate change in Mangio village

Reason for the introduction of external crops	**Percent (%)**
Shortage of rainfall	34
Drought	15.5
Cash crop	24.3
Alternative crop	26.2
Total	**100**

Results from this study revealed that several institutions were responsible for the introduction of external knowledge for adapting to climate change. Most (67%) of respondents mentioned retired extension officers, followed by government extension officers (15.5%) through different policies. Projects through various NGOs and government were also said to be the source of new knowledge although some of the respondents said that they get new knowledge from their neighbours (Table 2).

Table 2: Institutions responsible for the introduction of agronomic practices in the area

Name of the institution	Percent (%)
Extension officers	67.0
Government	15.5
Neighbours	10.7
Projects	6.8
Total	**100**

4.4 The effect of Interaction between Indigenous and External Knowledge for Adapting to Climate Change in the Study Area

Several practices are done by the local communities either to reduced or alleviate climate change impacts in the study areas. Local people in the study area mentioned the indigenous practices for adapting to climate change to include agronomic practices such as shifting cultivation, use of traditional ridges and monoculture, indigenous crops e.g. banana, indigenous tree species, indigenous water collection systems and indigenous food storage systems. Later on when the impacts of climate change started to be observed globally, it is when the external/more professional knowledge practices were introduced in order to cope with climate change impacts. To the local communities this brought confusion between their indigenous practice which they were used to have and the introduced externally influenced practices.

Results from this study revealed that local communities have different response following the introduction of new practices. Table 3 shows the communities' reaction to the indigenous practice when new practices were introduced. Majority (52.4%) of the respondents use external practices only, 43.4% use both indigenous and external practice and only (1.9%) use indigenous practices.

Table 3 Communities' reaction to the introduced agronomic practices

Agronomic practices	Percent (%)
Practiced indigenous only	1.9
Practiced exotic only	52.4
Both indigenous and exotic were practiced	43.7
Total	**100**

Results show that 62.1% of respondents grow both exotic and indigenous crops, 31.1% grew exotic crops only and 2.9% grew indigenous crops only (Table 4). It further indicate that 63.2% of the fruit trees planted are exotic species and they are the best, they grow for shorter period of time and provide maximum yield. About 19.4% of the respondents said there is no difference between indigenous and external fruits and only 1.9% of the respondents said the indigenous fruits are the best.

Table 4: Crops grown after the introduction of exotic crops

Crops grown	Percent (%)
Indigenous crops only	2.9
Exotic crops only	31.1
Both indigenous and exotic crops	62.1
Total	**100**

Results from the study imply that the introduction of new /external knowledge in adapting to climate change has brought positive impacts to the communities because the practices not only helping them to cope with climate change impacts but also increase agricultural and forestry yields. This was justified by the fact that 92.2% of the respondents said that the planted introduced crops improved production compared to the planted indigenous crops.

4.5 Influence of Socio-Economic Factors on Adoption of External Knowledge in Adapting to Climate Change

To establish the likelihood of the socio-economic factors influencing adoption of external knowledge for adapting with climate change, factors were entered sequentially in the logistic regression model, checked and the insignificant factors were removed from the prediction model. The socio-economic factors observed to have a profound influence on the adoption of external knowledge include; age, education level and income. The result shows that of the six factors studied only three factors; age, education level and income were statistically significant in influencing adoption of external knowledge.

This implies that old aged household heads contribute significantly to the adoption of external knowledge. The "age" of the respondent shows a negative logit coefficient (-0.041), which implies that an increase in one older person decreases the odds ratio of adoption of external knowledge by a factor of 0.960 (Table 5). As a matter of fact increase in the age of the household head increases the chances of not adopting external knowledge than young members can do. Elders have accumulated a lot of traditional knowledge and experience on indigenous knowledge as well as external knowledge on adapting to climate change as they were there since long time ago.

Table 5: Socio-economic factors influencing adoption of external knowledge for adapting to climate change impacts in Mwanga District, Tanzania.

Variable	ß	S.E.	Wald	df	P- value	Exp(ß)	95.0% C.I. for Exp(ß)	
							Lower	Upper
GENDER	0.722	0.975	0.913	1	0.339 **ns**	2.540	0.375	17.186
AGE	-0.041	0.081	5.423	1	0.020 *	0.960	0.927	0.994
INCOME	1.374	0.497	7.634	1	0.006 **	3.949	1.491	10.463
MARITAL STATUS	0.381	0.358	1.144	1	0.285 **ns**	1.467	0.727	2.962
EDUCATION	0.217	0.474	0.210	1	0.047*	1.243	0.491	3.137
HOUSEHOLD SIZE	0.283	0.592	0.228	1	0.633 **ns**	1.327	0.416	4.230
Constant	-3.973	2.058	3.726	1	0.04 *	0.019		

ß = estimated logit coefficient,
S.E. = standard error of the coefficient,
Wald statistics = $[ß/S.E.]^2$,
Exp (ß) = "odds ratio" of the individual coefficient (probability of success/probability of failure)
* = Statistically significant at 0.05 level of significance,
** = Statistically significant at 0.001 level significance,
ns = Statistically non significant at 0.05 level of significance,
Sig = Significance level and df = degree of freedom.

The positive logit coefficient (0.217) of "education" of the respondent indicates that an increase in one level of education of respondent increases the odds ratio by a factor of 1.234 of adoption of external knowledge (Table 5). The assumption here was that education level has an influence on the adoption of external knowledge. The influence of education level on adoption of external knowledge was statistically significant ($p<0.05$). This outcome implies that those who are educated have more influence on adoption of professional practices in adapting to climate change. The group with at least primary level of education showed more awareness and adaptation to climate change. Level of education significantly affected awareness to climate change and did have significant effect on adaptation. A study by Apata *et al.* (2009) indicated that education influenced adaptation positively. Furthermore, the study by Deressa *et al.* (2009) indicated similar results that education of head of household increased the probability of adapting to climate change. This is in contrary to previous research by Bayard *et al.* (2007) which indicated that education significantly but negatively affected awareness to climate change. Moreover a study by Kabubo-Mariara (2008) showed that education was negatively correlated with adaptation to climate change. The reason given was that educated farmers had alternative income earning opportunities.

The welfare of household shows a positive logit coefficient (1.374) indicating that an increase in one unit of household income increases the odds ratio of the adoption of external knowledge by a factor of 3.949 (Table 5). The effect of income and increase in well fare of the household on adoption of external knowledge was statistically significant ($p<0.01$). This would mean that the external practices for adapting to climate change are a bit expensive therefore would require someone to be well off in order to adopt.

The study indicate that three variables; gender, marital status and household size were not statistically significant but they were found to be important in contributing to adoption of external knowledge in the study area.

Results show a positive logit coefficient (0.722) of "gender" of the household head. This implies that an increase in one man headed household increases the odds ratio for adoption of external knowledge by a factor of 2.540 (Table 5). Man headed households significantly increases the adoption of external knowledge because in most cases it is the men who have all power in household for doing various activities and practices which involve finance. However, the study showed that the effect of gender on the odds of external knowledge in adapting to climate change was not statistically significant ($p>0.05$), which implies that gender has no influence on adoption of external knowledge. Results from this study are contrary to a study by Bayard *et al.* (2007) which showed that male farmers were more responsive to adaptation to climate change by planting trees in Haiti. Other similar studies by Hassan and Nhemachena (2008) and Deressa et *al.* (2009); indicated that males were more responsive in adapting to climate change.

The results from this study revealed a positive logit coefficient (0.381) of "marital status" of the household head implying that an increase in one married headed household increases the odds ratio for adoption of external knowledge by a factor of 1.467 (Table 5). Here it was assumed that with most of the mature male household heads married; having a number of responsibilities to accomplish, and more family demands and given that there is enough rainfall with no prolonged drought, married couples could have effect on adoption of external knowledge. However, the results indicate that effect of marital status on the odds of adoption of external knowledge in adapting to climate change was not statistically significant ($p>0.05$). These results are contrary to the study by Bayard *et al.* (2007) which indicated that married farmers were more aware and adapted to climate change compared to unmarried farmers. The possible reason was that those farmers interviewed had families who had stayed in the area of study for a reasonable amount of time to observe climate change.

Results show that household size of the respondent has a positive logit coefficient (0.283) implying that an increase in one member in the household increases the odds ratio for adoption of external knowledge by a factor of 1.327 (Table 5). It was assumed that household size was one of the factors for adoption of external knowledge in the study area. The increase in household size also increases options of respondents to engage in various activities. However, the influence of household size on adoption of external knowledge in adapting to climate change in the study area was not statistically significant ($p>0.05$). The results from this study are contrary to Deressa *et al.* (2009) who discovered that larger households are more likely to adapt to perceived climate change, probably because they are often associated with a higher labour endowment.

In terms of goodness of fit, the logistic regression model (LRM) fitted well to the data by 95% as shown by the significant value of 0.04 for a constant (Table 5). The overall model is also highly significant ($p = 0.001$) with a Chi-square statistics of 37.033 ($df = 6$) implying that the independent variables affected very well the outcome or dependent variable. The –2 log likelihood (-2LL) value of 140.156 indicated that the model fitted the data reasonably well and that the model predicts 72.5% of the responses correctly (i.e., the bigger the percentage correct predictions, the better the model). Also independent variable coefficients with high (significant) Wald statistics indicate superior specification of the variable (Whitehead, 1998). In this case age, education level and income were significant in influencing adoption of external knowledge.

Age, education level and income respond rationally to increase in adoption of external knowledge in the study area. The odds ratio of age of the respondents is 0.96 with a 95% confidence of [0.927, 0.994] and Wald statistics of 5.423 ($df = 1$). This suggests that increase in age is likely to increase the chances of an individual to adopt external knowledge. Similarly the "odds ratio" for education level of the respondent is 0.647 with a 95% confidence interval of [0.491, 3.137] and Wald statistics of 0.210 ($df = 1$). This suggests that those who are educated are almost 4 times more likely to adopt an external knowledge than those who are not educated. Likewise the odds ratio of income 3.949 with a 95% significance level and Wald statistics of 7.634 (df = 1) suggesting that respondents with high income are likely to adopt external knowledge than those with low income. The other independent variables are either insignificantly different from zero or continuous, interpretation of their magnitude has little meaning in logistic regression and thus do not have influence on adoption of external knowledge in adapting to climate change.

Testing of the hypothesis was carried out using Wald statistic (Pampel, 2000; Powers and Xie, 2000). The Wald statistics shown in Table 6 indicate both non-zero and zero values, implying that there are some kind of interactions between the dependent and independent variables. According to Powers and Xie (2000) non-zero values for the Wald statistics indicate presence of relationships between the explanatory variables. It can be observed from the results in Table 6 that three of the independent variables (i.e. age, education level and income) included in the prediction model have non-zero regression coefficients. This implies the existence of a relationship between the independent (socio-economic and demographic) variables and the dependent variable (extent of adoption of external knowledge). Based on these observations, the null hypothesis was rejected in favour of the alternative hypothesis at 5% level of significance.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study has shown that although the local people may not understand the concept of climate change in a scientific context, they can describe the impacts of long term and seasonal variation in rainfall, air temperature, increasing sunshine intensity, drought and floods as indicators of climate change. This implies that the communities in the study area have some local knowledge on climate change. This study indicated that there are several indigenous practices in the area in adapting to climate change including the use of a traditional water storage system 'ndiva', switching from upland cultivation to valley bottoms, use of drought resistant crop varieties, crop diversification and construction of shallow wells. This implies that communities are struggling to adapt to climate change in different ways.

It is concluded that local adaptation to climate change will continue being influenced by both indigenous and externally driven knowledge. Harnessing the potential of indigenous knowledge and its interaction with external knowledge is paramount in building a climate resilient community in the north Pare Mountains. Therefore measures to enhance the indigenous adaptive capacity and its interactions with external knowledge are necessary. Further education on climate change and its impacts is necessary so as to increase the communities' resilience to climate change impacts.

5.2 Recommendations

Based on the findings, this study considers that the following recommendations are desirable and appropriate for strengthening the existing household adaptive capacity to climate change impacts:

(i) Raising awareness on climate change: Since community awareness on climate change and its impacts is very low rising awareness is very critical. Education on climate change and its impacts is important to enhance resilience to climate change impacts

(ii) Improving water availability and irrigation systems; Because of erratic rainfall, drought has been more frequent and of larger magnitude. Water availability has dropped because groundwater recharge is lower as a result of rainfall being confined to fewer days. Possible intervention include introduction of irrigation systems, also restoring the traditional water storage systems called 'ndiva' could help to minimize the problem.

(iii) Off-season cash crop planting: erratic rainfall has reduced maize and other crops production and threatens food security. To combat this off-season, horticultural crops grown under irrigation are highly recommended especially in the lowland area of North Pare Mountains.

(iv) Participating local communities within negotiations on climate change with governments and international organizations in order to create awareness on traditional adaptation and mitigation strategies and expand knowledge on these practices.

5.3 Proposed future research areas

There still exist knowledge gap on some adaptation strategies in these study areas. However, the global problem of climate change is difficult to describe and understand on a local scale especially in communities that are struggling with daily survival. Specific use of traditional and indigenous adaptation practices to climate variability combined with scientific knowledge is a possible way forward to develop and implement strategies and so need be studied further.

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APPENDICES

Appendix 1: A questionnaire for household

SECTION A: IDENTIFICATION VARIABLES

Identification Number	
1. Time the interview starts	
2. Date of interview	
3. Questionnaire/household number	
4. Interviewee 1.Male 2.Female	
5. Village (Area) name	
6. Ward	
7. . Division	
8. . District	
9. Region	
10. Stratum (Highland ,Lowland)	

B. HOUSEHOLD SOCIO-ECONOMIC CHARACTERISTICS

11. Total size of the household ☐

12. Number of adults (≥18 yrs) : Female ☐ Male ☐

13. Wealth category (1 = High; 2 = Medium; 3 = Low) (* as established during PRA ☐

14. Provide the following information about the household members

Household member	Gender	Age	Marital status	Education level	Main occupation	Income/ Wage Salary (Tshs)/per month
	1. Male 2. Female		1. Married 2. Never married 3. Widowed 4. Divorced 5. Separated	1. Primary school 2. Secondary school 3. University level 4. Adult education 5. Never went to school 6 .Others (specify)	1. Agriculture 2. Livestock keeping 3. Employee 4. Others ….	
Respondent						
1.						
2.						
3.						
4.						
5.						

C. CLIMATE CHANGE IMPACTS AND ADAPTATION STRATEGIES

15. Have there been any of the following changes in this area?

1. Rainy season begins early 2. Rainy season begins late 3. Rainy season lasts longer 4. Rainy season compressed 5. Greater intensity of rainfall events 6. More frequent droughts 7.Other (specify……………..

16. Are there more or fewer of these events?

i. Drought; 1. More 2. Fewer

ii. Landslides; 1. More 2. Fewer

iii. Floods; 1. More 2. Fewer

iv. High wind damage to crops/houses; 1. More 2. Fewer

v. Plant and animal pests; 1. More 2. Fewer

vi. Plant and animal diseases 1. More 2. Fewer

22. How have these changes impacted your household? 1. Lost crops 2. Lost livestock 3. Lost water source; 4. More illness 5. Other (specify)…………………………

23. Why do you think these changes are happening? 1……………….2……………3………..

24. What are the ways that this household has adjusted to the changes? 1. Plant before/with 1st rain 2. Irrigate 3. Invest more in soil/ water conservation techniques 4. Cultivate in wet places 5.Move livestock elsewhere for grazing 6. Others (Specify)………………………

25. What do you think has been (in your opinion) impacts of climate change in your area?1……………………………………………2…………………………..3……………

26. How do you cope with the climate change impacts in qn 25?

Climate change impact	Coping strategy

27. How do you think the climate change impacts in qn 25 could be best addressed?………………………………………………………………….

D. INDIGENOUS KNOWLEDGE SYSTEMS PRACTICED AND THE INTERACTIONS.

28. What agronomic practices are indigenous in this area? 1. Shifting cultivation 2. Monoculture cultivation 3.Intercropping 4.Others…………………
29. What is your farm size (ha)……………………..
30. What types of crops did your household grow in the last year? (Mention in the order of priority) 1………………..2……………..3……………4………..5………
31. Among the above- mentioned crops, which one is indigenous to this area? 1…………… 2…………….3……………4………………………..
32. What types of indigenous fruit tree species are planted in this area? 1……………..2……………..3…………4…………
33. What indigenous tree species are planted in your farm? 1………………..2…………3………………..
34. How is the indigenous tree species important to your household? 1. Fruit trees 2.Fuel wood 3.Timber 4. Medicine 5.Others….

E. EXTERNAL KNOWLEDGE SYSTEMS PRACTICED

34. What agronomic practices which have been introduced to this area? 1……………..2…………3……..
35. Who introduced the agronomic practices?................................
36. What do you think were the reasons for the introduction of such practices?………………………..
37. Did you practice the introduced agronomic practices? 1. Yes 2.No
38. If yes, what agronomic practices did you practices? 1……………2………..3……………

39. What happened to the indigenous agronomic practices when new ones were introduced? 1. I practiced indigenous only 2.I practiced exotic only 3. Both indigenous and exotic were practices

40. How can you compare the indigenous practices and the introduced agronomic practices? 1. Indigenous practices are the best 2.Introduced practices are the best 3.No difference

41. Which types of crops were introduced to this area? 1…………..2………3………4…………………………….Others…..…

42. Who introduced the crops? 1. Government 2.Projects 3. NGO 4.Neighbours 5. Others (specify).

43. Did you plant the introduced types of crops? 1. Yes 2.No

44. If no, why………………………..

45. If yes, which one did you plant? 1…………..2……..3………

46. What happened to the indigenous crops in your farm when new crops were introduced? 1. I grew indigenous only 2.I grew exotic only 3. Both indigenous and exotic were grown

47. If you planted introduced the crops did the production improved? 1. Yes 2. No

48. What do you think were the reasons behind the introductions of such types of crops?1. Due to drought 2. Due to floods 3.Shortage of rainfall 4. Others (Specify)

49. In the previous years, what types of crops were you planting when these changes occur? 1………… 2…………….. 3……………4. Others (Specify)

50. How can you compare the indigenous crops and the introduced ones?

    1. Indigenous crops are the best 2.Introduced crops are the best 3.No difference

51. What types of fruit species have been introduced this area? 1……….2…………3……….4.

52 Who introduced the fruit species? 1. Government 2.Projects 3. NGO 4.Neighbours 5. Others (Specify).

53. Did you plant any of the introduced fruit tree species? 1.Yes 2.No

54 If yes, which one did you plant? 1……2……3……4……………

55. If no, why didn't you plant ?..

56. What happened to the indigenous fruit tree species when new ones were introduced? ? 1. I grew indigenous only 2.I grew exotic only 3. Both indigenous and exotic were grown

57. How can you compare the indigenous fruit species and the exotic ones? 1. Indigenous crops are the best 2.Introduced crops are the best 3.No difference

58. What types of exotic tree species have been introduced in this area?1……………..,2………………… 3 ,…………………..4

59. Did you plant any of the introduced exotic tree species? 1.Yes 2.No

60. If yes, which one did you plant in your farm? 1…………2………..3…….4

61. If no, why are the introduced ones not planted in your farm……………………………

62. Who introduced the exotic tree species? 1. Government, 2. Extension officers 3.Projects 4. NGO 5.Neighbours 6. Others (specify).

F. OWNERSHIP OF ASSETS

63. Resource types owned

Resource type	Quantity	Unit value	Total value	Ownership by Gender		
				Male	*Female*	*Both Male*
Livestock						
- Cattle						
- Sheep						
- Goats						
- Donkeys						
- Pigs						
- Chicken						
- Ducks						
- Other (specify)						
Assets						
- Tractor						
- Ox-plough						
- Ox-carts						
- Sprayers						
- Hand-hoes						
- Machetes						
- Sickles						
- Bicycle						
- Land						
- Motor car						
- Other (specify)						

Time the Interview end…………………

THANKS VERY MUCH FOR YOUR PARTICIPATION

Appendix 2: A checklist for group discussion

A. Basic information

1. Village................Hamlet..............district..................4. Region.........
2. What are the impacts of climate change in this area?
3. What are indigenous knowledge adopted adaptation strategies for adapting to climate change impacts in this area?
4. What are external adopted adaptation strategies for adapting to climate change impacts in this area?
5. What are the socio-economic factors influencing adoption of the external knowledge for adapting to climate change impacts in this area?
6. What are the effects of interactions between indigenous and external knowledge for adapting to climate change in this area?

Appendix 3: A checklist for agriculture extension officers

1. Village................Hamlet..............district..................4. Region.........
2. What are general the impacts of climate change in your area?
3. How climate change impacts are affecting agriculture?
4. How the local communities are coping with the climate change impacts?
5. What is the average farm size (ha) of a household in the area?
6. What types of crops are grown in this area?
7. What are the staple food crops grown in the area?
8. What are the indigenous crops grown in the area?
9. Have this area been introduced with any exotic crops?
10. Who introduced the crops?
11. What were the reasons behind the introduced crops?
12. What was the reaction of the local communities towards the introduced crops?
13. What were the reasons for adopting or not adopting the introduced crops?
14. How can you compare the indigenous and exotic crops?
15. What are the indigenous agronomic practices practiced in the area?
16. What are external agronomic practices practiced in the area?
17. Who introduced the agronomic practices?
18. What happened to the indigenous practices after the introduction of external practices?
19. How can you compare the indigenous and external agronomic practices?

Appendix 4: A checklist for forest officers

1. Village...............Hamlet..............district.................4. Region.........
2. What are general the impacts of climate change in your area?
3. How climate change impacts are affecting forest resources?
4. How the local communities are coping with the climate change impacts?
5. What types of indigenous tree species are planted in this area?
6. How the indigenous tree species do is importance to the local communities?
7. What exotic tree species have been introduced in the area?
8. Who introduced the exotic tree species?
9. What were the reasons behind the introduced tree species?
10. What was the reaction of the local communities towards the introduced tree species?
11. What were the reasons for adopting or not adopting the introduced tree species?
12. How can you compare the indigenous and exotic tree species?
13. What are the indigenous fruit trees species planted in the area?
14. What are exotic fruit trees species planted in the area?
15. Who introduced the exotic fruit tree species in the area?
16. What happened to the indigenous fruit tree species after the introduction of exotic ones?
17. How can you compare the indigenous and exotic fruit tree species?

Appendix 5: A checklist for livestock officers and community development officers

1. Village...............Hamlet..............district.................4. Region.........
2. What are the general impacts of climate change in this area?
3. How the climate change impacts are affects the livestock in the area?
4. What indigenous knowledge systems practiced in adapting to climate change impacts in this area?
5. What external knowledge systems practiced in adapting to climate change impacts in this area?
6. What are the socio-economic factors influencing adoption of the external knowledge for adapting to climate change impacts in this area?
7. What are the effects of interactions between indigenous and external knowledge for adapting to climate change in this area?

Appendix 6: PRA Methods

1. Participatory Resource Mapping where community members will draw maps of their villages/location indicating areas for:
    - Settlement, home gardens, farming, livestock keeping, water collection and fuel collection
2. Seasonal calendars showing all year round activities related with adaptation to climate change e.g construction of water dams, planting of trees, etc.
3. Daily activity profile can also be done to capture and differentiate daily routine activities between men and women.
4. Pair-wise ranking to score and rank the various indigenous and external knowledge systems practices in the area and the socio-economic factors influencing adoption of external knowledge.
5. Historical profiles and trend analysis to obtain:
    - Important historical events which might have an effect on knowledge on the interaction between indigenous and external knowledge systems in influencing adaptation to climate change impacts in the area.
    - The indigenous knowledge systems practiced in the area
    - The external knowledge system practiced in the area.