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Climate Change Adaptation for Smallholder Farmers in Rural Communities: the Case of Mkomazi Sub-Catchment, Tanzania

Dissertation

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ABSTRACT

Today, climate change is a global challenge that attracts much attention and debates at all levels. The current body of knowledge informs that human development quest has increased concentration of GHGs into the atmosphere thereby causing global warming. Most of the initial efforts to address climate change concentrated on mitigation. However, during the last decade, calls for implementing adaptation actions to deal with the impacts being experienced increased. Thus, adaptation is now a priority for developing countries particularly LDCs. Agriculture is an important sector worldwide but nowhere other than in the developing world is it the most crucial aspect to deal with. However, this sector is one of the most vulnerable and sensitive to change and variability of the climate. Significance of smallholder agriculture on livelihoods of a majority poor in the developing world and its vulnerability to impacts of climate change and variability motivated this study.

Changes in farming practices in the Mkomazi sub-catchment, Tanzania (for example, shifts in crop production areas, crop growing patterns and type of crops grown most) were reported and observed. However, the real factors motivating such changes in the area remained unknown. Thus, the objective of this research was to explore, analyze and explain factors that motivate smallholder farmers in Mkomazi sub-catchment to change their farming practices overtime. It also sought to analyze socio-economic implications of the changes and recommend appropriate policy and strategic actions to assist smallholder farmers adapt and enhance their resilience. Using a mixed research approach and five data collection methods (household questionnaire survey, experts' interviews, smallholder farmers FGD, rainfall and temperature records as well as stakeholder validation workshop), the study attempted to answer the following five research questions: Are there any possible changes in the local climate and how are they perceived and explained by smallholder farmers? Are there any changes in farming practices in the area? What factors motivate decisions to change farming practice? What are socio-economic implications of the changes in the local climate at household and community level? What are policy and strategic interventions to support smallholder farmers to adapt and enhance their long-term resilience?

Results from the study revealed that the state of climate in the area is changing; rainfall shows a decreasing trend while temperature indicates an increasing trend. Smallholder farmers have also been changing their farming practices overtime. These farmers have introduced new crops and crop varieties; adopted crops and crop varieties, which are shorter cycle, drought tolerant and marketable; and they have also stopped cultivation of some crops as well as crop varieties. Smallholder farmers are engaging in various economic activities to diversify their income sources. The changes were motivated by multiple factors but the leading included changes in the climate, markets and high living costs and demand for personal and household needs. Change and variability of climate is the most dominant factor.

Changes in the local climate and subsequent changes in farming practices had mostly negative implications at household and community levels. They include water shortage, decrease in income, food insecurity, threats to human health, social conflicts, increase in deforestation and forest degradation, and deterioration of life quality. Farmers recommended various interventions to support them to adapt in the following thematic areas: research and development to enhance resilience to changes in rainfall and temperature regimes; strengthening sustainable management of water resources to deal with increasing dry conditions and unpredictability of rainfall; and support diversification of household incomes through less climate sensitive income options. Other recommended aspects include enhancing access to incentives, subsidies and introducing crop insurance to farmers; and enhancing

farmers' adaptive capacity through provision of technological and technical support like adaptation technologies, early warnings, education and training.

Using a combination of three categories of data (agro-ecological, social and meteorological) from five sources (questionnaire, interviews, FGD, climate records and a workshop), the study successfully brings up multiple considerations taken into account by smallholder farmers to make farm production decisions; and heterogeneity of crops and crop varieties for four villages within similar agro-ecological characteristics. The study recommends use of incentives mechanisms such as REDD+ and PES in addressing problems of unsustainable resource use while increasing availability of ecosystem goods and services like water. It also recommends a multi-stakeholders approach in addressing issues of awareness creation and adaptation education to smallholder farmers; availability of inputs, markets, and institutional capacity building. The study emphasizes on use of available opportunities at all levels to support smallholder farmers to adapt and enhance their long term resilience.

Finally, the study recommends a scientific investigation to model climate variables against crop production to clearly identify the extent to which changes in the local climate economically affect smallholder farmers' production and incomes. In addition, it is important to identify the contribution of each of the several economic activities and income sources farmers depend on, i.e. crop production, remittance, charcoal making, animal keeping, small-scale fishing, small business, tourism, selling labour, etc. These two studies will fill the gaps, which the current study did not manage to cover.

ZUSAMMENFASSUNG

Der Klimawandel ist eine globale Herausforderung, der heutzutage viel Aufmerksamkeit zukommt und die auf allen Ebenen diskutiert wird. Nach dem Stand der heutigen Wissenschaft hat das menschliche Streben nach Entwicklung die Konzentration an Treibhausgasen in der Atmosphäre erhöht und dadurch globale Erwärmung verursacht. Die meisten anfänglichen Bemühungen gegen den Klimawandel konzentrierten sich auf Vermeidung, jedoch stiegen im letzten Jahrzehnt die Verlange nach Anpassungsmaßnahmen an die bereits erlebten Auswirkungen des Klimawandels. Demnach stellt Klimaanpassung heute eine Priorität für Entwicklungsländer dar, besonders für die am wenigsten entwickelten Länder. Landwirtschaft ist weltweit ein wichtiger Sektor, aber eine Auseinandersetzung mit dem Thema ist vor allem in den Entwicklungsländern von hoher Bedeutung. Der Sektor ist einer der empfindlichsten und vulnerabelsten Sektoren in Hinblick auf Klimaveränderungen und Klimavariabilität. Die Bedeutung der kleinbäuerlichen Landwirtschaft für die große Menge an Armen in den Entwicklungsländern und ihre Vulnerabilität für Klimaveränderungen und Klimavariabilität haben diese Studie motiviert.

Veränderungen in den Bewirtschaftungsmethoden (beispielsweise Verschiebung von Pflanzenanbaugebieten, Anbaumethoden und den am meisten kultivierten Pflanzen) wurden im Mkomazi Teilflussgebiet, Tansania, berichtet und beobachtet. Jedoch blieben die für diese Veränderungen ursächlichen Faktoren unbekannt. Ziel dieser Studie war es somit, die Gründe zu erforschen, zu analysieren und zu erklären, die die Kleinbauern im Mkomazi Teilflussgebiet motivierten, ihre Bewirtschaftungsmethoden zu ändern. Des Weiteren sollten die sozio-ökonomischen Implikationen der Veränderungen analysiert werden und daraus politisch-strategische Handlungsempfehlungen abgeleitet werden, die die Bauern bei der Erhöhung ihrer Resilienz unterstützen. Mit einem gemischten Forschungsansatz und fünf verschiedenen Datenerhebungsmethoden (Haushaltsbefragung, Experteninterviews, Gruppendiskussionen mit Kleinbauern, Regen- und Temperaturaufzeichnungen und Stakeholder Workshops) versuchte die Studie die folgenden fünf Forschungsfragen zu beantworten: Gibt es mögliche Veränderungen des lokalen Klimas und wie werden diese von den Kleinbauern wahrgenommen und erklärt? Gibt es Veränderungen in den Bewirtschaftungsmethoden in dem Gebiet? Welche Faktoren sind entscheidend für die Entscheidung, Bewirtschaftungsmethoden zu verändern? Was sind die sozio-ökonomischen Implikationen der Veränderungen des lokalen Klimas für die Haushalte und die Kommunen? Welche sind politische und strategische Interventionen, um die Kleinbauern bei der Anpassung an die Klimaveränderungen zu unterstützen und ihre Resilienz zu erhöhen?

Resultate der Studie zeigen eine Veränderung des Klimas in dem Gebiet: die Niederschläge nehmen ab während die Temperaturen steigen. Die Kleinbauern haben ebenfalls ihre Bewirtschaftungsmethoden über die Zeit angepasst. Es wurden neue Pflanzenarten und Pflanzenvariationen eingeführt; angepasste Pflanzen und Pflanzenvariationen in der Form kürzerer Zyklen mit höherer Dürretoleranz und guter Verkäuflichkeit; der Anbau einiger Pflanzen und Pflanzenvariationen wurde gestoppt. Kleinbauern sind in verschiedene ökonomische Aktivitäten involviert um ihre Einkommensquellen zu diversifizieren. Die Veränderungen wurden durch multiple Faktoren bedingt, doch zu den wichtigsten zählen Klimaveränderungen, Veränderungen der Märkte und hohe Lebenshaltungskosten und Nachfrage nach persönlichem Bedarf und Haushaltsbedarfen. Klimaveränderung und Klimavariabilität ist hier der dominierende Faktor.

Veränderungen des lokalen Klimas und dementsprechende Veränderungen der Bewirtschaftungsmethoden hatten vor allem negative Implikationen für die Haushalte und Kommunen. Dazu zählen Wasserknappheit, Einkommensverringerung,

Ernährungsunsicherheit, Gefahren für die Gesundheit, soziale Konflikte, zunehmende Entwaldung und Waldschädigung und Verschlechterung der Lebensqualität. Die Bauern empfahlen verschiedene Interventionsmöglichkeiten, sie in den folgenden Thematiken zu unterstützen: Forschung und Entwicklung zur Erhöhung der Resilienz gegenüber sich verändernder Niederschlags- und Temperaturmuster; Stärkung von nachhaltigem Wasserressourcenmanagement zur Bewältigung von trockenen Bedingungen und der Unvorhersagbarkeit von Regen; und Unterstützung bei der Diversifizierung von Haushaltseinkommen durch Ergänzung um weniger klimasensitive Einkommensoptionen. Weitere Empfehlungen betreffen eine Verbesserung von Anreizsystemen, Subventionen und Ernteversicherungen und die Verbesserung der Anpassungsfähigkeit von Kleinbauern durch Bereitstellung von technologischer und technischer Unterstützung wie Anpassungstechnologien, Frühwarnsysteme, Bildung und Training.

Durch eine Kombination von drei Datenkategorien (agrarökologische, soziale und meteorologische) aus fünf Quellen (Fragebogen, Interviews, Gruppendiskussionen, Klimaaufzeichnungen und Workshops) kann die Studie erfolgreich die multiplen Überlegungen aufzeigen, die den Entscheidungen der Kleinbauern bezüglich der Produktionsmethoden zugrunde liegen und die Heterogenität von Pflanzen und Pflanzenvariationen für vier Dörfer mit ähnlichen agrarökologischen Charakteristika. Die Studie empfiehlt die Nutzung von Anreizmechanismen wie REDD+ und PES um die Probleme einer nicht-nachhaltigem Ressourcennutzung anzugehen und gleichzeitig die Verfügbarkeit von ökologischen Gütern und Dienstleistungen zu erhöhen. Sie empfiehlt außerdem einen Multi-Stakeholder Ansatz hinsichtlich der Sensibilisierungsmaßnahmen und Anpassungstrainings für die Kleinbauern und die Verfügbarkeit von Input, Märkten und institutionellem Capacity Building. Die Studie unterstreicht die Notwendigkeit der Nutzung der verfügbaren Optionen auf allen Ebenen um die Kleinbauern bei ihrer Anpassung und Erhörung der Resilienz zu unterstützen.

Am Ende empfiehlt die Studie weitergehende wissenschaftliche Forschung um klimatische Variablen mit dem Pflanzenanbau zu modellieren. Damit soll genau bestimmt werden können, in welchem Ausmaß Veränderungen des lokalen Klimas die Produktion und Einkommen der Kleinbauern in ökonomischer Hinsicht beeinflussen. Zusätzlich dazu ist es wichtig, den Beitrag der einzelnen ökonomischen Aktivitäten und Einkommensquellen zu bestimmen, von denen die Kleinbauern abhängen: Pflanzenanbau, Geldüberweisung, Holzkohleproduktion, Tierhaltung, Fischen, kleine Geschäfte, Tourismus, Verkauf von Arbeitskraft, etc. Diese beiden Studien könnten die Lücken füllen, die mit der gegenwärtigen Studie nicht abgedeckt werden konnten.

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LIST OF ABBREVIATIONS

AF	Adaptation Fund
AfDB	African Development Bank
AR4	Fourth Assessment Report of the Intergovernmental Panel on Climate Change
AU	African Union
CO_2	Carbon dioxide
DALDO	District Agricultural and Livestock Officer
DPG-E	Donor Partners Group on Environment
ENSO	El Niño Southern Oscillation
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GIM	Global Impact Model
GCMs	General Circulation Models
GEF	Global Environment Facility
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HIV/AIDS	Human Immunodeficiency Virus infection / Acquired Immunodeficiency Syndrome
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IPCC TAR	Third Assessment Report of the Intergovernmental Panel on Climate Change
ITCZ	Inter-tropical Convergence Zone
IUCN	International Union for the Conservation of Nature
LDC	Least Developed Countries
LDC-F	Least Developed Countries Fund
MAXQDA	Qualitative Data Analysis Software
MGDs	Millennium Development Goals
NAPAs	National Adaptation Programmes of Action
OAU	Organization of African Unity
PBWB	Pangani Basin Water Board
SACCOs	Savings and Credit Organizations
SCCF	Special Climate Change Fund
SPSS	Statistical Package for Social Sciences
TANESCO	Tanzania Electric Supplies Company
TMA	Tanzania Meteorological Agency
UNAIDS	United Nations Programme on HIV/AIDS
UNCTAD	United Nations Conference on Trade and Development
UNDP-HDR	United Nations Development Programme-Human Development Report
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UN-Habitat	United Nations Human Settlements Programme
UNO	United Nations Organisation
UNIDO	United Nations Industrial Development Organization
UNWTO	World Tourism Organization
URT	United Republic of Tanzania
WHO	World Health Organisation
WMO	World Meteorological Organisation

APPENDICES

CHAPTER ONE: THE PROBLEM AND ITS CONTEXT

1.1. Introduction and Background Information

Today, climate change is a familiar concept to both academic and scientific communities around the world. This is because during the past decade, scientists finally, to a large extent, concluded that warming of the global climate system is now unequivocal and it is human induced (IPCC, 2007c). While this looks to be true at least due to available scientific findings, climate change is a concept that in recent decades generated many and long debates between and among scientists, academicians, policy makers and negotiators. Notwithstanding concrete scientific findings and indisputable signs of the warming happening on earth, some people have different opinions and discrepancies regarding climate change thereby raising debates particularly on different global temperature records, and over the exact magnitude including possible recent changes, warming rates as well as their future impacts on socio-economic and natural systems (Foster and Rahmstorf, 2011; Heath, and Peterson and Baringer, 2009). But with the release of the AR4 of the IPCC in 2007 and other similar scientific works (World Bank, 2012), now there is already enough scientific information to lead to enough understanding by the international community on the real cause of the problem, that is, deposition of huge quantities of anthropogenic produced global greenhouse gases (GHGs). In addition, the available knowledge also broadens understanding on the magnitude of climate change problem; severity as well as its predictable and unpredictable impacts (IPCC, 2007c; Al Gore, 2007; Leiserowitz, 2012; Foster and Rahmstorf, 2011). This understanding, in a way, has led to some consensus particularly on the fact that the global climate system is changing fast as a result of anthropogenic influence (Houghton, 2009; McMullen, 2009; Stern, 2006; Al Gore, 2008; Al Gore, 2007; UNDP-HDR, 2008; IPCC, 2007c; Leiserowitz, 2012).

Over 100 years of human quest for socio-economic development, including industrial and other socio-economic activities, has contributed to over-deposition into the atmosphere and hence, increased concentration of Carbon dioxide (CO_2), the key GHG with high radioactive forcing causing global warming, and other GHGs (IPCC, 2007c; Haughton, 2009; WMO, 2009; 2012). The GHG increased from about 280 parts per million (ppm) in the pre-industrial era (before 1750 AD) to around 390.9 ppm in 2011, being 140 percent increase during that period (WMO, 2012; Al Gore, 2006; IPCC, 2007c; UNEP/GRID-Arendal, 2009; UNEP, 2012a). For instance, in 1950, Carbon dioxide (CO_2) concentration in the atmosphere was 315 ppm but in 2007 had increased to 384ppm, contributing about 75 percent of the total human induced greenhouse gases, and higher than it had been in the past 650,000 years (IPCC, 2007a; Green facts, 2007; Al Gore, 2007; WMO, 2009). This scientific understanding confirms that global greenhouse gas emissions have grown since pre-industrial times, with an increase of 70 percent between 1970 and 2004. During this period (1970-2004), CO_2 emission grew by 80 percent and represented 77 percent of the total GHG emission in 2004. The following quote from the most recent WMO publication demonstrates the reality:

> *"The latest analysis of observations from the WMO Global Atmosphere Watch (GAW) Programme shows that the globally averaged mole fractions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) reached new highs in 2012, with CO_2 at 393.1±0.1 ppm, CH_4 at 1819±1 ppb and N_2O at 325.1±0.1 ppb. These values constitute, respectively, 141%, 260% and 120% of pre-industrial (before 1750) levels. The atmospheric increase of CO_2 from 2011 to 2012 is higher than the average growth rate over the past 10 year"* (WMO, 2013).

Such increasing concentration of GHGs leads to global warming (Leiserowitz, 2012). Hence, it influences change in the global climate system.

As a result, the global surface temperature is believed to have an average increase of 0.74 Degrees Celsius (^oC) in the past century and most of the warming occurring in the past three decades with eleven of twelve warmest years on record happening since 1995 (IPCC, 2007c; Haughton, 2009; UNEP/GRID-Arendal, 2009). With such global temperature increase during this period, there has been a decrease in the extent of snow and ice cover (IPCC, 2007c) and a rise in average sea level as well as the heat content of oceans. Various changes in weather patterns have also been observed (UNDP-HDR, 2008). AR4 predicts that the global average surface temperature is likely to rise by 1.8^oC - 4.0^oC by 2100. This is predicted to lead to sea level rise of 30-60 centimetres (cm) and increase climate variability almost everywhere (IPCC, 2007c; Al Gore, 2007). Details on the current impacts of climate change as well the predictions are presented in later chapters.

1.2. Climate Change Adaptation: A Discourse

The concept of adaptation is not really new in many fields. Even in the climate context, it remains to be a common practice that has been there since time immemorial (Burton, *et. al*., 2006; Nelson, *et. al*., 2007; Smit, *et. al*., 1999; Smithers and Smit, 1997). Human beings are among the most adaptable animal species on earth (Burton et al., 2006). They have ever since adapted to changes in their environment and harsh climatic conditions (Burton et al., 2006; Hill, 2008; Lamb, 2005). It is this form of adaptation that has given rise to several inventions in terms of human settlements, agricultural production practices as well as different human lifestyles from time to time. However, the anthropogenic induced climate change challenge experienced by the world today is probably bigger than any other change human beings have ever experienced in history. With climate change, adaptation has gained new prominence and probably a new meaning. The major difference in terms of the ordinary adaptation process commonly known and undertaken by human beings over centuries with one related to climate change impacts is mostly the level and scale involved. The current climate change impacts threaten to affect almost every sphere of human life across all sectors such as (Pittock and Jones, 2000; Adger, *et. al*., 2003) agriculture, human settlements, physical infrastructures, water resources, ecosystems and biodiversity, and the economy at large.

1.2.1 Why adaptation now?

It is very well known that from inception of the climate change process under the UNFCCC, mitigation was considered a main policy option to address the challenge. Even in climate change research adaptation did not receive equal attention like mitigation (Nyong, *et. al*., 2007; Paavola and Adger, 2006). However, in recent years, adaptation has emerged as a strong area of interest, not only for climate change research (Van Aalst, *et. al*., 2008; Smit, *et. al*., 1999) but also as an important policy response to impacts of climate change alongside mitigation. This was after the international and scientific community realised that mitigation alone cannot address climate change and hence, there was need to treat adaptation in equal footing with mitigation (Hill, 2008; Burton, *et. al*., 2006). To specifically point out the case, even a few research works that have been undertaken particularly in Africa, for example, (Grothmann and Patt, 2005; Campbell, 2009; Below, *et. al*., 2012; ACCCA, 2010) had focus on smallholder farmers' local level adaptation, which this research focused on. One may ask, 'why this is the case? Why, in recent years, adaptation has taken stride to become so important in the context of climate change?' Basically, there are many and obvious reasons but four are key and notable, that include the following:

The first obvious reason is that there are already vivid impacts of climate change and millions of people, particularly in developing countries, especially Africa and the rest of the Least Developed Countries (LDCs) are suffering (IPCC, 2007e). Thus, adaptation is not only an option but also a necessity so that those who are experiencing these impacts can be supported to survive. In addition, the impacts are not only vivid in the human system and livelihoods but also on the natural systems. In fact, evidences of climate change impacts are believed to be the strongest and more comprehensive for natural systems than for the human system (IPCC, 2014). Therefore, the pattern threatens ability and capacity of ecosystems to support people's livelihoods and maintain existence of species of flora and fauna. It is also true that much as the international community has over decades been making some efforts to address climate change through mitigation especially after enforcing the Kyoto Protocol, developed countries have all along failed to meet their emission reduction targets under the First Commitment Period of the Protocol (van Asselt, *et. al*., 2014; UNEP, 2010b; 2012b) and have not been ready to commit themselves to higher targets in line with available scientific information. Therefore, it means that adaptation should be given high priority since the impacts of climate change particularly to poor countries are not only expected but also taking their tall and are expected to increase. The following quote exemplifies this case:

> *"More than twenty years of international cooperation to tackle the problem of climate change have seemingly not produced the desired results in terms of climate stabilization. Even though there is a solid scientific basis for international action to mitigate the causes and impacts of climate change, the gap between pledged emission reductions and the internationally agreed goal to keep temperature increases below 2°C relative to pre-industrial times is still widening "* (van Asselt, *et. al*., 2014).

It is also important to note that much as efforts to reduce emissions continue, the amount of GHGs already deposited in the atmosphere is huge and implies that even if emissions are brought to 0 percent today, the impacts of climate change will continue (Solomon, *et. al*., 2009). Therefore, adaptation is a very important and unavoidable option to support those who are to suffer from the impacts. To developing countries, adaptation is an issue of equity and fairness by the developed countries (Thomas and Twyman, 2005). This is because developed countries bear an historical responsibility of climate change through long-time unchecked emissions especially from industrialization and energy use (Paavola and Adger, 2006; UNFCCC, 1992). Again, it is undisputable that impacts of climate change are felt locally (Paavola and Adger, 2006) and are not evenly distributed between those who have high levels of adaptive capacity due to their level of developments and technologies and who are historically responsible, against those whose contributions are negligible, and have very low adaptive capacity. The painful fact is that the latter are the most vulnerable (Paavola and Adger, 2006; Commission on Climate Change and Development, 2009; Global Humanitarian Forum, 2009; World Bank, 2012; Burton, *et. al*., 2006; Ayers and Huq, 2010; Dodman, Ayers and Huq, 2009). The quote below significantly summarises this fact:

> *"The countries least responsible for global warming-the poorest developing nations-will be the most affected by its consequences. In the cruel calculus of disasters, the poorer the community, the greater its vulnerability to natural hazards and the more difficult its recovery"* Margareta Wahlström (Global Humanitarian Forum, 2009).

This paradox leaves developing countries highly vulnerable due to several factors. They are located in lower latitudes areas where impacts of the changing climate are further pronounced (Mendelsohn, 2006). A larger part of their economies is derived from highly climate sensitive

sectors and natural environment (Adger et al., 2003; Nkomo et al., 2006). Such economies are mostly weak and poor compared to those in the West; and as a result of their poor economies including low levels of technologies (Nkomo et al., 2006), they have poor institutional capacity, which is one of important components of adaptive capacity. Therefore, for this part of the world, adaptation is a matter of showing integrity and justice for contributing in supporting those suffering as a result of others' actions (Paavola and Adger, 2006). Adaptation ensures good support in terms of enhancing long-term resilience to impacts of climate change and variability.

1.2.2 Challenges of adaptation

Despite being a clear policy option in addressing climate change, adaptation to the current and anticipated impacts will not be an easy task because there are various challenges standing on its way. For example, financing climate change adaptation remains a major challenge for developing countries, whose economies and livelihoods are so much vulnerable to climate change impacts, and the international community through the negotiation processes within the context of the UNFCCC. On one hand, developing countries consider adaptation as their priority due to being the most vulnerable of all parts in the world. However, there are many development priorities, which require financial investment such that adaptation is bringing an additional burden to the already stressed economies. On the other hand, the international community has not been able to ensure predictable and sustainable adaptation funding sources for developing countries particularly the LDCs. In addition, since the inception of climate change adaptation in the UNFCCC process, funding for adaptation has all along remained far less than the actual adaptation needs (Ayers and Huq, 2010). Complicating the issue further, even the exact adaptation needs have remained debatable. Many institutions and organizations, for example, the World Bank, UNFCCC Secretariat, UNDP and AfDB, each one has come up with some figures indicating estimates at different times. Table 1.1 summarizes examples of some adaptation needs estimates by different institutions.

Table 1.1 Some Adaptation Cost Estimates

Study	Methodology (decision rule)	Time period	Region	Sectors	Estimate (US$ billion/ annum)
World Bank (2006)	Top-down, investment flow mark-up	Short-term	Developing countries	All	9 – 41
Stern Review (2007)	Top-down, investment flow mark-up	Short-term	Developing countries	All	4 – 37
UNDP HDR (2007)	Top-down, investment flow mark-up & additional adaptation estimates	2015	Developing countries	All	86 – 109
Oxfam (2007)	Top-down, investment flow mark-up & additional adaptation estimates	Short-term	Developing countries	All	50 +
UNFCCC (2007)	Various, sector specific	2030	Developing countries	Agriculture, water,	28 – 67

				health, coastal zones, infrastructure	
UNFCCC (2007)	Various, sector specific	2030	Global	Agriculture, water, health, coastal zones, infrastructure	44 – 166
UNDP-HDR 2007/08 (2007)		2010-2015	Developing countries	All	86–109

Source: Agrawala and Fankhauser (2008).

As time goes on, new estimates come out sometimes from the same institution reviewing former estimates. This is positive because as more information becomes available, the estimates change. The World Bank through its study on the Economics of Adaptation to Climate Change estimates adaptation cost between 2010 and 2050 to a range of United States of America dollars (US$) 70 billion to US$100 billion a year (World Bank, 2010a). AfDB (2011) through its study on the Cost of Adaptation to Climate Change in Africa concludes that adaptation costs in Africa is at the tune of US$ 20-30 billion per annum, over and above the normal ODA, over the next 10 to 20 years. Watkiss and colleagues (2010) in a study called ADAPTCost Project estimate short-term adaptation cost for Africa from 2010-2015 to range from $5-30 billion for each year. While these estimates are important in making advancing a strong case for availability of adequate adaptation funds, planning and budgeting, they have not been consensually agreed and that is where the challenge emanates. Together, this makes adaptation financing remain one of the striking challenges in addressing climate change at the moment.

Adaptation still faces uncertainties in terms of information and database particularly in the developing world (Conway, *et. al*., 2011). Much as scientists using models have been able to project the expected change as well as the impacts, these projections are still mainly based on General Circulation Models. The need for down-scaling the predictions to regional level context especially for Africa, is vital for effective adaptation (MOHC, 2007) but remains a challenge. In addition, climate by itself is a highly complex and unpredictable factor in any projection (Dessai *et al.,* 2009). What is known and anticipated today may not necessarily remain the same. The expected changes are unknown and how the climate is going to behave in the next 20 or 30 years is difficult to precisely predict (Houghton, 2009).

There can also be confusions in terms of drawing a very clear line between what exactly entails adaptation needs and what entails normal development interventions (Klein *et al.,* 2007); and clearly differentiating between climate change vulnerability and normal variability. That is where the idea of mainstreaming climate change adaptation into national and sub-national development plans emanated (Klein *et al.,* 2007). Again, this is one of the challenges especially in regions where information and data gaps, like in Africa, are very high (Ayers and Huq, 2008).

Notwithstanding the fact that now it is high up in the climate change agenda; knowledge level regarding climate change adaptation in some of the regions remains low. In addition,

conceptualization of key issues like adaptation, capacity to adapt and vulnerability level require highly elaborate work (Below, *et. al.*, 2012) to reflect the local contexts of an exposure unit or system in question. Except for the natural adaptation, which normally takes place in natural systems, most adaptation actions require decision-making. However, the extent to which decisions are well informed and rational ones remains questionable because much as scientific projections help to provide some view of what will happen in future, many uncertainties in the area of knowledge exist as a result of the inability of human being to be exactly sure of what will happen both in the climate system, human and the social system as well as the specific timeframe, for example, the next 50 to 100 years (Tompkins and Adger, 2005; Scheraga and Grambsch, 1998). Therefore, making informed adaptation decision is complicated (Fankhauser and Tol, 1997) as well. This makes it very difficult to anticipate the impacts, their magnitude, spatial scope, duration and many other aspects, which would otherwise help in planning as well as executing adaptation actions (Burton et al., 2006). If making adaptation decisions is such an uncertain issue at a policy level, when it comes to the smallholder farmers' level the uncertainty increases much further because there are more perceptions, assumptions and probabilities rather than scientific facts and modeling. However, one fact stands that climate change is real and the impacts are evident and so the need to take actions cannot be overemphasized. Therefore, with all the uncertainties, anticipatory adaptation and flexibilities are imperative in supporting adaptation actions (Fankhauser, *et. al*., 1997; Smit, *et. al*., 1999) particularly to the smallholder farmers' level in the developing world. All these pose a great challenge for scientists, planners and policy as well as decision-makers on adaptation.

1.3. Motivation for the Study

Climate plays a significant role in existence and well-being of both the socio-economic and the natural/ecological systems worldwide (Ozor, *et. al.*, 2012). This is the reason variations in climatic conditions among regions have given rise to variations in almost everything from the type of plant and animal species, ecosystems, soils characteristics and even socio-economic activities and livelihoods options. This implies that changes in climatic conditions necessitate changes in form of adaptation, for both social-economic as well as the natural systems (Ozor, *et. al.*, 2012).

Agriculture (both crop production and animal husbandry), in its many forms, is an extremely essential economic sector globally. Through this sector, billions of people are ensured of their food demands, employment and livelihoods (IAASTD, 2009; Howden, *et. al*., 2007). However, it is a greatly important economic activity for the developing countries where it is believed to provide livelihoods for around 70 percent the rural poor (*ibid*.) About 5 million hectares of land, globally, are estimated to be under use through agriculture with crop production occupying 1.5 million hectares and animal husbandry occupying about 3.5 million hectares globally (Howden, *et. al*., 2007). The following quote justifies further why this sector is important to people's day-to-day life on earth:

> *"Agriculture accounts for a major part of the livelihood of 40% of the world's population and occupies 40% of total land area; 90% of farms worldwide have a size of less than 2 hectares"* (pg. 2, IAASTD, 2009).

Smallholder farming forms a greater majority of the farming community worldwide (IFAD, 2011). Smallholder farmers are cultivators, mostly in rural areas of developing countries practicing sedentary, intensive and diversified agricultural activities on relatively small farms, using family labour with little or sometimes no modern inputs and the farming is mostly rain-

fed (Arias et al., 2013; Morton, 2007). The main aim is for household consumption but little produce can be sold to support household on other pressing needs. The World Bank (2007) estimates that over 1.5 billion people, worldwide, live in smallholder households in rural areas where their livelihoods depend on smallholder farming activities. Therefore, it implies that smallholder agriculture is a life blood of around over a billion people worldwide. On the other hand, it is estimated that around $^{4}/_{5th}$ of the developing world's food comes from about $^{1}/_{2}$ a billion small farms (FAO, 2011), which are home to around 430 million households with almost two billion persons in the entire developing part of the world (Wiggins and Keats, 2013).

This form of agricultural activity has immense contribution globally and nationally on food security, employment, Gross Domestic Product (GDP), source of raw materials and much more (Arias, *et. al*., 2013; Fairtrade, 2013; Altieri, *et. al*., 2012). Altieri and colleagues (2012), for example, provide figures depicting the extent to which this form of agriculture contributes to a large number of the world population as well as the world economy. The examples include: Latin America where 16 million smallholder farmers' production units have a contribution of around 41 percent of agricultural output for domestic consumption in the entire region and are responsible for 51 percent of maize, 77 percent of beans, and 61 percent of potatoes of the total production for the region. On the other hand, in Africa, there are around 33 million small farms being about 80 percent of all farms in the region. Therefore, smallholder farmers are the backbone of rural economies particularly in the developing world and contribute significantly to both food production and the economy in totality.

Agriculture, in all its forms, worldwide is highly vulnerable and extremely sensitive to climate change and variability (Howden, *et. al*., 2007). However, smallholder farming is compounded by many challenges including poverty and decreasing land due to other expanding land uses. In addition, the nature of smallholder farming makes it most vulnerable to changes and variability in the climate (IFAD, 2011). Details on features that make it the most vulnerable are given in the next Chapter. However, it should be noted that smallholder farming is believed to be the most vulnerable form of agriculture to climate change due to its inherent features, mainly dependency on rainfall and natural conditions in general (IPCC, 2007e). The challenges and vulnerability facing smallholder farming in developing countries amidst climate and other environmental changes today are what really motivated undertaking this study.

The major desire and quest is to contribute to efforts of supporting vulnerable smallholder farmers and communities to adapt to climate change impacts and enhance their long-term resilience through measures such as awareness creation on climate change and its impacts, challenges and opportunities; stimulating strategic adaptation actions for the smallholder farmers through governmental, Intergovernmental and non-governmental actors in developing countries as a result of identifying the real situation faced by farmers. In addition, to recommend possible policy and strategic options to support smallholder farmers in adaptation; and stimulate further research to support informed policy decisions in this area, taking Mkomazi in Tanzania as a case.

1.4. Statement of the Problem

Developing countries have for many decades, after the colonial era, been struggling to develop and reduce poverty. Through the Millennium Declaration in 2000, 189 developing countries agreed and committed themselves to work towards halving extreme poverty by 2015 (UNO, 2000). Encouraged by support commitments made by the developed world, bilaterally and multilaterally, developing countries committed themselves to work towards achieving that

broad goal (AfDB, *et. al*., 2007; UNO, 2000) in the name of MGDs. However, such efforts and commitments were made at the time climate change had started being consensually recognized as a global challenge of this century (Vincent, 2007) threatening to even deepen poverty further (Ahmed, *et. al*., 2009) especially because poor countries and communities are also the most vulnerable and will suffer most with the impacts of climate change.

Climate change impacts are, and still will be, more detrimental to developing countries, with poor and economically disadvantaged communities, groups and individuals (IPCC, 2007e; AfDB *et. al*., 2007). Threats posed by climate change impacts on access to water, good human and animal health, infrastructures, human settlements, food production and food security as well as to economies of poor countries and people in Africa, Asia and Latin America cannot be overemphasized and are well documented by many scholarly works (for example, IPCC, 2007e; AfDB, *et. al*., 2007). Such threats have consequences in efforts to reduce poverty while poverty by itself undermines the ability of the poor to adapt.

Adaptation is a key characteristic feature for both plants and animals. It is a feature that has made it possible for survival of species alongside harsh climatic conditions and changes as well as other environmental changes (Burton, *et. al*., 2006; Hill, 2008; Lamb, 2005). It means that species, societies, communities and individuals taking into account their specific environments and climatic conditions, at one time or another, they had to transform so as to cope and adapt to stresses, mostly related to the climate or the environment for centuries, and this is well documented also (for example, O'Connor and Kiker, 2004). However, climate change brings with it new challenges that require new interventions to support adaptation. It is amidst those impacts and vulnerabilities the need for adaptation arises and is strongly justified (Hill, 2008; Paavola and Adger, 2006; AfDB, *et. al*., 2007) through a number of reasons for countries, communities, individuals and systems that are already and will be the most vulnerable (ref. Section 1.2.2).

Within developing countries, African region is believed to be most vulnerable to climate change and variability, with some key features being the reason behind its vulnerability (UNFCCC, 1992; 2007; IPCC, 2007e). One very clear feature for the African economy is dominance of agriculture, particularly small-scale agriculture. Other features include stresses like over-dependence on natural resource use (Raleigh and Urdal 2007), poverty, prevalence of diseases like Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS), food insecurity, water shortage and in some countries, internal conflicts and civil unrests (Ngigi, 2009). Smallholder farming in Africa plays a pivotal role to both livelihoods and the economy. It is the primary source of livelihoods, income, foreign currency, raw materials, and employment for millions in the continent. While this economic activity contributes immensely to the economies and livelihoods in Africa, it is important to reiterate that the economic activity is extremely vulnerable and sensitive to changes in the climate (Howden, *et. al*., 2007; Gandure and Alam, 2006). As a result of both the importance of agriculture and its sensitivity to changes, smallholder farmers, at times have been compelled to undertake changes in their farming practices in response to various social, economic, climate and environmental stresses.

Lushoto and Same are two administrative districts from two administrative regions in Tanzania, namely, Tanga (Lushoto) and Kilimanjaro (Same). In recent years, observation and quick assessments indicated and documented some changes in weather and climatic conditions in the two districts, like in many areas in the country (URT, 2009b; DPG-E 2009, UKaid, 2011). Such changes include increased dry spells, short-time heavy rains and perceived increase in average

temperature (URT, 2007; Lyamchai, et. al., 2011). Spontaneously or probably as a reflection of changes in weather and climate, some assessments reported and documented changes in farming practices in these areas (Lyamchai, et. al., 2011). These were such as shifts in crop production areas, crop growing pattern and the type of crops grown. The following were some examples of the shifts: coffee is no longer cultivated in many areas in the districts as it used to be in the past. South Pare Mountains, for example, were traditionally used for coffee cultivation but this was no longer the case. It was also been observed that some areas were used to cultivate beans once in a year but now the cultivation is done twice a year in the same areas. In addition, it had been noted that most of the smallholder farmers were concentrating on shorter cycle crops such as beans, specific rice as well as maize varieties and vegetables instead of traditional crops like coffee. For example, in a household baseline survey conducted in Lushoto by the Institute of Resource Assessment and the Seriani Agricultural Research Institute between 24th November to 17th December 2010 to get an in-depth understanding of farming practices and how they have changed over time in response to several drivers, it was found that majority of changes were invested in maize and beans and less if not none on coffee. It was also observed that there were new crop varieties with potential for high yield as well as with shorter cycle.

Various researches had been conducted on adaptation to climate and other non-climate changes and have generated immense knowledge.[1] The target of this research was to identify real factors that drive households to decide to change their farming practices, and their choice of a particular adaptation measure at a given time. It was difficult to be sure as to why, for example, smallholder farmers decided to change frequency of cultivation of beans into twice a year in an area where they used to cultivate the same crop once. How do they come to realize that the area can now produce beans twice instead of once? Or, why do not they cultivate three times a year instead of twice? Or, why do they decide to abandon coffee and why then are they concentrating on shorter cycle crop now and not earlier before? Is it the role of local knowledge? Is there an element of trial and error? Is it something related to intuition? Is there anything to do with scientific knowledge?

Much as it is possible to speculate and generalize the drivers, for example, changes in the local climate, influence of markets or of researchers, political leaders and so forth, real factors that drive households to decide to change the farming practices, and their choice of a particular adaptation measure at a given time in these areas were still not scientifically very well known. Therefore, the speculation required a scientific study for a better understanding of the situation and recommend appropriate as well as sustainable strategic and policy interventions to support local communities to cope with changes that drive them to undertake changes in their farming practices.

1.5. Objectives of the Study

The main objective of this research was to examine factors that motivate smallholder farmers in developing countries (using Mkomazi sub-catchment as a case) to change from one farming practice to another. This study further sought to analyse socio-economic implications of the changes and recommend appropriate policy and strategic actions to assist smallholder farmers to adapt and enhance their resilience.

[1] Park, et al., (2012); Olowa and Olowa, (2011); Below, et al., (2012);Acosta-Michlik and Espaldon, (2008); Thomas et al., (2007); Chinkhuntha (2004); Goldsmith (2003); Minja et al (2003); Critchley and Mutunga (2002); Reij and Waters-Bayer (2001); Wickama and Mowo (2001); O'Neil (1995); and Critchley et al (1999)

1.6. Research questions

This study was guided by five research questions through which instruments were prepared and data collected. The research questions are:

a) Are there any past, present and possible future changes in the local climate in the study area and how are they perceived as well as explained by local smallholder farmers?
b) Are there any changes in farming practices that have been undertaken in the area?
c) What are the factors that motivated smallholder farmers to decide at certain times to change their farming practice?
d) What are socio-economic implications of changes at household and community levels in the study area?
e) What are the appropriate policy and strategic interventions that can support smallholder farmers to adapt to changes they experience so as to enhance their resilience in future?

1.7. Significance of the Study

Coping with various changes that affect livelihoods particularly in poor rural smallholder agriculture dependent communities has been part and parcel of life of these communities for years in countries like Tanzania. But increasing climate risks and uncertainty from climate change is eroding the level of resilience of both socio-economic and ecological systems (Adger, *et. al*., 2003). Due to this situation and probably coupled with other non-climate factors, farmers are compelled to make decisions to change from one farming practice to the other in search of stabilizing their livelihoods. This study explored and brought out key details regarding factors individual households/farmers consider in before they decide to change their farming practices.

This study contributes further to broad understanding of local communities in developing countries, whose major source of livelihoods is smallholder farming, and their efforts to cope with various climatic as well as environmental changes that affect and/or threaten their livelihoods. In addition, it contributes to knowledge on smallholder farmers' adaptation decision-making process, related dynamics and key factors motivating their decisions to change their farming practices in response to any stresses that they face.

Likewise, the study is intended to contribute to measures for enhancing adaptive capacity and long-term resilience of smallholder farmers in poor local community settings. In the final analysis, results from this study will be a catalyst in designing, developing and implementing appropriate, suitable as well as viable adaptation policies and strategies in the developing countries context. All these are intended to enhance the level of adaptive capacity, increase resilience and support sustainable development (see also Burton, 1997; Munasinghe, 2000; Smit, *et. al*., 2000).

1.8. Outline of the Thesis

The thesis is organised in ten chapters. The first chapter explains the problem and its context in which background information; statement of the problem, objectives as well as rationale, are given. The second chapter is on climate change impacts, vulnerability and adaptation, which provide an overview and details regarding climate change challenge from the global perspective down to the African continent. The chapter also includes some explanations regarding adaptation efforts particularly in agriculture, water and other key sectors in Africa. Chapter three presents the Conceptual Framework by analyzing key variables considered in this research with a graphical depiction of the framework itself indicating linkages of key variables. It is then followed by Research Methodology and research process in chapter four. This provides details on the research process, namely, data collection, analysis and

presentation. This chapter also gives some details about Tanzania and much detail about Mkomazi sub-catchment as the research area. Chapter five to nine present and discuss findings of the study. They are orginised in the following titles: State of Local Climate: Smallholder Farmers' Perceptions against Long-Term Rainfall and Temperature Data; Changes in Farming Practices; Factors Motivating Changes in the Farming Practices; Socio-economic Implications of Changes in the Local Climate; and Policy and Strategic Interventions to Enhance Adaptive Capacity and Long Term Resilience. Finally, the last Chapter analyses and presents Conclusions and Recommendations of this study.

CHAPTER TWO: IMPACTS, VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE AND VARIABILITY

2.1 Introduction and overview

In this chapter, review of literature, focusing on impacts, vulnerability and adaptation to climate change and variability, is presented. The chapter is composed of three broad sections, i.e. an introduction and overview on climate change; impacts and vulnerability; and a summary of key lessons drawn from the review.

The urgency, worry and concern for the current impacts, uncertainties and projected climate trends have all created a strong coalition as well as cooperation by the international community with the aim of addressing the challenge. The worries come from threats that climate change has on national and human security; human and natural habitats; food security; water availability; natural systems sustainability; national and global economies; human, plants and animal health; and a broad spectrum of other themes. Through the UN Framework Convention on Climate Change, researchers, negotiators, governmental and non-governmental actors as well as indigenous people, just to mention a few, come together at different levels to discuss on how best and mutually they can take responsibilities, including policies and strategies to address climate change impacts. But why should the international community be concerned about climate change?

2.1.1 Reasons for concern

The increased concern of the international community on challenges of climate change is based on the scientific understanding of the climate system. The Sun's energy enters the atmosphere as light wave then heats up the Earth (Mitchell, 1989). Some of the energy warms up the Earth and some of it is re-radiated back into atmosphere in form of infrared waves (Mitchell, 1989). Under normal conditions, some of the outgoing infrared waves are trapped by atmospheric greenhouse gases, which keep the Earth's temperature around moderately warm, making the Earth comfortable and habitable as well as maintain the balance between natural and social systems (Al Gore, 2006; Haughton, 2009; McMullen, 2009; Mitchell, 1989). Thus, temperatures on Earth have always been right for living. The current problem is on the thickening of the atmospheric greenhouse gases layer through deposition of huge quantities of human induced atmospheric carbon-dioxide and other greenhouse gases (Mitchell, 1989). As the thickness increases, it traps more infrared radiation that would otherwise escape from the atmosphere (Al Gore, 2006). As a result, the temperature of the Earth's atmosphere and oceans are getting quickly and dangerously warmer (Haughton, 2009; Al Gore, 2007; McMullen, 2009). It is this understanding that led the IPCC in its Third Assessment Report released in 2001 to identify five reasons for concern about climate change (portrayed in a diagram called burning embers), namely, the risk to unique and threatened ecosystems; the risk of extreme weather events; distribution of impacts; scale of aggregate impacts; and risks of large-scale discontinuities (IPCC, 2001).

On adaptation, Adger and Barnett (2009) highlight key reasons the international community should be concerned about adaptation. They include interconnectedness between the scale of change and its impacts (*ibid*.). Concern here is that, if the scale of change and interconnectedness to the impacts is so close not allowing much time for adaptation to take place, then an opportunity for adaptation to be successful becomes narrow and the risk for catastrophe is high. The international community has not been successful in addressing

mitigation and hence, the emissions are still on the increase despite debates and emission targets in the Kyoto Protocol (WMO, 2012; 2013). This means that as emissions increase, the impacts and their severity will also become high in future, not allowing an opportunity for successful adaptation and resilience building.

The other reason for being concerned is the possible mismatch between capacity to adapt and real adaptation and response on the ground, that is, adaptive capacity versus adaptation as action (Eisenack and Stecker, 2011) or adaptation myth (Roperto, 2009). Having in place capacity in terms of institutions, finances, technologies, early warning systems and all those forming adaptive capacity base to climate change at a household, local, national as well as institutional levels does not entirely imply real adaptation actions on the ground (Roperto, 2009). It all depends on many other factors such as severity of change, timing and extent to which change is interconnected to impacts that are going to occur. Other factors include the manner through which resources are or will be distributed and used to ensure successful adaptation actions and so forth. Adger and Barnett (2009) give examples of hurricane Katrina in New Orleans in 2005. The authors argue that much as the United States of America possessed all necessary preconditions, implying that the country had the adaptive capacity, still many people died and huge loss in property and so forth, were experienced.

Apart from that, Adger and Barnett (2009) cite unsustainability of adaptation actions already in place. In some instances, responses are in form of merely coping strategies or unsustainable adaptation actions. These are actions, which do not take into consideration ecosystems, their roles and how they should continue to support the natural systems, social systems and the like. Therefore, such kind of coping strategies and adaptation actions would not, on a long-term, enhance sustainability and the possibility for more impacts as well as adaptation actions will be required.

The authors (Adger and Barnett 2009) have also highlighted that much as it is possible to adapt, the impacts of climate change may lead to individuals and communities suffering permanent losses of things they value most in their context. They (*Ibid.*) argue that such kind of losses must be of concern to individuals and communities who happen to have long cultural, spiritual, familial, and historical ties to some areas including properties especially when they might be required to relocate as a result of climate change impacts. How can such individuals and communities be compensated for the cultural, spiritual or historical values they attach to areas or lands lost as a result of climate change impacts? This is a daunting challenge.

In addition, adaptation should be a serious concern as climate change impacts already have and will continue to negatively availability and access to the very basic needs of human beings such as food, water and shelter (NRC, 2010; Boko, *et. al*., 2007; Easterling, *et. al*., 2007; Cruz, *et. al*., 2007); vulnerable populations and societies such as the indigenous people worldwide, elders, children and the majority poor particularly in the developing world (Wilbanks, *et. al*., 2007; World Bank, 2011; NRC, 2010; CCSP 2008); national and international security as a result of its impacts on water and food, such as in Africa (NRC, 2010; Boko, *et. al.*, 2007; Confalonieri, *et. al*., 2007; CCSP, 2008); and the vulnerable regions like Africa and the Small Islands (Boko, *et. al*., 2007; Mimura, *et. al*., 2007).

2.1.2 Global efforts and key challenges

It is already justified in earlier sections that climate change is a global challenge because, among others, its impacts and consequences are global in nature, and therefore, international

collective actions are critical in driving an effective, efficient and equitable response on the scale required (World Bank, 2012). However, it is also important to note and recognize efforts made by the international community, to-date, in addressing climate change as a global issue that requires global efforts and cooperation.

The most notable efforts include establishment of the Intergovernmental Panel on Climate Change by UNEP and WMO in 1988 (EEA, 2013). This was and remains an effort that needs to be acknowledged because it has helped to generate immense knowledge, which supports negotiations and policy as well as strategy developments at all levels. The IPCC has ever since been so instrumental in enhancing scientific understanding of the magnitude and severity of climate change. For the past two decades, there has been growing understanding of socio-economic, technical, and environmental risks of climate change, which then informed decision-making and negotiation process. In addition, the IPCC Assessment Reports 1-4, special reports and other scientific and technical works have catalyzed discussions and negotiations leading to some agreements under the UNFCCC and even beyond. Above that, also there has been a growing level of research and publications by many scientists at all levels in broadening understanding of climate change and further discussions at all levels. The quest for doing further research on climate change has also grown tremendously during this period.

Ratification of the UN Framework Convention on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 was a great milestone in addressing climate change (*Ibid.*). In addition, ratification of its Kyoto Protocol in 1997 in Kyoto, Japan was an additional milestone, though its effectiveness in achieving intended objectives remains questionable. Through the UNFCCC, the International Community in a way has succeeded in efforts to institute an international framework that enables countries to negotiate and agree on policies and strategies that can address climate change in the following key areas: mitigation and adaptation; scientific research to broaden understanding of the problem, its magnitude and predict the future impacts pioneered by the IPCC; and establishing funding arrangement and subsequent establishment of climate change funds.

For the past two decades, the UNFCCC has facilitated negotiations and discussions by experts, researchers, scientists and at some cases, global leaders, aiming at agreeing on appropriate policies, strategies and actions required to be taken in addressing the challenge. The negotiation process has led to adoption of various international climate change policy related agreements and key decisions such as the Marrakesh Accord, the Bali Action Plan, and the Cancun Agreement (EEA, 2013), etc. All outline various issues for addressing climate change. However, effectiveness in implementation of these decisions and related policy outcomes remains debatable and there remain a number of challenges and questions as to whether or not there is commendable success as a result of ratification of the Convention and its Kyoto Protocol and decadal negotiations. Notwithstanding the international agreements and efforts, however, to date, the international community has not been able to register any significant emission reductions of GHG. Thus, while the Kyoto Protocol is in place for several years now, and it just entered into its second commitment period up to 2020 agreed in Doha at COP18/CMP8 in 2012 under the Doha Amendment to the Kyoto Protocol (UNFCCC, 2013), emission of GHGs has been reported to continue increasing (WMO, 2012). It means that the said efforts are yet to be a success. But it is important to take note of the initial steps ahead in efforts to address climate change in that regard.

A number of efforts have been undertaken in the area of adaptation under the UNFCCC to date. Much as many of these remain mostly based on enabling activities and hence, little progress regarding concrete adaptation actions on the ground, in a way they have helped to shape the adaptation interventions and actions already instituted today in many developing countries. Table 2 summarizes some of the milestones in this area.

Table 2.1 Summary of some Climate Change Efforts

Programme details	LDC-Work Programme	Nairobi Work Programme	Cancun Adaptation Framework (CAF)
Preliminary details	Adopted 2001 at the 7th Conference of the Parties to the Convention, Marrakesh-Morocco as part of the Marrakesh Accords.	Was adopted in 2006, Nairobi-Kenya	Adopted in Cancun, Mexico, 2010. In this framework, Parties declared that adaptation must be addressed in the same level of priority as mitigation (even though it remains of high priority for developing countries).
Objectives/Focus	To identify urgent and immediate national adaptation needs through NAPAs and building capacity.	To assist all Parties, in particular developing countries to: improve understanding and assessment of impacts, vulnerability and adaptation; make informed decisions on practical adaptation actions.	To enhance action on adaptation and seek to reduce vulnerability and build resilience in developing country Parties.
Activities	The activities were mainly on assessments, capacity building through workshops and training as well as planning (NAPAs)	There are various areas of work: Methods and tools for impact and vulnerability assessments/adaptation planning; improving collection, management, exchange, access to and use of observational data; supporting climate modeling, scenarios and downscaling; promoting understanding of impacts and vulnerability; improving knowledge of the socio-economic aspects of climate change; enhanced adaptation planning and practices; promoting research on adaptation options; promoting economic diversification	Cluster activity areas include: • Implementation (planning of adaptation actions; formulating National Adaptation Plans-NAPs; a work programme to consider approaches to address loss and damage associated with climate change impacts in developing countries that are particularly vulnerable to the adverse effects of climate change). • Support (finance, technology and capacity building support from developed countries to developing countries). • Institutions (establishing an Adaptation Committee at international level to promote the implementation of enhanced action on adaptation; establishing regional centres and networks at regional level; and establishing and/or designation of national-level institutional arrangements

Outputs	The NAPA documents were prepared. Part of the Marrakesh Accords, the LDCF, SCCF and the AF were also established.	Synthesis and technical reports on the shelves	
	No concrete adaptation activities on the ground but those that aim to end up with documents in the shelves	As usual, no concrete adaptation activities on the ground but those that aim to end up with documents in the shelves mainly assessments, workshops and exchanges of information	

Source: Summarized from UNFCCC website and Mace (2006)

From the summary in Table 2.1, it is clear that for the past decade until now, climate change adaptation initiatives and efforts have mostly ended up in enabling activities. Basically, such activities do not have direct impacts on the rural poor who experience and suffer most from the impacts of climate change but mainly reach experts through workshops, training and meetings for capacity building, planning and negotiations. In the previous chapter, several challenges were highlighted. It is important to reiterate that the slow progress in the process towards implementing concrete adaptation activities on the ground is a result of various factors including inadequate funds to support developing countries on adaptation; difficulties in access to available funds particularly through the GEF (Mace, 2006) and when accessible, various conditions prevail like co-financing. All add on difficulties in the implementation process. In addition, longer negotiations and unresolved issues on technology transfer and development (Mace, 2006) to support implementation of adaptation are just a few examples of the factors.

The United Nations Framework Convention on Climate Change (UNFCCC) remains the central multilateral framework for cooperative actions to mitigate climate change and adapt to its adverse impacts. It will continue to guide the efforts by the International Community to reach its ultimate objective, which is:

> *"…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner"* (UNFCCC, 1992)

Much as it is now a fact that climate change is accelerated by human quest for development (Mearns and Norton, 2010; UNEP, 2012a), it is also important to reiterate that not all countries contribute equally to the challenge (*ibid*.) Developed countries had enormous share due to their industrial development processes (Adger, *et. al*., 2006; UNFCCC, 1992; 1997; Mearns and Norton, 2010; Commission on Climate Change and Development, 2009; the Global Humanitarian Forum, 2009). However, the impacts of climate change do not recognize borders. Hence, all countries, despite each one's contribution or adaptive capacity, are affected. Nonetheless, what differs is the level of vulnerability, magnitude and severity of the impacts as well as the capacity to withstand and transform the socio-economic systems to accommodate the impacts (Adger, *et. al*., 2006).

The global nature of climate change is also demonstrated by efforts to address its impacts. This makes it compulsory for both scientists and policy makers all over the world to consider taking efforts and developing policies, which, in turn, will be translated into domestic contexts and implemented (UNFCCC, 1992). Because climate change impacts are not limited by international and national administrative borders, these efforts have ever since been taking a global context. Developing policies, financing mechanisms and emission reduction targets together with commitments as well as adaptation technologies should all have a global perspective (Stern, 2006). While the international community is struggling to address climate change within the agreed framework Convention, a number of challenges remain unaddressed. They include the following:

a) ***Greenhouse gas increase:*** Despite having Kyoto Protocol in place, GHGs emissions continue to increase at a faster rate and many countries are not very much willing to take stringent measures to cut down emissions in line with scientific findings and recommendations of the protocol. Other developed countries like Canada decided not

to participate in the second commitment period of the Kyoto Protocol agreed in Durban in 2012 thereby setting back the effort to cut down emissions (WMO, 2012).

b) ***Develop a fairer and more effective global response to address mitigation and adaptation:*** While climate change mitigation has remained a priority for the developed countries since the coming into being of the Convention process (Smit, *et. al*., 1999; Adger, *et. al.*, 2006), developing countries are already suffering from the impacts of climate change and the need for adaptation efforts has dominated the climate change agenda in recent years. It is imperative to note that while mitigation is necessary to cut down the emission levels thereby limiting the increase in temperature to the agreed levels, supporting those countries and communities, which are already suffering is also of paramount importance. However, both adaptation and mitigation have to be fair not to leave the burden to those whose contribution is negligible but those who suffer most (UNFCCC, 2007; World Bank, 2012).

c) **Finance:** For developing countries to address climate change challenges, adequate and predictable financial support is necessary (Flåm and Skjærseth 2008). The international community has not been able to allocate and make available enough financial resources (*ibid*.). In addition, some of the resources are made available in form of loans, which add more difficulty to developing countries. Repayment of climate change related loans is difficult because climate change affects sensitive sectors such as agriculture, which in many developing countries are the key sectors for economic development.

d) **Technology transfer and development**: this is an important aspect in addressing climate change both in adaptation and mitigation. It is stressed from the word go that for developing countries to be able to implement the provisions of the Convention, that is, UNFCCC, developed countries will have to support other parties, particularly those developing in terms of environmentally sound technologies both deployment and development (UNFCCC, 1992; IPCC, 2000) as the Convention states that all Developed Country Parties and other Developed Parties included in Annex II,

"Shall take all practicable steps *to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention"* Climate Change Convention, Article 4.5.

Apart from promoting and facilitating transfer of technologies, the Convention also calls for the developed country Parties to support development and enhancement of endogenous capacities and technologies of Developing Country Parties. This is in addition to transfer of the new and exogenous technologies stated in the quote.

Therefore, for developing countries to be able to adapt and undertake appropriate mitigation actions, developing and accessing new as well as appropriate technologies are a prerequisite. However, there are barriers in such endeavors. Most technologies are very expensive and they have property rights as well as many other barriers for both transfer and access (Ockwell, *et. al*., 2008). Thus, it is important for all key parties to work together towards removing the barriers and make such technologies readily available as well as accessible to Developing countries particularly the Least Developed Countries to enable them to successfully address the impacts of climate change. The process should be negotiated, agreed and implemented.

e) **Capacity to adapt**: Basically, this is the ability to prepare for, facilitate and implement adaptation measures or the ability to absorb and withstand the impacts at any given time. It is determined by a range of many factors including level of wealth, technological capacity, timely access to information, possession of key skills, infrastructure, existence of institutions, social capital and equity (Vincent, 2007; Yohe and Tol, 2002). Enhancing adaptive capacity of the countries and communities most vulnerable to adverse impacts of climate change remains a very big challenge for the International Community. While efforts to mitigate climate change within the context of the Kyoto Protocol continue and even though not very successfully, adaptation to climate change is a priority for developing countries at the moment (AfDB, *et. al*., 2003). Enhancing adaptive capacity has been the most important area in addressing climate change for these countries. However, such countries need technologies, financial resources, expertise as well as appropriate institutional arrangement to be able to fulfil this role.

f) **Climate change and security:** While the challenges of climate change relate mainly to livelihoods, economy and sustainable development, there is an emerging security dimension which has received some attention in recent years (Slettebak, 2012). Currently, there seems to be no consensus within the research community regarding the climate conflict nexus (Koubi, *et. al*., 2012; Barnett and Adger, 2007; Gleditsch, 2012). Some publications make a caution that as the impacts of climate change intensify, they will cause diminishing of resources like arable land, widespread shortage of water, diminishing livestock, food as well as fish stocks thereby severe food insecurity will ensue, increased flooding and prolonged droughts, leading to greater migration either within countries or even beyond borders (Davitt and Tol, 2012; Christian Aid, 2007; Homer-Dixson, 2007; Shwartz and Randall, 2003; Hendrix and Salehyan, 2012). There are those who still believe and conclude that there is no enough empirical evidence to support that claim and connection between climate change impacts intensification and increased insecurity (for example, Koubi, *et. al*., 2012).

   However, common sense may at some point prevail. This situation may, overtime, fuel or exacerbate existing conflicts over depleting resources in areas most vulnerable like in the African continent. In areas where populations are already suffering from various livelihoods challenges such as unemployment and poor agricultural production due to changes in the local climate, people might tend to migrate from such areas to those at least still promise some good future (Barnett and Adger, 2007; Raleigh and Kniveton, 2012). That may, in turn, lead to more conflicts over resources. Thus, it is important for the International Community and developing countries' policy makers and experts to understand the climate change security dimension and related geopolitics across borders.

All risks, impacts, and costs for addressing global warming have to be globally contextualized (Stern, 2006). Climate change impacts across the entire array, for example, on marine and terrestrial ecosystems, most of which are trans-boundary shared ecosystems, have cross-border effects of which no country can act alone. Neither can there be a country to decide not to work together with others and still consider itself safe from climate change impacts. Therefore, a need for a broad based climate change policies focusing on both adaptation and mitigation, within short-term, medium-term and long-term timeframes cannot be overemphasized. These policies should finally be translated into efforts in various areas including emission reduction,

adaptation (supporting the most vulnerable communities and individuals to live with the impacts), pricing for loss and damages, supporting technology development and dealing with deforestation together with forest degradation particularly in developing countries.

2.2 Impacts and Vulnerability

Climate change is a concern because it has many impacts, which might be either negative or positive, depending on location and ecosystems. The IPCC and other scientific research works have been able to inform impacts experienced today and those not experienced but are predicted to happen (IPCC, 2007b; 2001; UNEP, 2012a; World Bank, 2012; Houghton, 2009). However, the initial departure on predictions and projections involve uncertainty and inaccuracy of those for the future. This is because while many other variables can be predictable and simulated through scientific models, some of the attributes cannot precisely be predicted. They include a lot of unknowns and uncertainties in how human societies will behave, their decisions on production and consumptions of energy as well as other resources in different regions and contexts such that they are all difficult to ascertain because human behavior is totally highly unpredictable (America's Climate Choices, 2010; Leiserowitz, 2012). There are also various earth and climate system processes, mostly related to atmosphere-hydrosphere-biosphere interactions, which are complex in nature and cannot certainly be predictable and correctly simulated such as ice sheet dynamics, cloud processes, and regional climate effects. Some of these are believed to be incompletely understood and hence, scientists are unable to use them in modelling as well as simulating what will exactly happen (NRC, 2010). Thus, there are many uncertainties related to the scale and degree of change in the global climate system and what will exactly lead to at the low levels. Generally, the global climate system is such a complex entity that probably what scientists know and are able to predict today is just a fraction of what is and will happen in future. Therefore, much as scientists can take up a number of variables and simulate them using GCMs, not all climate system complexities can be simulated and bring certain results to bank on 100 percent (Schneider, 1992).

Although it is difficulties to accurately predict consequences of climate change due to various obstacles including unpredictable human behavior (Schneider, 1992; IPCC, 2007b; Al Gore, 2007), today enough knowledge is available on the kind of risks posed (America's Climate Choices, 2010). Access to water, food security, food production, health, and use of land as well as the environment will be adversely affected especially in the developing part of the world (Global Humanitarian Forum, 2009). Severe impacts such as melting of glaciers, floods, frequent prolonged droughts, reduced water supply, decline in crop yields, increase in vector-borne diseases such as malaria and dengue fever, rising sea levels leading to displacement of people and disruption of both terrestrial and marine ecosystems and important natural habitats, particularly in Africa, are now vivid (IPCC, 2007b; UNFCCC, 2007).

Although many publications on climate change have had strong focus on how the impacts are and will be detrimental to human livelihoods and economies (IPCC, 2007b; FAO, 2008; Lyamchai, *et. al*., 2011; Stern, 2006; UN-Habitat, 2011; IPCC, 2012a), there are those focused on how ecosystems are being affected and extent they are projected to be affected by the changes in the climate system as a result of global warming (for example, Foden, *et al*., 2008; Ove Hoegh-Guldberg, *et. al*., 2010; Balor, *et. al*., 2008; Erwin, 2009). It should be reiterated that climate remains the determinant of life and existence of any ecosystem on earth thereby influencing ecosystems in different ways including: to limit the distribution and activity of organisms (Pearson and Dawson 2003), to influence availability of surface and sub-surface water (Vörösmarty, *et. al*., 2000), controlling dynamics of all ecosystem processes on time and

space basis (Bachelet, *et. al*., 2001) and influencing soil development processes (Dahlgren, *et. al*., 1997).

Climate change impacts are predicted to affect ecosystems, depending on nature and type of each particular one. Some of the impacts that have been highlighted in several research works include changes in distributions of some species in both higher and lower latitudes (Lee and Jetz 2008); changes in composition of some ecosystems as a result of an increase in temperature (Daufresne and Boet 2007; Lemoine, et. al., 2007); and spread as well as establishment of invasive species in particular ecosystems (Hellmann, *et. al*., 2008), just to mention a few. Therefore, impacts of climate change are not only confined directly to human beings but also they are apparent indirectly through important ecosystems, which offer goods and services to livelihoods and support life, ecosystem functions as well as other natural processes.
Some scientific studies have also indicated that climate change will affect groundwater in terms of its quantity and quality as well as its recharge, leading to other catastrophic effects such as exacerbating salt water intrusion into fresh water sources (Al-Gamal, *et. al*., 2009) particularly along the coast. This is already happening in countries like Tanzania where some of the fresh water wells along the coast have been abandoned and are no longer in use as a result of salt water intrusion (URT, 2007, 2009b).

Climate change is a serious challenge to human livelihoods especially in the developing world because it increases food insecurity (FAO, 2008), accelerates health risks like spread of malaria (IPCC, 2007b) and other diseases related to disasters such as cholera and it increases water scarcity as well as increases possibility of conflicts over resources among social groups (Barnett and Adger, 2007). FAO, (2008) makes a case that under climate change, the food system is vulnerable because if affects the four main components of food security, namely: food availability, food accessibility, food utilization and food system stability. In many developing countries, climate change is predicted to affects small scale agriculture, which, apart from generating revenues and a good contribution to GDP; it is a vital economic activity employing millions particularly in rural areas (FAO, 2008). Climate change impacts on agriculture, freshwater, livestock, fisheries and ecosystems will lead to devastation in developing countries (*Ibid.*). In addition, it is a source of food for a majority of rural and urban populations in such countries. In the end, it deepens poverty in many of these countries (Global Humanitarian Forum, 2009). Already in the past few years, it has been witnessed that millions of people were threatened to die with starvation in some parts of Africa particularly East, the Horn of Africa as well as some other countries in Central Africa in 2010 (OCHA, 2011). While several factors might be responsible for the droughts and hunger in these parts of the continent (for example, continued conflicts and political crises, poor production of soils and poverty), the role of climate change and variability cannot be overemphasized (Funk, Michaelsen and Marshall, 2011).

2.2.1 Farmers' Innovation in Developing Countries

Farmers' innovation and decision-making have normally involved a process under which farmers themselves develop ways of doing many things to improve their farming activities as well as coping and adapting to any changes that may seem threatening their farming activities and so, their livelihoods. There are several examples from literature that include the following: improving crop varieties through careful selection of seed, harvesting rain water, soil conservation measures as well as changing farming practices (Reij and Waters-Bayer 2001; Critchley and Mutunga (2002); Chinkhuntha 2004). Creative traditional irrigation by many local ethnic groups in many developing countries, for example, furrows by Wachagga and

Wasonjo in Tanzania and Qantas in Iran (Goldsmith, 2003); biological control in soybean (O'Neil, 1995); production of new pesticide concoctions (Minja, *et. al*., 2003); use of different plants and roots for soil fertility improvement (Wickama and Mowo, 2001); and cure for different animal as well as human ailments are some of the well documented farmers' innovations that entailed decision-making to change from one innovation to another and at a right time, definitely in response to a stressor climate.

These innovations clearly played, and still play, a significant role in improvement of rural communities. The major area of interest behind all these innovations remains how they are generated, tested and diffused. This is because it is known that smallholder farmers have no laboratories to experiment and test their ideas. Arguably, one other important question is to whether they are only a result of local knowledge or there are other contributing factors and which factor(s) contribute most, how and why.

Vincent (2007) noted that there is little empirical evidence existing in relation to what motivates and determines farmers' individual adaptation decisions. Smallholder farmers' households have been making decisions to change from one farming practice to another in response to change and variability of the climate as well as other stressors. When farmers are faced with problems that threaten their survival, they get courage and capacity to experiment, innovate as well as decide to test. Ultimately, they adopt new practices and in so doing, new solutions are devised. Throughout centuries, farmers, forced by stresses, have invented, developed, adopted and adapted ingenious ways/means for ensuring food security and economic welfare for their extensive households (O'Neil, 1995; Chinkhuntha, 2004).

The success cases explained in previous paragraphs demonstrate ingeniousness of smallholder farmers using their environments to devise technological options so as to support their livelihoods over time. Such success cases also played a major role in capturing attention of the scientific community, leading to recognition and documentation of the innovations of smallholder farmers' communities (Lyamchai, *et. al*., 2006; Reij and Waters-Bayer, 2001). Many of the studies found that local people possess sophisticated knowledge about their environment and that such knowledge can be useful in sustainable land use. The studies emphasized that coupling experimental protocols of the scientific method to farmers' deep appreciation of their system would seem to be a powerful way to generate new agricultural practices (Simpson, 1998; Winkelerprins, 1999; Barrios, *et. al*., 2001; Reij and Waters-Bayer, 2001).

As explained before, adaptation to climate change impacts was not really a priority by scientists till recent years. As for now, it is increasingly becoming a managerial and policy issue for governments, private sector and non-governmental institutions across the globe somehow rationalized by the idea that any successful adaptation interventions at any level and system will have a chance to reduce consequences of climate change impacts and enhance resilience of the local community to such impacts (Janjua, *et. al*., 2010). However, much as it is already known that climate change has and will continue to affect local communities' ability to cope and be resilient; many developing countries have put very little efforts to enhance the capacity of local communities to adapt to the impacts of climate change.

In addition, scientific studies on what is really being done, by governments and non-governmental actors, to support local communities to adapt, are very scanty, particularly in Africa. The reason behind this bottleneck might be due to inadequate reliable data on the exact magnitude and the problem because Africa lacks current and appropriate data on climate

projection, which really reflects the African context. Most data to support decision-making are not readily available and those found have been generated from global models and may not necessarily and exactly suit the African regional context, hence need for more downscaled data (MOHC, 2007). To address this "disconnect" between climate science and African agriculture, capacity capable of linking existing climate data and agricultural decision-making needs to be created. This is as much an institutional challenge as it is a technical and human resource challenge (SEI, 2008). The other reason might also be because many activities fall under other headlines other than climate change adaptation, for example, water resource management, agriculture, health and the like.

Findings from research work conducted by SEI (2008) on involvement of the African continent in programmes and strategic interventions to address climate change indicated that a few programmes are available. However, most are operated by donors and European as well as American scientists/researchers. While this is positive in terms of capacity building especially where collaboration exists, key interventions from the African governments in this area remain scanty.

Hassan (2010) notes that despite threat of climate change, efforts and investment levels in scientific and action programmes to better understand as well as respond to climate change continue to be low and the capacity to survive the vagaries and take advantage of potential benefits remains very weak in developing countries. As for Africa, the author (*ibid.*) reveals that knowledge on climate change adaptation remains to be low and very few have investigated the economics of climate change impacts and the potential adaptation measures for African agriculture. In addition, research on farmers' adaptation to climate change seems to be inadequate while predictions about future scenarios for Africa are based on GCMs (*ibid*.). This is possibly due to inadequate financial as well as technological capacity; low awareness level as well as little knowledge on the subject matter by those who make decisions. Nevertheless, it is difficult to be sure whether or not awareness and knowledge determine decision-making on this issue. It seems that other factors are important also (see also Blackmore, *et. al*., 2011). Awareness of individual households, managers and policy makers on climate change is not very well researched in developing countries and again, its linkage to adaptation requires further scientific works in various socio-economic contexts (Halady and Rao, 2010).

Smallholder Farmers adapting to stresses

Smallholder farming, small scale farming or family farming are different terms but used to refer to the same farming type (Murphy, 2012). It is predominantly found in the developing world and named after size as well as scale of the farming activity itself in terms of land, the amount of labour involved, inputs, mechanization level and so forth (Morton, 2007). Barnett and colleagues (1997 cited in Morton, 2007) define smallholder agriculture as farming activities undertaken in a relatively small area with little or no modern, purchased inputs and outputs are mostly directly consumed and with little or no output is send to the market. The term may also be used to describe a form of economy commonly found in the rural poor developing countries, that is, a predominantly small scale farming using family labour supporting livelihoods for majority in such countries (Cornish, 1998). In a broader sense, smallholder farmers also include pastoralists, whose livelihoods entirely depend on livestock and their products and all people, whose farming, pastoral or fishing activities are of small scale nature (Allison and Ellis, 2001).

Apart from production for direct consumption, smallholder farming is characterized by small farms mainly with traditional or informal tenure. In some cases, such farms are located in

marginal areas prone to environmental and natural risks such as soil erosion, floods, droughts, crops and animal diseases (Fairtrade, 2013). In addition, farmers practicing such kind of farming also take part in other off farm activities such as hunting/gathering and other forms of labouring or employment (Ellis, 2000). Much as it looks small scale and lowly developed, this form of production is ingenious with accumulated knowledge and technologies of landscape, land and water resource management together with conservation as a result of long time experience in the local environment (Altieri and Koohafkan, 2008), various stresses and quest for survival.

Changing farming practices or adapting to stresses by smallholder farmers in their local environment has existed since time immemorial. Over the centuries, smallholder farmers have drawn on traditional knowledge and historical observations to manage effects of a variable climate and other stresses (Altieri and Koohafkan, 2008). They have used their experiences and local knowledge to cope with such changes from time to time. Historically, for hundreds of years, smallholder farmers (crop producers as well as pastoralists) have managed to develop complex agricultural systems, which are adaptive to the local environment using locally tested techniques and practices, leading to sustained food security at household and community levels without even entirely and so much depending on influence including support from governments, scientists and researchers (Altieri and Koohafkan 2008). So many vivid examples exist in numerous parts of the world but they are few. They include the following: mountain rice terrace systems in Madagascar; multiple cropping systems in Chinampas, Mexico; nomadic and semi-nomadic pastoral systems of the Maasai in Tanzania and Kenya; ancient irrigation, soil and water management systems in Iran, Afghanistan and Mali; and complex multi-layered home gardens with wild and domesticated plants for foods, medicines, ornamentals and the like in China and India (Koohafkan and Altieri, 2011).

This fact is clearly elaborated in the previous Chapters as well. For instance, Koohafkan and Altieri (2011) document that majority of farmers in the developing world undertake smallholder, subsistence farming in lands that are sometimes marginal, with comparably small plots, employing little or no modern technologies for both farming and farm management and using local knowledge including techniques. Such farmers have, over ages, invented good ways of diversifying their farming through crops biodiversity (Altieri and Koohafkan, 2008; Koohafkan and Altieri, 2011). It is further documented that in West Africa and Latin America alone, more than 40 percent of cassava, 60 percent of maize, and 80 percent of beans are inter-cropped with other crops thereby demonstrating long time knowledge and techniques of local people in their traditional farming activities (Koohafkan and Altieri, 2011). This practice supports soil fertility, food security, crop disease prevention, biodiversity conservation as well as adaptation to climate variability and change. All these have taken place as a result of local inventions and knowledge accumulation for generations (Altieri and Koohafkan, 2008). But they are normally a result and response to particular stimuli that in a way form bases for farmers to make some changes in the production process, either part or whole in order to probably benefit more or cope with current changes.

African smallholder farmers have been part of the ingenious history of the smallholder farmers in the world as well. They, as their counterparts in other parts of the world, have a long time experience in adapting to various changes that in a way affected their farming activities. Amidst environmental change and climate variability as well as other stressors, literature mentions several strategies that have over time been employed by farmers to adapt. Hassan and Nhemachena (2008), for example, mention increased irrigation, multiple cropping and integration of livestock as some of the strategies employed by smallholder farmers in

responding to climate stressors in Africa. Paavola (2008) cites extension of cultivation, agricultural intensification, livelihoods diversification as well as migration as the most commonly used adaptation strategies by smallholder farmers in Morogoro, Tanzania. Other examples of strategies include improved farm management and technology use as well as farm financial management (Below, *et. al*., 2010) and changing planting dates, changing crop varieties as well as using various locally oriented and invented soil conservation techniques (Acquah, 2011). The list may be long but the whole idea here is that depending on the context, stress, available resources both internal and external, the environment, culture as well as the level of the economy and so forth. Furthermore, smallholder farmers decide to choose from options they have, and try particular strategies so as to be able to adapt to the specific stress.

However, today, the speed and intensity of change in the environment and climate are outpacing the smallholder farmers' capacity to do so. Historical averages and local means of forecasting may no longer be a reliable guide for the future production process in the farm. Losses and damages from extreme weather events keep increasing, as the pattern of droughts, floods and storms becomes ever more unpredictable than expected. Therefore, smallholder farmers' change of their farming practices in the context of environmental and climate change today may not necessarily and entirely support them to build resilience and lead to sustainable adaptation. But they might be helpful for a short time as climate change may soon erode their capacity to adapt since the frequency and intensity of the impacts increase (Nelson, *et. al*., 2007). Such knowledge and technology base remains very important in formulation of policies for advanced adaptation interventions at local, national and international levels.

2.2.2 Africa: Why is it the Most Vulnerable?

As a continent, Africa contributes the least to GHG emissions, yet it is the continent that is and will continue to be impacted most by climate change (IPCC, 2007e; Global Humanitarian Forum, 2009; Conway, *et. al*., 2010). For Africa, climate change is a serious threat to development and poverty reduction efforts because with its impacts, small scale African agriculture is and will severely be compounded (IPCC 2007b; Müller, 2011). In addition, other key economic sectors are affected by the frequent climate variability, and extreme weather events such as drought and flooding thereby increasing risks to livelihoods. The African continent is said to be at high risk of water scarcity and stress, which may lead to intensified conflicts (IPCC, 2007b; Bates, *et. al*., 2008; UNFCCC, 2007). The continent is also facing various health risks associated with climate variability and change including malaria. All these may threaten to reverse decades of development efforts and subject the continent into risks of long-term poverty.

In a general sense, vulnerability of the African continent to climate change is a function of many factors including long-term poverty, illiteracy, lack of skills, weak technical institutions, poor and probably limited infrastructure and poor technological development. Others include health risks due to HIV/AIDS and other health related stresses and poor information access to many particularly those in rural areas where transport and communication are also in poor conditions, just to mention a few.

The Economy: Dependence on Climate Sensitive Sectors, Natural Resources and the Environment

Africa experiences low level of industrialization. The industrial base in the continent, particularly in Sub-Saharan Africa, except South Africa, is not only low but also has been declining for the past two decades. To make the case clear, between 1990 and 2008, for example, the share of manufacturing sector in the African GDP growth declined from 15

percent to 10 percent (UNCTAD, 2012). African economies and growth are heavily dependent on smallholder farming (crop production and animal husbandry, forests, wildlife, fishery and the like) and natural resources such as fossil fuels, metallic as well as non-metallic minerals, mostly exported as raw materials and not as manufactured goods. Most of the natural resources are non-renewable. Thus, they are rapidly being depleted, threatening their sustainability and continued contribution to the economic growth in the continent (UNCTAD, 2012). Poor manufacturing industrial base and high dependence on agriculture and natural resources export makes African economies very fragile. Many details on vulnerability will be given in sector sections.

Low adaptive capacity

While there are many aspects that determine adaptive capacity at different levels, adaptive capacity is understood to be existence of preconditions that a vulnerable entity (individual, community, society, an institution, a system-natural or social or a country) possesses in creating ability and a base from which it can adjust itself (execute adaptation interventions) in response to a stimulus (Vincent, 2006). In addition, much as this is the general understanding of the concept, it is necessary to note that preconditions for determining adaptive capacity definitely vary, depending on many factors including time, space, level of the vulnerable entity as well as intensity of the stimuli or hazard. For instance, there are expected different preconditions to be available at the national level compared to the household level (Wheaton and Maciver, 1999). However, the basic preconditions (which were briefly itemized in the introduction) include availability of adequate financial resources, the extent to which the entity is organized, institutional equity in terms of resources distribution, levels of knowledge, awareness, information access and sharing as well as availability of appropriate technologies options, such as appropriate early warning systems and the like (IPCC, 2001; Vincent, 2007). If one looks at all key preconditions that determine adaptive capacity, and considering the previous sections about this issue, it is clear that the African continent is vulnerable all along since the determinants of adaptive capacity are mostly lacking and therefore, the level of adaptive capacity to climate change is unquestionably low (Adger, ***et. al***., 2003; Adger, 2003; IPCC, 2001; Paavola and Adger, 2006).

Other socio-economic stresses

Africa still experiences and is compromised by presence of various socio-economic stresses (Cornford, 2003; Basher and Briceño, 2005 cited in Conway, 2009), which may intereact with climate change impacts to increases vulnerability and reduce adaptive capacity. They contribute and compound the impacts of current climate change in Africa and will have negative effects on the continent's ability to cope with climate change (Conway, 2009). Such stresses include rampant poverty, various political, ethnic and economic conflicts (Lisk, 2009; Conway, 2009), ignorance, lack of skills, low level of technological advancement, weak institutional capacity, limited infrastructure, lack of technology, lack of information, and poor access to resources by majority. Climate change is and will interact with all these factors to further keep the continent at a very high level in terms of vulnerability at the same time eroding its little capacity to adapt.

2.2.3 Vulnerability and Adaptation in Key Sectors

While initially the main focus in addressing climate change was put on mitigation, during the past few years there has been progress and good attention to adaptation (Campbell, 2009; IPCC, 2007b; Grothmann and Patt, 2005). This change has possibly been due to various reasons such

as continued increase in GHG emission despite all mitigation efforts (WMO, 2012: 2013) and the fact that some impacts are already vivid and some individuals as well as communities are suffering (Ayers and Huq, 2010; Ayers, 2010). In addition, it should be reiterated that the amount of GHGs already deposited in the atmosphere is high, meaning that adaptation is inevitable regardless of the undertaken emission reduction efforts (Pielke, *et. al*., 2007; Snover, *et. al*., 2007; Nyong, *et. al*., 2007).

Therefore, adaptation is a necessary response to climate change impacts, whether or not mitigation occurs (Picketts, *et. al*., 2012), particularly in Africa (Nyong, *et. al*., 2007; Eriksen, *et. al*., 2007). With the same level of importance, there have been many calls to undertake mitigation and adaptation interventions complementarily (Nyong, *et. al*., 2007) indicating that each one is important and dependent on the other such that pursing them together complements efforts to address climate change and helps the most poor to adapt to the changes and fosters efforts to reduce poverty (Nyong, *et. al*., 2007).

In this section, an attempt is made to articulate vulnerability and adaptation according to key economic sectors for the aim of indicating the level of vulnerability as well as the level of response to the impacts. Adaptive responses vary depending on needs, severity of the impacts or stimuli, level of the available technological options and so forth. Therefore, responses can be technological, behavioral, managerial or policy (IPCC 2007; Flåm and Skjærseth, 2008).

Agriculture and food security (includes crop and animal production)

Africa is the second driest continent in the world after Australia and about 60 percent of its population dwell in rural areas, mostly depending on rain fed, small scale agriculture (UNECA, 2011). This type of agriculture is not only an economic activity for crop production and animal husbandry but also a way and pivot of life including economy for individuals, households and governments. For comparison purposes, in 2009, agriculture provided employment to more than 60 percent of the labour force in Africa compared to only 3.2 percent at the global level (World Bank, 2010b). FAO (2012) estimates that in 2010, World Agriculture Population stood at 32.3 percent while in developing countries at 40.5 percent. However, in Africa the percent was 55.2 while for Tanzania it was 73.3 percent (FAO, 2010a; Schlenker and Lobell, 2010). In addition, African agriculture contributes substantially to GDP, around 13 percent (World Bank, 2012); and 40 percent of export revenue in Sub-Saharan Africa (Schlenker and Lobell, 2010; Toulmin and Huq, 2006; Mendelsohn, *et. al*., 2000a). Thus, even though levels of farming activities are mostly at small scale, such farmers constitute a good percentage of all farmers in the developing world, contributing immensely in food security and national economy as well (Altieri 2012; Altieri 2004; Koohafkan and Altieri, 2011; IFAD, 2011; FAO, 1995). Even though, it is constrained by, among others, low average annual growth, less than 6 percent; poor investment below the pledged percentage of 10 percent of national budget (African Union, 2003; FAO 2012); low level of input use, poor agricultural technologies, small size production units; and high levels of subsistence farming that makes it difficult to be measured exactly, just to mention a few (FAO, 2010a).

As stated in sections before, the manufacturing sector in Africa is low and declining (UNTAD, 2012). This and the dependence on agriculture including natural resources as well as the environment are seriously threatening African economies particularly in the context of climate change. Industrial manufacturing should normally serve as the major drive and hinge for high, fast and sustained economic growth (UNCTAD and UNIDO, 2011). Poor level of growth and base in this sector means that the state of the climate and crop prices in the world market mainly

determine African economies as their fluctuation determine the fate of development and resilience of the continent amidst climate change impacts (Thomas, *et. al*., 2007). In addition, it also determines adaptive capacity and livelihoods for many rural poor and smallholder farmers in the continent (*Ibid.*). This nature and structure of African economies, coupled with other social and economic factors, make the continent most vulnerable to impacts of climate change.

With all those already putting stress and compromising African agriculture and economies, climate change is and will add more challenges to both the sector and the economies thereby affect livelihoods of the majority poor in many areas in the continent (IPCC, 2007a,b; Müller, *et. at*., 2011). Africa is already facing critical food shortage because of increased, recurrent droughts and other natural and man-made disasters in various parts of the continent. In 2010, for instance, out of 22 countries categorized by FAO to be in a state of protracted crisis, facing food insecurity worldwide, 17 of these were from Sub-Saharan Africa, mainly due to prevalence and recurrence of disasters as well as conflicts (FAO, 2010a). FAO also estimates that in year 2010-2011, around 350 million people were affected by drought and other natural disasters worldwide and those from Sub-Saharan Africa were among the mostly affected and experienced serious food-insecurity (*ibid*). It is estimated also that one third of African people already live in drought-prone areas and 220 million are exposed to drought each year (IPCC, 2007b). Crop production is projected to decrease for even small local temperature increases of 1-2°C, which would increase the risk of hunger and worsen food insecurity (IPCC, 2007b). Net revenues from crops could fall by 90 percent by 2100 (IPCC, 2007b).

In summary, despite agriculture being a key sector in the economy of many Sub-Saharan African Countries as far as the statistics and explanations in the preceding paragraphs are concerned, the sector is challenged by several obstacles:

Due to inadequate access to and use of production-enhancing inputs or capital, limited availability of support services (research and extension, agricultural information and plant protection services) and appropriate technologies (URT, 2013d; URT, 2006; FAO, 2010b), many smallholder farmers in Africa, particularly South of the Sahara, are compelled to produce for subsistence (Elasha et al., 2006). Heavy reliance on hand hoe cultivation and other technological limitations, such as poor access to inputs and overdependence on rainfall, significantly reduce productivity of labour (URT, 2001). African continent has good potential for irrigation but it is not developed to achieve its full production potential. For instance, the potential area for irrigated agriculture in Tanzania is estimated to be 29.4 million hectares but only 0.26 million hectares are irrigated (URT, 2010a). This makes the agricultural sector in Africa to continue to depend mostly on natural rainfall (Elasha *et al.,* 2006) which is one of the bottlenecks to African agriculture. This overdependence on rain-fed agriculture makes the sector highly vulnerable to climate change and variability (*Ibid.*).

Apart from dependence on rainfall, underdeveloped and/or poorly developed African infrastructures, particularly in rural areas are barriers for agricultural development in the continent (AfDB, 2000) and increase vulnerability. Poor and often impassable rural roads present a major disincentive to farmers because they tend to increase transport costs and often result in deterioration of produce quality (FAO, 2010b; Livingstone et al., 2011). Lack or/inadequacy of communication facilities constrains farmers' access to technology and market information (NEPAD, 2003). High level of post-harvest losses and wastage is a consequence of the weak rural infrastructure and processing facilities; and poor linkages with markets, processing as well as production chains (*Ibid.*). While some developments have been made

particularly on telecommunication, investment in rural infrastructure particularly rural roads, water supply, and transportation, processing facilities, communications, electrification and markets are fundamental to stimulating agricultural growth (NEPAD, 2003; IFAD, 2010).

Agricultural sector requires financial services but there is limited availability of formal credit supportive to agriculture (FAO, 2010b; Livingstone et al., 2011), particularly in rural areas in Africa. Limited capital and access to financial services to farmers is thus another impediment to improved agricultural sector in Africa (AfDB, 2000). In addition, weak farmer organizations are also obstacles to smallholder agriculture development in Africa (IFAD, 2003; Elbehri *et al.,* 2013). These organizations have a role in helping farmers to easily access production support services and negotiate for better prices with buyers (Ibid.). They can also, in the long run, enable their members to establish and manage their own infrastructure for processing as well as marketing their produce. With strong organizations, farmers can become highly independent, self-reliant and able to influence policy processes in their favour. Various forms of producer organizations exist in Africa. For example, in Tanzania they include cooperative societies, farmer groups, Savings and Credit Cooperative Organisations (SACCOs), Associations and Networks (URT, 2010b). However, taking an example of Tanzania, even these new organizations are weak in terms of management as well as finance and have limited capacity to attract professional staff, credit and related financial services.

Thus, climate change impacts on African smallholder agriculture increase threats and compound further capacity of the poor to fulfil their livelihood needs and put them into difficult conditions to cope with impacts of climate change and variability.

Water resource management

Water is life. It is an exceptionally important resource to all socio-economic development activities, including human health, energy production, agriculture, industries, natural resources and livestock. Containing 15 percent of the world's population, Africa has 9 percent of the world's freshwater resources (UNECA, 2011) spread around 63 basins as well as ground reservoirs, unevenly distributed mostly concentrating in the central part of the continent [(50.66%) UNEP, 2010a]. Much as the continent seems to have good water reserve, Africa experiences under average water availability per person (UNEP, 2010a). The continent is water stressed and around 300 million people have no access to potable water or adequate sanitation (UNEP, 1999 cited in Elasha et al., 2006). Some of the challenges include poor water infrastructures, poor water development and management financing, poor planning and strategizing for water distribution (Banerjee and Morella, 2011) and the like.

With changing climate and variability, pressure on the continents unevenly distributed and poorly accessed water by millions of people, it is expected to compromise and intensify further sufferings for a majority of poor dependents of rain-fed agriculture particularly in rural areas (UNFCCC, 2007). Climate change impacts will have varying consequences on water resources in Africa (Elasha et al., 2006). By examining the situation, it is possible that Africa will face increasing water scarcity and stress as a result of climate change impacts that would potentially lead to subsequent increase in water conflicts (Raleigh and Kniveton, 2012) due to the fact that many river basins are trans-boundary. Hence, an effect on one basin will seriously affect the other (UNFCCC, 2007).

Human Health

Human health is determined by both natural and social factors but more so by continued stability and functioning of the natural systems, both physical and ecological (McMichael, 2003). Climate change is a significant and emerging threat to human health. Effects of climate change on human health are largely based on impacts of climatic events on the physical environment. Key impacts of climate change on human health result from, among others, excessive and heavy precipitation; rising temperatures and extreme weather conditions such as flooding, drought and strong winds (Pittock, 2009; Watson, *et. al*., 1997). Many vectors, food and water-borne diseases are sensitive to changes in climatic conditions. Science is proving that under different climate change scenarios, geographical range of potential transmission and proliferation rates of infectious diseases is likely to increase (Githeko and Woodward, 2003).

Like it is in other sectors, Africa, particularly Sub-Saharan Africa (SSA), contributes the least in terms of emission of greenhouse gases but is the most vulnerable to the impacts of climate change in human health terms too (Kula, *et. al*., 2013). With less than 7 percent of the world's total GHG emissions (AfDB, 2011), Africa is already and will continue to be the most vulnerable and at risk continent in the world. WHO (2008), for example, estimates that Africa, South of the Sahara, has 34 percent of the global Disability Adjusted Life Years (DALYs)[2] attributable to effects of climate change.

In 2011, an estimated 23.5 million out of 34 million people living with HIV resided in Sub-Saharan Africa, representing 69 percent of the global HIV burden, meaning that nearly 1 in every 20 adults in the region live with HIV (UNAIDS, 2012). Out of the 23.5 million, 3.1 million were children. During the same year, 92 percent of pregnant women living with HIV resided in Sub-Saharan Africa and more than 90 percent of children who acquired HIV in 2011 lived in Sub-Saharan Africa (UNAIDS, 2012). This means that much as HIV/AIDs is not directly related to climate change, it compounds much to climate change impacts as the impacts interact with severity of the disease to intensify vulnerability

Africa is already vulnerable to several climate sensitive diseases such as malaria, tuberculosis, cholera and diarrhoea (Watson, *et. al*., 1997; Githeko and Woodward, 2003). For example, in 2010, WHO (2011) estimated that malaria caused an estimated 660,000 deaths globally. WHO (2011) also estimates that most deaths occur among children living in Africa where a child dies every minute from malaria. Thus, billions of US$ dollars have to be spent to support prevention and treatment interventions of malaria in this continent.

Results of predictive models have shown that under climate change scenarios, there would be a net increase in the geographical range of potential transmission of malaria and dengue fever (Tonnang, *et. al.,* 2010). The increase in temperature and rainfall regimes are threatening to change the distribution of the disease vectors geographically, meaning that they might be migrating to new areas and higher altitudes (Watson, *et. al*., 1997). Some other research results have reported incidences of epidemic malaria especially in highland areas that were traditionally free from mosquitoes and malaria (Yanda, *et. al*., 2006; URT, 2009b; Wandiga, *et. al*., 2010). This situation exposes millions of people who were not exposed to such infection thereby increasing death risks and need for governments to allocate more resources to tackle the disease. Climate change will probably exacerbate malaria and cripple the capacity of the continent to cope with both the disease and climate change impacts, making the continent

[2] A measure of overall disease burden , expressed as the number of years lost due to ill-health, disability or early death

highly vulnerable. Like in other cases, the poor majority in Africa will finally be at high risks even in this case.

Incidences of food-borne and water-borne diseases such as dysentery, diarrhoea, cholera and typhoid fever are also on the increase due to extreme weather events, which affect water quality and make it difficult for people to practice proper personal hygiene (Wlokas, 2008). Outbreak of Rift Valley Fever in the East African region has scientifically been linked to frequent flooding in the region (Linthicum, 1990). The rise in sea surface temperature coupled up with flooding has also accelerated the spread of cholera in many of the East African countries such as Tanzania, Kenya and Mozambique (WHO, 1998). Climate change is also among major causes of malnutrition through reduced agricultural production as a result of change in soil quality, increased crop pests as well as livestock diseases, prolonged drought and water scarcity (Wlokas, 2008).

With those explanations, it is possible that future climate changes and variability will continue to exacerbate the spread of climate related diseases, making the poor in the continent highly vulnerable to health related risks. Climate change impacts on health coupled up with problems of food insecurity, malnutrition and poor health services will have detrimental effects on the continent's efforts to reduce poverty and achieve other developmental goals, such as the MDGs.

A Recap

This section analysed vulnerability of the African continent to climate change taking into account key socio-economic sectors. Much as the analysis is comprehensive, it is important to summarize what are considered key factors, from literature, that make Africa the most vulnerable to the impacts of climate change. They include the following:

a) High dependence on natural resources and the environment for economy and livelihoods in general.

b) Its high dependence on agriculture (mainly smallholder farming, which is rain-fed) as a major economic activity with very low level of irrigation for employment of the majority of the labour force, food, foreign currency (through export of raw produce) and the national GDP at large.

c) The African infrastructure, both physical and soft, is not well established (Sachs, 2005). Technologies and skills are also poor in many aspects (Sachs, et. al., 2004). Many countries have no wide networks of roads and railways connecting rural and urban areas to enable farmers to access markets and even support adaptation in other ways. Many rural communities have little access to communication and transport such that they use crude means of transportation. While an increased use of mobile phones help farmers in terms of market knowledge and information, all these other factors increase food insecurity, poor access to market and hence, compound adaptation potential in the continent.

d) A good portion of the continent is already dry land, particularly the Sahel and other areas of similar characteristics, implying that their level of production is limited such that with climate change, there is a possibility for desert conditions to expand more.

e) Existence of strong governments as well as institutions to support adaptation and even response to impacts is extremely important. But for Africa, many governments and

institutions are weak due to several reasons including, corruption, poor financial capacity and low level of expertise as well as gaps in terms of information. They make them so incapable in supporting adaptation amidst challenges like water stress, food insecurity, floods and other hydro-meteorological disasters.

f) The continent is already stressed in terms of water shortage (Gueye, *et. al*., 2005; UNESCO-WWAP, 2006); prevalence of diseases such as malaria and HIV/AIDS, all of which claim lives of many people; food insecurity; and other countries are in conflicts (Eriksen, *et. al*., 2005; Benson and Clay, 2004). All these exacerbate vulnerability and interact with climate change to lower the adaptive capacity in the continent (Gueye, *et. al*., 2005).

g) Finally, there are no compensation or support schemes particularly at the local level, mostly in the villages where a majority of poor farmers live and work on farms. In addition, such local poor farmers have no surplus hence lack incomes to use for cover during hard times like droughts and floods. Such pattern makes it difficult for many poor in rural areas and in the fast growing cities to adapt where needed.

Whereas Africa is singled out to be the most vulnerable continent, there are few aspects that provide opportunities for the continent on adaptation to climate change. African societies have for a long time experienced harsh climate conditions, leading to losses in terms of crops and livestock as well as other properties. In such situations, governments have not played significant roles in supporting adaptation but rather, individual farmers, families, communities and local institutions, on their own, have developed innovative ways of dealing with such difficulties (O'Neil, 1995; Chinkhuntha, 2004). Thus, people and communities as well as local institutions have built their own ways and means to cope with these changes through a treasury of indigenous knowledge and technologies (Nyong, *et. al*., 2007). There are immense examples of these across the entire continent, for instance, indigenous knowledge on weather forecasting (Ajibade and Shokemi, 2003; Roncoli, *et. al*., 2001); and irrigation, soil and water management systems in North Africa (Koohafkan and Altieri, 2011). Others include adaptation knowledge and technologies among farmers and pastoralists, for example, through use of some local plant varieties for food and for soil fertility improvement and cure for different animal as well as human ailments (Wickama and Mowo, 2001; Eason and Roland, 2000) and pastoral systems such as those of the Maasai in East Africa, which have demonstrated strong resilience in facing threats to their systems, maintained associated social and cultural institutions in ensuring sustainability within the changing climate and the environments (Koohafkan and Altieri, 2011). These are just some of the well documented farmers' innovations in Africa. Through such experiences, people have built resilience into their social networks and systems, which may serve as a starting point for planners to establish strategies on how to support farmers in the entire process of enhancing their adaptive capacity and long-term resilience against climate change impacts.

Social ties and networks remain strong in Africa (Toulmin, 2007), starting from family level up to the society at large. This is demonstrated in many aspects such as self-help during calamities, disasters and other misfortunes. Africans, particularly in rural areas where a majority live, are used to mourning together, working together, enjoying together and the like. Such kind of networks might be a result of lack of strong government institutions that would otherwise support local communities to address similar challenges. But these are also in a way is an opportunity and a starting point in enhancing adaptive capacity within the continent.

In chapter three, conceptual issues on the Social Ecological Resilience Framework are analyzed. Elements providing conceptual guideline of this study are presented and an illustration indicating how these elements are interrelated is provided.

CHAPTER THREE: CONCEPTUAL FRAMEWORK

3.1 Introduction

This Chapter presents a Conceptual Framework, which guided this research work. In the Chapter, several elements related to climate change adaptation process within the context of socio-ecological resilience, for example, vulnerability, adaptation and resilience, are examined, analysed and explained with the view to broadening understanding of their linkage to changes in farming practices by smallholder farmers. The attention to smallholder farmers in the study is essential because as sated earlier, they form a majority of farmers in the developing world (IFAD, 2011; World Bank, 2007; FAO, 1995), Tanzania inclusive. In addition, they entirely depend on this form of production for their livelihoods; they form a majority of vulnerable communities to climate change due to their dependence on rain-fed agriculture (IFAD, 2011; IPCC, 2007d); and they have a significant contribution to both national economies and food security efforts (see also Altieri, *et. al*., 2012; Altieri 2004; Koohafkan and Altieri, 2011).

Later in the Chapter, attention is given to interconnectedness, links and the way elements within socio-ecological resilience framework can possibly explain the situation in this research. Finally, three core sets of elements, notably, possible factors motivating changes in the farming practices (vulnerability-stresses and disturbances), types of changes in the farming practices (adaptation strategies) and socio-economic implications of the changes (outcomes of the changes in this regard) are portrayed in the Framework developed to guide this study.

Since the study is not theory but rather objective-driven, focus on multiple possible factors influencing changes in the farming practices in the area is essential to provide room for farmers themselves to identify only those appropriate while avoiding possibility of limiting their choices. Use of multiple factors was also successfully undertaken in various research works such as by Acquah (2011); Acquah and Frempong (2011); Mtambanengwe and colleagues (2012); Deressa *et al.,* (2008); and Legesse *et al.,* (2013), just to mention a few.

3.2 Social Ecological Resilience Framework

The concept of resilience is rooted in ecological studies and is believed to have emerged in the 1960s and 1970s (Folke, 2006) with works of Holling in the field of ecological sciences (Nelson, *et. al*., 2007; Folke, 2006; Gunderson, 2000). Since then, the concept has gained good development and spread into many research disciplines including engineering, psychology, philosophy, economics and so forth (Folke, 2006; Martin-Breen and Anderies, 2011; Gallopin, 2006). Diversities in terms of use of the concept and variations in research fields have generated confusions in its meaning (Folke, 2006; Matin-Breen and Anderies, 2011; Grimm and Wessel, 1997; Janssen and Ostrom, 2006; Gallopin, 2006). Developments of the concept and its use in social sciences research brought up the social ecological resilience concept. For several years, it has been argued that social and ecological systems are better explained as one complex system, and adaptation to environmental change can well be considered and undertaken in the context of a system resilience rather than focusing on actors approach (Nelson, *et. al*., 2007; Berkes, *et. al*., 2003).

While there are variations in use of the phrase (Malone, 2009), and possibly slight variations in meanings, social-ecological systems (Janssen and Ostrom, 2006; Berkes and Forke, 1998), socio-ecological systems (Gallopin *et al.,* 1989) or Coupled human-environment systems (Turner *et al.,* 2003), it implies that social subsystem (human beings, their activities as well as

social structures and institutions) and the ecological subsystem (natural environment, its resources and everything, which directly or indirectly interacts with human beings) are integrated and interact (regardless of the level of interaction, that is, individual, household, community, country or even global level) in a manner that they are inseparable (Adger, 2006; Gallopin, 2001; 1991). Human life on earth is dependent on the ecological richness not only the surrounding environment but also interconnectedness between the surrounding environment and its relationship with the other components of the environment in general, such that human activities are entirely integral to nature (*ibid*.). Berkes and Folke (1998) provided a broad conception of the social-ecological system in that the ecological system is basically making reference to both biological and biophysical processes that are seen, known and even those not seen or are unknown, natural processes and interactions of natural components of the environment from minor, simple to complex interactions. The social system, on the other hand, includes socio-cultural institutions at all levels, governance systems (Berkes, *et. al*., 2003) with rules that govern human life and its interaction together with use of available resources for day-to-day survival (governance). Therefore, social and ecological systems influence each other such that the natural system is shaped by the social system influencing its change at all levels (Kirch, 2005), while the social system is also shaped by the natural system through human dependence and use of the natural environment for survival [Millennium Ecosystem Assessment (MA), 2005].

Many research works explain the social ecological resilience framework and transition theory together with key concepts of vulnerability to adaptation, adaptive capacity and resilience (Adger, 2006; Berkes and Folke, 1998; Carpenter, *et. al*., 2001; Berkes, *et. al*., 2003; Folke, 2006; Smit and Wandel, 2006; Holling, 1973, 2001, 2004; Gunderson, 2000; Carpenter, 2003; Walker, *et. al*., 2002; Gallopin, 2006; Nelson, *et. al*., 2007 are examples). Description under this Section shows suitability to use works by Park and colleagues (2012) as well as Yohe and colleagues (2007). While those are instrumental on social ecological resilience, works by Chamber (1989) and Scoones (1998) provide additional explanations on adaptation of smallholder farmers and sustainable livelihoods, respectively. They provide enough details regarding postulated aspects and other attributes related to climate change and variability adaptation as well as resilience capturing system perspective. The points in this case include the following:

- Social and Ecological systems should be observed and considered essentially interrelated and connected into a single complex system functioning dependently of each other (Nelson, *et. al*., 2007; Berkes, *et. al*., 2003). Therefore, analysis of this complex system should mainly focus on functioning of each component as part of the system and not as a distinct entity (*ibid*.).

- Though many people may consider the natural state of the system stable, any system possesses a natural state of change and not of equilibrium. Changes in socio-ecological systems are necessary (Folke, 2006; Gunderson and Holling, 2002; Berkes et al., 2003) and normally go through complex, variable, non-linear and dynamic phases called adaptive cycles (Marshall, 2007; Holling, 2001). Changes exist at different levels in both spatial and temporal scales (Nelson, *et. al*., 2007). However, the type of changes the system might experience and even magnitude, spatial and temporal forms of aspects of expected changes are unpredictable (Nelson, *et. al*., 2007). Depending on the need to continue supporting functions of the system as well as social, economic, political and ecological factors (Walker et al., 2004), if the system thresholds are crossed, changes

will mean undergoing transformations resulting into a new system (Nelson, *et. al*., 2007; Walker, *et. al*., 2004);

- In due regard, management of the system should entail promoting flexibility instead of ensuring or maintaining stability. Flexibility has potential to offer opportunities for new innovations, learning and new thinking all of which promote resilience instead of maintaining stability, which closes doors for new thinking and innovations (Nelson, *et. al*., 2007; Folke, 2006).

- Stresses and disturbances are features of any system. Therefore, adaptation should not only focus on response to stresses but also identify advantages and opportunities arising from stresses and disturbances to the system (Gallopin, 2006; Nelson, *et. al*., 2007). Stresses and disturbances are important to the system because they provide opportunities for innovation, learning and development (Folke, 2006).

- Adaptation is a never complete process since each time adaptation interventions are implemented, new stresses or threats continue to emerge and learning, innovation as well as development continue (Nelson, *et. al*., 2007). While adaptation in the vulnerability research context is so much focused on actors, for example, who/what adapts, adapts to what and how, in the social ecological resilience context, focus is on the system as a whole and not actors as distinct entities (Nelson, *et. al*., 2007). Therefore, implemented adaptation activities should not only be viewed as separate units but also must be considered in a system perspective and focus should be made on their feedbacks to the system, i.e., if positive or negative (*ibid*.).

- Unlike in the vulnerability analysis, in the social ecological resilience, adaptation is perceived to have both the social and ecological context (Nelson, 2007).

Development of the concept and related research in various disciplines throughout has been so useful such that it does not only provide an approach and a way of thinking for both natural and social scientists but also attempts to link researches in various disciplines with the view to enhance collaboration (Folke, 2006). Most importantly, coming into being of the social ecological resilience framework has been key in supporting explanation and analysis of co-existence of the social system and the natural environment dependent of each other (Lambin, 2005).

Much as the theory is helpful in some systems and organisations, some of the attributes are mainly not for small-scale farmers, fishers and pastoralists. The phases identified by Loorbach (2007), for example, look more applicable to highly advanced, well organised and technologically rich systems such as large companies or large scale farmers, and not small-scale, developing systems such as villages in developing countries. In addition, the transformation may not necessarily be positive to the system. In other words, it is possible that outcomes of the transformation in response to political, social, economic and ecological forces lead to poor capacity of the ecological sub-system, failure to support the social sub-system in terms of goods and services, leading to either massive movement or changes in terms of uses of the sub-system for survival. For example, massive deforestation may lead to poor rains thereby disturb and interfere with water flow, causing poor agricultural production as well as compromising ability of rivers to support ecological functioning in the entire system.

3.3 Adaptation, Adaptive Capacity, Vulnerability and Resilience

Vulnerability

Smit and Wandel (2006) as well as Adger (2006) find vulnerability as a concept with long history and different field backgrounds. It has been in use in various fields of research such as engineering disaster management, economics, anthropology, psychology, and recently, global environmental change (Adger, 2006; Vogel, *et. al*., 2007). However, with climate change adaptation research and discussions taking new heights, use of the term has increasingly been associated with the field (*ibid*.). Adger (2006) asserts that any socio-ecological system is characterized by vulnerability to change, and it is a feature linked to its resilience.

Multiplicity of fields to which the concept of vulnerability has been in use implies being defined differently depending on context, yardsticks used to derive the definition or even use of the definition itself. In the area of climate change, social system vulnerability reflects the level at which society is unable to cope with negative impacts of climate change and variability (McCarthy, *et. al*., 2001) and is expressed as a function of exposure, sensitivity and adaptive capacity (Adger, 2006; McCarthy, *et. al*., 2001). Chambers (2006) views vulnerability in the same angle, the extent to which one is exposed to stresses and the inability to cope. His (*ibid*.) work goes beyond by focusing at the individual and poor, small-scale farmer communities level. He (*ibid*.) introduces an internal and external exposure to imply inability to cope with external stresses and shocks but also an internal lack of resources and abilities to recover. The concept refers to the state of being susceptible, exposed to stress and incapable to adapt (Adger, 2006; IPCC, 2007e).

The definitions carry negative connotation. Being vulnerable, a society is at risk of suffering from, and being unable to cope with the negative impacts of climate change such as drought, floods and so forth as Chamber, (2006) precisely puts it, "….. *means defencelessness, insecurity, and exposure to risk, shocks and stress*." However, Young (2005) argues that it should not always be viewed negatively. This is because it is an important characteristic for survival and sustainability of the system itself. It has the potential to stimulate innovation, change process (adaptation), and where necessary, it can ultimately lead to transformation and hence, better adaptation of the system. Promoting system flexibility provides room for change to take place (Young, 2005). Change is important to maintain ability to accommodate any stresses to the system (Holling, 1973).

Adaptation

Adaptation, like any other technical term in social science research, has been defined differently based on contexts. Table 3.1 lists some of the definitions from literature.

Table 3.1. Some of the definitions of Adaptation

Definition	Scholar/source
Adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities, regions, or activities to climatic change and variability	IPCC (2001)

The process through which people reduce the adverse effects of climate on their health and well-being and take advantage of the opportunities that their climatic environment provides	Burton (1992)
Responses or actions taken to enhance resilience of vulnerable systems, thereby reducing damages to human and natural systems from climate change and variability	Scheraga and Grambsch (1998)
All changes in a system, compared to a reference case, that reduce the adverse effects of climate change	Füssel and Klein (2002)
Ways in which local individuals, households and communities have changed their mix of productive activities, and modified their community rules and institutions in response to vulnerabilities, in order to meet their livelihood needs	Rennie and Singh (1996)
Any adjustment, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change.	Stakhiv (1993)
Comprises both individual and collective decisions made and actions taken, in response to current – or in anticipation of projected –climate impacts	Hill, 2008
Adjustments in individual, group and institutional behaviour in order to reduce society's vulnerabilities to climate	Pielke (1998)
responses to climate change that may be used to reduce vulnerability	Burton et al. (1998)

Those are just a few sources with different definitions. In all definitions, much as differences occur, several similarities are clear, adaptation involves the following:

- both human and ecological systems (they co-exist and depend on each other);
- adjustment/changes from what is known to be common/normal to something that responds to stimuli through which the common practice cannot guarantee survival; and
- decision-making process.

Climate change adaptation is viewed as a package of actions through which individuals or communities adjust themselves to the impacts or threats posed by climate change (Nyong, *et. al*., 2007). It refers to adjustments at a system level, be it ecological, social or economic (Smit, *et. al*., 1999). Therefore, climate change adaptation is a process through which individuals, communities, societies or systems adjust their common ways of doing things in response to climate change stimuli, regardless of the purpose, timing, temporal and spatial scope, location, effects, form and performance (Smit, *et. al*., 1999).

These adjustments are a response to either impacts of climate change or threats- possibility of being impacted by climate change. Depending on the economic activity, the human system or an individual will have several options to go for and therefore, one is supposed to evaluate each of the options and choose one deemed to be viable at that particular time. Adaptation should not be viewed as an independent process. It normally takes place dependent on the role and influence of different factors ranging from socio-economic, cultural, political, geographical, and ecological to institutional, each of which independently and/or collectively influences the human-environment interactions (Eriksen, *et. al*., 2011). Some scholarly works have attempted to suggest forms of adaptation, namely, reactive vs anticipatory; planned vs natural; substitute vs complement (Fankhauser, 1999; Fankhauser and Tol, 1997) and on short-term vs long-term (Eriksen, *et. al*., 2011; Adger, *et. al*., 2003). In each case, there can be a thin line between each one in the nomenclature sense because they are interlinked in practical sense.

There are different purposes of adaptation analyses (Smit and Wandel, 2006). This argument is very important in linking sustainability discussion to climate change adaptation. Adaptation analyses can be carried out for the purpose of the following aspects:

a) Estimating the degree to which impacts of climate change, identified through modelling, could be minimised by adaptation interventions as exemplified by works of Parry (2002) as well as Mendelsohn and colleagues (2000a). This approach of analysis is top-down and does not take into account the real or practical situation of a particular area or case but rather, it takes some variables and then run into models to simulate the expected results. Mendelsohn et al., (2000b), for example, developed what they call an intermediate (to the top-down and the bottom-up approach) Global Impact Model (GIM) entailing distinct modules for climate, sectoral features, and climate response functions for each sector and uses spatial simulations to generate country-specific climates, which are then used to estimate and project country-specific market impacts (*ibid*.). However, this is done amidst a lot of complexities and unpredictability at specific local situations. The work of Parry and others (2002), on the other hand, makes an analysis of what they call millions of people with potential risks resulting from different amounts of global warming taking into account climate as well as non-climate factors. Considered climate factors are higher temperatures for two time periods, 2050s and 2080s, while the other factors (non-climate) include growth in population, and income as well as technology (Parry, *et. al*., 2001). Again, this is top-down and does not consider such aspects as specific non-predictable and un-simulated aspects like changes in human consumption and preference behavior, which are also very important. In addition, the predicted changes in temperature may not necessarily provide an actual prediction because the global climate system is so complex that it may be impossible to ascertain what and how it is going to behave or change in future (American Climate Choices, 2010).

b) Assessing alternative adaptation options, their merits and demerits, which one suits where and how. The idea for this type of analysis is to identify the most appropriate options. The analysis is normally done through a top-down approach for that matter. Scholarly works like those by Fankhauser and co-workers (1999) and Niang-Diop and Bosch (2004) are good examples in this case. In their analytical paper, for example, Fankhauser and colleagues (1999) discuss features of efficient adaptation strategies to climate change and argue that such strategies must have a reflection of timeframe and possible uncertainties.

c) Analysing vulnerability of countries, regions or communities through comparative evaluation guided by criteria determined by the researcher. The analysis by O'Brien and co-workers (2004); Adger and colleagues (2004); and Brooks and others (2005) are good examples. The main focus is to influence where adaptation efforts and interventions, including resources, should be directed to.

d) Practical analysis of adaptation needs with focus on a particular system (an area, community or region) aiming at contributing to practical and strategic adaptation intervention, mainly through bottom-up approach after investigating specific adaptation needs, available capacity and existing gaps in order to identify means for implementing adaptation initiatives or enhancing adaptive capacity. According to Smit and Wandel (2006), this kind of analysis is focused such that it is useful in a particular system, region or community context and does not consider issues from the researcher's

perspective. But it takes into account specificities and contexts of a very specific area including policies; local experiences, technological, institutional bases, knowledge bases; cultures and traditions; and political as well as governance factors including decision-making process and the like. Works by Keskitalo, (2004); Sutherland and colleagues (2005); Pahl-Wostl (2002); and Morduch and Sharma (2002) are good examples of such kind of adaptation analysis.

Emergence of the discussions on mainstreaming climate change adaptation into sector plans and budgets in the developing countries, as part of negotiations in the UNFCCC context, is a reflection of the practical, bottom-up approach of analysis. The reason is that addressing adaptation needs to be undertaken through a project-based approach in short-term and does not contain sustainability aspects. Planning and budgeting of government and non-governmental actors as well as local institutions have to reflect adaptation aspects. It is only possible if there are well analyzed, documented, practically undertaken studies indicating adaptation needs of specific localities, which take into account all key local variables. Much as the broad-based models and simulations may be useful to predict what is to happen in future using available information, localized studies are necessary to take into account the social-ecological system context and identify needs as well as the kind of support needs, when and how.

Adaptive capacity

IPCC defines adaptive capacity as the ability or potential of a system to respond successfully to climate variability and change, which includes adjustments in both, behaviour and resources as well as technologies (IPCC, 2007d). It depicts the ability of the system to prepare and adjust to stress for the purpose of addressing the adverse impacts while taking advantage of any opportunities brought by stresses for survival of the system (Smit, ***et. al***., 2001; Adger, ***et. al***., 2007). It means that adaptive capacity does not only save as a precondition for successful adaptation interventions alone but also enables sectors, institutions as well as individuals to take advantage of opportunities or benefits from climate change (IPCCd, 2007). Smit and colleagues (2001) outlined determinants of adaptive capacity, that is, availability of economic resources, the level of technology, availability and access to information and skills, various forms of infrastructure, availability and functioning of institutions, and equity.

In their contribution to the IPCC TAR, Smit and co-workers (2001) demonstrated with vivid examples from various researches, why and how economic condition (of a nation or a community) is a clear determinant of adaptive capacity. Various research works have also found that poverty is directly related to vulnerability (Chan and Parker, 1996; Fankhauser and Tol, 1997; Rayner and Malone, 1998). For example, developed countries demonstrate to be in an advantaged position when it comes to adapting to adverse impacts of climate change compared to poor nations because they possess financial and other forms of resources to enable them not only bear costs of adaptation and risks posed but also ameliorating side effects rather than poorer nations (Goklany, 1995; Burton, 1996). While distribution of wealth within the population is also one other important issue, economic condition has a bearing on access to food and nutrition, information, education, technology and infrastructure development, just to mention a few.

When one talks of climate change adaptation today and even in future, the centre of the discussion is normally on technology availability and access. This is because in most cases, potential adaptation interventions identified in almost all sectors involve use of a particular technology (Smit, ***et. al***., 2001). For example, in the agricultural sector, use of interventions such as new crop varieties, early warning systems, new as well as sustainable irrigation systems

and so forth are widely discussed at different levels but all seem to involve either access to or development of technologies relevant to support their implementation. Therefore, lack of access or inability to develop appropriate adaptation technologies is a clear barrier to adaptation and defines adaptive capacity at different levels.

The role of information and skills in explaining adaptive capacity cannot be overemphasized. For a population to take initiatives to adapt it has to be aware of risk posed and perceive that something is not right and there is need for changes so as to be able to adapt. For this to happen, people must have access to various pieces of information. Access to information can help to assess the magnitude of the challenge, possible options and those feasible within a relevant context (Fankhauser and Tol, 1997). The skills are important in so far as they can help in executing the identified adaptation options. It is from this view point that countries with limited skills related to adaptation in some aspects are in a disadvantaged position when it comes to analyzing adaptive capacity and executing particular adaptation strategies (Scheraga and Grambsch, 1998). Capacity to adapt is also defined by availability of relevant infrastructure, that is, physical, technological and so on. Availability of infrastructures to support early warning systems, weather forecasting, transport, communication, drainage systems as well as forms of relevant networks are all important aspects that have both a role in addressing potential impacts of climate change and respond to risks posed such as floods and droughts.

In terms of availability of strong and responsible institutions as one of important aspects defining adaptive capacity, it is argued that countries or communities with well-developed social institutions are considered to have greater adaptive capacity than those with less effective institutional arrangements (Smith and Lenhart, 1996). Social capital, social networks, values, customs and traditions can affect the ability to adapt to adverse impacts of climate change (IPCC, 2007d). Ahmed and colleagues (1999) maintain that having weak institutions with poor managerial capacities to cope with stresses makes it difficult for a country or community to address issues related to climate change vulnerability. In addition to institutional capacities, access to resources and their equitable distribution within the population facilitates adaptive capacity. It means that much as the country or community can have resources available to support adaptation, the extent to which such resources are accessible and how they are distributed to people within the country or community matters most when it comes to analysing adaptive capacity (Kelly and Adger, 1999). In some countries or communities, resources may be available but some people are denied access to such resources like land and other opportunities, making such people not only highly vulnerable but also have low adaptive capacity to the adverse impacts of climate change. This is also true at the international level where developed countries possess much wealth while the developing world has little thereby making them not only the most vulnerable but also incapable of adapting to climate change (Ribot, *et. al*., 1996; Mustafa, 1998; Adger, 1999; Handmer, *et. al*., 1999; Kelly and Adger, 1999; Rayner and Malone, 1998; Toth, 1999).

Resilience

A varying degree of conceptualization of resilience is a common phenomenon since it is used in different fields of knowledge and contexts. It is used to mean the capacity a system has to absorb shocks, that is, to undergo changes in response to stress, yet continue to provide the required functions (Nelson, *et. al*., 2007). As quoted from the IPCC, it is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress including change (IPCC, 2007e). However, other scholars look at resilience as the level or degree of stress that a system can take up as it undergoes transformation into a different state; including

the capacity to reorganise itself for taking up other new stresses (Carpenter, *et. al*., 2001; Berkes, *et. al*., 2003; Folke, 2006). It is important to take up sustainability concept into resilience. In this context, Gunderson and Holling (2002); Berkes and co-workers (2003); and Carpenter and others (2001) view resilience as the capacity of the system to rejuvenate, re-organize and undergo development, that is, having capacity to sustain itself despite any stresses into it.

Adger (2006) for example, contends that while many may see resilience only as a capacity to withstand shocks and still maintain system function, it can also be seen as an opportunity to undergo transformation for better including new inventions in terms of policies, technologies, knowledge and even development pathways that are much more adaptable than the previous one. Therefore, resilience can provide much better opportunities than probably as it was thought before. It is from this point that Walker and colleagues (2002) summarize resilience to mean level and extent of stress the system withstands and yet maintain its functional capacity and even structure; its level and ability to reorganize itself; and the level to which it is ready to adapt as well as maintain its development course sustainably.

The conceptual framework of this research was formulated based on works by Nelson and colleagues (2007); and Chambers (1989). Nelson and colleagues' (2007) work is so instrumental in explaining and analysing social ecological system adaptation in the context of the social ecological resilience framework and hence, provides a substantive impetus on adaptation within the social ecological resilience framework taking into account sustainability component. Chambers (1989) work is crucial because it explains, in detail, vulnerability and adaptation issues at a local level, which was the interest of this research. The work by Chambers (1989) captures many details on vulnerability and adaptation for smallholder farmers of which this research work focused on.

3.4 The Elements: Overview and Description

As it was explained in the previous Sections, it is argued that any social ecological system is characterized by vulnerability and is always in the state of change (Holling, 1973). Such state exists because the system is constantly disturbed and influenced by various factors (Nelson *et al.*, 2007) like biophysical conditions, economic conditions; technological innovations and developments; social, political and cultural factors; governance systems, institutional factors; knowledge base and information sharing. In this section, two examples of the factors, namely, biophysical and economic conditions are elaborated to show how each one tends to influence the behaviour of the social ecological system and some of the effects of the influences.

Biophysical conditions of a place are major determinants of what exists in the social ecological system (Nelson *et al.*, 2010). In addition, people's social and economic activities in the area are also influenced and shaped by characteristics of the ecological subsystem surrounding them. Interactions of the two sub-systems influence each other. Any changes in the variables of the biophysical conditions such as in the climate, especially if the changes are significant enough, they pose a lot of effects to the entire system both in the social and ecological subsystems (Lal, 2013; Kittel, 2013). For example, smallholder farming is, in most cases, stressed and influenced by changes and variability in climate variables such as rainfall, temperature and humidity. Such changes have potential to influence many other variables related to agricultural activities like moisture contents and regimes; type, recurrence, intensity of occurrence and effects of crop diseases and pests; frequency and intensity of dry conditions

and flooding; duration of rain seasons; and onset of rains (Lal, 2013) affecting production in the farm thereby compromising food security.

Economic conditions and developments have a lot of influences on both social and ecological sub-systems (Jodha, 1985). These conditions operate from both within and outside the system. For example, changes in the market demands have all along influenced production in many sectors. Market pressures have been driving systems progressively faster toward environmental degradation (Agrawal and Yadama, 1997). Many forest resources are being degraded due to market pressures for timber world-wide (Jodha, 1985). The high demand of timber from some tree species has led to almost extinctions of such species (WCED, 1987). The demand for coffee in the developed world has ever since influenced the production of this crop world-wide and hence, determine use of land made by people in the developing world. Demand for some fish species has also influenced significantly on how such species are exploited. From experience, it has been observed that high demands in ivory almost threaten extinction of elephants in the developing world, forcing stringent measures for international conventions to protect such resources. There are many examples explaining the power of markets and how it can influence changes in the way people behave, produce, consume, manage and utilize available resources in the ecological sub-system.

Technological innovations and developments have facilitated changes as well as developments in the economies today world-wide. In terms of smallholder farming, for example, acquisition of a tractor could change the size of land to be cultivated by farmers, the amount of forests to be cleared for farming, the amount of species lost over crop production and so forth. Even when technologies are considered at a very local level, the invention of animal ploughing not only simplified tilling land but also stimulated crop production and an increase in land under cultivation (Meertens et al., 1996). Other factors such as governance systems, political changes, cultural changes, institutional developments, knowledge and information all have a lot to offer to the social ecological system. They influence not only markets but also consumption behaviour, resources management, economic policies, production as well as information and knowledge, just to mention a few. Therefore, characteristics of the social ecological system are the major attribute of system change and adaptation for that matter.

Thus, stresses (factors motivating change) and characteristics (of the system) not only influence changes within the social ecological system itself but also define many other attributes related to changes or adaptation process including the adaptive capacity, level of vulnerability, type and magnitude of change or adaptation, change or adaptation options and resources as well as investments required for adaptation or change to take place.

In the context of smallholder farming, decision to change farming practices might be a function of multiple elements. They may include changes and variability in climatic conditions that are necessary for farm production such as timing of the onset rains, rain distribution and effectiveness in each precipitation event (Lema and Majule, 2009; Kurukulasuriya and Mendelsohn, 2006; Gbetibouo, 2009; Legesse *et al*., 2013); economic aspects (Paavola, 2008) such as income necessary to afford making changes in the farming practice and availability of markets which may motivate farmers to change from, for example, one crop to the other in response. Others include reliable infrastructure stimulating production and selling of particular crops, high demands for personal/family needs and financial capital that can facilitate a farmer to invest in a new farming practice; social factors like knowledge and skills, influence of neighbours, education and information access (Deressa *et al.,* 2008; Wood *et al.*, 2014); and governance issues (Mandemaker *et al*., 2011) such as influence of leaders at all levels as well

as policies. Farmers may opt to switch to new or different farming practices from what they are used to in response to either one or a combination of such factors. For example, recurrent drought due to changes in the local climate will definitely act as a stressor to farmers who in response, they may make decisions to either change crops or crop varieties and so forth.

Another example may be changes in agriculture policy where farmers are motivated to cultivate particular types of crops or are given incentive(s) to pursue a particular farming technique, soil conservation method and so forth. Policies like those related to credits to farmers, extensions services, farmers' income diversification, sustainable land management and incentives, just mention a few, may be very instrumental in changing farming practices by farmers (Thiombiano and Meshack, 2009). The factors operate within the social ecological system dependent on each other. To understand their influence, consideration is on a system perspective because there are always constant interactions within the system and any changes taking place in the agricultural system have a lot to influence in the entire system, good or bad. These considerations are important especially in ensuring long-term resilience and system sustainability. Examples of other possible factors important to mention in this contexts are the individual and social psychology; cultures and traditions; social norms and farmers' awareness level, leading to farmers' decisions to change farming practices in response.

Adaptation within the social ecological resilience framework is viewed as a continuous process because there is no permanent state of adaptedness (Nelson, *et. al*., 2007). This is because the system is taken to be a flexible entity all the time experiencing shocks and constantly in a state of change to absorb the shocks and maintain functions as well as ensure development (*ibid*.). In terms of changes or adaptation options, the system has a level of thresholds, the allowable level of options for change (Nelson, *et. al*., 2007). Some of the changes are undertaken within the allowable level but other changes require going beyond such allowable level, that is, outside the system thresholds. The thresholds have meaning on the type of changes/adaptations, which the system will make in response to stress or factors influencing the changes.

According to Nelson and colleagues (2007), one form of adaptation in the social ecological resilience framework is system adjustments. In this case, changes are within the social ecological sub-systems' thresholds. The changes do not require transforming the system but adjust what exists so as to ensure that adaptation is achieved at that moment of change and accommodate the current stress because the two subsystems still have allowable space to accommodate them in the system (Nelson *et al.,* 2007). Examples may include changes in the farming system such as introducing new crops (may be they are tolerant to dry conditions the system is experiencing as a result of changes in the climate); shifting from rain-fed to irrigation agriculture, from surface water irrigation to ground water irrigation, from only crop production to mixed form of production, that is, to include small-scale animal husbandry for trade off as a result of changes in the local climate; small-scale fishing to aquaculture; and the like. All these are adjustments within the same economic activity and do not necessitate transforming from agriculture to another economic activity, just improving the agricultural systems available to either respond to the climatic changes or even take advantage of any social economic opportunity within or outside the system.

Apart from system adjustment, the other form of adaptation is system transformation. This type of change is undertaken as a result of subsystems reaching thresholds and hence, it requires no more adjustments but transformation from one economic activity to the other, for example, from agriculture to fishing, agriculture to pastoralism or pastoralism to agriculture, agriculture to tourism, agriculture to mining or agriculture to working in industries for labour. The major

basis for this type of adaptation to happen is that there are some cases when the social or ecological subsystems can no longer support adjustments but complete transformations are required (Nelson, *et. al*., 2007). For example, until 1990s, the Maasai community in Tanzania was a pastoralist community practicing transhumance banking on abundance of land for pasture and good climate for availability of water during different seasons (Haller, *et. al*., 2013; Mung'ong'o and Mwamfupe, 2003). However, in recent years, as a result of changes in land policies, which have led the Maasai community to lose most of their land to other land uses, for example, large scale farming and conservation, and changes in the climatic conditions (recurrent droughts) causing massive deaths of cattle, have both led many Maasai to either abandon pastoralism at the expense of small-scale crop production or resort to engage in casual labour in cities and even doing other small-scale businesses to earn their living (Mung'ong'o and Mwamfupe, 2003). This means that some of the Maasai have undergone transformation, changing from the pastoral social subsystem (using the ecological subsystem for grazing) into farming, or migrating into cities and labouring because the social and the natural sub-system can no longer support their form of livelihoods but have to go for a different form of activities. Other examples from literature are such as changing from agriculture to tourism or industrial community to tourism as well (Nelson, *et. al*., 2007).

Adaptation process involves actions, which are implemented for a particular aim, mainly to avert the impacts of stress or disturbance if not taking advantage of an emerging opportunity. However, sometimes there is little thinking on what will exactly be the feedback of the interventions implemented for the system in future. In the social ecological resilience framework perspective, the relationship between components, that is, adaptation interventions, how they are connected to the other system components and the results of their interactions to the entire system, on short-term and long-term, are important to consider (Nelson, *et. al*., 2007). Some basic issues must be considered to determine the kind of outcomes to be expected as a result of the adaptation interventions such as: the kind of adaptation activities or interventions; technologies used; expected feedbacks (positive or negative); spatial and temporal aspects; the kind of political, social, cultural as well as governance systems; and the kind of system flexibility levels taken into account or maintained. The answers will indicate the kind of outcomes expected from the adaptation process. Depending on the answers, there are three possibilities: unsustainable short-term outcomes; sustainable outcomes and resilient social ecological system.

In light of this discussion, the conceptual framework of this research constitutes a combination of three key elements, namely, possible factors motivating changes in the farming practices (vulnerability-stresses and disturbances); changes in the farming practices (adaptation strategies) and socio-economic implications of the changes (outcomes of the changes). The influence of factors triggers motivation for changes in the farming practices. The implication can be positive or negative while the ultimate outcomes mostly depend on how factor(s) and/or changes interact with the environment. However, the outcomes are either sustainable or unsustainable. Figure 3.1 illustrates the interactions.

3.5 Smallholder Farmers' Context: Possible Factors and Outcomes

In this Section, possible factors motivating changes in farming practices in the research area and anticipated outcomes were hypothesized and explained. This derives the depiction of the framework at the end, portraying the three key elements that guided the study.

3.5.1 Possible factors

Existing farming practices for a particular area are a result of natural, social as well as other factors and decisions made by multiple players. Climate variability and change (Kurukulasuriya and Mendelsohn, 2006; Deressa *et al.,* 2008), level of education, agro-ecological settings (Deressa *et al.,* 2008), environmental risk perception and management, the introduction and uptake of new technologies, economic variables such as market price, government policies and social as well as cultural values are some of the factors that may influence farmers decisions on changes in the farming practices. In addition, demographic processes; knowledge, education and awareness can also play a role in influencing changes in the farming practices. At a broader scale, Hazell and Wood (2008) suggest grouping of factors motivating decisions to change agricultural land uses into three levels. Hazell and Wood (2008) further clarify the grouping: one is the global-scale, which refers to all factors originating and operating from the global level but their influences are felt at the specific national level and local level. They include trade expansion, value chain integration, rapid globalization of science and knowledge access and climate change impacts. Secondly, country-scale drivers, which influence agricultural land-use changes within a specific country. Examples of these are per capita income growth; urbanization; commercial factors; changes in agricultural policies such as technological support, extension services and credits including provision of other incentives to farmers and country's investment in agricultural science and technology too. The last level is named local drivers- factors that influence changes at very specific local geographical areas and different types of agricultural production systems. They include poverty; knowledge and technology design; land property rights; infrastructure and market access; off-farm employment opportunities; topography; soils; and micro climate (Hazell and Wood, 2008). While this analysis is broad enough, it seems to highly focus on commercial or large scale agricultural change and less on smallholder agriculture common in developing countries. In addition, other local factors such as local knowledge and technology, local culture and traditions as well as local leaderships and by-laws also play a very important role in agricultural change particularly for developing countries like Tanzania where extension services, access to credits and other motivating services are very limited.

Climatic influence

Climate is an important factor for life on earth. Its patterns have a very significant role in determining almost many aspects: settlements/habitats, housing, foods, clothing, human economic activities, ecosystems and their goods and services as well as interdependence and interrelationship on earth (Biswas, 1984), just to mention a few. It is a key factor in shaping natural ecosystems, human life, economies and cultures. Changes in climate can affect food production and consumption, water availability, wildlife health, human health and the like. It means that such effects resulting from changes in climate will normally trigger changes in the natural, social and economic systems in an attempt to adapt as well as sustain normal life (Schlenker and Lobell, 2010).

While they are necessary elements, precipitation and temperature are not constant and similar everywhere, they change and vary, depending on several factors such as latitude, altitude, proportion of land to water, pressure as well as wind systems, ocean currents and proximity to oceans including mountains. Key rainfall variables relevant for crop production that can influence decisions by smallholder farmers are intra-seasonal dynamics (Tennant and Hewitson, 2002) such as timing of onset of first rains, which is important for crop planting timings, rainfall distributed within the growing season (Mortimore and Adams, 2001), and without overemphasizing the extent to which rain is effective in each precipitation event. Each of these has serious effects on smallholder farmers who possess little alternatives but are

compelled to make tough decisions so as to change their farming practices to adapt. Again, the changes are various and may include new types of crops or crop varieties, change planting dates, or even introduce new ways of operations, take part in off farm activities and/or even diversify income generation activities without being sure about some point whether it is going to work for them or not (Thornton, *et. al*., 2007; Mapfumo, *et. al*., 2010).

Economic factors

Much as smallholder farming is small in terms of scale of production and not typically commercialized, it is also affected and influenced by economic variables (Lee, 2005) such as reliable and good market prices, reliable infrastructures as well as high personal economic demands (Fogg, 1965). Changes in economic variables may either discourage or encourage particular farming practices (Lee, 2005). For example, when market prices for a particular crop are reliable and good, smallholder farmers may tend to massively engage into its cultivation for the aim of getting income by taking advantage of the available good market. But the opposite is also true that when the price of the same crop falls, farmers will definitely tend to avoid its cultivation.

For example, in a review article intended to identify key factors responsible for abandonment of agriculture, Benayas and colleagues (2007) found that both social economic and physiographic factors contributed for the situation. But the significant factor was found to be socio-economic factors such as immigration into areas where new economic opportunities were offered to rural people (*ibid*.). Other studies which document emergence of new economic opportunities as an important factor motivating changes in farming/agricultural practices include: Aide and co-workers (1995); Futemma and Brondı´zio (2003); Lambin and co-authors (2003); Grau and others (2003); Romero-Calcerrada and Perry (2004); and Gellrich and colleagues (2007). In addition, market incentives also have strong contribution to changes in other areas (see, for example, Wiegers, *et. al*., 1999; Simmons, *et. al*., 2002; Cremene, *et. al*., 2005).

Social and Cultural Factors

Social factors are also very crucial in motivating changes in the farming practice by smallholder farmers. Social capital, collective action and knowledge as well as skills in new farming practices may motivate farmers to make decision to change farming practices (Lee, 2005) if they perceive that the mastery and know how will enable them succeed in adapting to a stressor. Information access and communication related to climate and farming techniques and the like have the potential to motivate farmers to make informed adaptation decisions by changing farming practices (Stone and Meinke, 2006; Challinor, *et. al*., 2007). In addition, farmers may change farming practices as a result of influence of their neighbours and other society members. Neighbours who have learned or tested any changes in their farming practices may influence their fellows if what they have tested becomes successful. For example, the role of collective action in many societies especially in Africa where social ties remain important is said to be a very important factor in influencing changes in many farming practices worldwide (Pretty, 1995). Social capital influences use of some technologies such as those related to conservation (FAO, Molinas, 1998); and adoption of fertilizer and soil conservation practices (Isham, 2000; Swinton, 2000).

Other factors such as individual and social behavior (Lee, 2005), culture and traditions, norms and perceptions (Frank et al., 2011) may also be instrumental attributes in motivating changes in the farming practices by smallholder farmers. They may have a role in either facilitating or inhibiting change. Cultures may inhibit changes to take place especially where, for example;

societies wish to maintain their production and consumption behaviour. In such circumstances, farmers may not be ready to accept new production and consumption patterns as well as behaviours.

Policy, Governance and Institutional Factors

Biermann *et al.,* (2010) provide a definition of governance as new forms of regulation that go beyond traditional hierarchical state activity, implying some form of self-regulation by societal actors, private–public cooperation in addressing societal problems, and new forms of multilevel policy. Stoker (1996) defines governance as the development of governing styles in which boundaries between and within the public and private sectors has become blurred. It is a new process of governing, or a changed condition of ordered rule, or the new method by which society is governed (Rhodes, 1996). However, Biermann *et al.,* (2010) caution that no consensus exists on the definition of governance globally. Governance in agriculture involves multiple institutions at various levels where production decisions are made. Governance systems have a very significant role to play in influencing changes in the farming practices. The roles of institutions and governance bodies like farmers' cooperative unions; water resource management and regulation bodies; local government authorities; the private sector; non-governmental actors; government and the state institutions including policies, laws, regulations and rules; the research and scientific communities cannot be over-emphasised. Cooperative associations play an important role in influencing changes to farmers through, for example, ensuring better access to credit, incentives and extension services; strengthening social capital, facilitating innovation; supporting market access and so forth (Frank and Buckley, 2012). Government/state policies, strategies and directives influence a lot of changes in farming practices as well as adaptation to climate change and variability (Yohe and Tol, 2002). The role of policy incentives to farmers is very influential in motivating decisions by farmers to change farming practices both in developed and developing countries (Bryan, 2013; Anderson, 2009). Influence of public investment in various aspects such as rural infrastructure, availability of subsidized inputs, farmers' education and training, provision of agricultural extension services as well as micro-credit services are policy decisions instrumental in supporting adaptation including changes in farming practices (Below, et. al., 2012; Kaliba, et. al., 2000).

Globalisation, increase, widening and intensification of connectedness among nations, communities and institutions (Held, *et. al*., 1999), can have both positive and negative results (Young, *et. al*., 2006) and it can stimulate development. But many changes have taken place at the global level, affecting both smallholder farmers and influencing changes in the farming practice as a result (Hazell, *et. al*., 2007; Lipton, 2005; Maxwell, 2003). These are influenced by global policies *inter alia*, global trade, climate change and energy policies particularly in the developed world (Miyake, *et. al*., 2012) as well as the quest for multinational companies to take business advantage. Climate change mitigation, for example, has created an opportunity to produce clean energy, which triggered changes in energy policies in many countries especially in the developed world (*ibid*.). The need for alternative clean energy sources has not only become a policy for the international community but also an opportunity for many companies to produce and sell clean energy. One source of this form of energy is cultivation of crops like jatropha, sugarcane, soya beans and maize for energy production driven by bio-energy policies (Miyaka, *et. al*., 2012). These policies have led to many changes in land uses in the developing world and there are already complaints in some countries especially among the poor rural communities that much of their land has been converted into bio-energy farms. In countries like Brazil and Indonesia, for example, a lot of changes in the farming practices have taken place as a result of such global policies (FAOSTAT, 2011; Miyake, *et. al*., 2012).

FAOSTAT estimates that between 1961 and 2009, the area for sugar cane production increased from 1.4 million hactares (ha) to 8.4 million ha and much of the sugarcane is used to produce clean energy (FAOSTAT, 2011). While this is also within the food-fuel international debates, it is an example of how such policies can play role in influencing changes in the farming practices and affecting smallholder farmers.

Technological Factors

Technology can potentially play an important role in adapting to climate change (IPCC, 2007e). Technological innovations and advances have a lot of influence on changes in the farming practices (Young, *et. al*., 2006; Friedman, 2005). They simplify many undertakings and facilitate easy access to information on markets and the like. In addition, they facilitate farmers to learn a lot of aspects related to production and access to markets (Young, *et. al*., 2006). The role played by seasonal forecasts and timely dissemination of weather forecasts information to farmers cannot be overemphasized. Weather forecasts, have and will continue to, influence various decisions in the agriculture sector in developing countries because farmers depend mostly on rain-fed agriculture. Such information can help support both short-term as well as long-term decisions (Ziervogel and Calder, 2003). With climate forecast information, smallholder farmers can decide on variety of crop to plant amidst the forecasted climatic conditions (Patt and Gwata, 2002; Ziervogel, 2004). For example, depending on the forecast, farmers may decide to go for drought-resistant crop varieties instead of long-maturing varieties that require more moisture, which might fail along the way (Ziervogel and Calder, 2003). Availability of technological options such as those related to water-harvesting systems, water conservation and agricultural practices, development of new drought-resistant and early-maturing crop varieties (IPCC, 2007e), sustainable irrigation and improved early warning systems, are just few examples of options, which cannot only motivate but also can facilitate smallholder farmers to decide to change farming practices amidst perceived changes in the local climate and other stresses.

Demographic factors

Various other studies have identified demographic factors contributing to changes including changes on farming practices as well as land use changes. Some of these include migration and rural depopulation (Cawley, 1994; Romero-Calcerrada and Perry, 2004; Aide, *et. al*., 1995; Douglas, *et. al*., 1996; Lasanta, *et. al*., 2001; Angelstam, *et. al*., 2003; Grau, *et. al*., 2003; Coelho, *et. al*., 2004; Gisbert, *et. al*., 2005; Lo´ Pez, *et. al*., 2006; Plieninger, 2006); and urbanization and population growth (Long, *et. al*., 2006; Ebanyat, *et. al*., 2010;Miller, *et. al*., 2009; Snyder, 1996).

In summary, decisions by smallholder farmers' households to change their farming practices might not necessarily be a response to only a single factor in the social ecological system. This is because the system components are integrated and so the functioning of each of the components (Nelson et al., 2007). Hence, linkage and multiplicity of factors influencing decisions by smallholder farmers in the move to change farming practices is possible, especially in the African context where climate related factors operate and are closely linked to other socio-economic dynamics. Literature provides some examples of factors that at different times and space have motivated farmers to opt for particular strategies as adaptation measures to different stressors. They include climate change and variability; economic conditions such as access to markets, extension services, credit services as well as technology and farm assets; social dynamics; government policies and interventions; and the role of NGOs, and/or private institutions (Hassan and Nhemachena, 2008; Mertz, *et. al*., 2008; Below, *et. al*., 2010). Table 3.2 summarizes factors against some literature in each of the factors.

Table 3.2 Summary of factors motivating changes in agriculture from literature

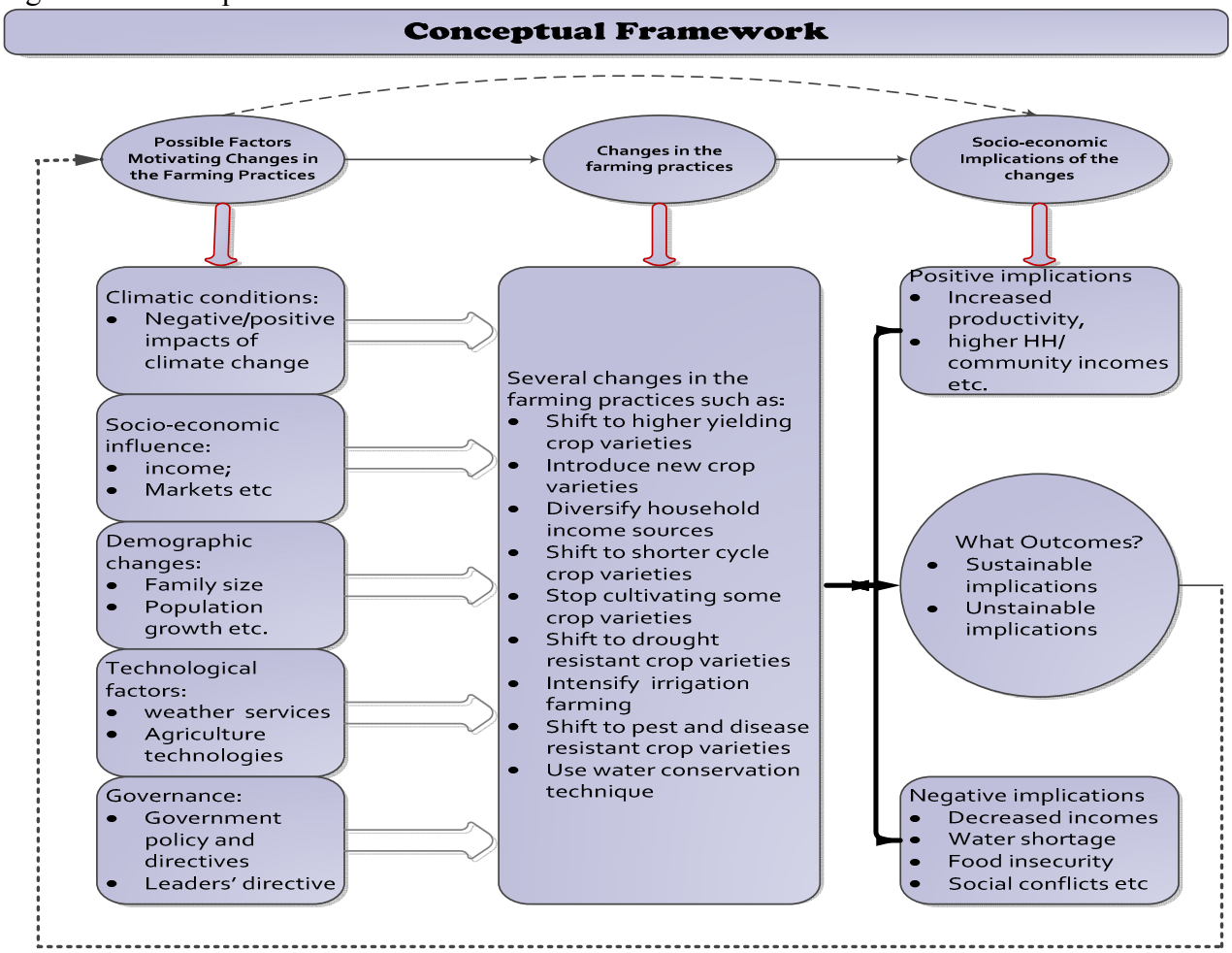
Driver	Specific factors/motivations	Examples of literature
Physiographic	Climate change and variability	Hezell and Wood, 2008; Miller et al., 2009; Soini, 2005
	Extreme events	
	New crop diseases and pests	
	New weeds and alien species	
	Water scarcity/availability	
	Degradation of the environment (soil erosion, deforestation, water pollution and degradation of water catchments etc.)	Hezell and Wood, 2008
Economic	Global trade and globalisation	Hezell and Wood, 2008; Miller et al., 2009
	Prices (inputs and outputs)	Hezell and Wood, 2008; Miller et al., 2009; Zaal and Oostendorp, 2002
	Incentives to agriculture	Hezell and Wood, 2008; Febles-González et al., 2011; Miller et al., 2009; Wiegers et al. 1999, Simmons et al. 2002, Cremene et al. 2005
	Infrastructures and accessibility	Hezell and Wood, 2008; Zaal and Oostendorp, 2002
	Industrialization	Hezell and Wood, 2008; Long et al., 2006
	Emerging/new economic opportunities e.g. biofulel cultivation, tourism	Aide et al. 1995, Futemma and Brondı´zio 2003, Lambin et al. 2003, Grau et al. 2003,
	Poverty	Hezell and Wood, 2008
	Economic, agricultural and crop diversification	Febles-González et al., 2011;
Governance, policy and institutional factors	Economic, Agricultural and land use policies	Hezell and Wood, 2008; Febles-González et al., 2011; Ebanyat et al., 2010; Miller et al., 2009; Long et al., 2007
	Energy and food security policies	Hezell and Wood, 2008; Miller et al., 2009
Political	Political instabilities, Political decisions	Ebanyat et al., 2010;
Technological factors, Research and development		Hezell and Wood, 2008; Miller et al., 2009
Social and cultural factors	Population dynamics/demographic changes e.g. population growth, migration and density	Hezell and Wood, 2008; Ebanyat et al., 2010; ; Miller et al., 2009; Cawley 1994, Aide et al. 1995, Douglas et al. 1996, Lasanta et al. 2001, Grau et al. 2003, Coelho et al. 2004, Gisbert et al. 2005, Lo´

		pez et al. 2006, Long et al., 2007; Soini, 2005;
	Social interactions	Miller et al., 2009
	Urbanisation	Hezell and Wood, 2008; Miller et al., 2009; Long et al., 2006
	Education and training	Onphanhdala, 2009; Pudasaini, 1983
	Individual perceptions and attitudes, social consumption behaviour, traditions, beliefs	Frank et al., 2011; Miller, 2009

3.5.2 Outcomes

Changes made in the social ecological systems such as by farmers in their farming practices are aimed at enabling them to take an opportunity or adapt to stress before them (Folke, 2006) and hence, they ensure that livelihoods efforts are successful. Adaptation is the expected result of change in the farming practice in response to the stressor. In the context of sustainability, it is interesting to note that not all changes in the farming practices may yield positive and sustainable results. Some can end up yielding only short-term coping mechanisms, which are not necessarily sustainable. In light of this, three possible outcomes of changes include the following: adaptation, which is positive with sustainable outcomes; short-term coping strategies possibly negative with unsustainable outcomes; and/or long-term resilience to climate change impacts. In addition, it is also important to note that much as adaptation is expected, similar or additional factors, depending on external, internal or both situations can continue to motivate other changes in the farming practices to take place over time. This is because sustainability is a process and not an event, which ends once it has been realised. Elements of the conceptual framework and how they are interlinked are illustrated in Figure 3.1.

Figure 3.1. Conceptual Framework



Source: Drawn using elements and concepts from Nelson and colleagues (2007); Yohe and Tol (2002); and Chambers (1989).

The next chapter provides details regarding methodological part of this research. It includes details about the research area, sampling procedures, data collection methods and data analysis plan.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

Kothari defines research as a scientific and systematic search for pertinent information (knowledge) on a particular issue of interest (Kothari, 2004). It is a scientific, rigorous scrutiny done by the researcher to obtain data so as to uncover something about a specific issue the researcher is interested in. It is an undertaking aimed to describe, predict and/or explain particular behaviour(s) (Jackson, 2009). It is a step-by-step process involving collection and examination of information, often to improve knowledge and understanding of a phenomenon (Matthews and Ross, 2010). Research process is a structured and purposeful; rigorous; robust and defensible; as well as a systematic process (*Ibid.*)

Research methods are the techniques or means and ways used to conduct research, that is, all methods one employs in conducting a study (Cohen, *et. al*., 2007; Kothari, 2004). They are tools or instruments the researcher uses to collect relevant information he/she wishes to obtain depending on the issue at steak. They include questionnaires, interviews, records, audiovisual (Kothari, 2004) or pictorial materials and the like. Research methodology, on the other hand, refers to the broader approach the researcher adopts in responding to research questions, including various methods, techniques and principles, which help research to create scientifically based knowledge by means of objective methods and procedures within a particular discipline (Kohen, *et. al*., 2007; Welman, Kruger and Mitchell 2005). Research methodology is helpful in many ways including controlling the study, dictating acquisition of data to address the research questions, arranging data into logical relationships to support its analysis, and at the end, drawing conclusions (Ndenje-Sichalwe, 2010; Teddlie and Tashakkori, 2009; Cohen, *et. al*., 2007; Leedy, 1997; Leedy and Omrod, 2005) if it is relevant, depending on the employed research approach.

This chapter presents Research Methodology employed in the study. It provides detailed description of the research area from a broader perspective, Tanzania, to a specific and narrower view of the Mkomazi sub-catchment capturing the South Pare and West Usambara Mountains. It also captures various aspects related to research methods, techniques and methodology employed in this study including: design and approach of the research; sampling; data collection methods as well as instruments; reliability and validity issues; and data processing, analysis and presentation.

4.2 Research Design

Today, there is a broad range of approaches and strategies for undertaking research, which on one hand, they offer the researcher an opportunity to choose the best among many available options (Creswell, 2003). On the other hand, they may pose a great challenge for the researcher due to the fact that having many options may lead to confusion or if one is not careful, there is a risk of choosing an inappropriate option. The multiplicity also poses a challenge for those who stick to use a single method (Mingers and Brocklesby, 1997).To avoid possible confusion, Crotty (1998) suggested that one needs to consider the following points while planning for research especially in social science: the theory of knowledge rooted in the theoretical perspective, which informs the intended research (Epistemology); the philosophical stance, which lies behind the methodology to be used (the theory); the methodology intended to be used (such as case study, survey research, ethnography, and the like); and methods, the

techniques as well as data collection procedures to be used (for example, questionnaire, interview, focus group and the like).

Research Design is a comprehensive description of the plan that indicates how systematically a scientific study is going to be conducted (Creswell, 2009 cited in Ndenje-Sichalwe, 2010). It describes the real problem to be addressed by the intended scientific study; aims and purposes the research is intended for; research methodology, which includes approaches and research styles such as survey; descriptive, case study, ethnographic, longitudinal, cross-sectional, correlational and so forth; and kinds of data required (quantitative, qualitative or both); the population and sampling process (Creswell, 2009 cited in Ndenje-Sichalwe, 2010) (for example, sample size and access, type and so on). Other aspects include data collection methods to be used like questionnaires; interviews; observation, and documentary reviews; validity and reliability issues; data analysis plan (Cohen, *et. a*l., 2007; Jackson, 2009). The difference in terms of questions a researcher wishes to respond to, types of data to help in responding to the questions, sources of data, where the data to be collected and availability of resources, are among issues that have for years dictated the type of design the researcher goes for in the endeavor to undertake a scientific study (*ibid*.).

4.2.1 Research Approaches

For many years, quantitative and qualitative research approaches have been in debates (Johnson and Onwuegbuzie, 2004). Advocates of each of the two approaches have all along been challenging each other over several philosophical as well as practical deficiencies and strengths for each research approach (*ibid*.). Aliaga and Gunderson (2002) define quantitative research approach as, "Explaining phenomena by collecting numerical data that are analysed using mathematically based methods." According to Creswell (2003) it involves collection of information in form of numbers and using quantitative analysis to explain phenomena. Qualitative research approach, on the other hand, involves collecting non-numerical data and using qualitative form of analysis to explain phenomena. Qualitative research methods aim to explain why things are the way they are, why people behave as they do and other similar questions (Hancock, 1998). Tashakkori and Teddlie (2003a cited by Venkatesh, *et. al*., 2013) describe mixed methods research as one that involves a design using multiple methods (quantitative and qualitative research methods) to conduct research. Tashakkori and Teddlie (2003 cited by Venkatesh, *et. al*., 2013) identify two categories of multiple research methods, namely, multi research methods and mixed research methods and they attempt to differentiate between the two. The former refers to one which can use two or more research methods, with or without being restricted to a single research paradigm (Mingers and Brocklesby, 1997; Teddlie and Tashakkori, 2003 cited in Venkatesh, *et. al*., 2013). Use of ethnography and participant observation, for example, involves two methods within the qualitative research paradigm. This cannot be seen as mixed methods but rather, remains to be multi research methods. But mixed methods involve use of quantitative and qualitative research methods in either concurrent or sequential mode (Venkatesh, *et. al*., 2013; Cohen, *et. al*., 2007). Table 4.1 provides details on the three research approaches.

Table 4.1 Features of a quantitative, qualitative and mixed research approaches

Criteria	Quantitative Approach	Qualitative Approach	Mixed Approach
Scientific Method	**Deductive or "top-down"** Test hypothesis and theory with data.	**Inductive or "bottom-up"** Generate new hypotheses and theory from data collected.	**Deductive and Inductive**

Most common research objectives	Description Explanation Prediction	Description Exploration Discovery	Multiple objectives
Focus	**Narrow-angle lens** Testing specific hypotheses	**Wide and deep-angle lenses** Examine the breadth and depth of phenomenon to learn more about them.	Multi-lens
Nature of study	Study behavior under artificial, controlled conditions.	Study behavior in its natural environment or context.	Study behavior in more than one context or condition
Form of data collected	Collect numeric data using structured and validated instruments (closed-ended survey items, rating scales, measurable behavioral responses)	Collect narrative data using semi- or unstructured instruments (open-ended survey items, interviews, observation, focus groups, documents)	Multiple forms
Nature of data	Numeric variables.	Words, images, themes, and categories	Mixture of numeric variables, words, and images.
Data analysis	Identify statistical relationships.	Holistically identify patterns, categories, and themes.	Statistical and holistic
Results	**Generalizable findings.** General understanding of respondent's viewpoint. Researcher framed results.	**Particularistic findings**. In-depth understanding of respondent's viewpoint. Respondent framed results.	Corroborated findings that may be generalizable.
Form of final report	Statistical report including correlations, comparisons of means, and statistically significant findings.	Narrative report including contextual description, categories, themes, and supporting respondent.	Statistical findings with in-depth narrative description and identification of overall themes.

Source: Adapted from Johnson and Christensen (2004).

While other scholars have tended to believe that quantitative and qualitative research approaches are incompatible and cannot be combined in practical terms (see, for example, Howe, 1988; Guba, 1990 cited in Johnson and Onwuegbuzie, 2004), others have opined that research today is less qualitative and quantitative (Newman and Benz, 1998), rather, stands in between. Others have gone further to suggest combining both quantitative and qualitative approaches to have mixed methods approach provided that it helps a researcher to find plausible responses to the relevant research questions, particularly when the researcher finds no barriers for using such an approach (Venkatesh, ***et. al***., 2013).

Quantitative research approach advocates (for example, Maxwell and Delaney, 2004; Schrag, 1992 cited by Johnson and Onwuegbuzie, 2004) have tended to believe that social phenomena like cultural, psychological as well as sociological observations should also be treated in the same way as physical phenomena such as geological, chemical or biological issues (Johnson and Onwuegbuzie, 2004).

According to Johnson and Onwuegbuzie, (2004), quantitative research advocates maintain that social science researches must be objective. On the other hand, qualitative research approach advocates (for example, Lincoln and Guba, 2000 Schwandt, 2000 cited by Johnson and

Onwuegbuzie, 2004) believe that it is not possible for all social science phenomena to be quantitatively treated when it comes to scientifically studying them (Johnson and Onwuegbuzie, 2004). These qualitative research advocates argue farther that time and context-free generalizations are neither desirable nor possible; it is not always possible to fully differentiate causes and effects in a phenomenon; and logic flows from specific to general (advocating inductive against deductive reasoning) (Johnson and Onwuegbuzie, 2004). Over decades, these inter-paradigmatic debates possibly motivated the rise and use of mixed methods to better understand various phenomena.

Qualitative and quantitative research approaches have been in use by both social and natural science community long before use of mixed approach (Creswell, 2003). As it is well known, and as clearly described before, quantitative research approach is normally conducted through experimental, non-experimental or survey designs. On the other hand, qualitative research approach is normally based on in-depth and detailed scrutiny of issues using narratives, phenomenologies, ethnographies and/or case studies and the like (*ibid*.). However, it is well known that each of the two methods has both advantages and disadvantages. To address those limitations, using them in combination is the best way to bring in the best qualities for each one of them (Jick, 1979). Onwuegbuzie and Leech (2005) as well as Johnson and Onwuegbuzie (2004) outline various advantages of using a mixed method approach including the following: it enhances flexibility of the researcher in investigative techniques, which help to address several emerging questions well without being bound by the myth of either qualitative research approach or quantitative research approach; promotes collaboration among researchers without taking into consideration the divide and differences in terms of philosophical orientation; views research in a holistic perspective (Lincoln and Guba, 1985; Newman and Benz, 1998); has an ability of obtaining many details about the problem and gain the broader aspect about the problem (Willems and Raush, 1969); it has an opportunity to combine macro- and micro- levels of a research issues; and allows merging of qualitative and quantitative aspects within a single scientific investigation.

Based on the works of Rossman and Wilson (1985); Greene, Caracelli and Graham (1989 cited by Onwuegbuzie and Leech, 2005); and Johnson and Onwuegbuzie (2004), using mixed methods approach allows a researcher to meet the following purposes: looks for convergence as well as substantiation of results from different methods studying the same phenomenon; makes elaboration, enhancement, illustration and clarification of results from one method with results from the other method; uses results from one method to help inform the other method; discovers paradoxes and contradictions that lead to re-framing of the research question(s); and seeks to expand the breadth and range of inquiry by using different methods for different inquiry components. Table 4.2 outlines the purposes of Mixed Methods research.

Table 4.2 Purposes of Mixed Methods Research

Purposes	Description
Complementarity	Mixed methods are used in order to gain complementary views about the same phenomena or relationships.
Completeness	Mixed methods designs are used to make sure a complete picture of a phenomenon is obtained.
Developmental	Questions for one strand emerge from the inferences of a previous one (sequential mixed methods), or one strand provides hypotheses to be tested in the next one.
Expansion	Mixed methods are used in order to explain or expand upon the understanding obtained in a previous strand of a study.

Corroboration/Confirmation	Mixed methods are used in order to assess the credibility of inferences obtained from one approach (strand).
Compensation	Mixed methods enable to compensate for weaknesses of one approach by using the other.
Diversity	Mixed methods are used with the hope of obtaining divergent views of the same phenomenon.

Source: Adopted from Venkatesh and colleagues (2013.

4.2.2 Case Study Research Methods

Before defining "Case study," it is important to define the meaning of a 'case' in the case study research context. Gerring (2007) defines case as a spatially delineated phenomenon or a unit observed at a single point in time or over some period of time. Case study is a research design aimed at investigating a contemporary phenomenon within its real life context, especially when boundaries between phenomenon and context are not clearly evident (Yin, 1994, 2003). Case Study Research refers to an inquiry with focus to describe, understand, predict, and/or control the individual case (Woodside, 2010), which can be a person, household, village, group, process, organization, culture, nationality and so forth (Gillham, 2000). Woodside (2010) proposes that the principal objective of the case study researcher is to develop deep understanding of actors (in a specific case), interactions, sentiments, and behaviors occurring for a specific process through time.

Case study research design is characterized by a focus on interrelationships constituting the context of a specific entity (a case); analysis of the relationship between contextual factors and the entity being studied; and the explicit purpose of using insights (of interactions between contextual relationships and the relevant entity) to generate theory and/or contribute to existing theory (Mills, *et. al*., 2010). One other key feature of the case study research design is the use of multiple sources of evidence, each with its strengths and weaknesses because no one kind or source of evidence is likely to be sufficient on its own (Gillham, 2000). This, in turn, becomes very important in ensuring validity of collected data (Baker, *et. al*., 2012). Over and above those, in case study research, possession of pre-conceived ideas or theoretical notions (*a priori*) are not applicable because until one is in there and gets hold of the data and understands the context, it is not possible to know theoretical explanations, which can work best or can make the most sense for that particular case (Gillham, 2000). Becker *et al.,* (2012) and Yin (2003) argue that case studies are appropriate: for the researcher intending to respond to how or why questions; when the researcher has little control over events; and when there is a contemporary focus within a real life context. Furthermore, the design is useful when there is a need to cover contextual conditions because they are relevant to the phenomenon under study or boundaries are unclear between the phenomenon and context (Yin, 2003). Likewise, case studies are relevant to solve a problem that seeks a holistic understanding of the event or situation in question using inductive logic-reasoning from specific to more general terms (Becker, *et. al.*, 2012).

Barkley (2006) suggests that case study research designs may be divided into four main types, namely, single-case against multiple-case studies and holistic against embedded case studies. The former categorization is based on number of cases in the research design, while the latter is based on the number of units of analysis within each case (*ibid*.). On the other hand, Becker and colleagues (2012) identify four types of case studies, namely, illustrative (which are basically descriptive, utilizing one or two instances of an event to describe how a situation is like); exploratory (condensed type of case studies undertaken prior to implementing a large scale investigation of a phenomenon); critical instance case studies, which examine one or

more sites for various purposes such as generalizability or challenging a highly generalized or universal assertion; and cumulative case studies, which, as the name suggests, they aggregate information from several sites collected at different times to see if it is possible to allow for generalization without additional cost to a new study on a particular phenomenon.

Mills and colleagues (2010) contend that case study research methodology has a somewhat long history especially within the sciences, social sciences, and humanities. An example is given on available evidence that it was "pioneered" at the University of Chicago by 1920 (*ibid*.). They (*ibid*.) further argue that much as most of the early case studies researches were qualitative in nature, quantitative and mixed methods research approaches were evident as well. This type of research design is currently found across various fields such as Political Science; history; education; management and administration; and global environmental change (Mills, *et. al*., 2010). However, like in other research designs case study method has its own strengths and weaknesses. Table 4.3 illustrates.

Table 4.3: Strengths and Weaknesses of Case Study Design methods

Strengths	**Weaknesses**
Comparatively flexible method of scientific research allowing the researcher freedom to discover and address issues as they arise in the real context	They are challenged that they are difficult to generalize because of inherent subjectivity and because they are based on qualitative subjective data, generalizable only to a particular context
Emphasize on deep data or thick description, information is based on particular contexts, giving rise to research results with a more human face	They can also be time consuming since a deep understanding of the case is sought hence requiring more time for the study
They are much appropriate in dealing with creativity, innovation, and context unlike homogeneous and routine behaviours	They may also require more resources because they normally involve learning more about the subjects being tested than most researchers would care to know, for example, educational background, emotional background, perceptions of themselves and their surroundings, their likes, dislikes and so forth.
case studies produce much more detailed information than what is available through a statistical analysis	

Source: Yin (1989); Dawidowicz, (2011); and Becker and co-workers (2012)

This study used a mixed research approach with case study methods, combining both quantitative and qualitative research approaches. In due regard, both qualitative and quantitative methods were concurrently used to collect data in a single phase of data collection. However, two gap filling visits were conducted after the main data collection phase. Using a quantitative research approach, data were collected through a questionnaire survey administered to smallholder farmers from four villages in the study area. In addition, long term daily rainfall records from three weather stations and daily temperature records from one meteorological station within the study area were collected. In terms of qualitative methods, interviews were conducted to experts, selected elders and local leaders, while Focus Group Discussions (FGDs) were also conducted to selected smallholder farmers.

In identifying suitable methodological approach for conducting this research, mixed methods approach was selected for various reasons. One of the reasons was to ensure better data quality, validity and reliability. Triangulation was necessary as means to strive for convergence and validation of results from qualitative and quantitative research approaches. Use of mixed

methods is normally credited for generating comprehensive research data. In this research, it was also found to be a useful approach for the same purpose. Mixed approach helped to ensure that research questions were comprehensively answered through use of many sources of information. Furthermore, using mixed research approach is an appropriate means to address weaknesses inherent in use of a single method, that is, either quantitative or qualitative methods (see also Bryman, 2006). Thus, it was necessary and fruitful to use mixed approach so as to benefit from advantages of each one of the qualitative and quantitative approaches while avoiding disadvantages of each of the two as well. In this study, use of mixed methods mainly concentrated on strengths found from both two methods for better conclusions.

While case studies are normally considered qualitative, they can involve use of either quantitative or qualitative data or both (Dawidowicz, 2011). This level of flexibility suited well within mixed research approach. Using this level of flexibility, it is possible for a researcher to adjust case studies to effectively address various research situations and contexts ((Dawidowicz, 2011). As argued by Teddlie & Tashakkori, (2009) cited in (Dawidowicz, 2011), studies that combine both aspects (quantitative and qualitative) can provide comprehensive insights into all types and levels of questions. Since the intention of this study was to have a comprehensive understanding of the situation using a broad range of sources of information (social, economic ecological and meteorological), the use of mixed approach with a case study design was relevant. Using this broad, multiple data sources allow researchers to gain in-depth knowledge about a given bounded case (Merriam & Associates, 2002; Stake, 2006 cited in Dawidowicz, 2011). The use of a wide variety of data sources such as observations, interviews, questionnaire etc., through a case study design can help a researcher to have a comprehensive view of factors involved in a phenomenon studied (Merriam, 1988 cited in Dawidowicz, 2011; Yin, 2009). Hence, the use of mixed research approach with a case study design was helpful in explaining factors which have from time to time been influencing smallholder farmers' decisions to change their farming practices in the Mkomazi sub-catchment.

In summary, use of both quantitative and qualitative methods in form of triangulation was helpful in supporting the researcher in order to realize the following aspects: obtain a variety of information on the same issue; use strengths of each method to overcome deficiencies of the other; achieve a higher degree of validity and reliability of results; and overcome deficiencies of a single method (see also Ndenje-Sichalwe, 2010). These are also articulated by various scholars (for example, Johnson and Onwuegbuzie 2004; Creswell and Garrett, 2008).

4.3 Description of the study area

4.3.1 Tanzania: An Overview

According to URT, (2013c;), Tanzania is located slightly South of the Equator, lying between latitudes 1°S and 12°S, and longitudes 29°E and 41°E. with a total area of 945,087 kilometre squares (km²). The country constitutes Mainland Tanzania (881,289 km^2) and Zanzibar (2,460 km^2) (URT, 2013c). The country has a total land area of 883,749 km^2 and 59,050 km^2 of inland water bodies (URT, 2013c). It also occupies part of the Indian Ocean on the East. Mainland Tanzania encompasses Mafia Island (518 km^2) while Zanzibar is formed by over 50 islets, with two Isles, Unguja (1,666 km^2) and Pemba [(795 km^2) *ibid*.]. The country has a total of 1,424km of coastline (CIA, 2014). In addition, there are several inland islands. Ukerewe, for example, is the largest island in Lake Victoria and the largest inland island in Africa, with an area of approximately 647km² (URT, 2013c). The country's borders are as follows: Kenya and Uganda to the North; Rwanda, Burundi and Democratic Republic of Congo to the West;

Zambia and Malawi to the South-west; Mozambique to the South; and the Indian Ocean to the East (See Figure 4.1; URT, 2007).

The country has a wide variety of physical features extending from a narrow coastal belt of the Western Indian Ocean with sandy beaches to an extensive plateau with altitude ranging from 1000 to 2000 metres (m) above sea level. The plateau is fringed by narrow belts of highlands, including Mountain (Mt.) Meru (4,566 m) and Mt. Kilimanjaro (5,895m), the highest mountain in Africa and other mountain ranges such as Livingstone, Kipengere, Udzungwa, Uluguru, Nguu, Usambara (West and East) and Pare (North and South) (URT, 2013b). The spectacular Great Rift Valley system traverses the country with two arms, the Western arm (to which Lakes Nyasa, Tanganyika and Rukwa fall in) and the Eastern arm crossing the central part with Lakes Eyasi, Manyara and Natron within it (Shemsanga, 2010; URT, 2013b). Other features include diverse vegetation types such as extensive savannah and bush lands fringed by narrow belts of forested highlands, thickets, the Masai steppes, the extensive miombo woodlands, and the mangrove systems along the coast. These features and ecosystems, both terrestrial and marine, are famous habitats for diverse types of flora and fauna, making the country among the top in terms of biodiversity richness in the continent (Shemsanga, 2010; URT, 2013b).

The country's geographical position, physical geological features and the like create various climatic patterns and conditions: tropical to temperate and alpine deserts (Shemsanga, 2010; URT, 2013b). These climatic patterns are influenced by several factors including the Inter-Tropical Convergence Zone (ITCZ), the *El Niño* Southern Oscillation (ENSO), *La Nina*, altitude and distance from the ocean (Shemsanga, 2010). In terms of rainfall, Tanzania experiences both bimodal and unimodal rainfall patterns. The former, consisting of long rains (locally referred to as *Masika*) experienced between March to May and the later, short rains, (*Vuli*) are experienced between October to December (Shemsanga, 2010; Mwandosya, ***et. al***., 1998).

Figure 4.1 Administrative Map of Tanzania

Source: URT, (2013c)

Tanzanian economic pattern is mostly similar to many developing countries' economies with an agricultural sector being dominant in terms of employment provision as well as having significant contribution in other economic variables. During the last decade, the economy, on average, grew from 4.1 percent in 1998 to 7.4 percent in 2008 (URT, 2010a). The growth was not uniform in all sectors because the service and manufacturing sectors registered the strongest annual growth rates of 7.5 percent and 8 percent, respectively, while the agricultural sector registered weaker growth, around 4.4 percent since 2000 (*ibid*.). In terms of percentage share, in 2011, shares of Gross Domestic Product (GDP) at current prices before adjustment for taxes and Financial Intermediation Services Indirectly Measured (FISIM) were 25.8 percent for Agriculture, 1.6 percent for Fishing, 24.8 percent for Industry and Construction, and 47.9 percent for the Services sector (URT, 2013e).

4.3.2 Climate Variability and Change: Impacts and Vulnerability

Tanzania is believed to have already been experiencing changes in the climate and its impacts said to be felt in various social and economic sectors (Yanda and Mubaya, 2011; Shemsanga, 2010). The country experiences extreme weather events, such as droughts and floods (see, for example, Figure 4.2) that have had major impacts on both people and the economy. Severe droughts are increasingly being felt in many parts of the country with negative consequences

to social life and the economy (URT, 2007). The most vulnerable sectors such as agriculture, fisheries, energy, health, water and tourism had been severely affected from time to time (URT, 2007: 2013b).

According to several studies related to Tanzania's climate change situation, projection indicates that frequency and severity of extreme climatic events will increase (for example, Mwandosya, *et. al*., 1998; Shemsanga, 2010; URT, 2009b; DPG-E, 2009; IIED, 2009; UKaid, 2011; URT, 2003). The country has, for the past few decades, been experiencing various signs thought to indicate climate change related impacts such as severe and recurrent drought. Provided examples include droughts in 2003, 2005 and 2009, which had severe effects on key socio-economic sectors such as agriculture, energy and livestock (URT, 2010a and b). Smallholder farmers, pastoralists and the poor have been among the seriously affected individuals because such extreme events have had both social, environmental and ecological consequences, leading to poor agricultural production, loss of livestock as well as wildlife due to massive deaths, food insecurity, health concerns and even compromising the fast growing and promising sector, tourism (URT., 2010a). Additionally, the business community has also been the culprit due to energy crisis as a result of recurrent droughts in the country (CTI, 2011). While peer reviewed scientific papers provide clear climate change related statistics, articulating the real climate change situation including scientific projections for Tanzania may seem to be deficient (Hepworth, 2010), observations, local people's perceptions and experiences as well as already available publications and reports provide clues to what is happening and highlight the expected situation in future on this issue.

Figure 4.2: Floods in Dar es Salaam, December 2011

Source: URT, (2013b)

Fresh Water Resources

Tanzania has several fresh water bodies, including Lake Victoria, the largest in Africa and third largest worldwide; Lake Tanganyika, the longest and deepest in Africa, and second deepest in the world; and Lake Nyasa (URT, 2002). The country also has many large rivers, draining into nine drainage basins. The major rivers include Rufiji, Kagera, Mara, Ruaha, Pangani, Ruvuma and Malagarasi (URT, 2013b). The nine water basins are Wami-Ruvu, Lake Victoria, Lake Nyasa, Lake Tanganyika, Lake Rukwa, Rufiji, Ruvuma, an internal drainage basin around Singida and Pangani Basin (URT, 2013b) in which Mkomazi River is part. Other water resources in the country include wetlands, springs, reservoirs and groundwater aquifers. Some of these water resources are trans-boundary.

Increasing rainfall variability and prolonged droughts cause serious pressure in the country's available water resources (URT, 2007). Severe and recurrent droughts are believed to have contributed to decrease in water flows in many rivers. Hence, there is shrinkage of receiving lakes as well as declines of water levels (as illustrated in Figure 4.3) in satellite lakes and hydropower dams. Furthermore, some of the perennial rivers have changed to seasonal rivers and some wetlands have dried up (URT, 2013b). Water as a finite resource is under pressure due to several reasons such as climate change and variability, pollution, over-abstraction, and encroachment of water catchments for various land uses (for example, agriculture and industrial development). These have negative impacts on important watershed and recharge areas as well as wetlands and other ecosystems at large (URT, 2013b).

Figure 4.3: Rocks showing the drop in water level of Lake Victoria

Source: URT, (2013b).

Agriculture and food security

Like it is in many African countries, agriculture in Tanzania is a key economic sector. It employs more than 75 percent of the total country workforce with a greater contribution to the economy in terms of GDP, raw materials, export earnings and food security (URT, 2008, URT, 2009a; URT, 2013b). However, most farmers are smallholders, whose farming is rain-fed, un-mechanized and with little use of inputs. Thus, much as it contributes immensely to the economy, the sector is highly vulnerable to effects of climate change and variability (URT, 2008, URT, 2009a). Changing climate and variability has resulted in a general decline in agricultural production, including changes in agro-diversity (Yanda, *et. al*., 2005). Prevalence of crop pests and diseases is also reported to have increased, posing further challenges to agriculture. Some studies indicated that certain areas, which were previously highly productive, such as the Southern and Northern highlands, will continue to be affected by declining rainfall, frequent droughts and significant increase in spatial as well as temporal rainfall variability (URT, 2009a).

A study by the Ministry of Agriculture, Food and Cooperatives indicated considerable changes in types of crops grown in agro-ecological zones with declining production trends (URT, 2008). A general perception by a majority of farmers is that incidences of crop pests have increased over the past few decades, and that the pests have become highly prevalent with time (URT, 2013b). As a result, emerging diseases such as *batobato*, Banana Xanthomonas wilt, Panama, coffee wilt, maize streak, cassava mosaic, and rust particularly in green grams were reported

to have become highly prevalent (URT, 2008). URT, (2008) provides further details and examples that in some parts of the country, cassava diseases were not serious for many years, but since the 1980s, the crop has increasingly been facing a lot of damage due to increased incidences of diseases. Moreover, increase in temperatures has been associated with increased incidences of some of plant species such as *Striga* spp, which is a noxious weed particularly for cereal crops; insect pests (for example, *Prostephanus truncatus*, and *Bemisia tabacci*); and vermins such as the mole rats (URT, 2013b). All these have had cost implications to farming because they increase the demand for pesticides, herbicides and other farm inputs, which would otherwise be unnecessary. Hence, they overburden the already stressed poor smallholder farmers in the country. Over and above the increased prevalence of diseases, pests and alien species, evidences have shown that there is a shift of agro-ecological zones as a result of perceived changes in the climate (URT, 2007). While more scientific evidences may be needed to ascertain this, present evidence of climate change supporting the shift paradigm is the observed shift in rainfall patterns from bimodal to unimodal rainfall regimes in some areas/regions (URT, 2008).

The National Food Security Policy of 1997 recognizes food availability, accessibility and utilization as three major pillars of food security. It is further understood that improved food security is associated with improved and stable human capital, which may lead to higher agricultural production and wages in the labour market. However, it has been noted that food availability is greatly affected by low production and production due to factors that are linked to climate change, for example, high incidence of pests and diseases, and unreliable rainfall that lead to recurrent droughts or floods in some parts of Tanzania (URT, 2013b). For instance, URT, (2010b) indicates that the quantity of maize produced in mainland Tanzania decreased from 5,406,088 tons in 2007/08 to 3,326,200 in 2008/09, while the quantity of paddy also decreased from 1,396,163 tons in 2007/08 to 1,334,800 tons in 2008/09. Likewise, during the year 2009/10, production of major traditional cash crops declined compared to levels recorded in the year 2008/09 except for tobacco, pyrethrum and tea. That was attributed to the long dry spell experienced in the year 2008/09. Assessment of food security undertaken by the Ministry of Agriculture, Food and Cooperatives (URT, 2008) revealed that semiarid areas experienced more food shortages and insecurity compared to other districts. Climate related factors were reported to have significantly contributed to food shortages and insecurity, with much of the food shortage being experienced in years with drought and floods. Major causes for the food shortages included drought, crop pests and diseases, low soil fertility, livestock diseases, and low household incomes (URT, 2008).

Whereas production of most crops seems to have declined due to perceived changes in the climate, particularly increasing rainfall unreliability, other crops seem to have benefitted with the changes as a few studies indicate that there has been an increase in production of such crops amidst perceived changes. Kangalawe and colleagues (2009), for example, documents that production of mangoes and oil palm in the Western plateau of Tanzania has increased considerably during the last 20 years compared to the past. Much as there can be other factors contributing to the increase in production, the study attributes warming of the environment as a key factor that has favoured production of both mango and oil palm in these highland areas (*ibid.*). The local experience indicates further that some twenty years ago, mango and oil palm trees produced only flowers without bearing fruits because of cold weather but today reasonable harvests can be realized from these crops (*ibid.*). What remains unclear is how local communities can take advantage of the increase in production of these crops so as to benefit more and probably offset loss from the decline of production in other crops that have been negatively affected by warming.

Summary

While several signs of climate change and variability are already vivid in Tanzania, the country is expected to be affected further in terms of its economy as a result of climate change impacts. The study on the economics of climate change in Tanzania undertaken by UKaid in 2011, projects an increase of 1°C to 3°C in the annual average temperatures above the baseline period from a range of models and emission scenarios by the 2050s, the years 2046-2065 (UKaid, 2011). The study further indicates that by the end of the century (2100), average temperatures are expected to increase in the range of 1.5°C to 3°C for the lower emission scenario and 3°C to 5°C for the higher emission scenario (*ibid*.). In terms of extreme events, floods and droughts, for example, the study reveals that many models indicate an intensification of heavy rainfall, particularly in some regions and thus, greater flood risks and droughts are likely to continue, particularly in some regions (*ibid.*). The study concludes that the estimated costs for addressing current impacts and preparing for future climate change is US$ 500 million per year (for 2012) and by 2030, it will have increased up to US$1 billion per year (*ibid*.). However, it is cautioned that it may even be higher than this if additional enhanced development for resilience and social protection is included (*ibid*.). The report conveys the following key messages, which are very well supported by IIED, (2009): currently, Tanzania suffers high economic costs due to extreme events; climate change will lead to potentially high future economic impacts; adaptation can reduce these impacts, but requires significant levels of funds; a more sustainable, low carbon pathway would be in Tanzania's self-interest; and Tanzania needs to get ready and act now. These highlight the need for urgent and long-term measures to be instituted to address today's and expected impacts of climate change in the social, economic and environmental thematic areas to ensure sustainable development.

4.3.3 Pangani River Basin

Pangani River Basin has five main sub-catchments, namely, Kikuletwa, Ruvu, Mkomazi, Luengera and the mainstream Pangani (see illustration on Figure 4.5; PBWB/IUCN, 2007). The Basin covers an area of about 43,650 km^2 shared between Tanzania (95%) and Kenya with approximately 5 percent (*ibid*.). In Tanzania, the Basin is spread over four administrative regions: Kilimanjaro, Arusha, Manyara and Tanga and in around 14 districts (Komakech, ***et. al***., 2011). Pangani River (from which the basin name is derived) rises as a series of small streams on the Southern sides of Africa's highest peak, Mt. Kilimanjaro, and on Mt. Meru, which together create Kikuletwa and Ruvu Rivers joining to form Pangani River, which then passes through the arid Maasai Steppe, draining Pare and Usambara Mountain Ranges (Mkomazi and Luengera tributaries) before reaching the estuary and Indian Ocean at the coastal town of Pangani in Tanga region (PBWB/IUCN, 2007). The river is 500 km long (Komakech, ***et. al***., 2012; 2011; Notter, 2010; IUCN, 2009; PBWB/IUCN, 2007).

In terms of climate, there are variations, which are mostly related to topography with the flatter, lower-lying South-western part of the Basin being arid and hot; while the mountain ranges along the Northern and South-eastern parts having cooler and wetter climatic conditions (Komakech, ***et. al***., 2011; IUCN, 2009; PBWB/IUCN, 2007). The high altitude slopes above the forest line on Mt. Meru and Mt. Kilimanjaro have an Afro-Alpine climate and receive more than 2500 millimetres (mm) of rainfall per year (IUCN, 2009; PBWB/IUCN, 2007). Mean annual rainfall increases in a Southerly direction along the mountain ranges, and varies from about 650 mm per year in the North and South Pare Mountains to 800 mm per year in the Western Usambara Mountains, and 2000 mm per year in the Eastern Usambara Mountains (PBWB/IUCN 2007; IUCN, 2009; Komakech, ***et. al***., 2012).

Many of the basin's rivers, which used to be perennial, now flow for only part of the year because of water abstraction and changes as well as variability in the local climate. Some examples may be given: in Kikuletwa sub-catchment, most stream flow is from springs in the middle of the basin. Upstream of flows are no longer perennial as they used to be. Luengera and Mkomazi Rivers, which used to be perennial, are now highly seasonal (IUCN, 2009). Recent studies show that the Mkomazi sub-catchment (see Figure 4.4) is most developed, with about 58 percent of its natural annual flow being abstracted for agriculture and other uses (IUCN, 2009).

The basin supports more than 4 million inhabitants, 80 percent of which depend on agriculture, directly or indirectly, for their livelihoods (PBWB/IUCN, 2007; Komakech, *et. al*., 2011; Notter, 2010). Irrigated agriculture is a significant consumer of water in the basin (PBWB/IUCN, 2007). Coffee, sugar, flowers, and fruits as well as vegetables, much of these for export, are irrigated in large plantations or estates in the northern part of the basin (Notter, 2010). Many other crops, including paddy, maize, beans, bananas and vegetables are grown for local markets. Small-scale farmers grow a main staple crop such as maize, and a variety of other crops that vary from place to place across the basin (PBWB/IUCN, 2007). Coffee, bananas and paddy are important in the highland areas and most fields are irrigated via a system of traditional furrows. Livestock also provide an important source of income to households throughout the basin and are dependent on natural sources of water (PBWB/IUCN, 2007; IUCN, 2009).

Mkomazi Sub-catchment

Mkomazi sub-catchment, a Pangani River Basin sub-catchment, is formed by Mkomazi River and its tributaries. It is made up of four tributaries, namely, Saseni, Yongoma, Hingilili and Nakombo (JICA, 1984; PBWB personal communication, 2012). Each of these tributaries drains a different area in the valley as follows: Saseni feeds Lake Manga further South near Manga Mikocheni village and down Lake Karamba; Yongoma feeds Kalimawe dam where upstream there is ginger farming particularly Mamba Myamba where Kambeni village is located and downstream there is Kalimawe Dam with Ndungu Rice Irrigation Scheme; Hingilili supports small scale irrigation upstream where now they have ginger cultivation and downstream there is paddy irrigation mainly at Gonja Maore; and along Nakombo upstream they irrigate bananas, vegetables and they have also started ginger cultivation (PBWB personal communication, 2012). Downstream is also used for cultivation of vegetables. In addition to those four tributaries, which originate from the South Pare Mountains, Mkomazi River is also joined by Muraini River (with its source at Lake Jipe) on the North and Luengera River on the West from the West Usambara Mountains (Komakech, *et. al*., 2011; PBWB, 2006). Mkomazi River flows through forests, valleys as well as drier areas joining Pangani River at a confluence near Makuyuni (Kashimbiri, *et. al*., 2005)

Geographically, Mkomazi sub-catchment is located between $4^0$45'S and $5^0$2'S; and between $37^0$48'E and $38^0$18'E (Kashimbiri, *et. al*., 2005). It is situated between South Pare Mountains on the West and West Usambara Mountains on the East. In terms of Sub-catchment, it is bordered by Pangani Mainstream on the West and South, Luengera Sub-catchment on the West and the Ruvu Sub-catchment on the North [see Figure 4.5 (PBWB/IUCN, 2007; IUCN, 2009)].

Located in Same district, Kilimanjaro Region, the South Pare Mountains range from 600-2400 Metres Above Sea Level [MASL] (Komakech, *et. al*., 2012; 2011). The West Usambara Mountains are located in Tanga region between 610 to 2300MASL (Nyambo, *et. al.*, 2006). They are characterized by steep slopes and narrow valleys, and they are said to occupy about

1968 km^2 out of which 1575 km^2 are arable lands (Nyambo, *et. al.*, 2006). They are estimated to have about 220 km^2 of forests. The South Pare Mountains peak is 2,462MASL at Shengena while the West Usambara Mountains is 2,400MASL (IUCN 2003). Apart from their hydrological functions as water towers, the West Usambara and Pare mountains are also very rich in terms of biodiversity (IUCN 2003) and are part of the Eastern Arc Mountain Ecosystem in Tanzania.

In terms of population, Lushoto has a total of 492,441 people with an average household Size (HHS) of 4.7 (URT, 2013a). According to URT, (2013a), Mtae ward (where Mtae village, which was one of the four villages covered by this research, is administratively found) has 12,851 people with an average HHS of 4.6. The Usambara Mountains are believed to be densely populated with an estimated population density of 312.6 persons per km^2 (URT, 2013a). URT, (2013a) further asserts that currently, Same district population is 269,807 and the HHS is averaged to be 4.5. Myamba ward has a total of 13,168 people with an average HHS of 4.6. Korogwe district has the least population among the three districts whereby it has 242,038 people with an average HHS of 4.6. Mkomazi ward has a population of 8,069 with an average HHS of 4.4 (URT, 2013a).

While local variations in terms of climate is experienced, generally, the entire study area is within the bi-modal rainfall pattern, which involves a short rainy season normally between October and December (*Vuli*) and long rainy season, between March and May [*Masika* (PBWB, 2006; IUCN, 2009)]. In terms of precipitation in this sub catchment, the upper part is much more endowed than the lower part because the former reaches maximum of 2250 mm in some areas, while other areas in the latter receive only 250 mm (Kashimbiri, *et. al*., 2005). Topography is the main factor responsible for the local variations in precipitation (Odiyo, 1994) and the subcatchment is estimated to cover an area of approximately 3,600 km^2 [(Kashimbiri, *et. al*., 2005 see the illustration on Figure 4.4].

Figure 4.4: Pangani Basin Sub-catchments

Source: PBWB/IUCN (2007).

4.3.4 Population and sampling

In this research, the population involved 2421 households in four villages, namely Mkundi with 348 households and 1753 inhabitants; Mtae had 768 households with 2552 inhabitants;

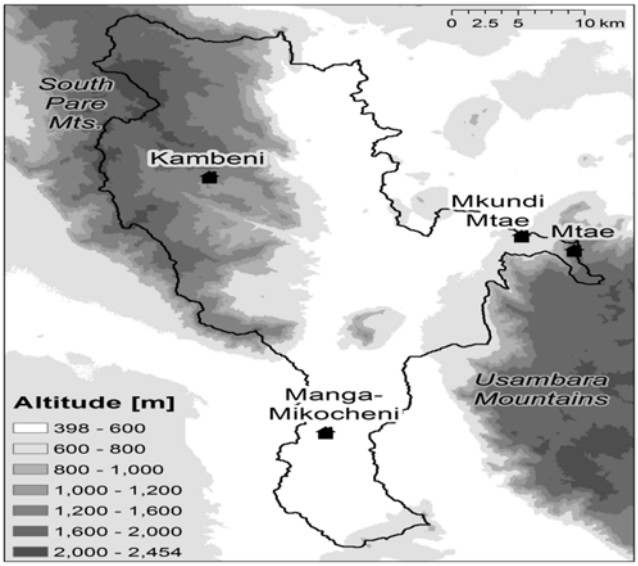
Kambeni had 765 households with 3827 inhabitants; and Manga Mikocheni had 540 households with 2694 inhabitants (Village Governments personal Communication, 2012). In addition to these villages, there were three institutions, namely Same District Council, Lushoto District Council and the Pangani Water Basin Office. This made the population to have a total of 2424 units (households, district authorities and institutions).

Mkundi village is located on the foothills of the West Usambara Mountains, an area of deciduous bush lands. The village has no access to permanent water sources and the climate is semi-arid, characterized by unreliable economic activities. People depend mostly on smallholder agricultural production limited to mostly Lablab, which is a drought tolerant crop. The village also has a good number of pastoralist Maasai who graze their cattle in and around village land. In most cases, beyond smallholder agriculture and pastoralism, there are limited livelihood options.

The other village is Mtae, located on the narrow West Usambara mountain ridge North of Lushoto town. Like Mkundi, the village has no permanent water sources and the area experiences semi-humid climate with people involved in diverse economic activities such as smallholder agriculture, tourism, small businesses and small-scale animal keeping. While they lack access to permanent water sources, a few villagers undertake small scale irrigation using tap water for producing mostly shorter cycle crops such as vegetables and potatoes in small gardens.

Unlike the two, Kambeni village is located on South Pare Mountain. Permanent flow of water from Chome Forest Reserve and availability of market support dominance of ginger cultivation as a commercial crop. Other food crops such as maize, bananas, potatoes, cassava and beans are cultivated too. In terms of size, the village looks like a small town with most of the services such as electricity, water and public transport from nearby towns like Moshi and Dar es Salaam. Figure 4.5 shows the research area with the four villages. It is necessary to acknowledge that no appropriate references were found describing these villages.

Figure: 4.5 Research area Map showing the Four Villages



Source: Clima-A-Net Project, University of Oldenburg

The last village in the list is Manga Mikocheni located on the vicinity of Lake Manga plain and along the main Dar es Salaam to Arusha road. Field observation shows that it is characterised by seasonal swamps with sodic soils, decidous bush lands, seasonal water availability, semi-arid climate and moderately diverse economic activities mostly smallholder agriculture, pastoralism and fishing. Smallholder agriculture is predominant but people mostly depend on water flow from Kalimawe Dam. The village looks highly vulnerable to climate change and variability because of lack of reliable water for irrigation while there is unreliable rainfall.

The four villages were purposively selected into the study considering the following aspects: coverage of other studies within the Clim-A-Net project such as one on Landscape ecology, which was conducted in the villages as well. This is because the study was conducted as part of implementation of the Clim-A-Net project. The project was implemented collaboratively between the Universities of Oldenburg-Germany, Dar es Salaam-Tanzania and the Nelson Mandela Metropolitan University-South Africa along three key lines of activities, i.e. education, research and networking. For Tanzania, focal research area was the Pangani River Basin. This criterion was helpful because it made it possible to exchange and share some of the data from these studies within the project context. In addition, recommendations for appropriate adaptation framework(s) can be made, for the study area and other areas with similar socio-economic characteristics in the country and elsewhere in the developing world. The other factor for selection of the four villages was to try to compare those villages with access to water for irrigation and those without access but entirely depend on rainfall for their crop production. In this regard, water accessibility or inaccessibility was included for comparing different villages. Climatic conditions of the villages was also another factor, which guided selection of the villages with the aim to identify the impacts of different climatic conditions on agricultural production and how such variations relate to changes in the farming practices by the smallholder farmers. Then, location of the villages within the valley, that is, highlands and lowlands, upstream and downstream was also considered as a criterion for selection of the villages. The three institutions were selected because of their mandates and technical as well as administrative functions in the study area.

The sample was either randomly or purposively selected. To select individuals at the village, random selection was used to obtain the sample for both questionnaire and FGD. This was executed by using the village household register assisted by the village government leaders. A total of 200 households were selected into the sample for the questionnaire, that is, 50 households for each of the four villages. Using the village registers for each of the four villages, in Kambeni and Mtae villages, every 15^{th} household in the list in the village register was selected into the sample. In Manga Mikocheni, every 10^{th} household was selected while in Mkundi, every 7^{th} household in the list was selected. For the FGD, a total of 32 households were selected. However, the final number of household heads who turned up to fill the questionnaire was 189, 94.5 percent of the total for the questionnaire and 25 (78%) for the FGD. For the questionnaire, the distribution of the individuals was the following: Mkundi-47, Mtae-48, Kambeni-45 and Manga Mikocheni-49. In the case of FGD, the distribution was Mkundi-6, Mtae-6, Kambeni-7 and Manga Mikocheni-6.

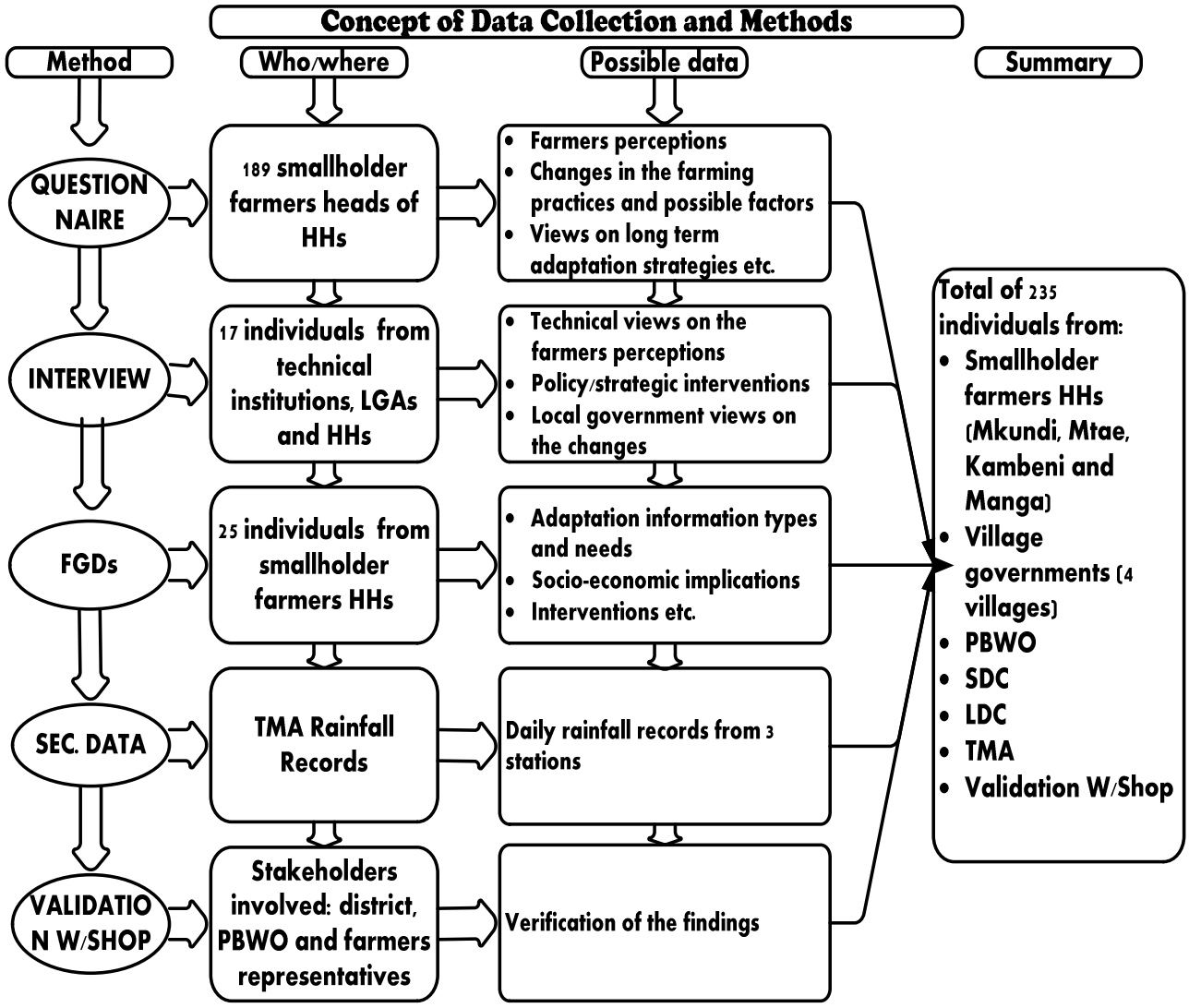
Selection for interviewees was made purposively guided by heads of the respective institutions for the experts. Heads of institutions were consulted to identify the right individuals to be interviewed. For the village leaders and extension experts, selection was also made purposively considering their roles and mandates in their areas of jurisdiction. The village administration was consulted to identify elders to be interviewed in each of the villages. In total, 17 individuals were interviewed in this research. As for the stakeholders' validation workshop, invitation

letters were sent to Pangani Basin Water Board, Same District Council, Lushoto District Council and the Mamba Myamba Ginger Cooperative Society requesting each to nominate a representative to attend. Thus, four nominees attended the workshop. In the final analysis, the whole sample constituted a total number of 235 individuals distributed as follows: 189 for questionnaire; 25 for the FGD; 17 for the interviews; and 4 for the stakeholders' validation workshop. That was 93 percent the expected number of the sample units.

Each of the household head selected into the sample was asked to respond to questions from the questionnaire and the enumerator filled in the responses as per participant's responses. The questionnaire did not take into consideration ethnic background of respondents for two main reasons. First, in the Tanzanian context, tribalism is highly discouraged and people do not prefer or entertain being identified through their ethnic group backgrounds but rather, their nationality. This actually has a long history since independence and was a government policy to strengthen national unity as well as support the national ideology of Socialism and Self-Reliance. For quite long, it has been supported to build a country with strong unity and peace regardless of having over 120 ethnic groups in the whole country. The second reason was that since the investigation was on factors motivating farmers to change farming practices, ethnic group differences did not seem to play any role as smallholder farmers are more or less having similar characteristics especially because they are within a particular environment and the type of farming system is almost similar.

Twenty five respondents took part in the FGD discuss a number of issues related to historical perspective of their areas, changes in the farming practices and motivating factors thereof as well as long-term adaptation strategies for enhanced adaptive capacity and long-term resilience. Then, seventeen experts and village elders as well as village and ward leaders selected for participation in the study were interviewed, through a semi structured interview, to obtain details used to substantiate the data collected through questionnaire and FGD. The number of all the units drawn into the sample formed 10 percent of the entire population. To summarize the data collection process, Figure 4.6 depicts the whole process: the total sample and brief details of the data collected through different methods and sources, including the stakeholders' validation workshop and field excursion.

Figure 4. 6: Overview on data collection



4.3.5 Data collection

This research was designed to use both quantitative and qualitative design (mixed design). Both primary and secondary data were collected. Quantitative data were collected through the use of a questionnaire and obtaining daily rainfall records from four stations. Qualitative data were collected through interviews and FGD. Figures 4.7 and 4.8 illustrate data collection exercise while Table 4.4 provides details on the type of data and the data collection method. Figure 4.7 indicates questionnaire data collection process in Manga Mikocheni and Mkundi village respectively while figure 4.8 illustrates rainfall data collection in Suji Mission village.

Table 4.4 Theorized Variables and Conceptual view of Data Collection

Broader category of factors	Variable	Data required	Data type and method
Environmental factors	Climatic conditions	Perception of the local community on changes in climate in general, with the focus on temperature and rainfall	Qualitative and Quantitative: Questionnaire, FGD and Interview

		Recurrence of extreme weather events like droughts and floods, their severity and related impacts	Qualitative and Quantitative: Questionnaire, FGD and Interview
		Emergence of new weeds and crop diseases and pests, their perception as to why these have emerged in recent years etc.	Qualitative: FGD
Economic factors	Financial capital and income	The role of financial capital asset as a motivating factor for decision making to change farming practices	Qualitative and Quantitative: Questionnaire
		Average annual household income in Tanzanian Shillings (TZS) and whether this motivates making changes in farming practices	Quantitative: Questionnaire
	Access to markets, infrastructure and communication	Market access and its role to the changes	Qualitative and Quantitative: Questionnaire, Focus Group Discussion and Interview
		Availability of infrastructures, communication system and their role in motivating changes to farming practices	Qualitative and Quantitative: Questionnaire, FGD and Interview
		Increasing demands of agricultural produce and quest for personal/household own development as motivation for changing farming practices	Qualitative and Quantitative: Questionnaire, FGD and Interview
Social	Education, knowledge and skills	Formal and informal education institutions in the area and/or nearby, what and how they do contribute to the decisions by households to change farming practices	Qualitative and Quantitative: Questionnaire
		Visits of extension officers with their contribution to the changes	Quantitative: Questionnaire, FGD and interview
		Various other sources of agricultural knowledge and skills as well as how such sources are accessed by the farmers, and how the acquired knowledge contributes to changes	Qualitative and Quantitative: Questionnaire, FGD
	Information and awareness	Learning visits by the farmers, feedback from researchers, co-operative societies and farmers associations or social groups (if any) and their contribution to the changes by those farmers	Qualitative and Quantitative: Questionnaire, FGD and interview
Cultural dimensions	Social norms	Any social norms that influence your decision to change farming practices, such as food preferences and prohibition of farming some crops in this area	Qualitative: Questionnaire, FGD
	Traditions and beliefs	Traditional groups such as council of elders which do influence/dictate changes in the farming practices for any purpose	Qualitative and Quantitative: Questionnaire, FGD
		Local techniques and technologies for weather forecasting/prediction and their influence in changing farming practices over time	Qualitative: Questionnaire, FGD and interview

Demographic changes	Population growth	Increase in the number of household members as a factor for decision to change farming practices	Qualitative: FGD
Psychological:	Individual character	Whether the changes are a result of individual character and experience to try to improve one's agricultural production or address problems such as crop failure etc.	Qualitative and Quantitative: Questionnaire, FGD
	Influence of neighbours and significant others	If the changes are influenced by others and how	Qualitative and Quantitative: Questionnaire
Governance	Leadership	The influence of leadership at all levels in farmers decisions to change farming practices	Qualitative: Questionnaire, FGD and interview
	Policy decisions	If the changes are response to government policy decisions	Qualitative and Quantitative: Questionnaire, FGD and interview
	Political decisions and influences	If political decisions have a role to play in the changes by the farmers	Qualitative and Quantitative: Questionnaire, FGD and interview
Technology		Various technologies that have constantly been motivating farmers to change farming practices and whether they have improved their production, their sustainability etc.	Qualitative and Quantitative: Questionnaire, FGD and interview
Meteorological Data	Climatic conditions	Rainfall and temperature trends and conditions in the area over 30 years ago to check if there have been changes and correlate with the perceptions of the local communities on the state of their local climate as well as the changes in the farming practices happening or recently happened in the area	Quantitative: TMA Meteorological records

4.3.5.1 Primary data

Household Questionnaire

A questionnaire having both close-ended and open-ended questions was administered to 189 households aimed at obtaining information on, among others, important demographic and socio-economic information from the identified households; farmers' perceptions on the local climate status; any changes in their farming practices overtime; and explanation of those changes in terms of specific types of crops and crop varieties as well as factors that motivate farmers' decisions to undertake such changes farming practices. Other aspects included socio-economic implications of the changes at both household and community levels; and long-term policy and strategic interventions for enhanced resilience, which farmers believe they could be able to support them to not only adapt but also enhance their resilience to climate change and variability in future. Figure 4.7 is an illustration of the data collection exercise using questionnaire.

To capture the data from farmers' perceptions, possible changes in the climate relevant to smallholder farmers' context were listed. Then farmers were asked to select only possible changes in the local climate they believed that they had been experiencing according to their

best level of knowledge and experience in the area. The baseline was a minimum of 30 years. Apart from perceptions on changes in the local climate, the study was of interested also to enquire on farmers' views regarding their prediction on the state of climate in future. Farmers were asked to predict how the immediate future climate would be, approximately the next five to ten years, whether they had the feeling that it would slowly be going back to normal or the situation would continue to be worse as time goes on.

Regarding changes in the farming practices and factors influencing these changes, two initial lists, one for the possible changes and the other for possible factors motivating changes in the farming practices. The possible factors were obtained from similar studies (for example, Acquah, 2011; Gbetibouo, 2009; Mertz *et al*., 2008; Belaineh Legesse, 2013) and researcher's experience in the smallholder farmers' Tanzanian context as well as the research area. In addition, smallholder farmers had a room to propose any other changes and factors which seemed to have been left out from the lists. After a pretest and initial results, the lists were reduced. Possible changes, which had a score below 10 percent from both the pretest and the data collection exercises were identified as insignificant and rejected, hence dropped. On the other hand, reduction of the factors considered both rejection of some possible factors at the stage of pretest before data collection (please refer to Section 4.3.6); percentage score of each of the factors (those with less than 1% overall score were considered rejected and removed from the list); and results from the qualitative data on the same.

Thus in the final lists, there were eight possible changes and seven possible factors. The final list of changes in the farming practices contained: shift to higher yielding crops/varieties; introduce new crops/varieties; shift to shorter cycle crops/varieties; stop cultivating some crops/varieties; shift to crops that command good market prices; shift to drought resistant crops/varieties; intensify irrigation; and diversify household income sources. The seven factors forming the final list were: negative effects of climate change and variability; financial capital; income needs; good markets; high living costs and demands for personal and household needs; household size; and influence of others, for example, neighbors.

To obtain the data on factors motivating such changes in the farming practices, a table containing both possible changes in the farming practices and possible motivating factors was developed. In the first row, it contained a list of fourteen possible factors. In addition, possible changes in the farming practices that have already been discussed in the previous paragraphs were also listed in the first column of the same table (Appendix 1, Question 6.1 is an illustration). This was meant to allow smallholder farmers to identify changes in the farming practices that they had been making and correlate them with possible factors that motivated them to make decision(s) to undertake those changes. Then, they were able to check the boxes where possible changes and possible factors cross each other. Each of the respondents was allowed to tick multiple factors against multiple changes and vice versa. In addition, a follow-up two columns table (the first with containing similar changes in the farming practices and the second with blank spaces) was prepared to allow farmers to provide details of the changes made in the farming practices including types of crops and crop varieties as well as other details on alternative income generating activities and the like.

For the immediate future coping/adaptation options and long-term policy and strategic interventions, two separate lists were made. The first list contained a table with potential immediate future coping/adaptation options, while the second contained a list of potential long-term strategic and policy adaptation interventions. The items making the lists were drawn from both literature (for example, Hassan and Nhemachena, 2008; Middison, 2006; Panda, *et. al*.,

2013; Gbetibouo, 2009; Mertz, *et. al*., 2008; Deressa, *et. al*., 2008; Below, *et. al*., 2010) and researcher's local experiences. The lists covered various thematic areas such as water resource management, sustainable natural resource use and management, adaptation technologies, research and development as well as information management. Farmers were then asked to identify those, according to their knowledge and experiences, they can form the best possible options to support them in both enhancing their adaptive capacity and long-term resilience to adverse impacts of climate change and variability.

As for the social economic implications, ten possible implications were listed and respondents were asked to identify those they thought were correct according to their knowledge and experiences. Respondents were also asked to indicate whether the implication(s) they identified were experienced only at household level, at community level or both.

Figure 4.7: Questionnaire data collection in Manga Mikocheni and Mkundi villages

Semi structured and non-structured Interviews and Focus Group Discussion

A checklist of questions was used to undertake interviews to 17 interviewees from institutions specified in the list of the sample (Table 4.4 and Figure 4.6). The aim was to obtain technical information on all issues raised by the farmers and validate farmers' information through a technical and experts' window. In addition, a few selected elders from the villages were also interviewed with a similar aim of cross checking the information obtained through the questionnaire in a historical perspective.

In this study, 25 individual smallholder farmers (forming four groups, one for each village) from randomly selected households were asked to discuss issues related to historical background of the villages and changes in the local climate that have been experienced over time. Other aspects included decision-making to change farming practices, timing and reasons for such decisions as well as projections of future climate impacts and their adaptation interventions. For both interviews and FGD, the responses were directly recorded and later on, transcribed into text for analysis.

4.3.5.2 Secondary data

Alongside perceptions from the questionnaire, interviews and FGDs, daily rainfall records were collected from three stations, which are under the Tanzania Meteorological Agency (TMA). These are Suji Mission, whose code number is 9437004 and its elevation is 1560 MASL (Figure 4.8); Buiko Hydromet with code number 9438009 and elevation of 536 MASL; and

Same Meteorological Station code numbered 9437003 at an elevation of 860 MASL (Notter, 2010). In addition, temperature data from Same Meteorological station was obtained. As alluded earlier, use of rainfall and temperature data was intended to ascertain the perceptions of smallholder farmers; local leaders; village, district and PBWB experts on the state of the local climate, which were expressed in the questionnaire, interviews and FGD. In other words, it was intended to gauge the perceptions against actual climate data obtained from the relevant and mandated authority in Tanzania and see how these two sets of data tally in terms of results.

While this was a relevant and approach, two challenges need to be stated at the outset. One is that of all the four villages in which the socio-economic data were collected (through questionnaire, interviews and FGD); only one village (Mtae) had a rainfall station. However, rainfall data from this station could not be used in the research due to major data gaps (740 days, almost 2 years missing). This means that rainfall data used are from stations located in different areas outside the four villages but within the research area except for Same Meteorological Station, whose inclusion was due to the fact that it is the only main station with both temperature and rainfall data. It is important also to state that Buiko Hydromet had 2.6 percent of data gaps. However, this was found to be manageable, hence its data were used in the study. Details on how the gaps were handled during analysis are explained in the next sub-sections. The two other stations, Same Meteorological Station and Suji Mission rainfall station, had no gaps thereby making them perfect benchmarks for the state of climate in the area especially because one (Same) is located in the lowlands while Suji Mission is located in the highlands. The other challenge was lack of temperature data for the rest of the stations except Same Meteorological Station. This compelled the researcher to rely only on data from Same Meteorological Station (for temperature). Please see the details in Table 4.5.

Table 4.5. Details of the weather stations in which rainfall data were collected

Station	Lat.	Long.	Approx Distance apart	Data Years		No. of Years		Gap (Rainfall)
				Rainfall	Temp	Rainfall	Temp	(%)
Buiko Hydromet Station	-4.650	38.050	1.5km for Manga Mikocheni and about 15km for Mkundi village	1962-2012	-	51	-	2.6
Same Met Station	-4.083	37.733	Between 40-70km from the closest to the furthest village	1962-2012	1970-2013	51	44	0
Suji Mission Rainfall Station	-4.371	37.900	About 8km to Kambeni	1977-2012	-	36	-	0

Source: Notter, (2010); field data and observation

Same Meteorological Station is located in the north eastern part of Tanzania (Tumbo *et al.,* 2010). Same town lies on the foothills of the South Western Pare Mountains and is characterised by semi-arid climate with highly variable and unreliable rainfall (Tumbo *et al.*, 2010). Suji Mission Station is located in the highlands, South Pare Mountains at an elevation of 1560MASL. The location of this station in terms of elevation and being on the windward side of South Pare Mountain gives it an advantage of recording high rainfall as compared to Same Meteorological Station, which has a history of recording low rainfall because it is on the leeward side of South Pare Mountains. Rainfall data for Buiko Hydromet station in this study represent Manga Mikocheni and Mkundi villages. The two villages, Buiko and Manga

Mikocheni, are about 0.5 km apart while Buiko and Mkundi are about 25 km apart. This station is located in the lowlands along Dar es Salaam-Arusha Road. Being in the lowlands, it is a good representative of the two villages because they are in almost similar elevation and share a number of characteristics such as the type of crops grown and climatic conditions as well as the average amount of rainfall they ought to receive, according to the interview data.

Figure 4.8: Rainfall data collection at Suji Mission Rainfall Station

4.3.5.3 Stakeholders' validation workshop and field excursion

As part of Clim-A-Net Project implementation, a workshop was held in Lushoto, Tanzania on 2nd, followed by a field excursion on 3rd of April 2014 (Figures 4.9a and 4.9b illustrate). This workshop was attended by stakeholders from Same District Council, Lushoto District Council, Pangani Water Basin Office and the Mamba Myamba Ginger Cooperative Society alongside researchers, professors and Clim-A-Net project coordinating team. In addition, a field excursion was undertaken to selected areas and villages within the research area including Manga Mikocheni village. These were important in not only for the team to have opportunity to observe but also allowing stakeholders to validate the data collected from smallholder farmers in the villages, local leaders, experts and elders.

Figure 4.9a: Workshop Participants Group Photo

Figure 4.9b: Field Excursion- Manga

4.3.6 Data Processing and Analysis

Data processing and analysis were undertaken by compiling information collected using different data collection methods (in cognizance of the mixed approach used for data collection). Therefore, both numeric and non-numeric data analysis software were used, depending on the type of data collected. The qualitative data from key informant interviews, focus group discussions, household interviews and observations were coded and analyzed using the Qualitative Data Analysis software (MAXQDA) version10 and are presented in form of descriptions (texts, photos, tables) and quotes. Quantitative data from questionnaire were analysed using Statistical Package for Social Sciences (SPSS) software Version 20. Descriptive statistics were run to generate frequencies and percentages. Cross-tabulation was made, particularly for the multiple response questions. This allowed comparison of different study parameters among villages. As for the meteorological records, i.e. long-term rainfall and temperature trends, Matlab and R software were used to analyze the data and graphical presentation is used in the data presentation.

It is necessary to note that on rainfall, two variables were considered during the analysis of climate data. The first one is average annual rainfall trend. Rainfall trend is portrayed for each of the three stations with reference to the timeframe indicated in Table 4.5. To get the general rainfall trends, monthly totals were computed for each year for each station. They were then summed up to obtain total annual rainfall for each year for each station. The total annual rainfall for each year formed a data point. That was done across all years in a specific station. Then a trend line using simple regression was plotted across all the years for each of the station to determine the trend of average annual rainfall for a specific station (i.e. increasing, decreasing or constant). To address the gaps for Buiko station, monthly averages were computed using the monthly totals across each month for all 51 years. The averages were then used as data point. For example, if a gap of one week was spotted in January 1970, an average of January total rainfall for Buiko station across all 51 (1962-2012) years was calculated and the average obtained was used to obtain the average monthly rainfall for Buiko for January 1970.

The second variable considered in the rainfall data was the trend of number of rain days. This is because much as farmers and other stakeholders had concerns over the general rainfall trend, they also argued that according to their experiences; even the rain-days have been decreasing. Similarly, they argued that not only the amount of rainfall has been decreasing but also rainfall

distribution has been a problem and difficult to predict. Therefore, the trend of the number of rain-days is presented to ascertain this perception.

Definition of a rain-day, according to the Tanzania Meteorological Agency, is 1mm of rainfall or above recorded within 24 hours in a rainfall station. It means that any rainfall record below 1mm was not counted as a rain-day. To plot a trend line indicating the number of rain-days for a particular station, an average number of rain-days for each month across all years was obtained using the total number of rain-days for each month. The averages for each month within a year for each station were used to compute total number of rain-days for each year for a particular station. The results formed a data point through which the trend line was plotted to indicate whether rain-days have been increasing, decreasing or remained constant in each of the three stations.

Temperature trends for Same Station for the two rain seasons (short rain season-October, November and December abbreviated as OND and long rain season-March, April and May abbreviated as MAM) are presented in both Maximum and Minimum temperatures categories from 1970 to 2013.

4.3.7 Validity and Reliability

Quality of any research work is important for its results to be trusted and even be put into practical use by the consumers. This then brings the issue of how credible and trustworthy were the methods used in the research process as they justify why and the extent to which they can yield results to be trustworthy, credible, precise and accurate so as one can really believe (Neuman, 2006; Cohen, ***et. al***., 2000; Babbie, 2010). What this literally means is that the instruments used in data collection must yield the intended and expected data to lead the researcher to precisely answer the research questions (Babbie, 2010). It is from this viewpoint that validity and reliability ought to receive an ideal treatment in both quantitative and qualitative research (Bashir, ***et. al***., 2008). Validity of the research is related to correct conclusions (Cohen, ***et. al***., 2007), while reliability is related to replicability of the findings (Babbie, 2010).

Babbie (2010) defines reliability as the quality part of the technique/tool, which makes it possible to yield the same results each time it is used in different measurements of the same phenomenon. As Cohen and colleagues (2007) argue, it is the stability and consistency of the measurement used, which ensure that each time it is used it is capable of yielding the same results. Thus, for one to be sure that the results are reliable, repeatability should be observed (*ibid*.). The conception of reliability in quantitative research differs from one in qualitative research (Cohen, ***et. al***., 2007). Some scholars contend use of reliability in qualitative research (Golafshani, 2003; Winter, 2000). According to Cohen and colleagues (2007), in quantitative research, reliability normally focuses on consistency, accuracy, predictability, equivalence, replicability, concurrence, descriptive and causal potential. However, in qualitative research, apart from accuracy, some other nomenclatures are proposed instead of reliability. These are such as fairness, dependability, comprehensiveness, respondent validation, checkability, empathy, uniqueness, explanatory and descriptive potential as well as confirmability (Lincoln and Guba, 1985 cited in Cohen, ***et. al***., 2007). In the context of quantitative research, three types of reliability are identified: reliability as stability to mean the measurement of consistency over time and samples; reliability as equivalence, which refers to equivalent/alternative forms of the same instrument, as well as inter-rater reliability; and reliability as internal consistency meaning the split-half reliability (*ibid*.). There are various ways to ensure reliability in research.

Babbie, (2010) lists three common ones, namely, use of Test-retest method, use of Split-half method and use of established/tested questions/measures from either standardized formats or other questions applied in past researches.

Babbie (2010) and Kothari (2004) define validity as a term describing a measure that accurately reflects what exactly is intended to measure. It is whether the measure is truthful or indeed genuine (Jackson, 2009). That is, if the plan is to measure influence of markets in driving changes in types of crops grown in an area, the researcher must be sure that the tool used is going to exactly measure the influence of markets and not probably the influence of climatic variables or otherwise. Maxwell (1992) maintains that in qualitative research methods, there are five types of validity: descriptive validity- the factual accuracy or truth of what happened (it can be related to objectivity of the account); and interpretive validity-the extent to which the meanings, interpretations, terms, intentions that situations and events are captured in research and within the real situation context. Others are theoretical validity, which means the extent to which abstract issues (constructs) are explained by the research, i.e., whether the theory generated can be used to understand other similar conditions; and evaluative validity which involves an evaluative framework to the objects of study as to whether in an account, an action made was justifiable or not. Cohen and colleagues (2007) maintain that in both qualitative and quantitative research approaches, internal and external validity are addressed.

While earlier versions of explanations regarding validity were mostly based on the view that it is essentially a demonstration that a particular instrument in fact measures what it is intended to measure, currently, literature appraises that there are different forms of validity, depending on the research tradition one decides to use. These forms are more encompassing than the earlier understanding (Cohen, *et. al*., 2007). Generally, validity it remains an important component in any research tradition regardless of some contentions. For example, in qualitative data, validity might be addressed through the honesty, depth, richness and scope of the data achieved, the participants approached, the extent of triangulation and the disinterestedness or objectivity of the researcher (Winter, 2000). In a general and comprehensive sense, the following types of validity are the commonly and mostly discussed types of validity (Table 4.6):

Table 4.6: Summary of some of the types of validity and their meaning

Type	Meaning	Reference
Face validity	Whether the instrument facially appears to be a measure for measuring what is intended to measure. That indicator which makes it seems a reasonable measure of the variables intended to measure regardless of the details but just how it appears.	Babbie, 2010; Jackson, 2009
Internal validity	This strives to demonstrate that the findings describe/explains accurately the phenomena.	Cohen et al., 2007
External validity	The degree to which the results can be generalized to the wider population, cases or situations.	Cohen et al., 2007
Content validity	The degree to which a measure comprehensively covers the range of meanings included within a concept.	Babbie, 2010
	The extent to which an instrument sufficiently and satisfactorily assess/covers the content being examined related to what is studied	Kothari 2004; Jackson, 2009
	The instrument demonstrates that it fairly and comprehensively covers the domain or items that it purports to cover.	Cohen et al., 2007
Construct	The degree to which a measure relates to other variables as expected within a system of theoretical relationships.	Babbie, 2010

Criterion-related	The level/degree at which a particular measure relates to some external criterion or is able to predict the outcomes.	Babbie, 2010

In this study, the following ways were used to ensure that validity and reliability of the findings were achieved. They involved pre-testing of the instruments, use of experts and triangulation.

Review of experts

While in most cases content validity is judgmental (Kothari, 2009), use of experts in reviewing the instruments and providing comments to the researcher on how they can be improved can be a better way of ensuring validity (*ibid*.). It is along the lines of this argument that the researcher subjected the questionnaire to several climate change experts for the aim of getting it reviewed. In this way, six experts were consulted and requested to review the questionnaire. The experts involved were two from the University of Oldenburg; one from the University of Dar es Salaam (Tanzania); and three from the Department of Environment, Tanzania. The reviewer provided comments most of which were incorporated, shaping further the instrument before it was used in the field. Most of the provided comments were related to simplicity of language used to portray some concepts so as to relate them to respondents' understanding level; the scope of the questions and whether they really reflected all required issues intended to be measured; avoidance of repeatability of some of the questions; lengthy of the questionnaire; and the practicality in terms of both data collection and data analysis.

Use of tested questions

Using tested questions/instruments is another way of addressing validity and reliability. Many of the questions designed and used in the study especially on factors motivating farmers to change farming practices were found from literature. This does not really mean that they were copied and pasted for use but modifications were made so as to suit the need and context for this study. Thus, having been tested and used in previous studies, the questions ensured validity and reliability in this research. Examples of the sources included: Below (2012); Miller (2009); Hassan and Nhemachena (2008); Deressa and colleagues (2008); Acquah and Frempong (2011); Acquah (2011); Kristjanson and colleagues (2012); and Kurukulasuriya and Mendelsohn, (2006).

Pre-testing the instruments

Pre-testing an instrument is another way that may be used for content validation (Bowden, ***et. al***., 2002; Ngulube, 2005 cited in Ndenje-Sichalwe, 2010). This is necessary in order to identify and rectify shortcomings in the instruments (Bowden, ***et. al***., 2002) and get them addressed well before they are fully used for data collection in the field (Babbie, 2010; Bowden, ***et. al***., 2002). There are various advantages of pre-testing instruments identified in literature such as having a possibility of refining data collection instruments as well as predicting as to whether or not results are really going to be meaningful and reflecting the real context of the study (Mugenda and Mugenda, 2003 cited in Ndenje-Sichalwe, 2010). In addition, pre-testing helps to ensure validity and reliability of results.

For this study, pre-testing of the questionnaire was done at Chatembo village, Mkuranga district, Coast Region between mid-July to early August, 2012. Ten smallholder farmers were randomly selected by the researcher in collaboration with village leadership, and then briefing on the pre-test exercise was provided before they were requested to take part in the pre-test exercise. The pretesting exercise included but was not limited to: identification of any words from the questionnaire, which were unclear in the context of smallholder farmers; question

items, which would otherwise cause any lack of appropriate answers; clarity of the instructions; and any missing or misplaced items in the list.

The results from the pre-test was addition of two items in the list of types of adaptation information needs for smallholder farmers; deletion of one item from the list of proposed strategic and policy interventions for long-term adaptation and resilience; rewording of several question items and rearrangement of the same. Modification of the questionnaire along the lines of pre-test results was undertaken and many other improvements were made well before printing the final version of the questionnaire ready for data collection exercise in the field. Besides, all the questions had to be translated into Kiswahili which is the language respondents are conversant with. This was not only necessary but also important in order to ensure that all the questions are accurately answered by the farmers.

Triangulation

Triangulation denotes a designed use of several different research methods, for offsetting biases in a study on a phenomenon and strengthening validity of the results (Jick, 1979; Babbie, 2010; Cohen, *et. al.*, 2007; Guion, 2002). The concept of triangulation is based on the assumption that an inherent bias or limitation in particular data sources, investigators and methods would be counteracted when used in conjunction with other data sources, investigators and methods (Cohen, *et. al*., 2007; Creswell 2003; Denscombe, 2007 cited in Ndenje-Sichalwe, 2010). According to Hammersley, 2008 cited in Ndenje-Sichalwe, (2010), in obtaining data from sources that have very different potential threats to validity, it is thought that there is a possibility of reducing the chances of reaching false conclusions. According to this assertion, when such data from different sources confirm the original conclusion, then the conclusion will confidently and reasonably held than before. The interview and observation data, for instance, can be used to confirm the conclusions reached on the basis of questionnaire and so forth (Guion, 2002; Hammersley, 2008 cited in Ndenje-Sichalwe, 2010). It is a way of cross-checking results obtained in one method against those obtained in other methods in a similar study thereby making the study results strongly convincing and technically, strongly supported. Jick (1979) advances that triangulation allows researchers to be more confident of their results.

> "*Triangulation has risen an important methodological issue in naturalistic and qualitative approaches to evaluation [in order to] control bias and establishing valid propositions because traditional scientific techniques are incompatible with this alternate epistemology"* (Mathison, 1988:13 cited in Golafshani, 2003).

Guion (2002) proposes five types of triangulation, namely, data triangulation, investigator triangulation, theory triangulation, methodological triangulation and environmental triangulation. Data triangulation refers to use of different sources of information so as to increase validity of a study (Denzin, 2009 cited in Ndenje-Sichalwe, 2010; Guion, 2002). It is a type of triangulation in which the research supports one set of date collected using one type of instrument with another set(s) of data collected using a different type(s) of instrument. It is said to be the mostly used type of triangulation (*ibid*.). Guion (2002) further explains that investigator triangulation is one involving use of different investigators in the data analysis process so as to provide a wide chance for experts to evaluate and then compare the findings. Theory triangulation, on the other hand, is use of multiple theoretical perspectives to interpret a single set of data (Guion, 2002; Denzin, 2009 cited in Ndenje-Sichalwe, 2010), that is, using experts from outside the field with different theoretical views and background to evaluate the data and see if they can arrive to a similar conclusion. Methodological triangulation is a bit similar to data triangulation except that the researcher uses multiple methods, that is, qualitative

and quantitative methods in the study. For example, use of survey, interviews, focus group discussion and observation in the same study. This means that if the conclusions from each of the methods are the same, then validity in the study is established and broader conclusions are drawn on that basis. Environmental Triangulation uses environmental factors such as locations and settings and the like, which in a way they relate to the environment in which the study took place, to identify environmental factors, if any, might influence information received during the study. If the findings do not change under different environmental conditions, then validity has been established (Guion, 2002).

In the present study, both methodological and data triangulation were used. In the qualitative methodological approach, there was the use of semi-structured interviews and the focus group discussion through which data were collected and separately analyzed. Some observations were also made and photos collected on some of crop types, their mode of cultivation as well as traditional water collection techniques. On the quantitative methodological approach, the researcher used a survey questionnaire to collect data from the smallholder farmers. The data were analyzed using SPSS. In addition, 30 years daily rainfall data for four meteorological stations were obtained from the stations and analyzed. The results from all these methods and data sources were all compared to validate so as to finally draw conclusions.

4.4 Limitations

Limitations are inherent in research due to the fact that no study is 100 percent free from outside influences. This is particularly evident in the social researches, which are carried out involving both social and natural environments. In this study, a few limitations can be highlighted: use of semi structured interview, rainfall data gaps and limited temperature data.

Experience with interviews shows that people respond differently, depending on how they perceive the person asking the questions. Some of the aspects, which lead to variations in response include sex, age, ethnic origin (Denscombe, 2010), personal status and generally, the researcher's personal identity. However, literature informs that influence of personal identity mostly depends on who is being interviewed and nature of the topic including its level of sensitivity (*Ibid.*). Literature further advises that the researcher can maximize chances of getting appropriate responses by remaining neutral and non-committal on statements made during the interview by the respondent (Denscombe, 2010). Similarly, it is also important to present oneself in a manner that does not antagonize the interviewees including clothing, personal introduction as well as the way one conducts the interview and the like (Denscombe, 2010).

In this research, interviews were conducted with experts in Pangani Basin Water Board, Same District Council, Lushoto District Council and Mamba Myamba Ward; elders at the village level; and village leaders and politicians. It was a mixed group in terms of their level of understanding and analysis of issues, education, age, roles and authority. In government offices (villages, districts and the PBWB), the researcher was normally asked to sign in the visitors' book and introduce himself. In which case, the introduction involved all necessary details including the organization he works for. Therefore, it is possible that some of the responses might have been influenced by the presence of the interviewer and the organization he works for. However, the researcher encouraged interviewees to be free to express themselves. In addition, the nature of the topic and the questions did not involve or need very sensitive information, which would otherwise deter someone to talk about. Use of multiple data collection method was, in one way, intended to address such kind of limitations. Besides, the

researcher also used the Stakeholders' Validation Workshop to validate the responses from not only interviews but also across the entire study.

It is also necessary to reiterate that this study intended to use climate data, particularly rainfall and temperature from stations within the study area in order to validate or rather, crosscheck the data collected using questionnaire, interviews and FGD on changes in the local climate. However, stations within the study area mostly record only rainfall. As stated earlier, many of these stations have so many data gaps such that it becomes very difficult to use their data. This necessitated selecting a few stations and leaving out the rest. Selection of Suji Mission, Same and Buiko Hydromet was made in consideration of amount of data available and in continuation. In addition, selection of Same Meteorological Station also considered the fact that it has both rainfall and temperature data. Again, use of many sources of data collection as well as the validation workshop in the end helped to validate the data.

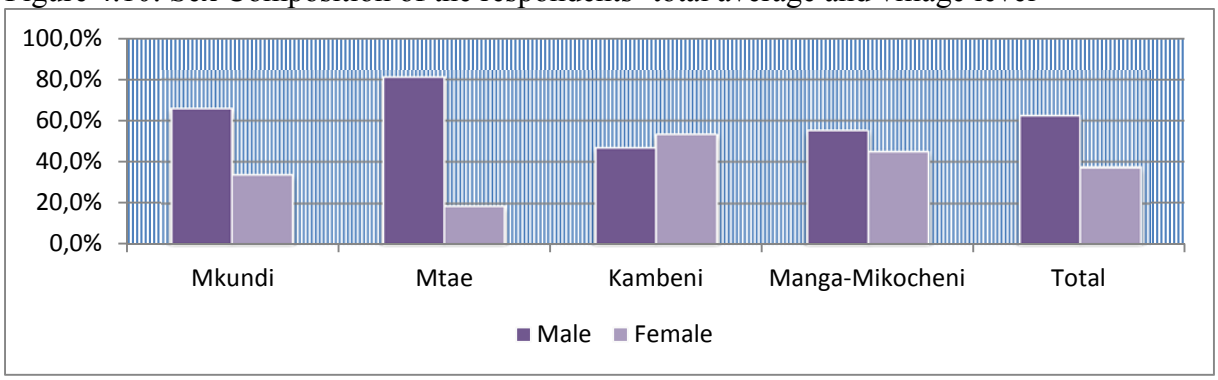
4.5 Socio-economic Characteristics of the Sample

This section presents, in brief, the socio-economic and demographic characteristics of respondents from all the four villages in the study area. This information was obtained using the administered questionnaire. The information is helpful in so far as it might help to discuss and explain some variables and issues related to results. In addition, the data shed light on profiles and basics of the respondents and interviewees.

4.5.1 Sex Composition

In terms of sex composition, the analysis of the data showed that 62 percent of all respondents were males and 38 percent were females. At the village level, three villages, namely, Mkundi, Mtae and Manga Mikocheni, had more male respondents than females. In comparison however, Mtae had the highest (81.3%) number of male respondents. In Kambeni village, the number of female respondents was slightly higher (53.3%) than that of males. For Mkundi village, the number of female respondents was almost half of males. It is important to note that the sex composition refers to respondents and not the whole villages. Therefore, the reference made to villages should not be confused with the village population but rather, the questionnaire sample. Figure 4.10 summarizes the percentage distribution of the respondents.

Figure 4.10: Sex Composition of the respondents- total average and village level



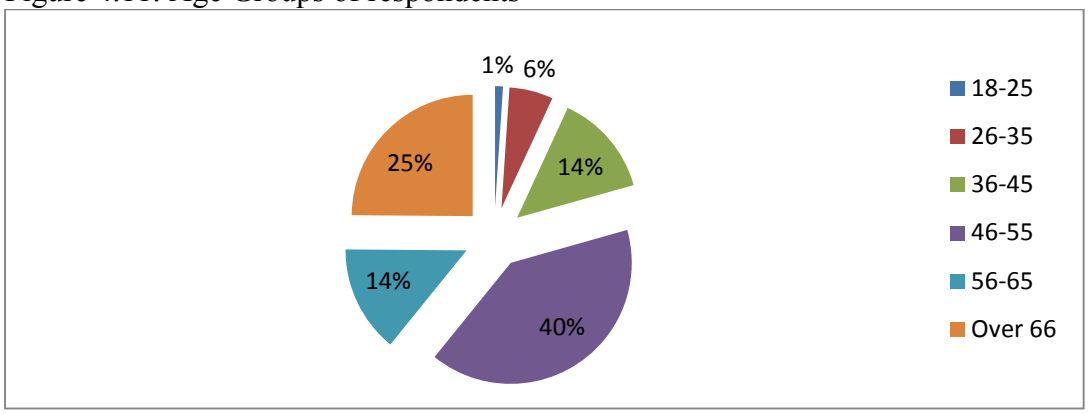
The data indicated that males were highly represented in questionnaire filling in Mkundi, Mtae and Manga Mikocheni villages, while in Kambeni village; females were highly represented compared to males. Mtae and Kambeni villages presented a unique situation because while Mtae had the highest representation of males, Kambeni had a higher representation of females than males. However, the total showed higher representation of males than females. One of the main scenarios explaining this phenomenon is the fact that respondents were household heads

and most of the households are headed by males. The male-female representation, however, did not play a role in influencing the results because what was relevant was about farming practices as well as key factors for changes in the farming practices, which in the final analysis, had nothing to do with sex or gender.

4.5.2 Age groups

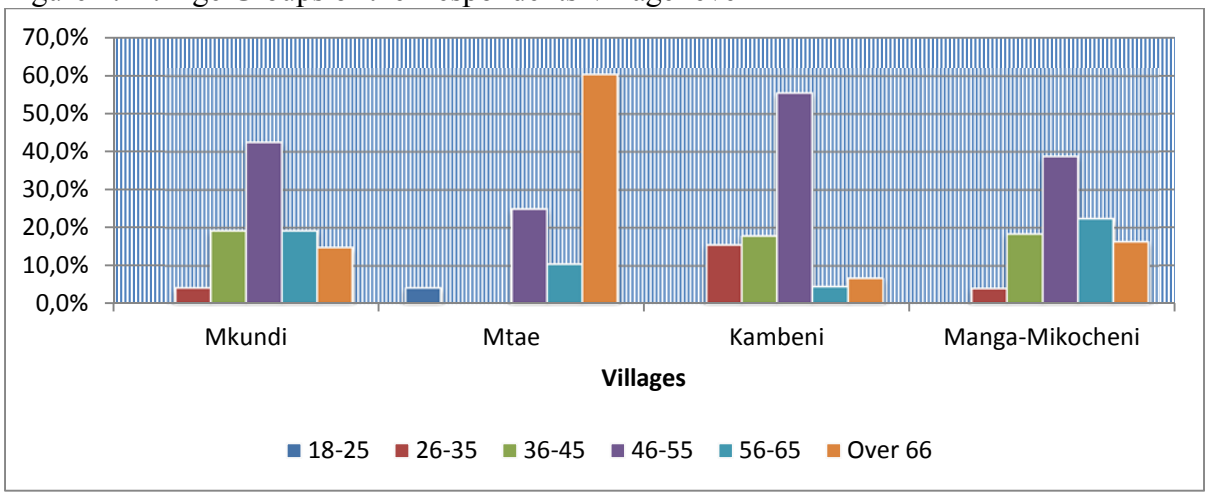
In terms of age group, around 40 percent of the respondents were aged between 46-55 years. In total, respondents with 46 years and above formed 79.4 percent of the total number of 189 respondents. This is clear both in the general summary of results as well as at village level (Figures 4.11 and 4.12).

Figure 4.11: Age Groups of respondents



At the village level, 60.4% of all the respondents from Mtae were above 65 years; 55.6% of all the respondents from Kambeni were age group of 46-55, while only Mtae village had respondents at the age group of 18-25 years. However, the village had no respondents in the age groups of 26-35 and 36-45 years (Figure 4.12).

Figure 4.12: Age Groups of the Respondents-village level



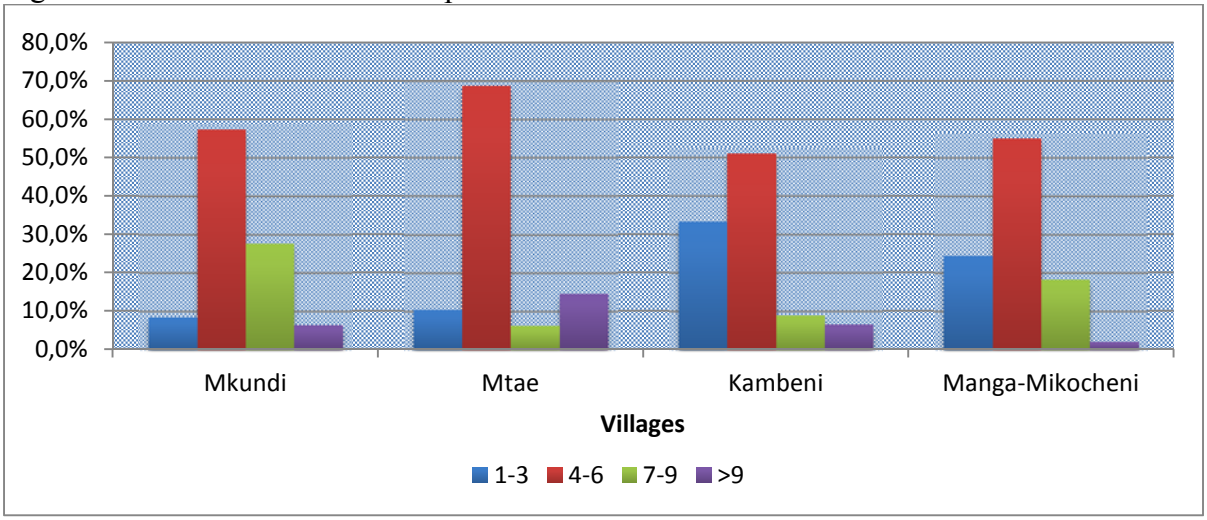
Taking into account objectives of the study, having a high percentage of respondents aged 46 and above was much appropriate because the information sought required one to have a historical understanding of the state of climate in the local area at least for the past 30 years. It required one to have an understanding of how the state of the local climate has been behaving (changing or not), the extent to which the farmers have been changing their farming practices in line with changing climate and other factors during the past 30 years and the like. Therefore,

respondents who filled in the questionnaire were the right one because those aged 46 years and above formed 79 percent of the total.

4.5.3 Household size

From the data, most of the households had the size between 4-6 individuals, representing 58.2 percent of the total sample in the four villages (Figure 4.13). The household size of 1-3 individuals represented 19 percent, while 7-9 individuals' households represented 15.3 percent. Only 7.4 percent of the households had more than ten individuals as their household size.
The national average household size, according to the Population and Housing Census of 2012, is 4.8 (URT, 2013a). From this population census, looking at the district level, Lushoto has an average household size of 4.7, while the average household size for Same is 4.5, and Korogwe is 4.6 (*ibid*.) Average household size in the four wards is as follows: 4.6 for Mtae (Mtae village), 4.6 for Mamba Myamba (Kambeni village), 4.6 for Mnazi (Mkundi village) and 4.4 for Mkomazi [(Manga Mikocheni village) URT, 2013a]. Therefore, the average household size in this research reflects the national statistics as per the population census of 2012.

Figure 4.13: Household size of respondents



4.5.4 Education Level

Respondents' education level was one of the information to capture. The data revealed that the higher number of respondents had attended basic education, i.e., seven years of primary school (59.3%). About 25.9 percent of the respondents reported to have attended up to middle school. They are mostly elders who attended school well before the current system of primary education cycle of 1-7 was introduced in Tanzania in 1974. Cross-tabulation of age groups and education level shows that 85.1 percent of the elders over 66 years attended schooling up to middle school level (Table 4.7). These elders form 25.9 percent of the total number of respondents (Table 4.8).

Table: 4.7: Cross-tabulation of age and education level

Age Groups	No education	Primary school	Middle school	Secondary school	Total
18-25	0.0%	1.1%	0.0%	0.0%	1.1%
26-35	0.0%	5.8%	0.0%	0.0%	5.8%
36-45	.5%	12.2%	1.1%	0.0%	13.8%
46-55	3.2%	32.3%	1.6%	3.2%	40.2%

56-65	4.8%	7.4%	2.1%	0.0%	14.3%
Over 66	3.2%	.5%	21.2%	0.0%	24.9%
Total	11.6%	59.3%	25.9%	3.2%	100.0%

In this research, about 12 percent of the respondents were found to have not attended any level of formal education. While it is possible that they might have attended informal learning, this can have some implications on their access to knowledge through reading and writing. However, it is notable that reading is not the only way of obtaining knowledge, and for the smallholder farmers, local knowledge may play an important role as well. Mtae was the only village where some respondents reported to have attended secondary school education, accounting for 3.2 percent of all the respondents in this research. Table 4.8 illustrates the details.

Table 4.8: Respondents' Education Levels

Village	**Education Level**			
	No education	Primary school	Middle school	Secondary school
Mkundi	12.8%	55.3%	31.9%	0.0%
Mtae	6.3%	25.0%	56.3%	12.5%
Kambeni	4.4%	91.1%	4.4%	0.0%
Manga-Mikocheni	22.4%	67.3%	10.2%	0.0%
Total	11.6%	59.3%	25.9%	3.2%

4.5.5 Purpose of Production

Smallholder farmers were also asked to indicate their purpose of production, if it production for cash crops, subsistence or both for subsistence and cash production depending on circumstances. The data showed that 54 percent of all the respondents produce for subsistence, while 42 percent produce for both cash and subsistence depending on the amount of harvest. The remaining (4%) indicated to produce for cash. Figure 4.14 illustrates.

Within villages, 95.7 percent of the respondents in Mkundi indicated to be producing for subsistence, while the remaining (4.3%) were producing for both subsistence and cash. In Mtae village, all respondents had the view that their production was for subsistence only. Different from the two villages of Mtae and Mkundi, in Kambeni village, 75.6 percent indicated that their production was for both cash and subsistence, 15.6 percent produced for cash, while only 8.9 percent produced for subsistence. The case of Manga Mikocheni was also somehow different as 87.8 percent produced for both cash and subsistence, while the rest (12.2%) produced for subsistence. Figure 4.15 illustrates.

Figure 4.14: Purpose of Production

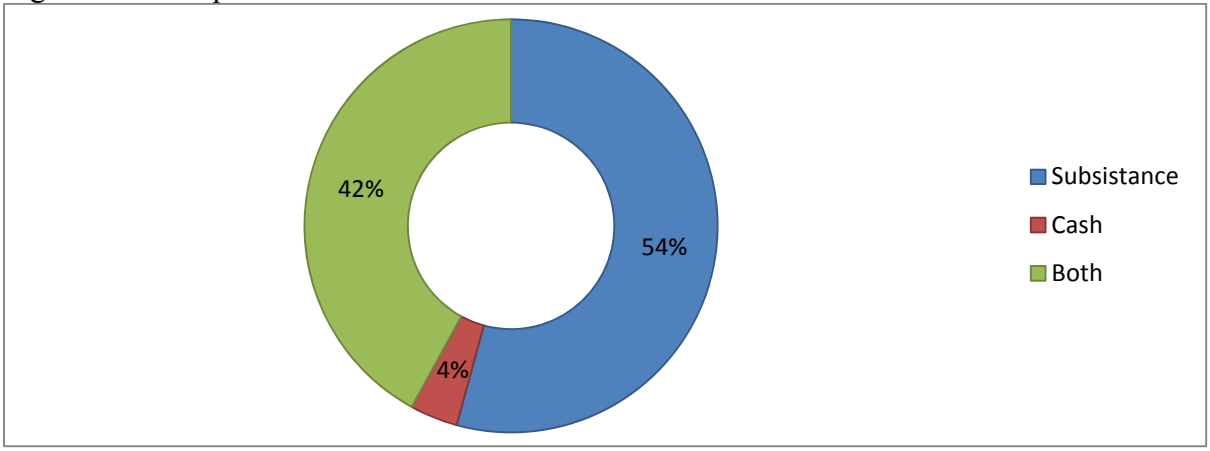
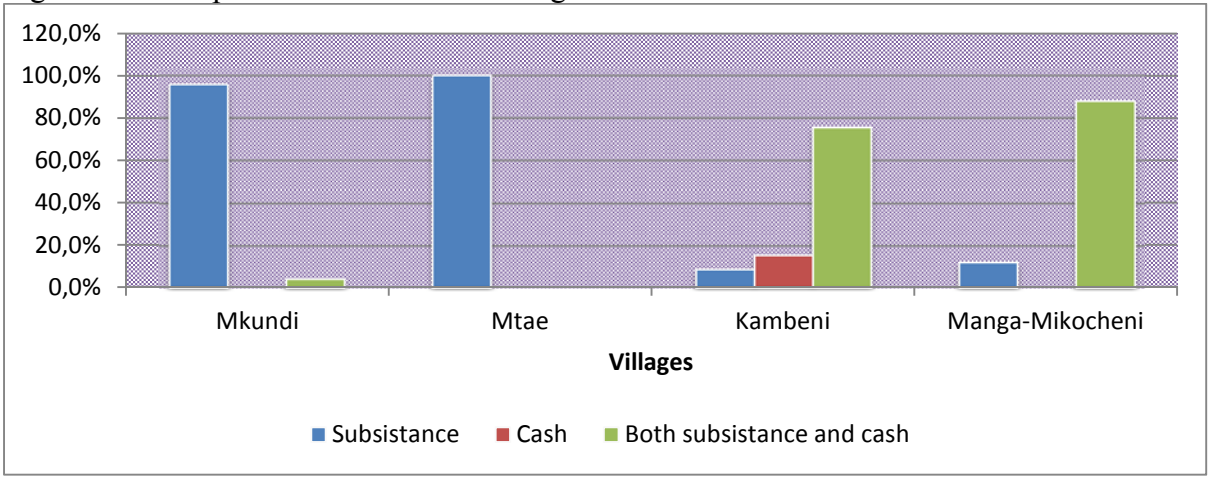


Figure 4.15: Purpose of Production at village level



The high percentage of those who produced for both subsistence and cash in Kambeni and Manga Mikocheni villages reflected the fact that in each one of the two villages, there is a crop that is produced for sell and other crops are produced for food. In Kambeni village, ginger is a cash crop produced mainly for obtaining cash. However, the cash obtained is then used to, among others, buying food for the family. Therefore, ginger production not only supports farmers to obtain cash but also access to food for their families. In addition, there are other crops such as maize, cassava, yams and bananas, which are produced for family consumption. In Manga Mikocheni village, much as some of the paddy produced is consumed in the households, but the production of this crop is mainly for cash. The farmers in this village treat paddy as a cash crop. In addition to paddy, they also cultivate water melon for cash. The common food crop is mostly maize supported by paddy, to a lesser extent.

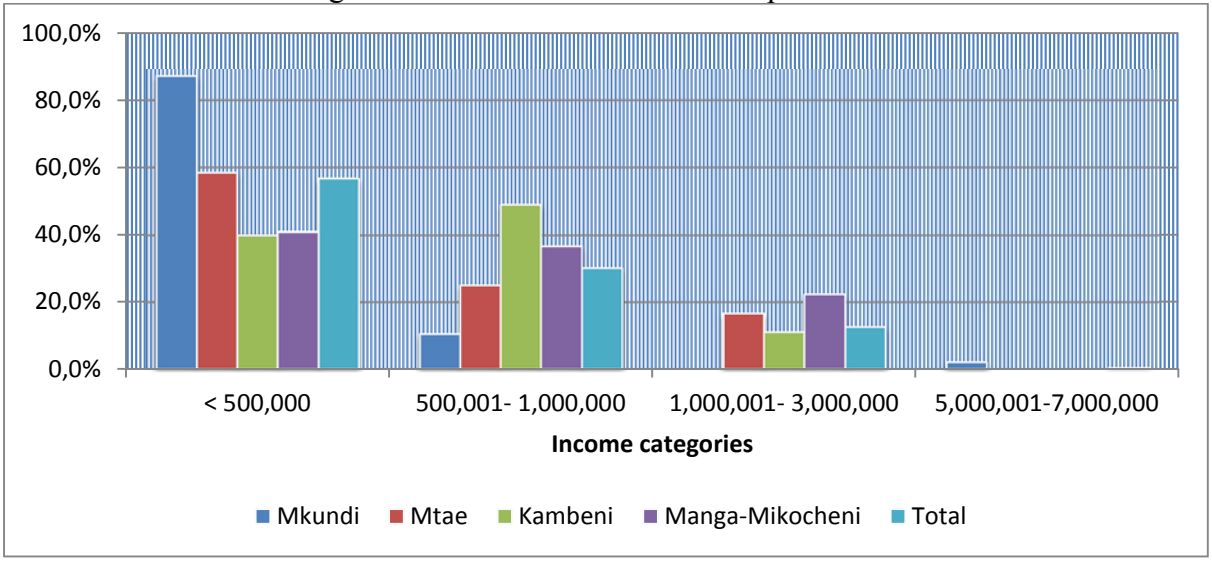
The interesting results are for Mtae village where crops such as irish potatoes and various types of vegetables such as cabbages, tomatoes, spinach and onions are produced and sold to, among others, obtain rice, maize and other produce for food but the results indicated that all (100%) respondents produced for subsistence. The main explanation for this might be due to the fact that they sell such produce and buy food for their families. They define that as only cash but for subsistence and possibly they have no surplus income for that matter.

4.5.6 Household Income

It was of interest also to know the annual average household incomes because it can have some implications on other variables. There were six groups of income levels (approximate Euro

equivalents in brackets), that is, < Tanzanian Shillings (TZS). 500,000 (€227); TZS. 500,001-1,000,000 (€227-454); TZS. 1,000,001-3,000,000 (€454-1364); TZS. 3,000,001-5,000,000 (€1364-2273); TZS. 5000,001-7,000,000 (€2273-3182); and >TZS. 7,000,001 (€3182). About 56.6 percent of all respondents fell in the category of <TZS 500,000. However, at the village level, Mkundi village had the highest percentage of the respondents falling under this lowest category of average household income probably because it is highly affected in terms of dry conditions. This village is also the mostly supported in terms of food aid as compared to other villages. The village had 87.2 percent of all its respondents with an average income of <TZS. 500,000, followed by Mtae village, which had 58 percent. Kambeni and Manga Mikocheni villages had 40 percent and 41 percent of the respondents, respectively, falling under this income category. Regarding the second income level, 50 percent of the respondents in Kambeni had an average income of TZS. 500,001- 1,000,000 per year. However, much as highest percentage of Mkundi village, respondents fell in the lowest category in terms of average household income, 2.1 percent of the respondents from this village reported to have an income level between TZS 5,000,001-7,000,000 per year. There were no respondents in the category of TZS. 3,000,001-7,000,000 and >TZS.7,000, 001. Figure 4.16 illustrates the details.

Table 4.16: Annual average Household Incomes in the Sample



In the next chapter, data on changes in the local climate are presented by comparing smallholder farmers and other stakeholders' perceptions against rainfall and temperature records from various meteorological stations. In addition, information from stakeholders' validation workshop is presented to substantiate the perceptions and results from meteorological data.

CHAPTER FIVE: STATE OF LOCAL CLIMATE: SMALLHOLDER FARMERS' PERCEPTIONS AGAINST LONG-TERM RAINFALL AND TEMPERATURE DATA

5.1 Introduction

Before exploring the factors that motivated farmers to change farming practices, it was necessary to get a clear picture of the perceptions of the smallholder farmers and other stakeholders on how they explain the state of the local climate including their prediction according to their experience and knowledge. It was much more important as well, to understand the state of the local climate by analyzing actual rainfall and temperature records for the area. The two forms of data, i.e. smallholder farmers and other stakeholders' perceptions as well as historical rainfall and temperature trends, would reveal the real state of the local climate and indicate if it has been changing, and the type of changes it actually experiences. In this chapter, the data on the state of local climate in four villages (Mtae, Mkundi, Kambeni and Manga Mikocheni) in which the research was conducted are presented. In addition, and as indicated earlier, results of rainfall data collected from three stations and temperature data from one station will also be presented. The focus on rainfall and temperature are due to these being necessary elements of climate for crop production (Lobell and Burke, 2008) and thus for smallholder farmers' survival since their main economic activity is rain-fed crop production. Data presentation on the state of climate will not only reveal what exactly smallholder farmers perceive against the actual rainfall and temperature records but also is going to serve as an important entry point and a baseline for the next chapters' discussions and conclusions of this study.

The chapter contains five sections, namely, introduction, smallholder farmers' perceptions of local climate, historical rainfall and temperature trends, discussions and summary. Section two presents smallholder farmers perceptions. In section three, results from analysis of actual rainfall and temperature data are captured to depict historical trends so as to substantiate farmers, experts and local leaders' perceptions from the questionnaire, interviews and FGDs. This is followed by a discussion in section four and a summary in section five.

5.2 Smallholder farmers' perceptions

The first research question in this study was intended to help to identify how smallholder farmers perceive and explain their local climate, that is, to identify the perceptions on the state of the local climate for the past 30 years or more, and how they provided those perceptions in relation to their livelihoods. In addition, it was envisioned to appreciate their prediction on how the state of the local climate would be in the future, taking into account their current perceptions, information access, and local experiences as well knowledge. Perception in the context of adaptation is considered an important aspect for the stressed to awake and take initiatives as well as measures to adapt (Maddison, 2006). Understanding smallholder farmers' perception on their local climate is significant because it raises individual cognition (Grothmann and Patt, 2005) to what he/she should do to adapt and hence, having a bearing on adaptive capacity (Smit, *et. al*., 2001). For smallholder farmers, for example, perception on changes in the local climate may help them to make decisions at the right time to either change their practices to accommodate themselves to the changes or do otherwise to adapt. It is in this line of argument that perception was necessary to be identified as a first step before getting into other details. Maddison (2006) suggests that perception is an important aspect and a first step in the adaptation process as he wrote:

*"……. adaptation to climate change actually involves a two-stage process: first perceiving that climate change has occurred and then deciding whether or not to adopt a particular measure" (*Maddison, 2006).

5.2.1 The Questionnaire

Results from the study showed that smallholder farmers had various, mostly negative, perceptions on the state of their local climate within that timeframe and seemed to perceive many changes to have taken place in their local climate when they compared the current state of the local climate against the past 30 years. The most notable and commonly cited changes included the following: the amount of rainfall was on the decreasing side; the temperature of the areas was on the increasing side; rains have become shorter than normal; and changes in the onset of rainfall in which farmers feel that onset is now abnormally late. Table 5.1 and Figure 5.1 depict results from the questionnaire (in frequencies and percentages, respectively).

Table 5.1: Perceptions on Changes in the State of Climate by the Smallholder Farmers

Perception	**Mkundi (N=47)**		**Mtae (N=48)**		**Kambeni (N=45)**		**Manga (N=49)**	
	Yes	No	Yes	No	Yes	No	Yes	No
Increasing rainfall in amount during main rain season	1	46	0	48	0	45	0	49
Decreasing rainfall in amount during main rain seasons	45	2	48	0	45	0	47	2
Rainfall fluctuating	34	13	16	32	16	29	12	37
Shift in the timing of the onset of rain in the main season	37	10	37	11	35	10	37	12
Rain starting later than normal	44	3	42	6	34	11	41	8
Rain starting earlier than normal	5	42	7	41	6	39	2	47
Short rains than normal	44	3	46	2	43	2	49	0
Long rains than normal	5	42	2	46	0	45	0	49
Temperature of the area decreasing	8	39	20	28	11	34	11	38
Temperature of the area increasing	33	14	15	33	32	13	32	17

The data indicated that 98 percent of the respondents perceived rainfall to have been decreasing for the past 30 years. In addition, 77 percent perceived to have experienced shifts in the onset of rainfall, while 85 percent perceived that rainfall started abnormally late than it used to be 30 years ago or more. It is also important to note that 96 percent of all respondents perceived rainfall being abnormally shorter these years than before. In the same token, very few farmers (3.7%) agreed that rainfall was longer than normal these years. As for temperature, 59 percent perceived that it has been increasing, while 26.5 percent felt that it has been decreasing. Details are presented in Table 5.1 as well as Figures 5.1 and 5.2.

Figure 5.1: Summary of Farmers' Perceptions on the State of Local Climate

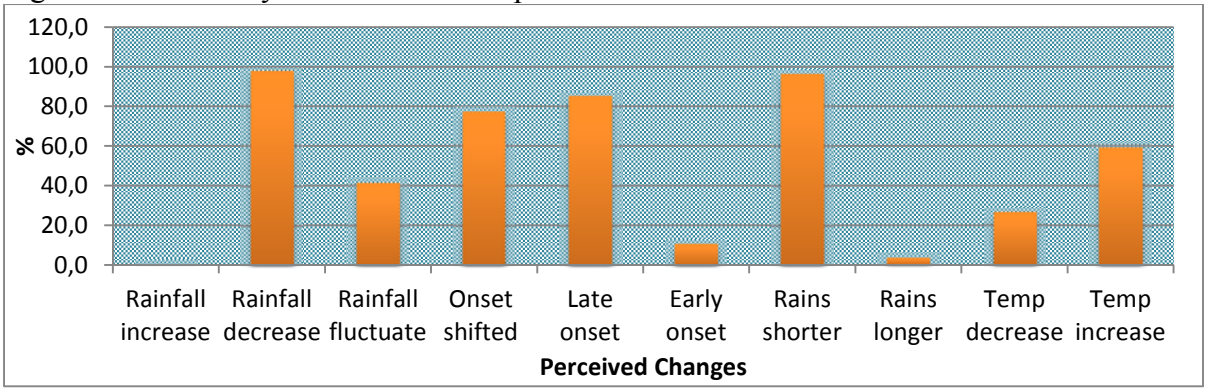
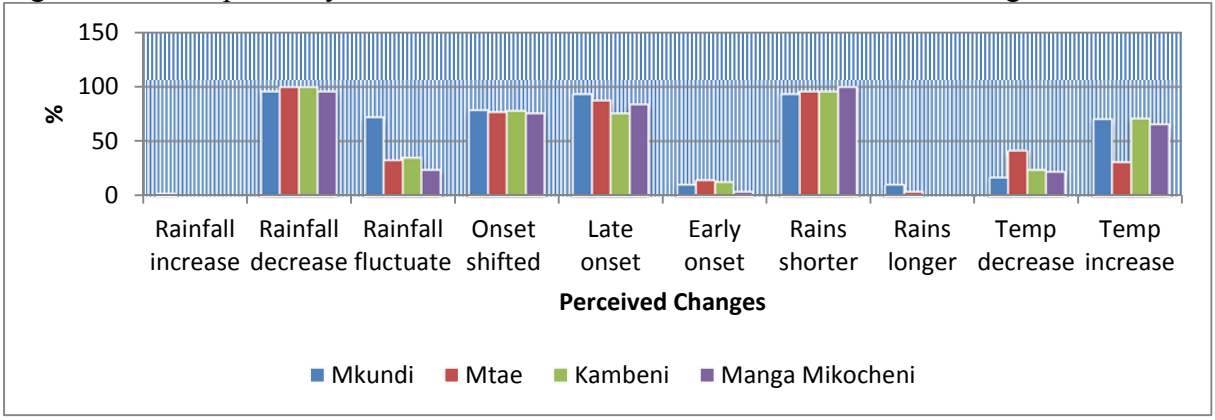


Figure 5.2: Perceptions by the Farmers on the state of local climate at the village level



Village perspective

At the village level (see Table 5.1 and Figure 5.2), most of the results reflected the general overview from all four villages. In due regard, results at village level showed no major variations from the general summary on the changes in the local climate (as illustrated in Figure 5.2). Almost all the perceptions from the questionnaire data indicated a similar trend even at the village level.

It was interesting to note that many respondents from all villages (95.7% for Mkundi, 100% for Mtae and Kambeni, and 95.9% for Manga Mikocheni) perceived rainfall to have been decreasing in amount. Apart from changes in the amount, smallholder farmers also indicated that onset of rainfall has shifted. The data showed that over 70 percent of the farmers from four villages, that is, 78.7 percent from Mkundi, 77.1 percent from Mtae, 77.8 percent from Kambeni and 75.5 percent from Manga Mikocheni felt the timing of onset has shifted. As to whether rainfall starts abnormally early or late, 93.6 percent in Mkundi, 87.5 percent in Mtae, 75.6 percent in Kambeni and 83.7 percent in Manga Mikocheni were of the view that in these years, it is abnormally late. Apart from increasing or decreasing, some of the farmers in the villages thought that rainfall has been fluctuating rather than decreasing or increasing. The percentages were as follows: 72.3 percent for Mkundi, 33.3 percent for Mtae, 35.6 percent for Kambeni and 24.5 percent for Manga Mikocheni. Inquiring about the duration rainfall takes, farmers indicated that nowadays rains are shorter than they used to be in the past 30 years or more. The percentage of agreement with this claim was 93.6 percent for Mkundi, 95.8 percent for Mtae, 95.6 percent for Kambeni and 100 percent for Manga Mikocheni villages.

Regarding the state of temperature, many farmers expressed views that it has been increasing for the past 30 years with the following percentages: 70.2 percent in Mkundi, 31.3 percent in Mtae, 71.1 percent in Kambeni and 65.3 percent in Manga Mikocheni. Those who felt that temperature has been decreasing were 17.0 percent for Mkundi, 41.7 percent for Mtae, 24.4

percent for Kambeni and 22.4 percent for Manga Mikocheni villages. In the data, one can note a difference in terms of perception on the state of temperature between Mtae and other villages. While there were no temperature data from these villages to ascertain the perceptions, but the great variation of opinions between Mtae and the remaining three villages was clear. Then, 41.7 percent of the respondents from this village felt that temperature has been decreasing for the past 30 years. This view from Mtae respondents might have been influenced by the location of the village in the Usambara such that by being located over 1500MASL, they experience lower temperatures than their counterpart in Mkundi and Manga. Therefore, even if it were to be true that there is a slight increase in temperature in the area, this might have a little influence for the village due to its location in the highlands. In Sub-section 5.2.3, presentation of results from the analysis of rainfall and temperature data is done to compare the perceptions against actual rainfall and temperature data. The results of perceptions are illustrated in Figure 5.1.

5.2.2 Interviews and FGDs Narratives

Data from interviews supported farmers' perceptions that there have been a number of changes in the local climate for the past 30 years. The data mostly indicated changes in the local climate, though with slightly different explanations on reasons associated with the changes perceived. Changes that were referred mostly related to the state of rainfall and temperature in the area.

Changes on Rainfall

Qualitative data conformed to the data collected through questionnaire in most of what farmers perceived. The perception that rainfall has been decreasing for the past thirty years and that there are changes in the onset as well as the distribution of rainfall within seasons was articulated during the interviews. The interviewees confirmed that there are changes in terms of rainfall in the area and the amount is decreasing compared to the past 30 years. First, a detailed explanation was given, on the state of rainfall in the area, by Same District Agricultural and Livestock Development Officer responding to the question: 'how do you explain the state of climate in the district?' The officer had this to say,

> *"Climatic conditions of the area vary with altitude. In terms of rainfall, we have three zones in the district: low lands, which are supposed to receive about 500-800mm, midlands, which normally receive about 800-1000mm and the highlands, which ought to receive over 1000mm annually"* (Official, Same District Council).

As to what is the state of climate this time compared to the past 30 years, it was found that the local climate has not remained static but has been changing. The changes identified from the interviews, however, were negative to both farmers and all other stakeholders including the experts. On this one, the official from Same District Council was very explicit that there are changes in terms of rainfall amount, onset and the distribution. In addition, he also put it clear that for the farmers, they are nowadays facing hard time because predictability of rainfall is very difficult and sometimes impossible because unlike in the past, currently, it has no clear and predictable pattern. Currently, farmers are unable to predict rainfall patterns as they used to in the past because there are many changes that make it difficult for them to do so. In the following quote, the official explained further that:

> *"In the past, rainfall was regular, predictable and of the normal amount. We had some fluctuations in terms of amount but not very much. This was appropriate for farmers and they rarely experienced water shortage for their agricultural activities. However, for these years, rainfall is unpredictable in terms of amount and onset. Generally, there is a decreasing trend in rainfall in all those areas. For instance, this year almost all areas received much less in terms of amount and of course, the onset was not as expected"* (Official, Same District Council.

This explanation makes a case that there are changes especially in terms of rainfall. Such changes have made it difficult if not impossible for farmers to be sure of what is going to happen in a season because of the unpredictability nature of rainfall in recent years.

Not only the district official had such views on the state of climate in the area but also almost all those who were interviewed and those who participated in the discussions. It is worth taking other examples of the interviewees and find out how they perceived and explained the state of the local climate according to their knowledge and experiences in the area. For example, one elder from Mkundi village made the following comment on this issue by stressing the unpredictability of the nature of rainfall in these years:

> "*When you talk about changes in the local climate, you remind me those good years of 1960s-early 1980s. In those years, it was very predictable that in early October, Vuli rainfall started and came December and January, we harvested. Again, in March we expected and got rainfall for the main season. Rainfall was not a problem. But now this is not the case. No one can predict the onset of rainfall anymore and even how long it will last. Rainfall is totally unpredictable and the amount is not normally sufficient at all. Nowadays, it is difficult!" (*Elder1, Mkundi).

In a similar note, Kambeni Ward Councilor had this to say while explaining the state of the local climate especially rainfall in the area:

> *"I can tell you, the climate of this area has changed so much when you compare with the past 30. Nowadays, we do not receive good rainfall as it used to be. In many cases, rainfall comes very late and normally, it is short such that it does not meet farmers' expectations. Rivers that used to flow annually are now flowing seasonally"* (Ward Councilor, Kambeni).

The explanations indicate that while seasonality of rivers can be influenced by many factors some of which may not necessarily be attributed to climate change, the farmers use it as an indicator to support their arguments and perception that the local climate has changed because the rivers they used to see flowing annually are now flowing during rainy seasons and get dry just a short while after that.

Apart from interviews, the data from FGDs also support farmers' perceptions on the changes in the local climate and the main reference to these changes is made on rainfall. This is because rainfall supports smallholder farmers because their production in the farm is mainly rain-fed. Some quotes provide justification to what farmers said during group discussions. For instance, one elder from Kambeni village put it very clearly referring to 1960s through 1970s to 1990s and what has the situation been all along:

> *"In real terms, the climate condition of this area was very conducive. For instance, in the 1960s, conditions were so good and there were no problems with rainfall. There was no food shortage, coffee was flourishing and people had money due to continuous good harvests. But starting from late 1970s through 1980s up to now, the condition was slowly negatively changing. These recent years we are experiencing shortage of rainfall and the rivers that have all along been supporting farmers to irrigate are now disappearing slowly because there is no enough rainfall. For instance this year, we received very little rainfall and this puts the future of people in jeopardy. So this is the situation according to my knowledge."* (R.K.1, Kambeni).

However, not all the years farmers receive small amounts of rainfall. Through interviews and FGDs, it was found that while some of the years the amounts recorded might be optimum, in some few occasions, the distribution within seasons becomes a problem. In such cases, too

much amount of rainfall may concentrate in a few weeks within the seasons, leaving many other weeks or months without rainfall thereby affecting farmers in their farming activities. Besides affecting farmers, such rainfall was also reported to be destructive of infrastructures and even some of the farms in some places.

> *"In some specific seasons, rainfall is up to the expected amount but falls in dramatic fashions. The areas may receive heavy downpour in a short period like one or two weeks. These rains become so catastrophic because they damage crops, infrastructures and properties. Then after two or three weeks, the areas are dry and they do not receive any rainfall till the next season. These are common cases nowadays."* (Official, Same District Council).

This explanation showed that the perceived changes in the local climate are in a way complicated especially for the farmers who entirely depend on rainfall for their livelihoods. This shows that much as in some of the years rains can be enough in terms of amount, the distribution within season is not something farmers can take for granted and it is beyond their control. Hence, they cannot define their fate for that matter. Apart from not being appropriate for farmers, the catastrophic nature of such kind of rainfall effects socio-economic development of the areas through destruction of bridges and other infrastructures available. This in a way creates other socio-economic problems to the households as well as the community while overburdening the government through rebuilding infrastructures.

Regarding the state of temperature, various views and perceptions expressed worries that there has been an increasing trend for the past 30 years. Many of the interviewees and the participants in the FGDs had the view that the temperature is increasing. Examples of quotes form the basis for this argument include the following:

> "*As for the temperature, in my view and according to my experience, it is increasing. Because ten or twenty years ago, during this month of August it was not very hot as it is now. For instance, nowadays, it is difficult to stay in the house during day time. It's very hot during the day."* (Leader, Mkundi).

In some of the instances, increased occurrence of malaria was used as justification for the increase of temperature in the area. For example, in Kambeni village, some of the interviewees made a case that 30 years ago, they rarely had malaria and were being told that the other villages in lower parts of the mountains had malaria. But now they experience malaria too, much as they are located in the highlands.

> *"In terms of temperature, I feel like it has increased because when I grew up, it used to be very cold and we never had malaria here. We used to be warned by our parents and grandparents not to go down to Kihurio because there was malaria but now we have malaria as a common disease here."* (Ward Councilor, Kambeni).

During interviews with the chairperson of the village, he showed a stock of malaria treated nets, which had been kept in his office ready to be supplied to the villagers as a measure of reducing malaria. He categorically said that during his youthhood, he never got infected by malaria until in recent years. In addition, he also said that many people in the village are not used to mosquito nets that is the reason they have not been active enough to collect their share at the village government office since they were delivered about 3 months by then. A summary of quotes indicating various views of the farmers, local leaders, experts and district authorities is presented in Table 5.2.

Table 5.2: Summary of data on changes in the Local climate from selected interviews

Interviewee	Quote	What he/she concludes
Official, Same District Council	In the past, I cannot recall 30 or 20 years ago because I wasn't in this district yet, rainfall was regular, predictable and of the appropriate amount. These years……, rainfall is unpredictable and decreasing in terms of amount	Generally, there is a decreasing trend in rainfall in all those areas.
Official, PBWB	In all these areas, the climate has changed leading to serious water shortage.	There is serious water shortage threatening the flow of rivers
Leader, Mtae	There are many changes nowadays in terms of the local climate one can speak of. Rainfall doesn't complete the cycle. In terms of temperature, you are shivering here now but if you had come 20 or 30 years ago, you wouldn't have seated there wearing so light.	Rainfall is decreasing while temperature is increasing.
Elder1, Mtae	The climate has been changing for the past 30 years. About temperature, I am not so sure. In some of the years the temperature is like increasing but in other years it's like decreasing.	I mostly depend on remittance from my children for survival.
Elder2 (she), Mkundi	In the past it was somehow hopeful because we used to get enough rains and whenever failure happened, food prices were at least affordable but now everything is bad	Our only hope and alternative is charcoal making.
Official, Lushoto District Council	In terms of rainfall yes there is a decreasing trend although we really don't have real data…….additionally, the onset has changed, many times they are outside the normal seasons. Rains are also short these years. Apart from that, population has increased in most of the villages hence high land fragmentation.	……. there is poor continued harvests and in some of the villages like Mkundi, we have been forced to give them food aid every year, at least for the past five year.

5.2.3 Reasons for the changes in the local climate perceived

One of the necessary parts of the first research question was to understand how farmers explain the perceived changes in the local climate including the factors which they themselves think are behind the perceived changes. On this issue, different explanations and views were recorded elucidating about farmers thinking in associating with the changes in the perceived local climate. The most surfacing reasons that were identified included the following: climate change impacts as part of changes in the global climate system; environmental degradation at local level, mostly through deforestation/forest degradation (for timber, charcoal, mining and construction materials, agriculture and so forth); soil erosion; population pressure accelerating overuse of the available resources such as water, land and forests; failure to respect local culture, traditions and knowledge (such as abandoning the culture of making sacrifices to gods annually); and the will of God as a punishment to human beings because they are now sinning and do not respect Him. Therefore, it is a punishment like HIV/AIDS. The following quote makes a summary of some of the reasons expressed by some of the interviewees:

> *"Global warming has a major contribution to the changes because climate data indicate that rainfall has been decreasing for the past 30 years or so. The population has also been increasing for the past 30 years. The population in 1970 was not the same like today but all continue to depend on the same streams for agriculture and other water uses. Deforestation in Chome Forest Reserve, which is the source of many streams, has been increasing. This affects rainfall and flow of water in the streams. Many people are concentrated in the water sources in the mountains and they undertake small-scale*

irrigation. Downstream there are big herds of cattle, which use water. These lead to soil erosion and siltation of Kalimawe Dam. Small-scale mining in Chome Forest Reserve is also a serious environmental problem that undermines water conservation in the area." (Official, PBWB).

These views, especially on population increase were also supported by one official of Lushoto District Council (Table 5.6) and one elder in Mtae village as he said:

"I think population has also increased very much. Many of the areas, which had forests, are now small farms. Also deforestation is serous now. Currently, young-men do not respect our culture, traditions and local knowledge. May be there are other reasons beyond my knowledge but I feel those might have contributed to the changes." (Elder2, Mtae*).*

From the presented reasons, there are probably two aspects reflected about the situation: first, the conflicting views between experts and local farmers. The experts had the feelings that global warming is contributing to the changes in the local climate that the area experiences. However, much as some of the farmers had similar thinking, others especially elders felt that the condition would probably be able to be rectified if young men and local leaders could encourage people to make traditional sacrifices. This is a conflict between elders, in one part, and the young men as well as experts, on the other. The second is related to conflicting views between those who believed that environmental degradation is accelerating the changes against those who feel that it is God's willingness and probably a punishment to people for going against the will of God. Responding to the question about reasons leading to the changes in the local climate, the Same District Council official had this to say:

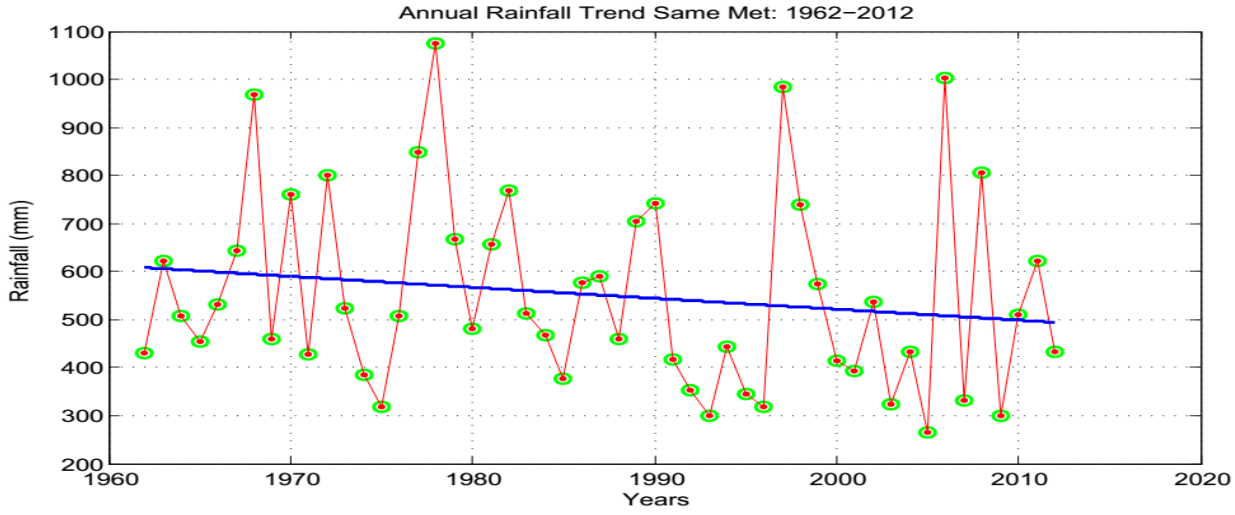
"*I think it is mainly due to climate change impacts, and environmental degradation particularly deforestation in Chome Forest Reserve."*

5.2.4 Historical Rainfall and Temperature Trends

Same Meteorological Station

The results from Same Meteorological station indicated that there has been a decreasing trend of rainfall for this station. If one observes closely the graphic representation of the results (Figure 5.4), a difference of 100 mm between year 1962 and year 2012 is depicted through a negative gradient. This is illustrated in Figure 5.3.

Figure 5.3: Annual Rainfall Trend for Same Meteorological Station (1962-2012)

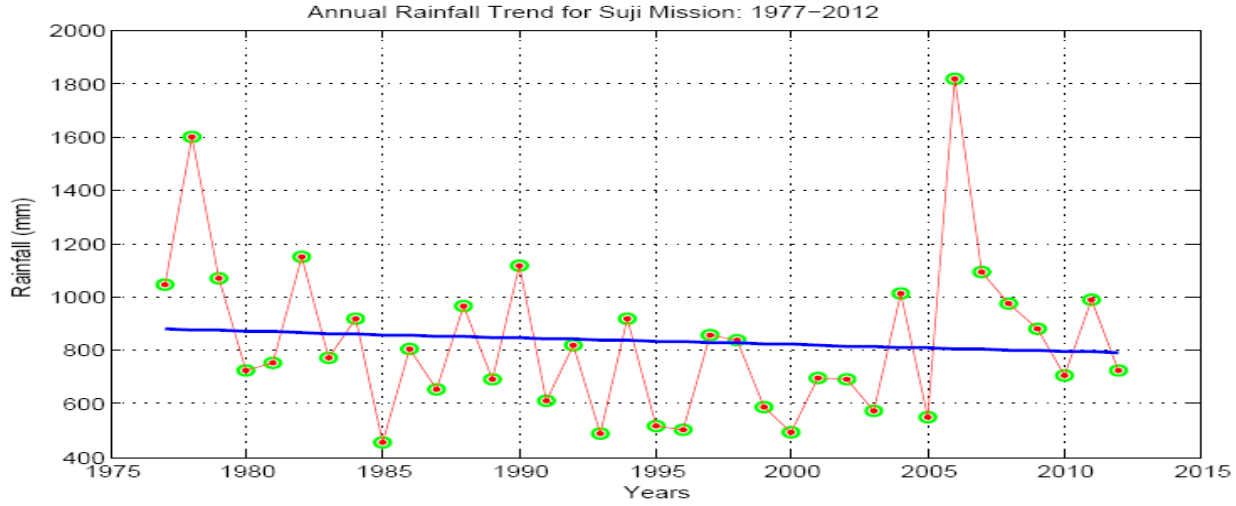


These results conform to the perceptions of the smallholder farmers, experts and village leaders that rainfall for the past thirty years showed a decreasing trend in the area, Same Meteorological Station being one of the benchmarks.

Suji Mission Rainfall Station

According to interview data, the average rainfall in the highlands in the research area is over 1000mm annually while for the lowlands is below 800mm. In terms of general trend of annual rainfall, Suji Mission receives more rainfall than Same (see Figure 5.3 and Figure 5.4 for comparison). However, results from the analysis of 36 years rainfall data (1977-2012) showed a decreasing trend for Suji Mission station. Figure 5.4 portrays this fact. The results support smallholder farmers' perceptions on the decreasing trend of rainfall in the area.

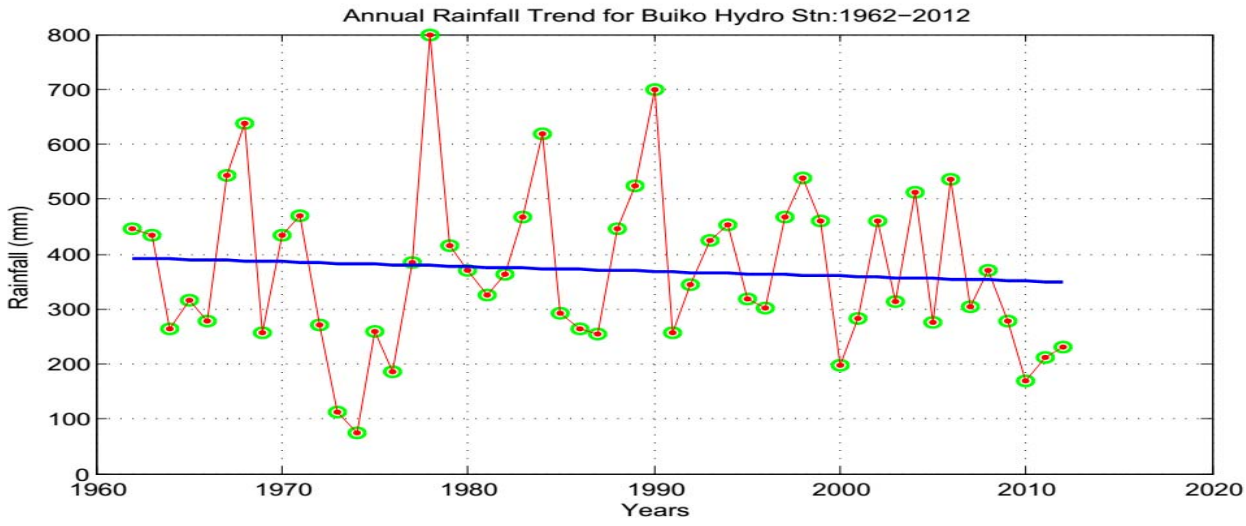
Figure 5.4 Annual Rainfall Trend for Suji Mission Rainfall Station (1977-2012)



Buiko Hydromet station

The analysis of 51 years (1962-2012) rainfall data for Buiko Hydromet showed a decreasing trend in rainfall. As indicated in Figure 5.6, the level of decrease within the period of 51 years is about 50 mm, which is unlike that of Same Meteorological station (comparison can be made between Figures 5.3 and 5.5).

Figure 5.5: Annual Rainfall Trend for Buiko Hydromet station (1962-2012)



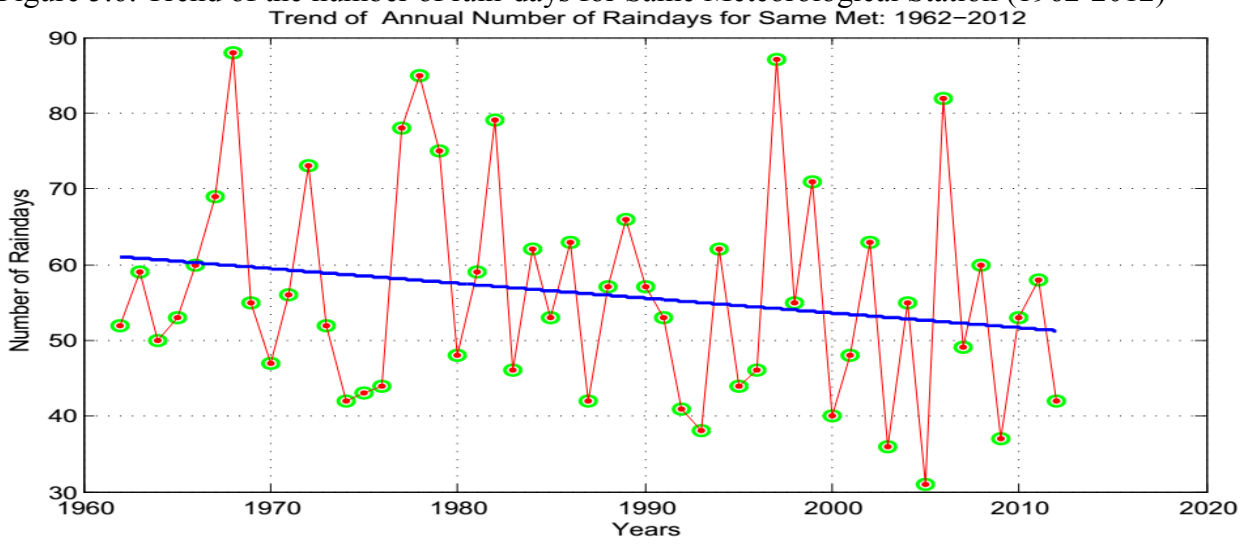
5.2.5 Number of Rain days per year

One other key perception of smallholder farmers and other stakeholders who took part in this research was that changes in the local climate in Mkomazi Sub-catchment not only manifest themselves through general decline in the total annual rainfall but also decrease in the number of rain-days within seasons thereby affecting production in the farms.

Same Meteorological Station

On this aspect, the results from the analysis of 51 years rainfall data for Same Meteorological station indicated the number of rain-days to be decreasing. This is depicted in the graphical presentation in Figure 5.6.

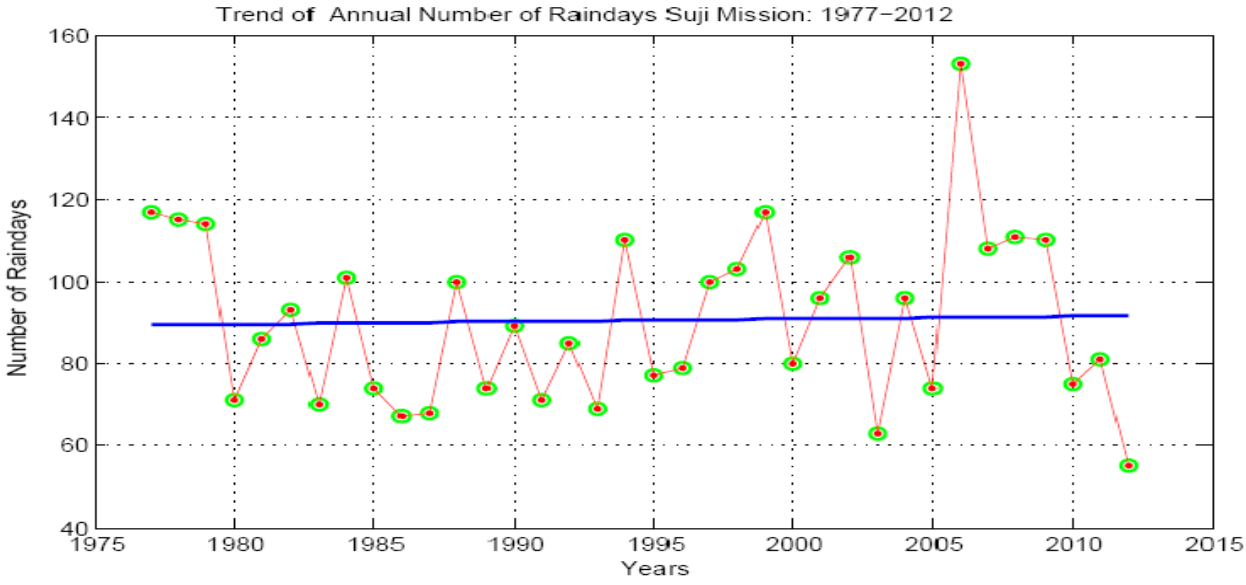
Figure 5.6: Trend of the number of rain-days for Same Meteorological Station (1962-2012)



Suji Mission Rainfall Station

Regarding the number of rain-days, the analysis of rainfall data for Suji Mission Rainfall Station gave out results indicating a very slim increasing trend contrary to the general rainfall trend for this station, which indicated a decreasing trend. This is also contrary to what was found in Same Station where both rainfall trend and the number of rain-days indicated a decrease. Figure 5.7 is an illustration of the results for this station.

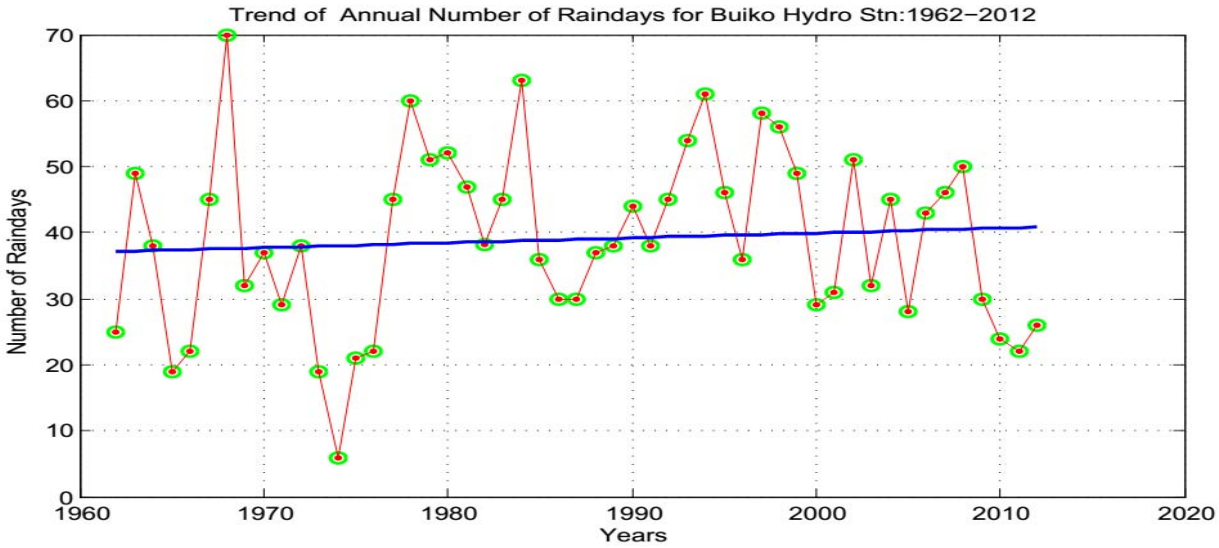
Figure 5.7: Trend of the number of rain-days for Suji Mission Rainfall Station (1977-2012)



Buiko Hydromet Station

The analysis of rainfall data for Buiko Hydromet station yielded results indicating an increasing trend for the number of rain-days as well even though it is a slight one. This is contrary to the overall annual rainfall, which showed a decreasing trend for this station as well. Figure 5.8 illustrates.

Figure 5.8: Trend of the number of rain-days for Suji Mission Rainfall Station (1977-2012)



5.2.6 Temperature trend for Same Station

Temperature is another essential climate variable that affects crop production alongside rainfall (moisture). To try to cross-check the perception of farmers and stakeholders that temperature has likely been increasing within the past thirty years, mean maximum and minimum temperatures for Same Meteorological Station for 44 years (1970-2013) for October, November and December and March, April and May were collected and analyzed using R software and a simple regression to get the general trend of temperatures within the two rain seasons. The results indicated an increasing trend for both minimum and maximum temperatures in both two rain seasons. However, there were slight variations in terms of the rate of increase as the OND minimum temperature and MAM maximum temperature showed a bit higher level of increase than OND maximum temperature (compares Figure 5.9a and Figure 5.9b). In addition, the increase in maximum temperature for OND is higher than that of minimum temperature in the same season. Figure 5.9 presents the results of trend in temperature for Same Meteorological station.

Minimum and Maximum Temperature Trends for Same Station (1970-2013)

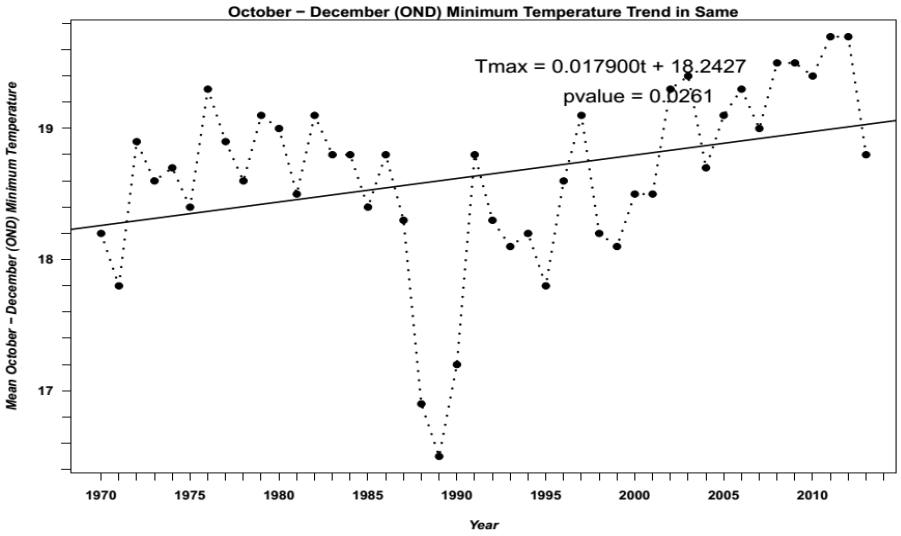


Fig. 5.9a: OND Minimum Temperature trend for Same (1970-2013)

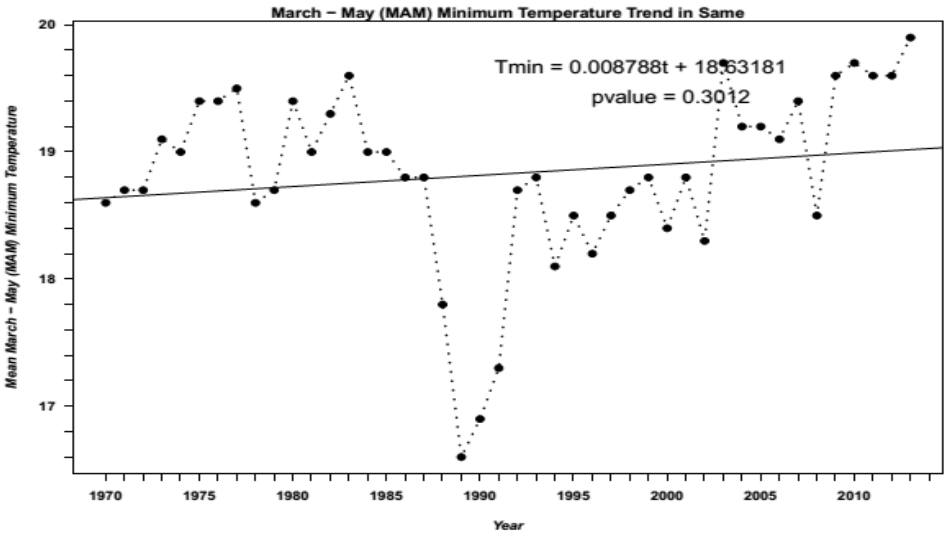


Fig. 5.9c: MAM Minimum Temperature trend for Same (1970-2013)

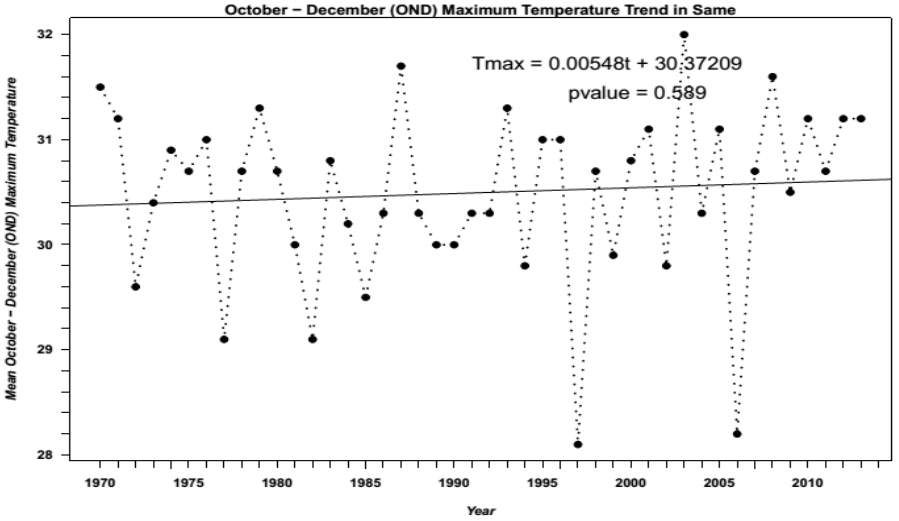


Fig. 5.9b: OND Maximum Temperature trend for Same (1970-2013)

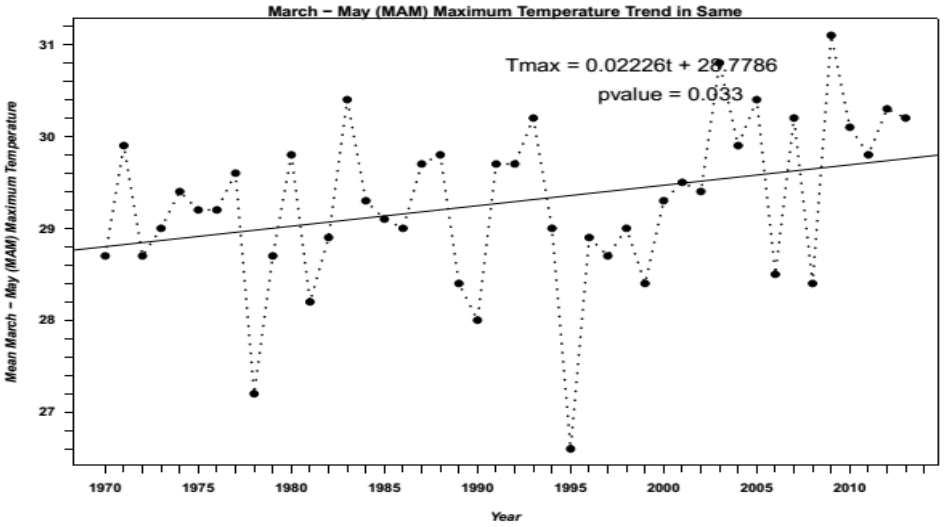


Fig. 5.9d: MAM Maximum Temperature trend for Same (1970-2013)

Stakeholders' Validation Workshop and Field Excursion

During this important workshop, the researcher presented results from both quantitative, qualitative and the climate data to stakeholders for them to comment and make any observations as to whether or not what was presented regarding changes in the local climate and other aspects represented the real situation, what is probably missing and any other important observation they would see necessary. Stakeholders supported the data by informing that they were indeed correct and reflected the real situation on the ground. They further stressed that much as not all villages experienced a similar level of vulnerability as a result of continued changes and variability in the state of climate, generally, the conditions were changing and possibly will continue to do so in the future. See Figures 5.10a-d for illustration.

Figure: 5.10a Workshop-Open Discussion

Figure: 5.10b Workshop-Open Discussion

Figure: 5.10c Field Excursion- Manga

Figure: 5.10d Field Excursion- Manga

From the field excursion, it was justified that rainfall onset in some of the seasons has been changing and in most cases, the onset is late rather than normal as it was found through the questionnaire, FGD and interviews earlier. This was justified by some farmers in Manga Mikocheni village where the validation workshop team visited.

During the excursion, some of the smallholder farmers and village leaders in Manga Mikocheni village informed the team that the short rains, which are very important in paddy cultivation, did not rain during October-December 2013. Therefore, there were no harvests at all. In addition, the few farmers and village leaders that the team had an opportunity to talk to reported that in the year ending December 2013, the village asked for and received food aid because there were poor harvests. However, they were clear that not all farmers were able to access the aid provided because it was little and those who got, was too little to take the family through

the hard times. With the short rain season failing to rain on time and little long rains, it is possibly the village may have to be supported with food aid in 2014 as well.

5.3 Discussions

In the preceding sections of this chapter, results on the state of the local climate are presented, indicating that long-term trends in both temperature and rainfall are increasing and decreasing, respectively. It is also fair to remind that the results on temperatures were obtained from only one station within the study area. However, some other studies conducted in the country and across the African continent have documented this fact (for example, Kangalawe and Lyimo, 2013; Legesse, *et. al*., 2013; Teka, *et. al*., 2012; Acquah and Frempong, 2011; Acquah , 2011; Mongi, *et. al*., 2010; Gbetibouo 2009; Agrawal, *et. al*., 2003). What needs to be noted is that in this study, all five sources of data confirmed this fact. Results from questionnaire, interviews and FGD indicate the perceptions that there are changes in the local climate in the area involving decreasing rainfall and increasing temperature trends. These results were crosschecked through the use of actual rainfall and temperature data from stations within the study area and nearby main meteorological station (Same); and the stakeholders' validation workshop held in Lushoto town. All these sources yielded similar results on the aspect of changes in the local climate, specifically rainfall and temperature trends. Even though much needs to be done to quantify the magnitude of changes in both, temperature and rainfall, the fact that the long-term records in rainfall showed a decreasing trend is an issue that requires policy and strategic focus.

Similar results have been documented in other studies in the past. While some differences in terms of focus, methodologies and findings are evident, the results from this study are similar to findings from some other related studies (for example, Acquah and Frempong, 2011; Legesse, *et. al*., 2013; Acquah, 2011; Gbetibouo 2009; Maddison, 2006). For example, in their study on farmers' perception of impact of climate change on food crop production and the adaptation strategies to cope with climate change in Volta Region-Ghana, Acquah and Frempong, (2011) found that most of the farmers perceived an increase in temperature, decrease in precipitation and an increase in wind temperature in their district. However, the study used only interviews. There were no additional sources of information to help cross check farmers' perceptions on changes in the local climate such as using actual climate data or opinions from experts etc. Much as the study findings are similar to those from the current study, lack of different data sources and especially climate data to gauge farmers' perceptions against actual rainfall and temperature data makes one question the extent to which the expressed perceptions can be correct or not. In addition, the study missed an important element, i.e. explanation of the farmers as why they think their local climate is changing. This would have given an important finding as well, and might have been of policy and strategic interest particularly on awareness creation and enhancing farmers' adaptive capacity.

In a research to understand farmers' perceptions and adaptation to climate change and variability conducted using farm household survey comparing with climate records (1960-2003) in the Limpopo Basin, South Africa, Gbetibouo (2009) found that the results were in line with farmers' perceptions. The most notable changes in the climate were on temperature as it showed to have been increasing. While temperature showed an increasing trend, precipitation had no clear trend, indicating that the most notable changes were on the inter-annual variability during that period. In terms of precipitation, Gbetibouo (2009) found that 81 percent of the respondents noticed a decrease in the amount of rainfall or a shorter rainy season. The results from the study by Gbetibouo (2009) showed both similarity and differences with the results

from the current study. In the current study, both temperatures and rainfall showed a clear pattern. Rainfall showed a decreasing trend while temperatures indicated an increasing trend. Farmers' perceptions also indicated that rainfall was shorter than normal and onsets as well as cessation were unpredictable. Much as the current study did not go into detail to statistically analyze the inter-annual variability using the climate data available, the results from all other sources (interviews, FGD and the validation workshop) support this fact.

The other interesting finding is that farmers and stakeholders attributed changes in the local climate they perceived to both global warming and environmental degradation particularly deforestation and forest degradation within Mkomazi. Given the fact that climate change is a worldwide problem, one cannot dispute the possibility of its adverse impacts to have contributed significantly to the changes in the local climate in Mkomazi. While this might be the case, local factors contributing to the decreasing rainfall and increasing temperature trends cannot be ignored as well. Of much interest, however, was the attribution of changes to religious and cultural beliefs. During interviews and FGD, some of the participants, particularly the elderly people, reported that the changes are part of punishment from God, others said that it is Gods will while others indicated that the changes are a result of failure of the people to respect their culture, that is, lack of respect to the culture and traditions. The fact that most of those who had these views were elders, this showed the divide between the old and young generations in terms of how they perceive, explain and understand different social, economic and natural dynamics.

It was argued with evidence in previous chapters that a majority of Tanzanians particularly the rural poor depend heavily on rain-fed smallholder farming. The fact that results indicated decreasing rainfall and increasing temperature trends raises concerns and worries on the future and livelihoods of the rural poor smallholder farmers if this kind of situation continues. While it is true that these farmers have accumulated enough knowledge and experiences in coping with similar changes, if the magnitude of change increases it may overwhelm them and their level of local knowledge and experiences may have a limit in supporting their local adaptation. Whereas many details are required to clearly quantify the magnitude of change and crop production in statistical and economic terms in the Mkomazi Sub-catchment, some of the similar studies indicated that increase in temperature and decrease in rainfall has negative effects on crop production (Mongi, *et. al*., 2010; Hassan, 2010; Kurukulasuriya, *et. al*., 2006). In their study on vulnerability and adaptation of rain fed agriculture to climate change and variability in semi-arid Tanzania, Mongi and colleagues (2010) found that rainfall in the study villages showed a decreasing trend while temperatures showed an increasing trend. They (*ibid*.) concluded that there were strong evidence to demonstrate the vulnerability of rain fed agriculture to adverse impacts of climate change and variability in the study area. Thus, changes in the local climate and its variability have a bearing on increasing vulnerability of the smallholder farmers.

Another interesting issue on results is the mixed picture on the trend in number of rain days. At Same station, rainfall, number of rain days and temperature trends support as well as confirm farmers as well as stakeholders' claims and perceptions. However, at Suji Mission and Buiko Hydromet stations, rainfall showed a decreasing trend while number of rain days indicated a very weak increase. Hence the data disagree with farmers and stakeholders' perceptions. However, the increase is too small to be optimistic of. In a thorough view, it is possibly wise to argue that the increase is insignificant and hence, has insignificant effects. On the other side of the coin, however, the situation may mean that rainfall is getting less in terms of amount but it is probably spreading more and thus, it might have an effect if the spread continues while the

amount gets smaller. In addition, the definition of a rain-day by the smallholder farmers is quite different from that of the meteorologists in the Tanzania Meteorological Agency. Those farmers do not comprehend the number of rain days within the definition of TMA, i.e., 1mm of rain or more recorded within 24 hours. For the farmers, rain days are days during the rain seasons when rain falls and the amount of rain that falls is within their expectations in the context of crop production activities in the farms. For the smallholder farmers, 1mm of rain recorded in dry seasons such as in July or August do not count because they are not within seasons when they have to produce in the farms. It means that for the farmers, the rain day means something else in the context of crop production. Hence, the smaller amounts of rainfall recorded in the rainfall stations and probably outside the relevant rain seasons are not really rain days for the farmers. Therefore, the possibility of having variations in terms of farmers' response on number of rain days and the actual climate data are possibly a result of different definitions and understanding what a rain-day is between farmers and the meteorologists together with timing of the rains.

But it is scary to find that results on average seasonal maximum and minimum temperature showed an increasing trend even though the rate may seem to be small. The fact that the results showed an increasing trend, they demonstrate a clear case that some interventions need to be considered by both policy makers and the district and regional authorities. It implies that while the increase may today seem small, but if the situation continues, it might have devastating effects in the future. Several negative effects of higher temperatures on crop production are highlighted in literature including reduction in crop yield and encouraging weeds as well as pests (Nelson, *et. al*., 2009). In his paper that synthesizes methods and results from a continent wide study, Hassan (2010) makes a case that African farmers loose on average US$ 39 per hectare for every degree centigrade rise in temperature. This is a reminder that the increase in temperature in the research area may have consequences to farmers, if not now, it might be in the near future and hence, there is a need for intervention to support farmers to adapt to the situations of weather change.

5.4 Summary

In this chapter, a detailed presentation and discussion of data on changes in the local climate in the area was made. Smallholder farmers, district experts, PBWB experts, ward extension experts; village elders as well as local leaders perceived that the state of the local climate has been changing in the past 30 years. Elders made comparison of the state of the climate in the 1960s, 1970s and early 1980s with that of 2010s and were in the view that there has been various changes ever since. All key stakeholders who took part in the research were clearly sure in their explanation that Mkomazi Sub-catchment is not the same as it used to be 30 years ago in terms of climatic conditions in the sense that there are several changes being experienced.

Identified changes include rainfall decreasing; shift in the onset of rainfall, i.e. late onset; and rainfall being unpredictable to smallholder farmers. In addition, farmers and experts had the view that rainfall distribution within seasons is not always uniform these years as some of the seasons experience good rainfall in terms of amount but not well distributed. This means that rainfall may concentrate in few days or weeks, leaving most part of the season dry and unhelpful for the farmers. Likewise, many farmers and experts argued that for these years, the number of rain days has been decreasing compared to the past 30 years. Finally, farmers and other stakeholders were of the view that not only rainfall but also the state of temperature has

been changing. They further indicated that temperature in the area is increasing compared to the past 30 years.

Long-term rainfall records were used to cross-check smallholder farmers and other stakeholders' perceptions on the state of the local climate. The results from three stations within the area verified that farmers and stakeholders perceived correctly. This is because the trend of rainfall was found to be mostly on the decreasing side for all three stations although the rate of decrease differs from station to station. Same Meteorological Station experiences high decreasing trend in rainfall compared to Suji and Buiko stations. Apart from the general trend, Same also experiences decreasing trend in the number of rain days as claimed by the farmers and other stakeholders. The number of rain days trend for Suji and Buiko stations showed an insignificant increasing trend. Likewise, stakeholders who attended the validation workshop were in agreement with the results thereby increased validity and reliability of the study findings. The next chapter presents data on changes in the farming practice by smallholder farmers in the Mkomazi sub-catchment as a result of various factors, which are explored in detail in chapter seven.

CHAPTER SIX: CHANGES IN FARMING PRACTICES

6.1 Introduction

While the major focus of this research was to identify factors motivating smallholder farmers to change their farming practices over time, it was important to be sure of whether or not there are changes, and their kind. Identification of changes in the farming practices by smallholder farmers not only provided the basis for revealing factors motivating them to happen but also would help in identifying their implications to the smallholder farmers, community and the environment at large. This chapter presents changes that smallholder farmers had been making in their farming practices in response to various factors overtime.

The chapter contains five sections: Introduction is followed by a general overview reflecting changes made in the farming practices across villages. The third section reports on details of changes including the type of crops and crop varieties at village level. Then a detailed discussion of findings is presented in the fourth section followed by a summary in the last section.

6.2 General Overview

The results from the analysis of the quantitative data showed that smallholder farmers had been making various changes in their farming practices in the area. The identified changes included shifting to higher yielding crop varieties such as new paddy and maize breeds that offer farmers higher yields instead of the traditional breeds; introducing new crops and varieties, which were not commonly cultivated in the area before; shifting to shorter cycle crop varieties, which can take short periods of time like three months from planting to harvesting; concentrating on crops that command good market prices; shifting to drought tolerant crops and varieties; and concentrating on and intensifying small-scale irrigation in the river valley instead of fully depending on rain-fed cultivation alone.

Figure 6.1: Summary of the changes in the Farming Practices

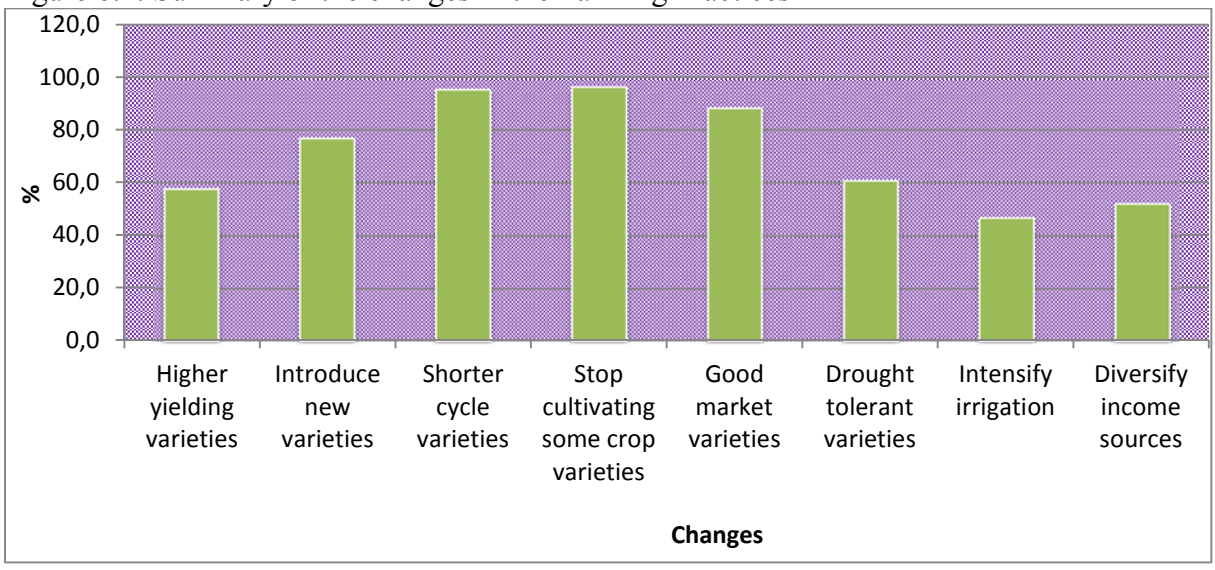


Figure 6.1 shows that 76.7 percent of the respondents from all villages agreed to have introduced new crops or new crop varieties as part of changes in their farming practices within the past 30 years. In addition, 95.2 percent of all respondents agreed to have shifted their concentration to cultivation of shorter cycle crops and crop varieties. The shift in attention to

other crops had impact on some of the common crops, which used to be cultivated in the area because as a result, 96.3 percent of all the respondents reported to have stopped cultivating some crops and crop varieties. Besides, 88.4 percent of all respondents reported that they shifted their attention to crops that command good market prices. While some farmers in the area, representing 60.8 percent of all respondents, reported that they made changes in the farming practices by shifting to cultivation of crops and crop varieties that are drought tolerant and 57.7 percent of the farmers concentrated more on crops and crop varieties that have higher yields.

Likewise, slightly below a half of all the respondents, 46.6 percent reported to have concentrated more on intensifying small-scale irrigation as part of their strategy to ensure that they increase the chance of harvesting instead of entirely depending on rain-fed cultivation. Apart from changes directly related to crop production, some smallholder farmers were found to had been concentrating on diversifying their income sources so that they do not only rely on crop production but also engage in other activities, both off and on-farm. They represent 60 percent of all farmers who responded to the questionnaire. Figure 6.1 summarizes details on changes in the farming practices farmers agreed to have made in all the villages.

6.3 Details on Changes Made

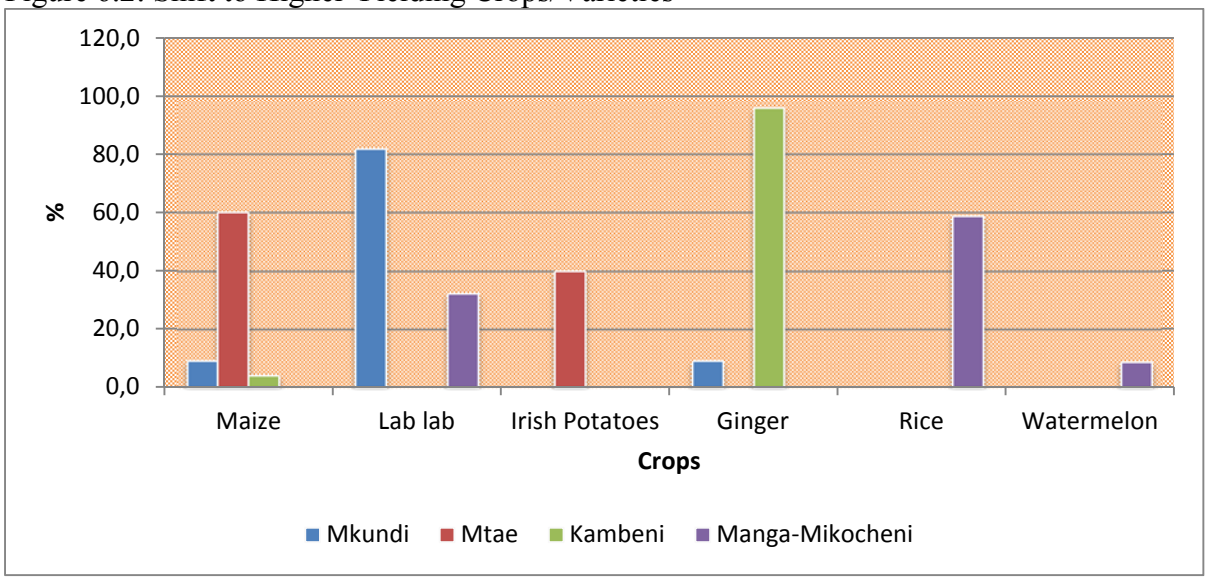
Apart from identifying changes in the farming practices that smallholder farmers have been making overtime, it was of interest also to get into detail in terms of changes in the farming practices. For example, type of crops farmers have adopted for having good markets, drought tolerant crops or crops, whose cycle is short and thus, they are much preferred to save that purpose and so forth. This section explores the details on changes in the farming practices.

Higher yielding crops and crop varieties

As to farmers shifting their attention to crops and crop varieties that are characteristically of higher yields, data showed clear divisions on the types of crops and crop varieties according to villages. This is also reflected in qualitative data discussed later. From the quantitative data, five crops identified as higher yielding ones. These are *Dolichos lablab* commonly cultivated in Mkundi village; irish potatoes and improved maize varieties commonly cultivated in Mtae village; ginger, a common cash crop in Kambeni village; and improved paddy varieties common in Manga Mikocheni village. However, qualitative data indicated that farmers had new maize and paddy varieties, which are both shorter cycle and tolerant to dry conditions than traditional varieties (details presented in the later sections). Figure 6.2 provides summary of details on crops that are higher yielding and were mostly preferred by farmers now for each of the villages.

Figure 6.2 shows that 37 percent of the respondents identified *Lablab* as a crop that has higher yields. But at village level, 75.8 percent of the respondents in Mkundi village identified Lablab as a higher yielding crop while in Manga Mikocheni village it was reported by 32 percent. Ginger is another crop that farmers in the research area reported to have opted for within the past 30 years. Thus, 96 percent of respondents in Kambeni village reported that ginger is a higher yielding crop. Farmers in Manga Mikocheni village identified the new paddy varieties as being of higher yields. In Mtae village, improved maize varieties and Irish potatoes are crops/varieties reported to be of higher yields and thus, good for the farmers. In addition, 60 percent of the respondents in this village identified improved maize varieties and 40 percent Irish potatoes as higher yielding crops.

Figure 6.2: Shift to Higher Yielding Crops/Varieties

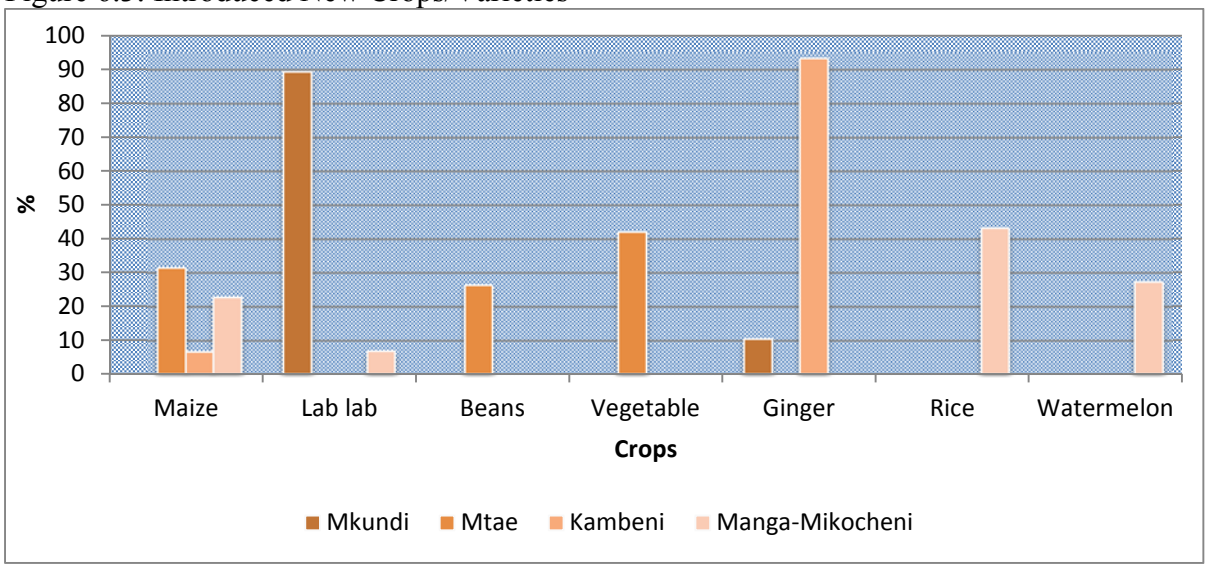


New crops and crop varieties

As part of the changes farmers reported to have been making for the past 30 years, data indicated that there are both new crops and crop varieties depending on farmers' purpose and interests. From the illustration in Figure 6.3, dolichos lablab, ginger, water melon, some vegetables, maize and beans (varieties) are the crops and crop varieties that were reported to have been introduced in the area within the past 30 years (depending on a particular village). More details are given in the qualitative part of data presentation.

In this case, however, each village seemed to have particular crop(s) or varieties of crops, depending on conditions and may be other factors. Presentation and discussion of the factors motivating changes in the farming practices are made in the next Chapter. While *Dolichos lablab* is most common in Mkundi and to some extent in Manga Mikocheni village, ginger was the main crop in Kambeni and other surrounding villages (which were not covered in this study). Watermelon was found to be a new crop in Manga Mikocheni most preferred because it is a shorter cycle and cultivated in the flood plain. Improved maize and beans varieties as well as some types of vegetable varieties are considered new for Mtae village. The data, however, showed that there are new maize and beans varieties, which have replaced the traditional varieties. In due regard, 93.3 percent of respondents from Kambeni village identified ginger as the new crop that farmers introduced within the past 30 years as a result of various factors. Besides, 89.5 percent of the respondents in Mkundi village identified lablab as a new crop that they introduced. In addition, 43.2 percent of the respondents in Manga Mikocheni identified some rice varieties as new varieties in their village. In Mtae village, 42.1 percent of the respondents identified some vegetables as new crops/varieties that they introduced in the village within the past 30 years. Likewise, some maize and beans varieties (31.6% and 26.3%, respectively) were identified to be new in Mtae village. As for Manga Mikocheni, watermelon was identified as a new crop that was not common but is now a preference for many and is commonly cultivated in the valley and mostly irrigated. Figure 6.3 illustrate.

Figure 6.3: Introduced New Crops/Varieties



In qualitative data, interviewed farmers, experts and local leaders as well as those who participated in the group discussions identified introduction of new crops and crop varieties as one of the changes smallholder farmers have made in the area within the past 30 years. The interviewees reported that depending on various reasons, farmers, from time to time, had to make decisions to introduce new crops and/or crop varieties in the area. Some of the reported new crops include *Dolichos lablab* (common in Mkundi and Manga Mikocheni as *Nkwasha*) and ginger, which was introduced in Kambeni village in the 1980s. In addition, new varieties of paddy and maize (in Manga Mikocheni) and maize, beans and tomatoes varieties in Mtae village were reported. From the Focus Group Discussion, one of the respondents had this to say regarding introduction of new crops:

> *"Lablab is common now but we never had this crop here in the past. We used to hear about it from Hedaru but now it is the crop we depend on because even when there is little rain, you can get some harvests unlike maize. Nowadays, maize cultivation is rare in this village. We do not cultivate beans also because there is no enough rain for one to be able to harvest."* (RM5, Mkundi village-Lushoto District).

From that quote, *lablab*, which is most common in the drier areas particularly West of the South Pare Mountains such as Hedaru, was identified to be a new crop introduced in the village. It was not the traditional crop in the village but now they depend on it because it is very adaptable to poor climatic conditions smallholder farmers report to be experiencing currently. The researcher's observation confirmed cultivation of the crop with almost absence of any other crop in the farms. This was observed in Mkundi village (Figure 6.4a-c shows the crop in the farm and the seeds)

Figure 6.4a: Dolichos Lablab-plant

Figure 6.4b: Dolichos Lablab-Field

Figure 6.4c: Dolichos Lablab-seeds

Apart from *lablab*, there are new maize and paddy varieties that were found to be cultivated by the smallholder farmers replacing the local varieties. Most of these were found to be cultivated in Mtae (maize), Manga Mikocheni (both maize and rice) as well as Kambeni village (maize). The representative of the District Agricultural and Livestock Development Officer for Same had this to say in justification of the responses from the farmers:

> *"Farmers also cultivate new and improved varieties of maize and paddy, which can tolerate harsh climatic conditions. For instance, Stuka, Staha, TMV1 and SIDCo 403 are new maize varieties while Super saro, Japan and Thailand are new paddy varieties. These varieties are better because they are not only tolerant but also have a shorter cycle than the old local breeds. All these varieties are new to the farmers; they were not there long ago. They are replacing the local varieties, which take too long for farmers to harvest and need much favorable climatic condition."* (Official, Same District Council).

Most of what the District Official said was reiterated and stressed by the Chairman of Manga Mikocheni village supporting the explanation that in their village, they now cultivate new varieties of maize and paddy. He also added that they now cultivate watermelon in addition to the new paddy and maize varieties. He insisted that climatic changes they experience compel them to concentrate to mostly shorter cycle and more tolerant crops and varieties otherwise they can be in trouble because rainfall is mostly scarce and not very much predictable as it used to be in the past.

In Mtae village, the findings showed that farmers have new beans varieties. In the interview with the Ward Councilor of Mtae, two varieties of beans were identified as being new to the area. The quote illustrates:

"There are also new varieties of beans called Roscoco and Soya instead of Kamba, which was the common beans variety in this area. The two new breeds are higher yielding varieties than Kamba, which is rarely cultivated nowadays in this village." (Ward Councilor, Mtae).

The cultivation of ginger in Kambeni and other surrounding villages within South Pare Mountains was also found to be new and reported to have been pioneered by one farmer in the 1980s. Before that, farmers cultivated coffee and other crops but now it is ginger, which is the important crop supporting livelihood in the area. The representative of the Pangani Basin Water Board had this to say regarding cultivation of ginger in the area:

"Yes there are changes and new crops or crop varieties are now evident in the area. …….. Cultivation of ginger has overtaken coffee, cardamom and other crops in Yongoma Stream. This is a new crop, which was not there in the area before 1980s. Its cultivation started in the 1980s. By then it was at a very small scale but now it is the common cash crop upstream." (Official, PBWB).

This was justified and supported by the Ward Councillor; Kambeni who also echoed that cultivation of ginger was not traditional for Kambeni: The Councillor had this to say,

"*Our common crops were coffee, maize, bananas, sugarcanes, beans, cardamom and many others. Coffee used to be our main cash crop here in those years. But now we do not grow coffee anymore. Even sugarcane and cardamom are no longer grown in this area. The other crops are still grown although very occasionally and at a very small scale. Now we have ginger as a cash crop instead of coffee."* (Ward Councillor, Kambeni).

However, the official from the Pangani Basin Water Board expressed worries on the sustainability of water resources amidst decreasing rainfall and increasing demands for irrigation particularly making reference to ginger cultivation. His views were that ginger cultivation is using a lot of water unsustainably. He proposed changes to allow farmers adopt another crop instead of ginger, which much as it supports smallholder farmers' livelihoods, it will not be sustained much longer because water abstraction from the streams is too high to be maintained and tolerated. The argument was that ginger requires too much water and hence, increases the demand for abstracting much water to feed the farms. According to him, not many years from now flow of streams will totally be affected and both farmers and the ecosystem will suffer. He reported that,

"Ginger cultivation is also a challenge. It is a great challenge because too much water is used for irrigating even when it is ready for harvesting but farmers continue to irrigate while waiting for markets believing that with a lot of water ginger becomes heavy and therefore one will fetch many kilos during selling." (Official, PBWB).

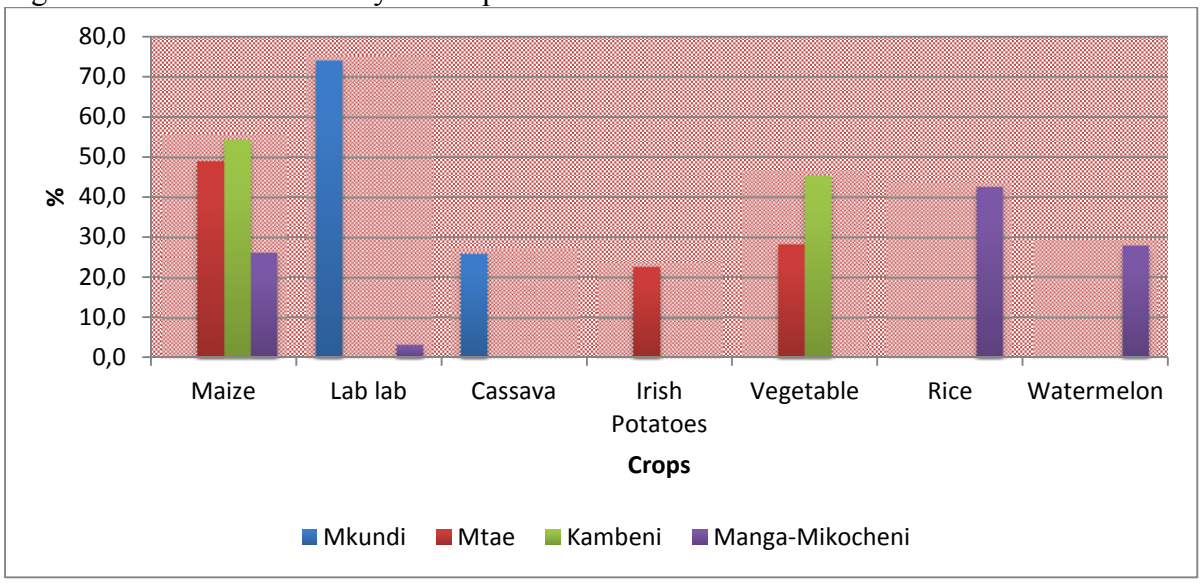
Shorter cycle crops and crop varieties

Shorter cycle crops and crop varieties are sometimes preferred by smallholder farmers especially when they are not sure of the climatic conditions and most importantly when these crops and crop varieties have potential to fetch good markets. This is the case in Mkomazi Sub-catchment where farmers have mostly been influenced to change their crops and crop varieties by concentrating on cultivation of shorter cycle crops and crop varieties. Quantitative data

indicated that farmers have some preference to shorter cycle crops and crop varieties mostly *Dolichos lablab*, improved maize and paddy varieties, various types of vegetables and watermelon.

Again, the crops appeared to be distributed differently in each of the four villages because *Dolichos lablab* remained a preference for Mkundi village; maize varieties are somehow distributed in Mtae, Manga Mikocheni and Kambeni; paddy varieties are dominant in Manga Mikocheni, while Irish potatoes are grown in Mtae village. Other crops in this category were watermelon in Manga Mikocheni and vegetables in both Mtae and Kambeni villages. Details on the percentages are illustrated in Figure 6.5. Figure 6.5 indicates that 42.6 percent, 27.9 percent and 26.2 percent of the respondents in Manga Mikocheni cultivated improved rice, improved maize varieties and watermelon, respectively as the shorter cycle crops/varieties. In Mkundi village, 74.2 percent of the farmers reported lablab being the shorter cycle crop they now concentrate on. Furthermore, 54.5 percent and 45.4 percent of the farmers in Kambeni indicated that they now concentrate in cultivation of improved shorter cycle maize varieties and vegetables respectively while maintaining their concentration to ginger as well. As for Mtae village, 49 percent, 28.3 percent and 22.6 percent of the farmers identified improved maize varieties, vegetables and potatoes, respectively, as being shorter cycle.

Figure 6.5: Shift to Shorter cycle Crops/Varieties



Supporting and justifying data collected from the questionnaire, focus of smallholder farmers on cultivation of shorter cycle crops and crop varieties also surfaced very strongly during interviews and FGDs. This implies that not only experts but also farmers are aware that such type of crops and crop varieties increase chances for harvesting than the longer cycle ones. The interview with the representative of the Pangani Basin Water Board is a case in point:

> *"Almost everywhere in the Mkomazi valley there is now cultivation of shorter cycle but also higher yielding crops like watermelon, cabbage, bell peppers, tomatoes, spinach and new rice as well as maize varieties which can be harvested within two to three months after planting. In addition, some of these varieties are more tolerant to dry conditions than the old varieties."* (Official, PBWB).

The Chairman of Mtae village hinted on the fact that being uncertain of what rainfall can offer, farmers are compelled to cultivate shorter cycle crops and varieties like maize and vegetables.

Such shorter cycle crops and varieties give the farmers some hope and assurance of harvesting even though the climatic conditions are uncertain.

> *"Many farmers do not cultivate local crop varieties, which needed about six months or more from planting to harvesting. No one is ready to take that risk and waste time as well as money. Instead, they mostly concentrate on these shorter cycle varieties."* (Village Chairman, Mtae-Lushoto).

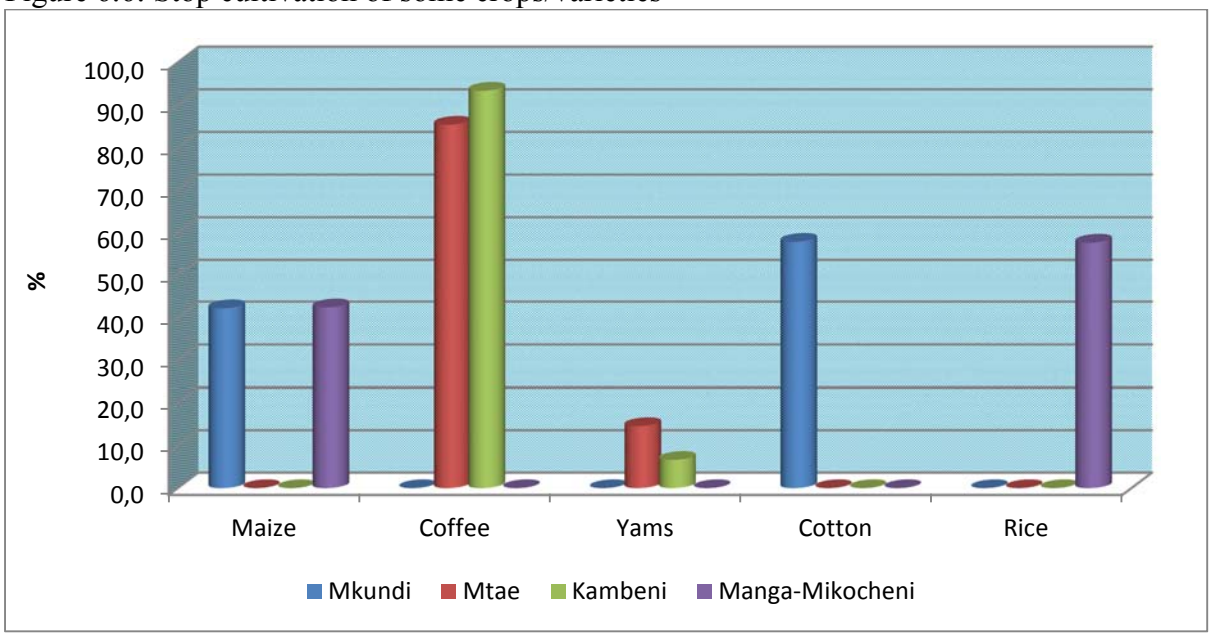
In some cases, it was found that farmers also cultivated some crops, which are tolerant to dry conditions like cassava because of the fear that if they do otherwise they face a risk of losing if rainfall fails. The leader of Mtae village had this to say,

> *"Many people have also concentrated on cassava instead of maize because this crop does better despite the changes in the local climate."*

Stop cultivating some crops and crop varieties

One of the changes, which smallholder farmers in the area reported to have done in their farming practices in the past 30 years was stopping cultivation of some crops and crop varieties, which were like traditional in the area because they were part and parcel of their livelihoods for many years. Results of the analysis showed that coffee is the main crop which farmers no longer cultivate. Other crops were cotton as well as local maize and paddy varieties. Coffee cultivation, which used to be common in the highlands (e.g. Mtae and Kambeni villages), was reported to have been abandoned by the farmers. In terms of village details, the data showed that 93.3 percent of the farmers in Kambeni and 85.4 percent of the farmers in Mtae abandoned coffee cultivation. In Mkundi village, 42 percent and 57.7 percent of the farmers reported to have stopped cultivation of maize and cotton, respectively. In Manga Mikocheni village, farmers reported to have stopped cultivation of local paddy (42.3%) and maize (57.7%) varieties. Figure 6.6 illustrates these details.

Figure 6.6: Stop cultivation of some crops/varieties



In the qualitative data, similar crops and crop varieties were identified. The interviews confirmed this change by reporting that,

"*They (farmers) have abandoned crops like coffee. There was a co-operative society for coffee here but it is no longer working because people have abandoned coffee cultivation. Traditional maize varieties are cultivated very occasionally because people know that the harvests are poor due to poor rains.*" (Ward Councilor, Mtae).

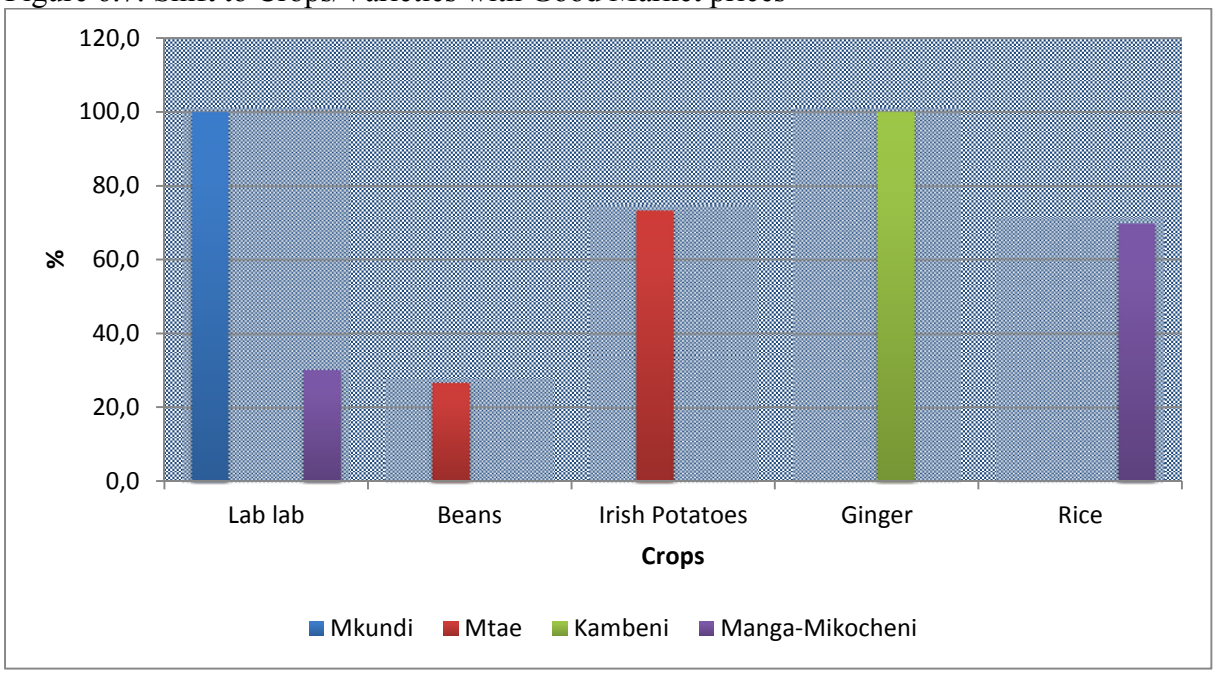
One elder confirmed abandonment of coffee but added on the list by asserting that,

"*Other crops which are no longer common are groundnuts, yams and sesame. Crops that we concentrate on today include different varieties of vegetables like magrobe tomatoes, cabbage, different varieties of spinach and most importantly, Irish potatoes.*" (Elder1, Mtae-Lushoto).

Shift to Crops with Good Market Prices

One other revealed change in the farming practice was that of smallholder farmers' shifting preference to crops, which have good markets. This is because markets can influence smallholder farmers' decisions on the kind of crops to cultivate with the aim of getting more cash. The results from the surveys showed that farmers opted for some crops or varieties of crops, which have good markets. An example of the crops, which farmers identified in this category, is ginger. In addition, some of these crops such as *lablab* were introduced for some motives but they turned out to be attracting good markets at a later stage. The type of crops and crop varieties were not the same in all villages but they varied almost in each of the four villages. In Manga Mikocheni village, paddy varieties were identified by the farmers as having good markets while in Kambeni village, ginger was found to have good market. It was a different case for Mkundi village where lablab (locally called *Nkwasha*) was found to have good markets unlike Mtae village where Irish potatoes, beans and vegetables were found to have good markets. These variations reflect both favorability of the condition as well as the role of markets. Figure 6.7 indicates the details.

Figure 6.7: Shift to Crops/Varieties with Good Market prices



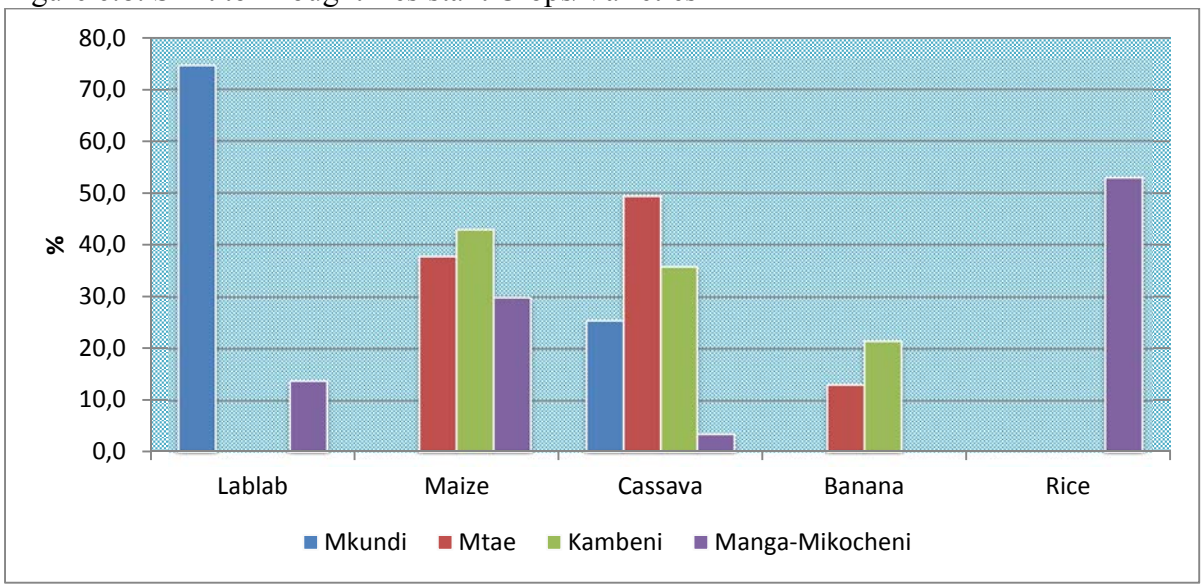
Details indicated that in Mkundi village, all (100%) of the respondents identified *lablab* to be the crop, which apart from being tolerant to drought conditions and higher yielding, its produce also has a good market. Similarly, all (100%) farmers in Kambeni village confidently identified

ginger as having a good market. In addition, 73.3 percent of the farmers in Mtae identified Irish potatoes to have good market. A similar case was found in Manga Mikocheni village where 69.7 percent of the farmers identified new paddy varieties to have good market. The details are illustrated in Figure 6.8.

Drought Resistant Crops and Crop Varieties

Influence of what is perceived to be changes in the local climate, particularly decreasing rainfall, on the choice of crops and varieties was found to be in terms in percentage was high. In this regard, cassava, *lablab* and new maize as well as paddy varieties were the main crops and/or varieties identified tolerant to dry conditions. Like in other changes, the choice for crops somehow varied from village to village. The data presented in Figure 6.8 indicate *lablab* was the main crop in this category. In Mkundi village, 74.6 percent of the farmers identified this crop drought tolerant. For Kambeni and Mtae villages, cassava and new maize varieties were the identified crops. In Mtae, 49.4 percent were for cassava and 37.7 percent for maize; and in Kambeni it was 42.9 percent for maize and 35.7 for cassava. In Manga Mikocheni, 52.9 percent and 30 percent of the respondents identified new paddy and maize varieties, respectively as being drought tolerant. Illustration is given in Figure 6.8.

Figure 6.8: Shift to Drought Resistant Crops/Varieties



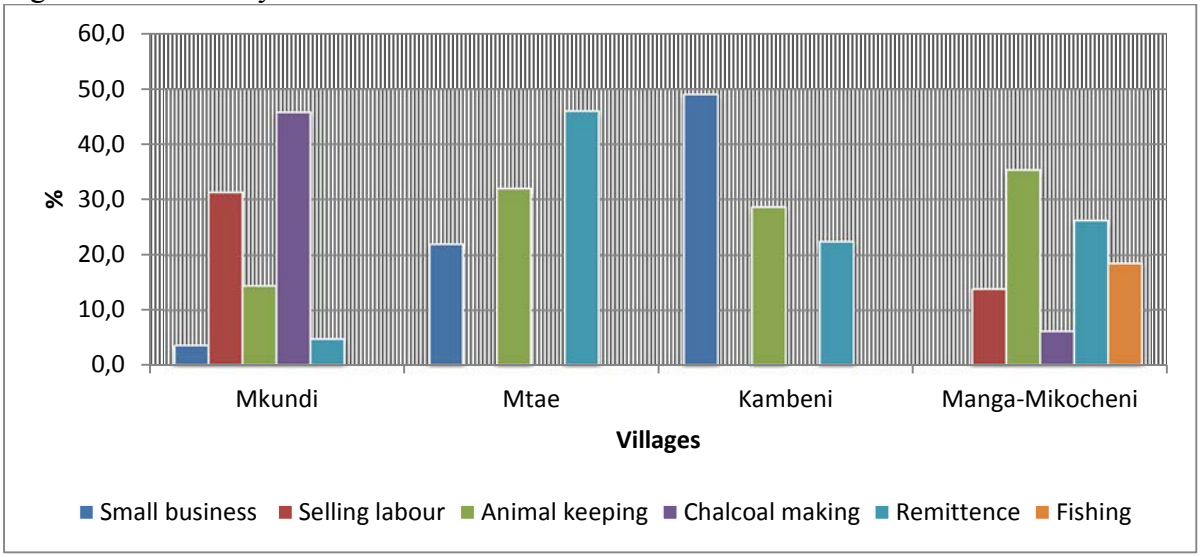
Diversification of Household Income Sources

Amidst perceptions that there are changes in the local climate, there was an expectation that may be farmers are combining on-farm, off-farm and non-farm activities as a way of offsetting loss from the impacts of the changing climate on agricultural production. Many smallholder farmers in these villages engage in a number of alternative activities for the aim of alternative income. These activities include small businesses, animal keeping such as goats and sheep; poultry (such as chicken, duck and guinea fowls); and charcoal making as well as selling.

Analysis of the quantitative data revealed that seven alternative income generating activities were identified in this category. These were small businesses, selling labour, animal keeping, charcoal making, remittance and fishing. In terms of percentage at the village level, 45.8 percent of the smallholder respondents in Mkundi village engage in charcoal making and selling while 31.3 percent sell their labour outside their village. Likewise, 46 percent of the farmers in Mtae receive remittance while 32 percent keep animal for the aim of getting income

to offset any gaps they experience. In Kambeni village, 49 percent of the farmers engage in small business such as kiosks and other petty trade for the same purpose of filling income gaps. In the same village, 28.6 percent and 22.4 percent of the smallholder farmers keep animals and receive remittance, respectively. Similarly, in Manga Mikocheni village, farmers keep animals (35.4%), receive remittance (26.2%) and engage in small scale fishing in Lake Manga (18.5%) so as to support their livelihood especially during hard times of the year. Figures 6.9 and 6.10 illustrate the details.

Figure 6.9: Diversify of Household Income Sources



In addition to the quantitative data, interviews and FGDs also had some contribution, mostly confirming the type of activities and income sources smallholder farmers depended on outside crop production in their farms. The qualitative data identified similar income generation activities, off-farm and non-farm, which were used by farmers to offset the income gap they sometimes experienced. The same income sources were identified, namely, charcoal making and selling, remittance, animal keeping, selling labour, fishing and small businesses such as vending. While animal keeping was universally identified as an alternative source of income additional to crop production in all four villages, small business was found to be common in Kambeni while remittance was common in Mtae. Charcoal making and selling labour were common alternatives in Mkundi while small scale fishing was dominant in Manga Mikocheni.

Making and selling charcoal as well as firewood were the most common income sources in Mkundi village. Many of the smallholder farmers who participated in both interviews and FGDs made it clear that they normally cut down trees from small forests nearby their village to make charcoal and firewood for selling as part of their source of income. It was claimed that the rate of cutting down trees increased in recent years as a result of the perceived poor rainfall and unreliability. While the claimed increase in the rate of forest harvesting for charcoal and firewood could not be verified, interviewed smallholder farmers as well as the village government leaders agreed that firewood and charcoal had been one of the dependable source of income for many in the village in recent years. It was reported that,

> "*The changes are very bad ones my son. Currently, as you can see yourself, the area is dry and we have no hope for rains. Our main alternative is charcoal making. Even now, after here I will go down to the forests to make charcoal. What do you think can I do for my survival?"* (RM7, Mkundi village).

When asked about reliability of the charcoal market, the interviewee added that,

> *"Charcoal is the main economic activity here. One bag of charcoal goes for Tshs. 3000.00 (about €1.5). If you manage to sell 10 bags, you can buy some maize to support your family for some time."* (RM7, Mkundi village).
> *"Trucks come here with businessmen to collect charcoal and this is the major source of my income now."* (Elder2, Mkundi).

The Chairman of the village justified this during the interview as he said that,
"There is serious deforestation due to charcoal making as a result of prolonged drought. Many people here have found charcoal making their daily and dependable economic activity. People here depend on charcoal making and selling labour in neighbouring villages for income so as to buy food for their families." (Leader, Mkundi).

Figure 6.10: Charcoal and Firewood for sell at Mkundi village

Remittance was found to be an important alternative income source to some smallholder farmers in the area, which supports them to meet their needs outside the farms. Much as it was identified in all four villages, many of those who cited it as a main source of their income were elders in Mtae village. It is an alternative to support farmers using their sons, daughters and relatives who happen to have moved to urban centres and work to support themselves, at the same time supporting their parents and relatives back in the villages. One of the elders in Mtae had this to say:

> *"For these years, the onset of the rains is not predictable too. Dry spells are very frequent. So I mostly depend on my children who work in Tanga and Arusha to support me otherwise the farms are no longer giving me enough food for my family."* (Elder1, Mtae village, Lushoto district.

In villages like Kambeni and Mtae, some of the smallholder farmers reported to have established some small businesses mostly kiosks for selling small consumables to their fellow villagers. The items given as examples of what they sell include kerosene, sugar, salt, biscuits, juice and other consumables. One of the farmers said:

> *"Using some little money I got from selling ginger three years ago, I established a small kiosk where I sell small items such as kerosene, cooking oil, salt, sugar and the like. It is*

very helpful because last year my harvest was very poor due to unreliable rainfall but was able to buy food and pay school fees for my children using this small business." (R.K.1, Kambeni).

Some farmers also sell their labour to neighboring villages and towns or other places such as in sisal plantations along the road to Moshi/Arusha and in Mnazi where they get some money and use the same to support their families particularly during dry seasons or in years they experience poor harvests. This alternative source of income was mostly reported in Mkundi village as the following quote justifies:

"Some men out-migrate to nearby villages or towns to find casual labour, work for some time particularly during the dry season. What they get helps them to support their families." (Chairman, Mkundi village, Lushoto district).

Many farmers in all four villages reported to be keeping animals such as goats, sheep and rabbits as well as birds like chicken and duck. Farmers sell these animals to cover some family expenses such as school fees and food. For example, during the FGDs, one smallholder farmer in Mkundi had this to say,

"Keeping animals helps me also. I keep some goats although it is not a serious business, they are currently fifteen. ……..you can take two or three goats, sell them and pay part of the school fees or school contribution, buy some maize and so forth. But I must admit that when it comes to daily bread, charcoal is a very good source of money here." (R.M.3, Mkundi village).

In Manga Mikocheni village, small scale fishing mainly for consumption is common in Lake Manga further in the South of the research area. While what they catch is small in terms of amount and age of the fish, it still supports some of the farmers for protein and offsetting the income gaps they experience. However, it was stated that fishing depends on seasons because the lake does not contain enough water all year around. In some of the seasons, there is more mud in the lake such that they cannot get fish out of it. Their leader had this to say,

"There is small scale fishing in Lake Manga down there. The boys do some fishing although the fish they catch are so small. During hard times, it is very helpful as a source of food. It all depends because some other times the lake contains a lot of mud making it impossible to get any catch." Chairman, Manga Mikocheni village.

The data presented on alterative income generating activities were also strongly supported by stakeholders during the validation workshop in Lushoto. The stakeholders clearly said that farmers currently are getting involved in a number of alternative income generating activities, which help them to survive amidst changes and variability of the climate, which, in turn, affects their production in the farms. The stakeholders said that much as not all villages experience the same level of vulnerability, smallholder farmers are already struggling to adapt. While production in the farms may be having unpromising results, smallholder farmers try to withstand the impacts on the changes and frequent crop failure by opting for alternative income generating activities. They can still survive not necessarily because they continually have good harvests from the farms but mostly due to having alternative income generating activities, which they engage in. These activities are such as small businesses, keeping animals, selling labor and remittances they receive from family members who work in towns and cities.

Intensification of small-scale irrigation

From the interviews and the FGDs, farmers as well as local leaders and experts confirmed that one other change in the farming practices involved intensification and more concentration of farmers on small-scale irrigation than rain-fed agriculture, which used to be very common in the past. This is the common system now in the villages except for Mkundi village, which has no access to water for irrigation. It is this situation, which differentiates it from the other three villages with access to water for irrigation in some parts of the year (much as the access also differs significantly). The farmers, experts and leaders clearly stated that currently, it is too risk to entirely depend on rain-fed cultivation because its reliability and predictability is difficult compared to the past 30 years. Therefore, small-scale irrigation is now the main solution to the problem.

> *"Farmers have mostly based on small scale irrigation farming instead of depending entirely on rain-fed cultivation. However, the big challenge now is water availability. Scarcity of rainfall coupled with high demands for water constrains the farmers on small-scale irrigation, which, in turn, increases the level of abstraction of water from rivers. The two combined, lead to diminishing water flow every year."* (Ward Agricultural and Livestock Extension Officer, Kambeni).

The Chairman of Manga Mikocheni village also made a similar statement confirming much more dependence of the farmers on small scale irrigation nowadays than in the past when rainfall used to be reliable:

> *"Now we depend much on small scale irrigation unlike those years when we had good rains. For some of the crops, which we cannot irrigate like potatoes we no longer cultivate them. That is why we mostly cultivate paddy in the valley."* (Chairman, Manga Mikocheni Village).

For Mtae village, small-scale irrigation is also done using tap water. Having access to tap water allows the farmers to cultivate vegetables, which do not need too much water to attend but have shorter cycle, allowing them to cultivate as many times in a year as possible. The sale of the produce gives the farmers some money to buy maize, rice and produce to feed families:

> *"Nowadays, many households use tap water to operate small scale irrigation by cultivating shorter cycle crops like Irish potatoes, vegetables such as cabbage, tomatoes, bell peppers, okra, spinach and the like."* (Village Chairman, Mtae-Lushoto).

Tap water availability in Mtae was made possible through the Water Management Mtae Project, whose implementation started in 2002 and completed in 2006 (Weinig, *et. al*., 2007). The partners of the project were the University of Applied Sciences in Bielefeld, the University of Dar es Salaam, the Lutheran North East Diocese in Tanzania, the Lutheran parishes in Mtae and the parishes of St. Marien and St. Martini in Minden, Germany (*ibid*.). The project involved laying a water pipe, building a water intake, a water storage tank, a distribution system, public taps, pits, sewer lines and a septic tank. This allowed spring water to be transported into the village (*ibid*.). The project budget was estimated to be 90,000 € sponsored by the Lions Club Porta Westfalica-Germany and the State of North Rhine Westphalia as well as some other individuals (Weinig, *et. al*., 2007). For project sustainability, a user association was formed to both manage and ensure that some money is charged to users so that maintenances of the system are regularly made to keep it operating (Weinig, *et. al*., 2007).

Interviews conducted informed that in order to be able to irrigate, farmers in many of the areas, particularly Kambeni and Manga Mikocheni villages, have moved into the river valleys for cultivation and are rarely cultivating the farms outside and far from the river valleys since they do not guarantee water access and harvests. The main areas where farming is possible and harvests are guaranteed are the river valleys close to water for small-scale irrigation. Farmers claimed that in the past, they cultivated both types of farms depending on the season but now they mainly if not entirely, have to depend on small-scale irrigation in the valleys because rainfall is not reliable and predictable. The interview with the Chairman, Kambeni village revealed this clearly:

> *"Farmers have mostly shifted to the lower valleys where irrigation is possible and abandoned many of the areas, which are distant from the valleys because it is difficult to irrigate in those areas. We harvest water through making night storage dams locally called ndivha, which temporarily store water for irrigation."* (Leader, Kambeni village).

6.4 Discussions

In the previous Sections, changes in the farming practices in the four villages, including details on specific crops are presented. Both quantitative and qualitative data clearly showed that farmers have, for the past 30 years, been making various changes in their farming practices motivated by different factors (presented and discussed in the next Chapter). These findings are supported by various similar studies conducted in many other places in the developing countries. Looking at the presented data, it is also clear that there are key changes in the farming practices mostly undertaken by farmers in all four sampled villages. However, the data showed both differences as well as similarities in changes and types of crops and crop varieties between and among villages.

The data presented demonstrated that much as some similarities in terms of specific changes in the farming practices and the crops exist, it is also clear that each village is dominated by particular changes and crops characterizing not only farmers' preferences but also socio-economic, micro climatic conditions as well as access to water for irrigation as important resources. If one looks at the situation in Mkundi village, it is clear that *Dolichos lablab* or *Lablab purpureus* ought to have been adopted as a common crop because of its ability to withstand harsh climatic conditions, particularly persistent dry conditions. Lack of access to water for irrigation as well as the current climatic conditions in the villages are key reasons this is the case. The characteristics of lablab justify why in Mkundi village, according to their climatic conditions, they adopted cultivation of this crop. The following quote explains briefly about the crop:

> *"Lablab purpureus combines a great number of qualities that can be used successfully under various conditions. Its first advantage is its adaptability, not only is it drought resistant, but also it is able to grow in a diverse range of environmental conditions worldwide. Staying green during the dry season…"* (Murphy and Colucci, 1999).

The crop not only can be used as food (for both humans and animals) and cash source but also it has valuable environmental advantages as it is summarized that,

> *"Lablab purpureus with its ability to out-yield conventional crops, especially during the dry season, and its enhanced nutritive value, is a fodder crop of great significance for the Tropics. Lablab can be used advantageously as a cover crop. Its dense green*

cover during the dry season protects the soil against the action of the sun's rays and decreases erosion by wind or rain. As green manure it provides organic matter, minerals and fixes nitrogen into the soil thereby improving crop yields in an economic and environmentally friendly manner." (*op. cit.).*

This village is situated on the leeward side of West Usambara Mountains and hence, it receives little rains compared to villages in the highlands like Mtae. The narratives from the farmers both in Mkundi and Mtae imply that before the perceived changes in the local climate, heavy rains falling in West Usambara Mountains supplied enough water downstream as well thereby enabling Mkundi village to have water access for irrigation. In addition, Mkundi also used to receive optimum rainfall during rainy seasons to enable them to cultivate and produce various crops. The perceived changes in the local climate are believed to have affected not only availability of optimum rainfall but also accessibility of running water downstream from upstream in the Usambara. Hence, Mkundi village is the main victim from both two situations and the adoption of *Dolichos lablab* and similar crops was in a way inevitable. This is because many crops such as maize, potatoes, beans and so on, which farmers reported that they used to be grown in the village in the past, cannot do well under the current conditions. The adoption of lablab, a drought tolerant and most commonly cultivated in the semi-arid areas in the Western side of South Pare Mountains, is a clear testimony of the role of farmers in decision-making to change farming practices by adopting appropriate crops and crop varieties suitable for a particular climatic condition as part of their adaptation process.

The case of Kambeni village slightly differs from that of Mkundi. This village is located in the highlands of South Pare Mountains. While farmers, district authorities as well as the Pangani Basin Water Board all complained and indicated concerns over decreasing rainfall in the areas, the village retains advantage over access to little water for irrigation. After abandoning coffee in the late 1980s, farmers adopted ginger cultivation. The interviews and FGDs revealed that the crop was introduced by an individual farmer in the late 1980s but later on, it overtook coffee as a cash crop in the area. For Kambeni village, ginger is the crop smallholder farmers heavily depend on. The data from both quantitative and qualitative sources justified this fact. Much as other crops such as maize, vegetables and potatoes are cultivated as well, but ginger remains the crop farmers depend on most as a substitute for coffee, which is no longer cultivated. Details on the factors for these changes are presented and discussed in the next Chapter.

Mkundi and Manga Mikocheni villages showed some similarity in that they both adopted different crops and abandoned other crops at the expense of the new ones. In Manga Mikocheni village, however, the situation is different because the farmers reported to have been cultivating paddy and maize throughout. But to put paddy and maize cultivation on a safe side and out of risk from the perceived changes in the local climate, farmers have been proactive and now have new and improved, resistant, higher yield and shorter cycle paddy varieties. That has been done through introduction of new paddy and maize varieties, which are believed to be tolerant to dry conditions thereby reflecting the changes in the local climate. One official from Same District Council explained about this issue during the interview by indicating that much as farmers still cultivate maize and paddy, they have adopted new and improved varieties of maize and paddy tolerant to harsh climatic conditions. These varieties were reported to be better and appropriate for the farmers because not only they are tolerant to the current climatic conditions but also have a shorter cycle than the old local varieties. The varieties were not being cultivated by farmers in the village fifteen or twenty years ago but have been introduced in recent years as part of farmers' adaptation to the climatic changes and variability.

The second change for Manga Mikocheni village was adoption of crops such as watermelon and *lablab*, which farmers clearly reported that they were not being cultivated in the village in the long past. If observed closely, there is uniqueness in the changes for this village. This is something different from Mkundi where the concentration is on *lablab*. Manga Mikocheni has adopted new varieties of their common crops (maize and paddy) and at the same time, they have also adopted new crops (watermelon and *lablab*). This village seems to have diversified crops widening the ability to adapt using various crops and crop varieties.

Mtae village, which is located in West Usambara Mountains, shares a similar change to Kambeni because they abandoned coffee cultivation and are now concentrating in cultivation of shorter cycle crops and crop varieties. The most common crops cultivated are Irish potatoes, improved maize varieties, roscoco and soya instead of kamba beans and vegetables such as cabbages, onions and tomatoes. Farmers reported that they now cultivate *kidinya* potatoes variety instead of the old one called *mzohotwe*. The new variety is regarded as higher yielding and of much shorter cycle. Their concentration on shorter cycle crops and crop varieties that have good markets after abandoning coffee is a good form of adaptation. For they are able to cultivate and produce several times a year through small-scale irrigation using tap water, which they have access to, different from their neighbors downstream in Mkundi village.

If one locates the villages and makes a comparison of how far apart a village is from the others, the distance does not exceed 30 kilometres from one village to the other and in most cases, it is even less than that. But due to various factors (to be discussed), each village adopted particular crop(s) supporting livelihoods. This is unique because much as the micro-climate may slightly differ, they fall within the same broader climatic and ecological conditions. For example, Mtae and Kambeni have almost similar conditions because they are found on mountains over 1500 MASL. They are both on the windward sides but when it comes to changes in the farming practices or identifying appropriate crop(s), data showed that each had a specific preference.

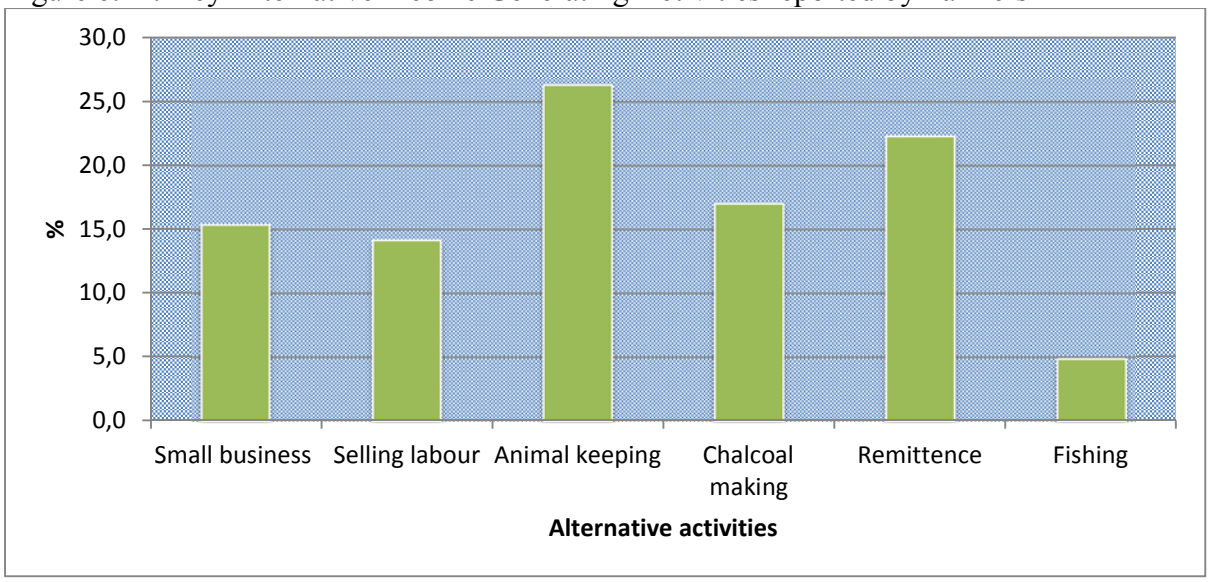
The second unique characteristic feature is that the changes are dominated mainly by five crops and some varieties within those crops. The main crops dominating almost in all the changes that farmers had been making are ginger, *Dolichos lablab*, paddy (some improved varieties), vegetables and Irish potatoes. In a broad study conducted continent-wide in Africa, Maddison (2006) found that across Africa, planting of different crop varieties was considered one of the common type of adaptation. However, some of the practices were country-specific like shorter cycle varieties were found to be much relevant in Senegal, while in other counties, it was not the case. In this study, however, the adaptation strategies were not as localized as in Mkomazi Sub-catchment where the villages are just nearby but each village has opted for a specific crop of preference and mostly five crops stand out to be the most preferred by farmers in this small area.

It is interesting also to note that overall, 51.9 percent respondents engage in activities aimed at diversifying household income sources in all villages. However, it varied so much when one looks at the village level because in Kambeni village, 84.4 percent of the respondents were engaging themselves in different alternative income generating activities, while in Manga they accounted for 73.5 percent respondents, Mkundi, 53.2 percent and Mtae, 43.8 percent. It implies that much as smallholder farmers have been changing farming practices as part of their adaptation, they are also aware of the difficulties they are to face if they entirely depend on crop production alone. Hence, diversification is a good sign that farmers are not only aware but also they are taking actions to make sure that they are safe when it comes to addressing the

challenges of climate change. In view of that, six alternative income generating activities were identified by farmers that help them to diversify household income sources in order to cover gaps in terms of household incomes particularly during hard times. These activities and their percentage contribution in brackets are animal keeping (26.3%); remittance (22.3%); charcoal making and selling (17%); small business (15.4%); selling labour (14.2%); and fishing (4.9%). Figure 6.11 provides illustration.

In a study conducted in China by Hegeback and colleagues (2005), farmers' perceptions were found to concur with climate records in terms of changes in the climate. As part of adaptation to the changes in the local climate, farmers showed to have concentrated on more tolerant crops and varieties as well as diversifying their household income sources and reducing dependence on farm activities thereby making them less vulnerable to the changes and variability in the climate. The key crops that were found to have been farmers' preference included millet, sorghum, soy bean and potatoes. These results indicate a similar pattern of response in terms of both changes in the farming practices as well as diversification of household income sources but differences are observed between the two studies in the area of the crops. In Mkomazi, more drought tolerant crops like millet and sorghum were not found to be cultivated at all but mostly the tolerant varieties of common crops except in Mkundi where there was introduction of lablab beans.

Figure 6.11: Key Alternative Income Generating Activities reported by Farmers



While animal keeping remained within agriculture (animal husbandry), it is the alternative economic activity (beyond crop production), which was found to be common in almost all villages. In Mkundi village, 14.5 percent of all farmers reported to have been diversifying income sources by keeping animals. For Manga Mikocheni village, 35.4 percent of the smallholder farmers were also engaging themselves in animal keeping. The case was the same in Kambeni and Mtae villages in which 28.6 percent and 32 percent of the farmers, respectively, were engaging themselves in animal keeping with the aim of offsetting the income gap that may be due to poor production from the farms. Much as smallholder farmers maintain that the local climate has and continues to change, animal keeping (part of agricultural production) was found to be the main alternative form of income generation. The animals commonly found to be kept were such as goats, sheep and rabbit. In addition to such animals, farmers also mentioned different types of birds such as chicken, guinea fowl, regions and duck as examples of their alternative income sources.

Out-migration especially among the youths was mostly reported during interviews and FGDs as another means for diversifying household income sources. It was reported to increase during hard times or bad years when there were poor harvests. The study by Afifi and colleagues (2014) on interrelation between rainfall variability, food insecurity and human mobility makes a case on the issue of out-migration in response to changes and variability of the local climate, which lead to poor harvests and hence, food shortage. In their study, which was conducted in Same District, they found a positive relationship between rainfall shortage and out-migration. They also found that the effects, which motivated out-migration, were mostly food insecurity for humans and livestock.

The findings from the current study indicated that the youths out-migrate to nearby urban centres such as Moshi, Arusha and Tanga to look for casual jobs so as to support their parents and relatives back home. The young men and women constitute a good source of income in form of remittances to the villages. Remittance was found to be an important source of income for the smallholder farmers in the study area. While the overall of the respondents depending on remittance accounted for 22.3 percent, data clearly showed that respondents in Mtae village identified this source of income by 46 percent as an alternative income source they depend on, being the highest of all four villages followed by Manga Mikocheni (26.2%). Kambeni village, on the other hand, reported this by 22.4 percent. Mkundi village had the least percentage (only 4.8%). However, these results may also signify that some villages had good efforts in providing education to their children than others within the sub-catchment, which then provides them job opportunities and finally, being able to support their parents and relatives back home. When enquiring about the role of remittance during the interviews, many of the interviewees, particularly the elders, identified it as a major source of income for their survival. Most of the money was accrued from their sons and daughters, who were compelled to out-migrate or got some jobs after schooling and formal training. They support their parents and relatives by regularly sending money back home. A similar case was found in Kambeni and Manga Mikocheni villages. Mkundi village seemed to be different because there were few cases reported on this source of income. Generally, the role of remittance in supporting farmers cannot be overemphasized. Several farmers, for example, particularly in Mtae village reported that without remittance, their survival would have been at risk.

There was another form of migration, which was temporary and mostly found to be practiced in Mkundi village where smallholder farmers reported to be temporarily out-migrating to nearby villages so as to find some jobs in other people's farms for cash. This form of alternative income generation source had an overall of only 14.2 percent of respondents and only reported in Mkundi (31.3%) and Manga Mikocheni (13.8%) villages both of which are located in the lowlands. This might be an indicator of the disparity in terms of income between villages in the highlands (which have good access to water for irrigation) and those in the lowlands (whose access to water depend mostly on whether or not farmers in the highlands have water in excess to allow it to flow downstream).

A particular section of the farmers engage in small businesses mostly selling of consumables such as sugar, maize flour, kerosene, match boxes, soap and so forth. With an overall of 15.4 percent, it was found to be very common in Kambeni (49%) and Mtae (22%) villages. This was not reported in Manga Mikocheni while in Mkundi it was only 3.6 percent. The situation reflects income levels among farmers between those in the highlands and their counterparts in the lowlands. Opportunities to cultivate ginger in Kambeni and potatoes as well as vegetables, all of which have good markets, helps some farmers in the highlands to accumulate small capital to establish such small businesses. Production and selling of ginger in Kambeni was

reported by farmers during interviews to have enabled them get small capital to engage in small businesses, which, in turn, helped them to cover incomes gaps unlike farmers in Mkundi who have to mostly depend on Lablab and when there is poor harvest, they have to sell their labour or make and sell charcoal.

Fishing in Lake Manga was also identified to be one other alternative income source for the farmers in Manga Mikocheni village, mostly helping them to get protein and some little cash. It was found to be very limited and mostly depends on seasons and water availability in the lake. With such limitations, its sustainability as an income source was found to be unguaranteed and minimal.

Despite being unsustainable and environmentally destructive, charcoal making and selling were found to be dependable sources of income and an alternative to crop failure particularly in Mkundi village where 45.8 percent of the farmers reported to be taking part in the activities using the small forests in their vicinity. In Manga Mikocheni, this was just as small as 6.2 percent, while there were no cases of farmers in Kambeni and Mtae villages engaging themselves in this activity. Unlike Mtae and Kambeni, Mkundi and Manga Mikocheni villages are located in the lowlands. These are villages, which, according to the villages and district authorities, have been receiving food aid for the past few years. This shows that charcoal is a dependable alternative livelihood source not just because of quest for more income but survival. Their continued poor harvests from the farms in some years as a result of recurrent rain failure is a reason they have continually being receiving food aid and might be the best explanation they engage themselves so much in charcoal business unlike in other villages.

Charcoal making and selling is a good business generating billions of money not only in Tanzania but also all over Sub-Saharan Africa. In a review article, Mwampamba and colleagues (2013) argue that charcoal business, particularly in Africa South of the Sahara, forms a significant source of livelihoods, income and employment. The World Bank (2009), for example, estimated that the charcoal sector for Dar-es-Salaam (Tanzania) provides labour and cash income in rural and urban areas to several hundred thousand people. Examining livelihood responses to climate variability and other stressors in Morogoro region in South-eastern Tanzania, Paavola (2004) found that there are different responses farmers who use to cope with variability and changes in the climate. Some of these were related to reduction in dependence from agricultural production. The author added that many households take advantage of abundance of natural resources in their vicinities to tap them in order to not only cater for their subsistence needs but also earn cash income Paavola (2008). An example was given of the forests, which provide timber, firewood, fruits, spices, traditional medicines as well as meat (through illegal hunting); and charcoal for local as well as remote markets and the fuel. In another study in Mali, de Bruijn and van Dijk (1994) examined how drought drives farmers to use different forms of diversification with focus on gender and ethnicity. The authors found that each of the ethnic groups reacted differently but the common forms of diversifications were migration for laboring, petty trading, weaving, hair plaiting, gathering bush products, and small scale trading.

Having in place many income generating activities off the farm may increase flexibility and enhance resilience to expected or potential shocks (Fankhauser, *et. al*., 1999) but the use of natural forest for charcoal making is not a promising alternative due to its unsustainability nature. This is because harvesting does not consider any replacement of the trees. In addition, it is possible that the rate of harvesting is high hence outpacing regeneration of the harvested trees. This threatens to undermine sustainability of the forests. Thus, as an immediate copying

strategy, charcoal making has serious consequences both on the environment and livelihoods of the farmers and other resource users (Chakravarty et al., 2012). Forests are sources of treasured ecosystem goods and services. Also forests serve as habitat for a wide variety of flora and fauna. In addition, in the context of global efforts to address climate change, forests are a good standing stock of global carbon (FAO, 2005). Therefore, deforestation not only endangers access to ecosystem goods and services but also contributes to long-term changes in the climate thereby creating a cycle of course and effects relationship (Chakravarty et al., 2012). While some may blame farmers in Mkundi and other charcoal users countrywide and beyond, it is important to assess the whole charcoal production and market chain to understand the situation. In addition, both producers and consumers need to be provided with sustainable alternative income generating options as well as affordable and reliable alternative energy sources in order to save the forests.

Many changes do not match to only one but more needs in almost all villages. Changes made the farming practices reflect the fact that they are not done to cater for only one purpose but multiple purposes. For example, lablab, ginger, improved paddy varieties, vegetables, Irish potatoes and cassava are crops that have been involved in almost all key changes farmers have made in the farming practices. For the higher crop yields, lablab, ginger and paddy represent 87.6 percent of all the responses from farmers (39.2%, 27.8% and 20.6%, respectively). Of all the identified shorter cycle crops, maize, vegetables, paddy and lablab represent 62.3 percent of the crops involved in this type of change. For the drought tolerant crops/varieties, cassava, lablab, maize and paddy represent 93 percent. Likewise, on crops that have good market prices, ginger, Irish potatoes, lablab and paddy represent 91.2 percent of all the crops farmers identified to have adopted.

Smallholder farmers in Mkomazi are part and parcel of the Tanzanian and global economy and their farming activities are meant to sustain their livelihoods and supporting Tanzanian economy as well. The farmers, just to reiterate, have accumulated long-term knowledge, experiences and traditions, which together with the socio-economic and environmental dynamics have enabled them to struggle for their survival. Thus, changes in the farming practices must have been part and parcel of their day-to-day struggle to cope with the social, economic, environmental as well as other changes in Tanzania and in Mkomazi, in particular.

All these changes in the villages may imply that farmers are aware of what is facing them and hence, they have been able to apply various adaptation measures to ensure that they accommodate themselves within the changes in the local climate they experience. Much as they might still not be getting it right because during some of the years they experience crop failure and are compelled to ask for food aid (reference is being made to Mkundi and Manga Mikocheni villages), the fact that they have been making these changes signifies that with some support, they can produce enough to feed themselves within the context of the changing climate and variability.

6.5 Summary

This chapter presents and discusses key changes that farmers have been making in their farming practices. Using three data collection sources, namely, questionnaire, FGD and interviews, key changes that were generally found to have been made by the farmers in their farming practices are shifting concentration to shorter cycle crops and crop varieties such as lablab commonly cultivated in Mkundi and Manga Mikocheni villages. Others are stop cultivation of crops such as coffee, and some crop varieties such as the traditional maize and paddy varieties; and

concentrate more on crops and varieties that have good markets mostly ginger, lablab, rice, vegetables and potatoes. Other changes were diversifying household income sources, found to be very common in all villages but with different economic activities and with different levels of concentration for each and every village. Some of the common alternatives were animal keeping, charcoal making, remittance, small businesses and fishing. Farmers also introduced new crops and crop varieties not cultivated in their villages before. The most common crops and crop varieties introduced are ginger in Kambeni, which replaced coffee as a cash crop; lablab being very common in the dry parts of Mkundi and, to a lesser extent, in Manga Mikocheni; improved paddy in Manga Mikocheni and similar improved maize varieties in Manga Mikocheni, Mtae and Kambeni; and water melon, which are cultivated in Manga Mikocheni. The other changes found to have been made relate to concentration of farmers on crops and crop varieties with ability to tolerate dry conditions and diseases. Most of these are lablab, cassava and the improved paddy as well as maize varieties.

The results provide evidence that while changes are common in almost all villages; the level of concentration of smallholder farmers in each of the villages differs. Shorter cycle crops and crop varieties were found concentrated much in Manga and Mtae, while in Mkundi, it was mainly one dominant crop commonly cultivated but with few other crops but not commonly cultivated. In Kambeni village, concentration was on ginger which is a longer cycle and water consuming crop. In addition, there was cultivation of shorter cycle maize varieties but less dominant as compared to ginger. However, farmers complain that water flow is diminishing. In addition, there are increasing concerns and outcry by farmers in the lowlands that their counterparts in the highlands are consuming much water hence denying them access to this important resource while compromising some ecological functions. This means that ginger farmers may be compelled to adopt other less water consuming crops or ginger varieties. Abandoning cultivation of some crops and crop varieties seemed to be equally found in all villages with the leading crops being coffee, traditional paddy and maize varieties and cotton. In the lowlands, particularly Manga Mikocheni village, traditional paddy and maize varieties have been replaced by highly improved varieties, which are shorter cycle, tolerant to harsh conditions and diseases and are higher yielding varieties as well. In all four villages, crops and crop varieties with good markets attract attention of the farmers too. A similar case is on diversification of household income sources whereby in each of the villages, smallholder farmers do not only depend on crop production but also engage in other activities to obtain income. Intensification of irrigation was mainly found in Kambeni and Manga due to water availability. New crops and crop varieties are also found in all villages but mostly common in Manga Mikocheni, Mtae and Kambeni.

In terms of types of crops and crop varieties, similar variations were evident. In Kambeni village, concentration was on ginger which is the main cash crop for this and other surrounding villages. Other crops such as improved maize varieties and cassava are grown as well. For Manga Mikocheni village, farmers concentrate more on improved paddy and maize varieties because they are shorter cycle, tolerant to dry conditions and have the ability to produce higher yields. Mtae village is more concentrated on shorter cycle crops and varieties such as Irish potatoes, vegetables, maize as well as beans. Mkundi village case is somehow different because due to poor climatic conditions and lack of access to water for irrigation, they concentrate more on lablab, which is drought tolerant, shorter cycle, higher yielding and has good market. Diversification of income sources also varied in terms of specific activities for each of the villages, depending on available options as well as other factors such as access to such options. Mkundi village mostly depends on charcoal making, selling labour and small scale animal keeping. Mtae village mostly depends on remittance, animal keeping and, to a lesser extent,

small businesses. In Kambeni village, their common alternative income sources are small businesses, animal keeping and remittance. In Manga Mikocheni village, the farmers depend on animal keeping, remittance, small scale fishing and, to a lesser extent, selling labour. The next chapter presents data and discussion of key factors that influenced changes in the farming practices in Mkomazi.

CHAPTER SEVEN: FACTORS MOTIVATING CHANGES IN THE FARMING PRACTICES

7.1 Introduction

This chapter presents identified factors responsible for motivating smallholder farmers to make decisions of changing their farming practices over time in Mkomazi sub-catchment. Like in the two previous chapters, the data are both quantitative and qualitative. Results from the questionnaire are presented showing a general overview of the factors reported to have motivated smallholder farmers to change farming practices. Apart from the quantitative results, qualitative data are also captured. In addition, a detailed look into variations of views at each and every village is also made before going into the interview and FGDs data. The chapter also provides details along the lines of each and every identified factor. Apart from the factors, sources and types of adaptation related information for the farmers are presented and discussed. As a way of maintaining good flow, the data on factors are presented and discussed separately with those on sources and types of adaptation related information. All these are captured in four sections contained in this chapter, namely, introduction, data presentation and discussion (factors), data presentation and discussion (adaptation related information needs and sources) and summary.

7.2 Data Presentation: Factors Motivating Changes

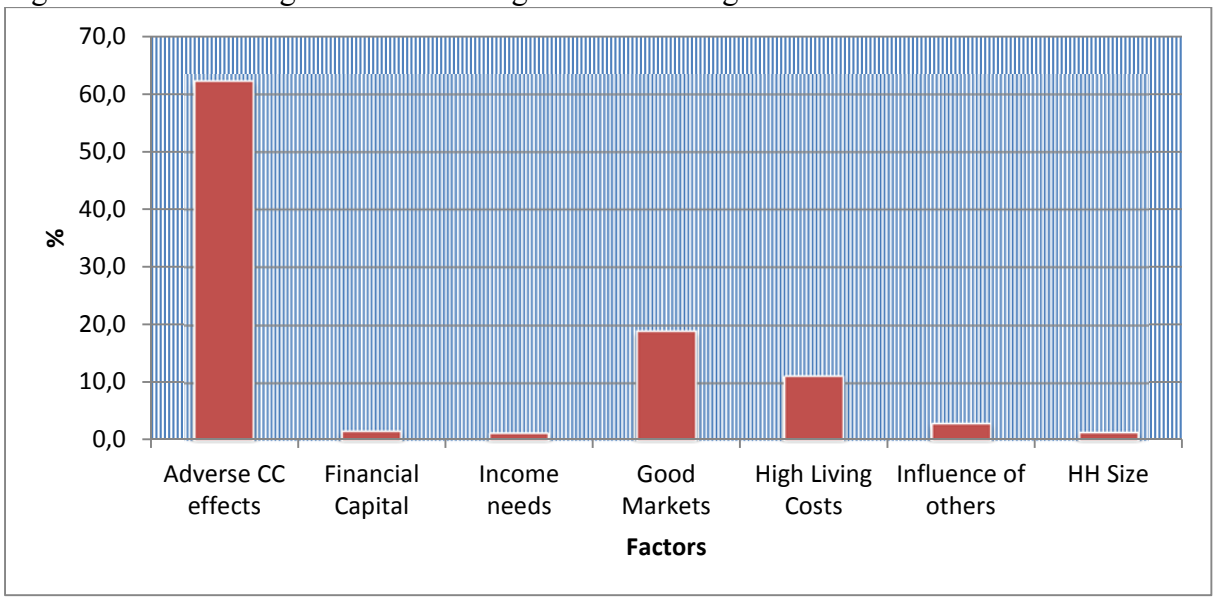
7.2.1 An Overview

Results from the questionnaire showed that three main factors strongly played a role in motivating farmers to change their farming practices. The factors include the following: negative effects climate change mainly recurrent and intensive dry spells; market forces; and high living costs together with demands for personal as well as family needs. This is because 92.6 percent of all 189 respondents were found to believe that the three factors are motivating them to change their farming practices in all the four villages (Figure 7.1 illustrates the details). The remaining four factors, namely, financial capital, income needs, influence of others such as neighbors and household size accounted for only 7.4 percent, implying that their level of influence in motivating farmers to change farming practices was lower and insignificant. Figure 7.1 presents a summary of factors and their level of influence to farmers in changing farming practices.

Negative effects of climate change and variability was found to be the main factor, accounting for 62.4 percent of influence on farmers changing their farming practices. In almost all the changes in the farming practices that farmers have been making, negative effects of climate change appeared to be playing a central role in all villages. The mostly cited effects of changes in the local climate are decrease in the amount of rainfall in the seasons, late onset of rainfall in almost all seasons, rainfall becoming very short in terms of its cycle and rainfall having poor distribution per season, much as it may be adequate in terms of amount in some of the seasons, but not well distributed to allow farmers to get good harvests. In addition to negative effects of climate change, 19 percent of all respondents reported to believe that they made decisions at different times to change their farming practices in response to market forces. The role of the market was found to be influential in three key changes, namely, shift to higher yielding crops and crop varieties, shift to crops that command good market prices and introduce new crops and crop varieties. Influence of high living costs and demands for personal and family needs was mostly found to be higher in shift to higher yielding crops and crop varieties, introduce

new crops and crop varieties as well as shift to shorter cycle crops and crop varieties. Overall, however, this accounted for 11.2 percent. The findings also indicated that other people (word of mouth) influenced some farmers to change their farming practices because 3 percent of the farmers reported to have changed their farming practices in response to influence of neighbors, friends, relatives and so on. Examples of the changes given in this category are: introduce new crops and crop varieties as well as shift to higher yielding crops and crop varieties. The other factors and their contribution to the total percentage were financial capital (1.7%), income needs (1.3%) and household size (1.5%).

Figure 7.1: Motivating Factors for change in the Farming Practices



7.2.2 Village perspective

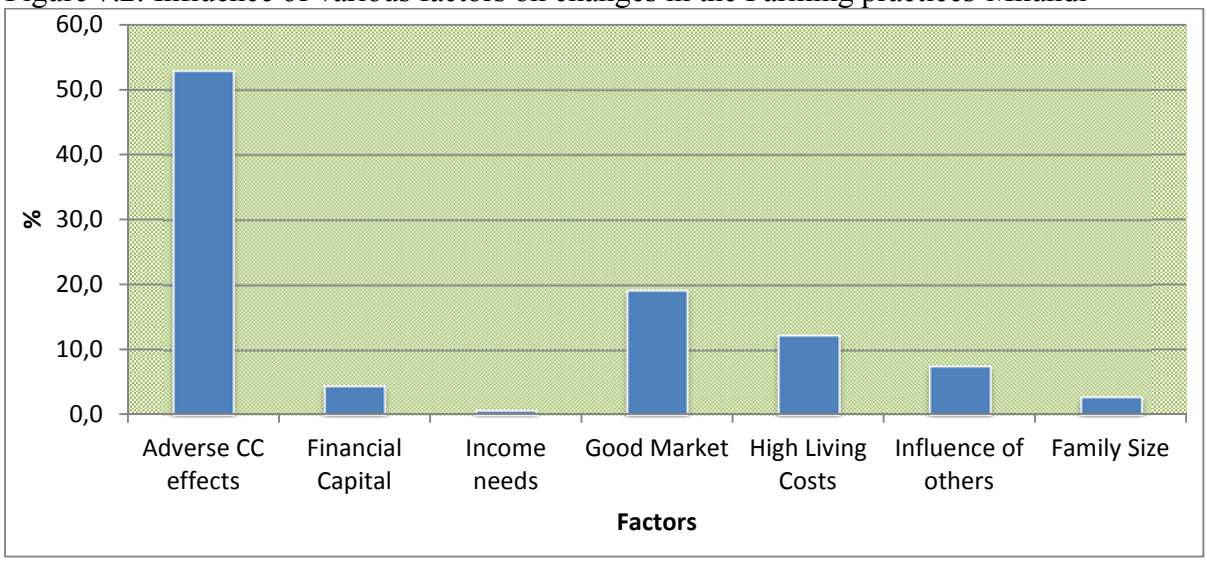
In looking at the village level, the data clearly demonstrate the key role the three main factors played in motivating farmers to change their farming practices. However, the details depict small variations in terms of levels of influence from one village to another.

Mkundi village

In this village, as in the general summary of the data presented and illustrated in Figure 7.1, the perceived changes in the local climate expressed by farmers seemed to have played a key role in influencing changes in the farming practices in the village. The effects of climate change stood at 53 percent followed by the role of the markets with 19.1 percent, high living costs and demands for personal and family needs with 12.3 percent and influence of other people including neighbors accounting for 7.6 percent. Influence of other people in the changes in farming practices in Mkundi was higher than in all other villages combined. Thus, it indicated that much as it was well below 10 percent, it played a good role in influencing changes in this village. As it was noted in the interview, influence of other people was part of factors that motivated spread of Lablab in this village. In addition, this might also have some meaning when it comes to social cohesion. The Size of the village can also explain why this factor is relatively high in Mkundi compared to all other villages combined. Unlike Mtae and Kambeni for example, Mkundi is a small village with only 348 households and 1753 inhabitants. Thus, close interactions among individuals and households might possibly be easy in this regard. In addition to those four factors, financial capital (4.5%) and household size (2.8%) were also higher in Mkundi than in any other villages. Figure 7.2 is an illustration of the details. What

can be comprehended from this figure is that influence of the effects of perceived changes in the local climate was strongly stressed but the role of good markets was strongly highlighted as a factor having motivated some of the changes in the farming practices in the village. Besides, respondents also supported the contribution of high living costs and demands for personal as well as household needs and influence of other people even though at a level well below that of changes in the local climate.

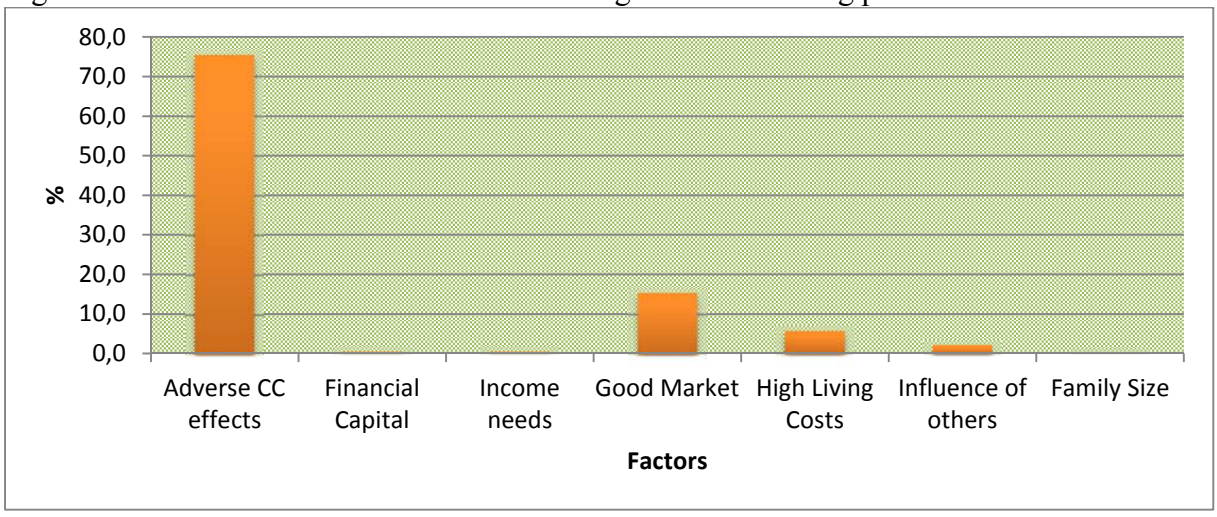
Figure 7.2: Influence of various factors on changes in the Farming practices-Mkundi



Mtae village

In this village, the role of negative effects of climate change to the changes in farming practices was higher than in all three other villages with 75.4 percent. The role of markets was found to be 15.4 percent, while that of high living costs and demands for personal and family needs accounted for 5.7 percent. Like in other villages, financial capital and income needs did not seem to have greater influence on the changes as far as smallholder farmers were concerned (each one representing 0.6% only). However, influence of other people including neighbors was 2.3 percent in this village, being second to that of Mkundi village. These details are illustrated in Figure 7.3.

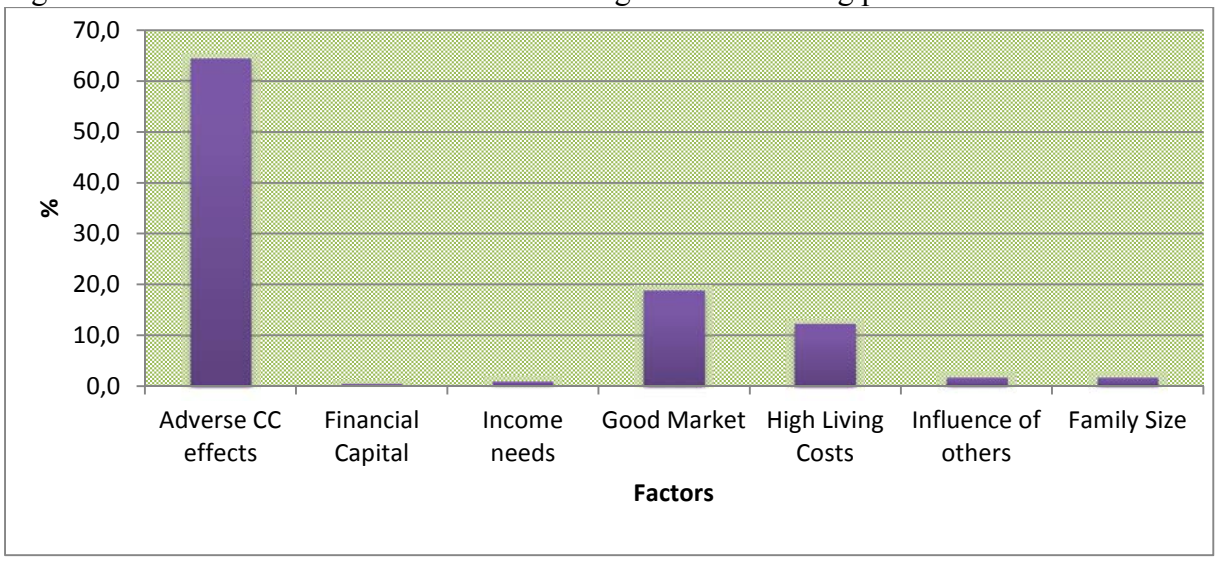
Figure 7.3: Influence of various factors on changes in the Farming practices-Mtae



Kambeni village

In addition to the adverse effects of climate change, which had 64.4 percent, Kambeni, similar to Mkundi village, showed good influence of markets to the changes in the farming practices with 18.8 percent. The other factors, whose influence was remarkable, encompassed high living costs and demands for personal and family needs, accounting for 12.2 percent of the total and made it the third in terms of the factors influencing changes in farming practices in Kambeni village. The remaining four factors were found to have no significant influence as illustrated in Figure 7.4.

Figure 7.4: Influence of various factors on changes in the Farming practices-Kambeni



As per respondents, influence of adverse effects of climate change and variability on the changes in the farming practices was higher in villages located in the highlands (Kambeni and Mtae) than those in the lowlands (Mkundi and Manga Mikocheni). However, it was understood from the interviews and the rainfall data that rainfall the area is much influenced by elevation. Hence, villages located in the highlands receive higher rainfall (over 1000mm per annum) than those in the lowlands. In this regard, one would expect that respondents from villages in the lowlands could rank adverse effects of climate change and variability high compared to those in the highlands. But the results are contrary. The ranking of adverse effects of climate change and variability as a factor influencing changes in the farming practices was slightly higher in Mtae (75.4%) and in Kambeni (64.4%) and somehow lower in Manga Mikocheni (59.2%) and Mkundi (53%) villages. This paradox might have been caused due to the fact that the two villages in the highlands are used to receiving higher rainfall as compared to their counterparts in the lowlands. Manga Mikocheni and Mkundi villages have semi-arid climatic conditions and normally, they received moderate rainfall (between 500-800mm per annum). Therefore, for those who are used to higher rainfall, any change even if it is smaller, can be taken seriously as a significant change. Hence, the results might be a reflection of this situation.

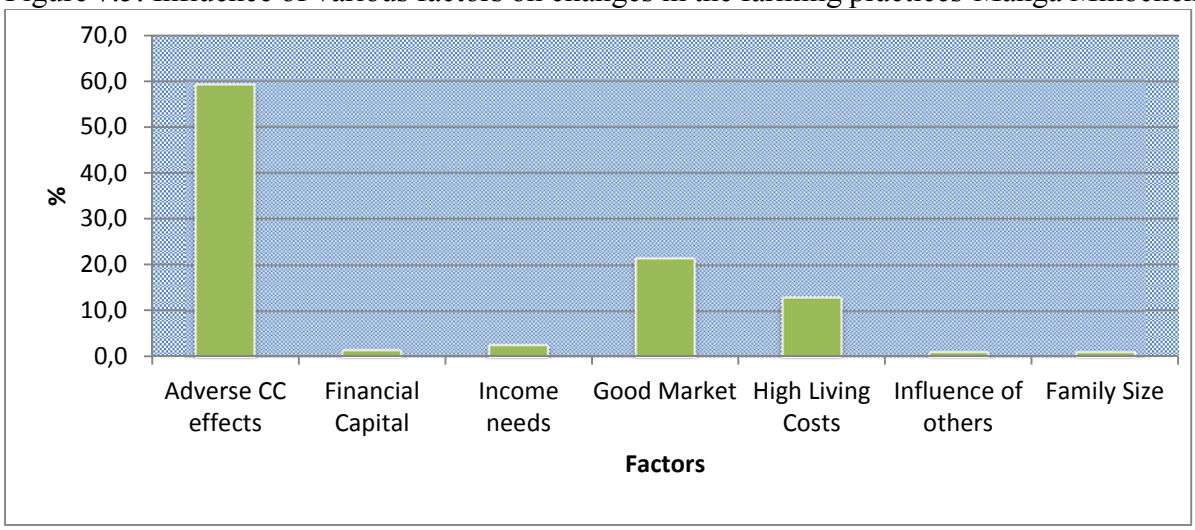
In addition, the variety of factors that were identified from all sources as having influenced changes in the farming practices might also be confusing farmers as to which one started, which one followed or which one is stronger than the other. For example, in Kambeni village, the farmers clearly indicated during the interviews that the change from coffee to ginger was motivated by interplay of the perceived changes in the local climate particularly decreasing amount and unpredictability of rainfall, high recurrence and severity of coffee diseases and hence, overburdening the farmers in terms of pesticides and herbicides as well as the poor

markets of coffee in those years. Thus, the said factors motivated them to change slowly from coffee to ginger. In this context, it is difficult for the farmers to disaggregate the factor they should take as a primary one in having influenced them to change but might be captivated by the perception that climate change and variability had a high influence. This means that it is difficult for them to be sure as to the kind of factor that influenced the changes more than the other and hence, confusion is possible.

Manga Mikocheni village

The location of this village makes it experience advantages and disadvantages in terms of access to water for agricultural activities. Overlooking the seasonal Saseni stream (part of Mkomazi River), which feeds Lake Manga and down Lake Karamba, the village can benefit from water, which flows especially in good seasons when there is enough water and Kalimawe Dam is opened for its release. This is an advantage because villages like Mkundi have no such access. However, during bad seasons water diminishes upstream. In such cases, Manga Mikocheni village suffers most because such water access is cutoff as a result of consumption upstream. This means that during such times, no water flows and since Kalimawe dam becomes short of water, there is no release and hence, Manga Mikocheni is dry and no water for irrigation. This is unlike Kambeni village, which has direct access to water just by being upstream where Yongoma stream passes, feeding Ndungu Irrigation Scheme and Kalimawe Dam. It is from this context that 59.2 percent of the smallholder farmers identified changes in the local climate as the leading factor behind their changes in the farming practices for the past 30 years in the village. They claimed that, year after year, they have been experiencing poor rainfall and the flow of water in the river has also been diminishing. While factors such as financial capital (1.5%), influence of other people such as the neighbors and household size (1.1% each) showed insignificant contribution to the changes in the farming practices in the village, the role of the markets (21.5%), high living costs and demands for personal and family needs (13%) and income needs (2.6%) were the highest in this village compared to the three other villages. This indicated that much as climate change was identified as an important factor, these three also, considered collectively (form 37%), they play a great role in influencing changes in the farming practices in the village. Figure 7.5 illustrates.

Figure 7.5: Influence of various factors on changes in the farming practices-Manga Mikocheni



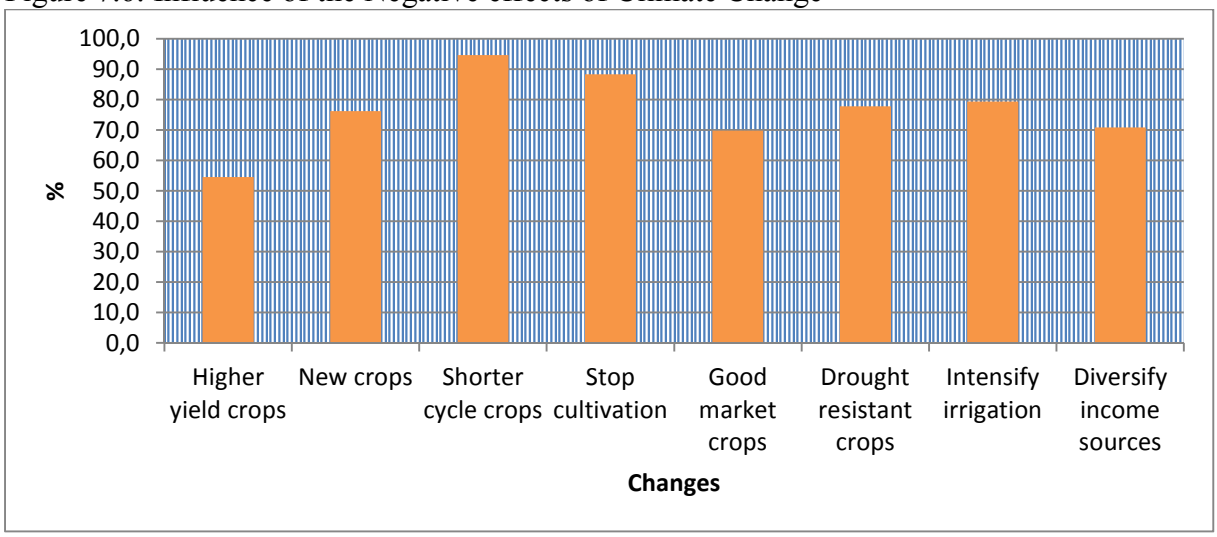
7.2.3 The Role of Each Factor

In order to paint a broader picture of influence of factors in prompting decisions by smallholder farmers to decide to change their reported farming practices, it is important to clearly display the role of each of the seven factors that were analyzed and show the level of influence of each of those factors against the changes identified. This Section provides detailed explanation of the level of influence each factor had in the changes reported by smallholder farmers using percentages of score and graphical illustrations.

Negative Climate Change Effects

This is one among the factors identified by the respondents as having influenced them to decide to change their farming practices in the area. The most important variable attributed to the influence of climate change in farming practices was rainfall. After cross-tabulating factors against changes in the farming practices it was found that influence of negative effects of climate change and variability was as follows: 94.7 percent on shift to shorter cycle crops/varieties; 84.4 percent on stopping cultivation of some crops/varieties; 79.9 percent on intensification of irrigation in three villages, namely, Kambeni, Manga Mikocheni and Mtae; 77.8 percent on introduction of crops/varieties believed to be tolerant to harsh conditions including dry conditions; and 76.2 percent on introduction of new crops/varieties. Other changes influenced by negative effects of climate change were diversification of household income sources (70.9%) and the farmers shift to cultivation of higher yield crops/varieties with a score of 54.5 percent. In general, as it was categorically illustrated in Figure 7.1, negative effects of climate change had an overall of 62.2 percent when compared to all other six factors. The details are illustrated in Figure 7.6.

Figure 7.6: Influence of the Negative effects of Climate Change



Influence of change in the local climate was found to be behind all changes in the farming practices in the area although at different level of influence both in each of the changes as well as at village level. However, its contribution to the changes was well above 50 percent in each of the changes. Its influence, in the order of level of percentage, was shift to shorter cycle crops and crop varieties; stop cultivation of some crops and crop varieties; intensify irrigation; shift to drought tolerant crops and crop varieties; introduce new crops and crop varieties; diversify household income sources; concentration of farmers to good market crops and crop varieties; and shift to higher yield crops and crop varieties.

Through interviews and FGD, the role of negative effects of climate change in motivating changes in the farming practices in the area also surfaced clearly and strongly. In most of the interviews conducted, climate change and variability was strongly echoed with some examples related to the local context particularly on rainfall and temperature. Identification of this factor was made in all the interviews and FGDs regardless of who participated, farmers, elders, local leaders, experts and district authorities. The Pangani Water Basin Board had this to say as to the factors:

> *"Mostly due to changes in the local climatic conditions, for instance, shorter cycle crops give them (farmers) a possibility of harvesting even with little water they get. Cultivation of lablab is also driven by changes in the climatic conditions because farmers cannot produce other crops due to limited and unreliable rainfall. As for the shift into the river valley, it is the same climatic conditions because the other areas have no water and so they concentrate in the valley for irrigation."* (Official, PBWB).

In Kambeni village, a similar concern arose that changes in the local climate, among others, had an influence on changes in the farming practices farmers had been undertaking. This is justified by the Ward Extension expert in explaining about the changes from coffee to ginger as he said:

> *"I think there are two main factors: …..The second factor was that by then the climate was changing, leading to recurrent shortage in rainfall and farmers were experiencing a boom of pests and coffee diseases. So it became very expensive to manage a coffee farm because the farmer was supposed to expend much on pesticides and insecticides at the same time the coffee market price was going down. That is why ginger was found to be a better alternative and economically appropriate for the farmers."* (Expert, Kambeni Ward).

On the same, the village chairman for Kambeni made the following remarks:

> *"As I have just said, the climate was also changing and because coffee was being grown in the slopes, it was difficult to irrigate. So the combination of climate factors and market factors led to the changes from coffee into ginger."* (Leader, Kembeni Village).

In Mkundi village, adoption of lablab cultivation was also associated with the changes in the local climate particularly recurrent dry conditions, leading to farmers' inability to produce common crops they used to such as maize, sweet potatoes and the like. This is what farmers reported during interviews and FGDs. In the following quote, for example, the Chairman of the village elaborated why they decided to change and adopt lablab:

> *"I think changes in climatic conditions were the driving force because people were cultivating maize but getting poor harvests. Climatic conditions did not favour cultivation of other crops. So they needed something different to replace the failing maize. Lablab is tolerant to drought even if you get just one rain, you will have something to harvest. So we now rely mostly on lablab for those reasons."* (Leader, Mkundi village).

For the Manga Mikocheni village farmers, introduction of new paddy and maize varieties as well as new crops like watermelon, tomatoes and other vegetables is considered an option due to changes in the local climate mainly recurrence of dry conditions.

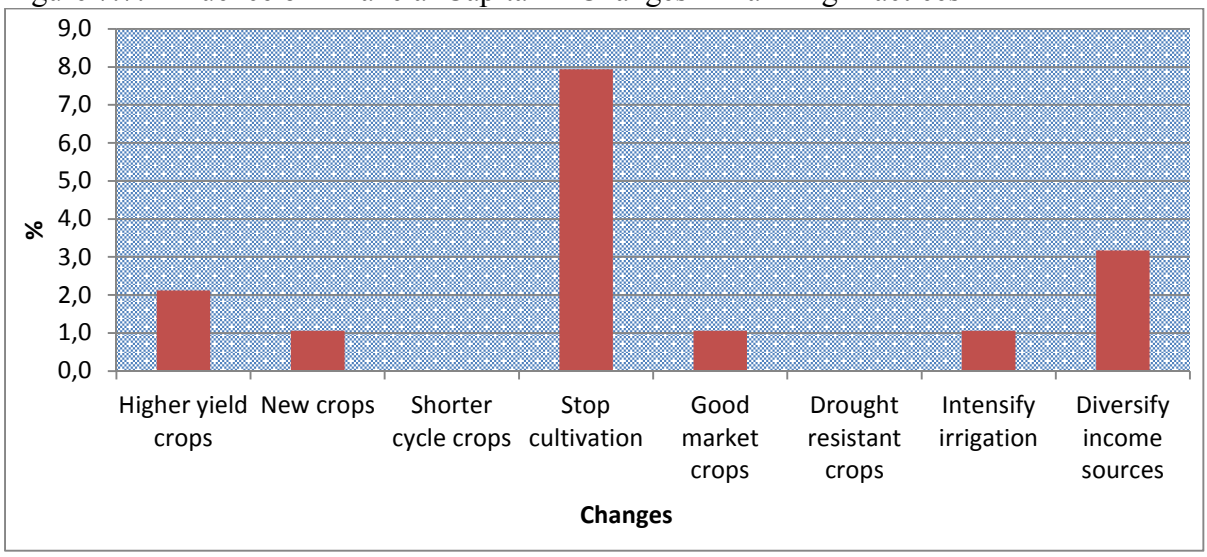
> *"We have been told that the new varieties are better especially because we are now experiencing recurrent dry conditions. Therefore, even if we do not get enough water,*

with these varieties we can still harvest. Watermelon, tomatoes and bell papers are shorter cycle crops and therefore, in a short time you harvest, you sell and buy little maize for the family. As for the lablab, it is very suitable to the dry conditions we experience. For instance, if it rains once in a season and you plant it, you will still harvest. So we like it because it is very tolerant." (Elder, Manga Mikocheni village).

Financial Capital

This is another factor anticipated to play a role in influencing changes in the farming practices in the area. However, as illustrated in Figure 7.7, after the analysis, it was found that the role of financial capital in motivating changes in the farming practices was almost negligible because it had an overall of only 1.7 percent. In terms of details, checking its influence on individual changes in the farming practices, 7.9 percent of the farmers reported that they stopped cultivation of some crops, mostly coffee due to problems with financial capital. In the other changes, the reported level of influence was very low: 3.2 percent on diversification of household income sources; 2.1 percent on farmers shifting to higher yielding crops/varieties; and 1.1 percent for each of the other changes namely: introduce new crops/varieties; shifts to crops/varieties with good markets; and intensify irrigation.

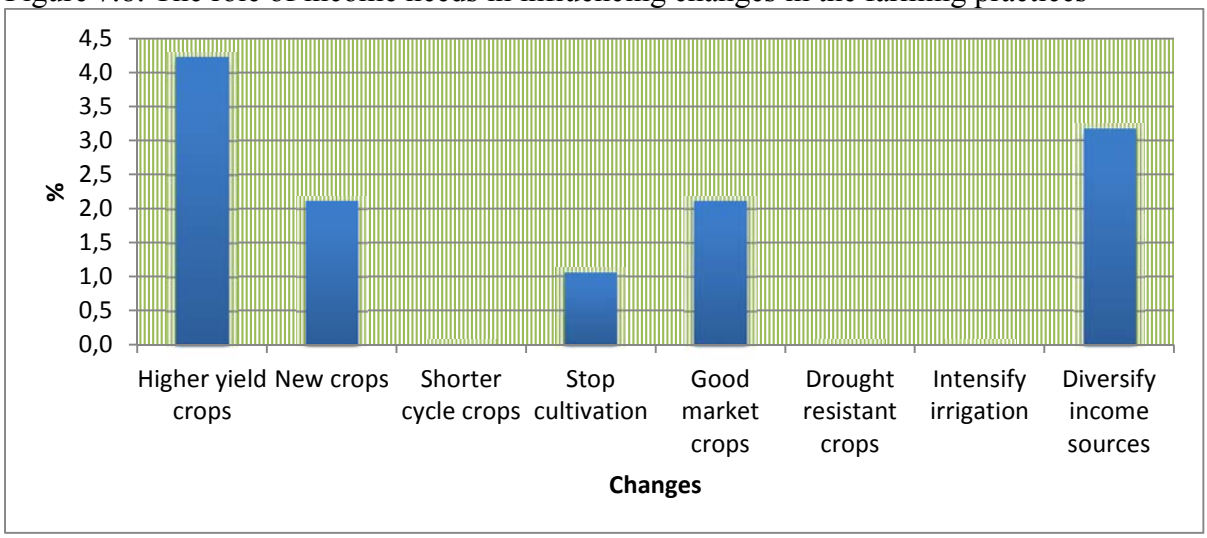
Figure 7.7: Influence of Financial Capital in Changes in Farming Practices



Income Needs

The need for more income was one other factor anticipated to probably have played a role in motivating farmers to change their farming practices in Mkomazi. Surprisingly, analysis indicated that income needs was an insignificant factor in motivating farmers to change their farming practice in Mkomazi. The strength of the role of climate change and variability might have obscured the role of income needs. This is because all along during interviews and FGD as well as questionnaire, the outcry of the farmers, leaders and experts was on changes and variability in the local climate. Its overall contribution among all seven factors in terms of percentage was only 1.3 percent. It is shown to have played a role in influencing farmers to shift to higher yielding crops/varieties at a level of only 4.2 percent; diversify household income sources by 3.2 percent; and introducing new crops/varieties by 2.1 percent. The rest of the details, which are clearly insignificant, are illustrated on Figure 7.8.

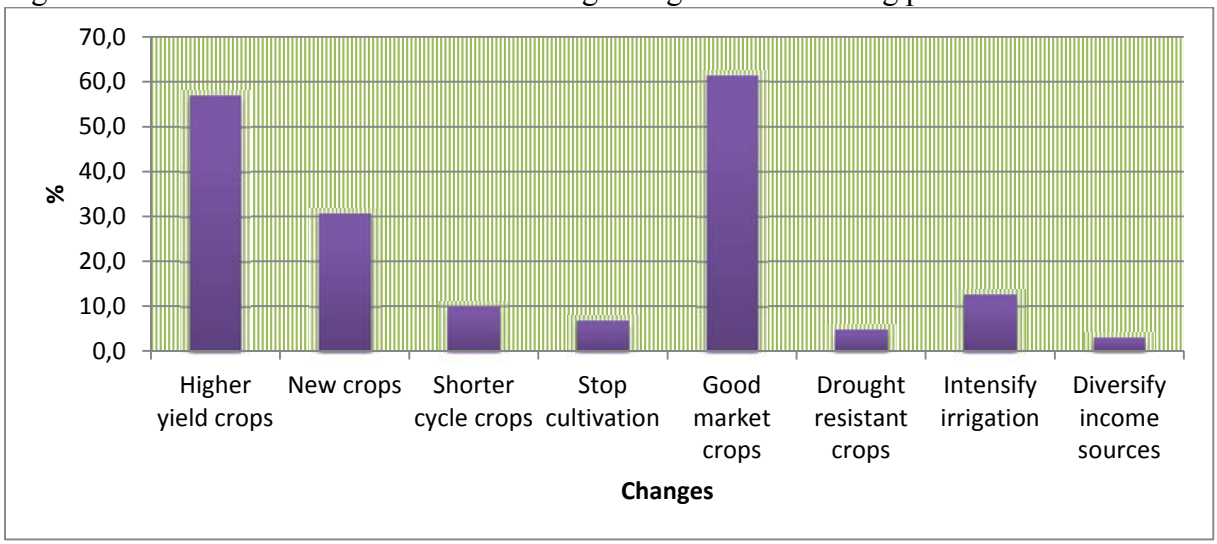
Figure 7.8: The role of income needs in influencing changes in the farming practices



The Role of Markets

In this research, the analysis of data revealed that markets played a very great role in motivating farmers to make decisions to change their farming practices. Overall, the factor was the second in terms of percentage score after negative effects of climate change with 19 percent. In terms of details (considering specific changes in the farming practices), its role was the most remarkable in motivating farmers to concentrate in crops and crop varieties with good market prices (at a level of 61.4%) particularly in Manga Mikocheni village. In this village, many reported to have concentrated on shorter cycle crop because of very good markets for such crops. In Kambeni, farmers' cultivation of ginger is influenced by availability of good markets. In addition, markets influenced farmers to shift their attention to crops and crop varieties with higher yields by 57.1 percent, with the same intention of benefiting from the available markets. In Mtae, for example, concentration of farmers in cultivation of vegetables and Irish potatoes was reported to be much influenced by availability of markets. Likewise, introduction of and concentration on watermelon, new paddy and maize varieties in Manga Mikocheni as well as on lablab in Mkundi villages was reported to have also been influenced by availability of good markets for those crops. All other details on the remaining changes are illustrated in Figure 7.9.

Figure 7.9: Influence of markets in motivating changes in the farming practices



Influence of the market was also very well-articulated in almost all interviews and FGDs in this research. Many farmers and experts as well as leaders viewed the role of the market as having been at per with influence of the changes in the local climate. Adoption of lablab in Mkundi village is so much supported by the availability of markets in the neighboring country of Kenya and farmers, much as the crop is tolerant to the dry conditions they are experiencing. They are now motivated to cultivate it because they know there is a good market for the produce in Kenya. The Chairman of the village elaborated as presented in the following quote:

> *"The crop (lablab) is also good because it has good price in the market. Businessmen from Kenya come here and buy for the good price. We are told that they use it to manufacture biscuits in Kenya."* (Leader, Mkundi village).

In Kambeni, much as the changes in the local climate were perceived to be one of the factors for change from coffee to ginger, the good markets for ginger and poor markets for coffee combined together to form part of the factors that motivated the change into ginger as the following quote justifies:

> *"I think there are two main factors: ……..…the market price for ginger was and remains to be better than that of coffee even today; the farmer needed up to three years from planting to harvest coffee. This means higher investment in terms of time, labour and inputs all of which mean cost because during that time the farmer must be spending money for pesticides and labour. But with ginger it is different. The farmer needs only eight months from planting to harvesting."* (Expert, Kambeni Ward).

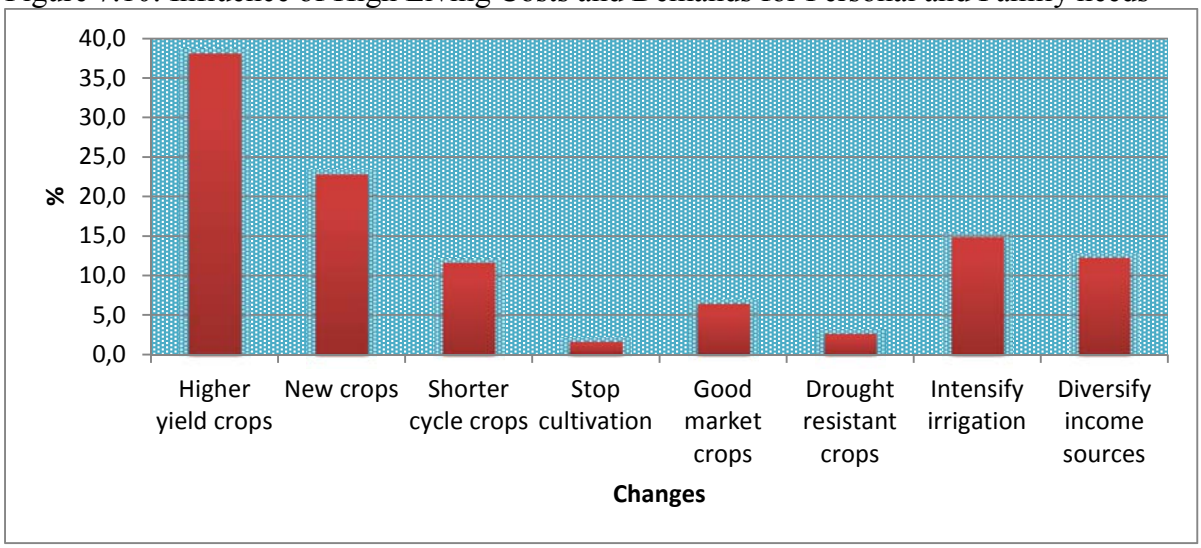
In Manga Mikocheni, the role of good markets having stimulated the changes in the farming practices in the village was also highlighted in the interviews as presented in the following quote.

> *"As for the new crops, they have good price in the market. Watermelon, tomatoes and bell papers are shorter cycle crops and therefore, in a short time, you harvest, you sell and buy little maize for the family."* **(**Elder1, Manga Mikocheni).

High living costs and demands for personal and family needs

Overall influence of high living costs and demands for personal as well as family needs ranked third behind negative effects of climate change and the role of markets with 11.2 percent. However, details show that its influence on different changes was diverse. The details indicate that the factor played a good role in farmers' decisions to shift to higher yielding crops and crop varieties by 38.1 percent. Apart from that, other changes greatly influenced by this factor and the percentage level of influence in brackets are as follows: introduction of new crops and crop varieties (14.8%); intensification of irrigation (14.8%); diversification of household income sources (12.2%); and concentration on shorter cycle crops and crop varieties (11.6%). Figure 7.10 summarizes the details.

Figure 7.10: Influence of High Living Costs and Demands for Personal and Family needs



During the interviews and FGD, demands for personal and family needs particularly school fees for children, clothing, food, housing and others were also reported to have contributed to the farmers' decisions to change farming practices in the area. Increasing costs for consumables, requirements to make contribution to such village projects as school constructions, purchase of desks and other related costs for village developments were also given as examples, which have been compelling farmers to adopt some farming practices so as to cater for such needs. In Mkundi village, for example, several farmers explained that without engaging themselves in cultivating of lablab and making charcoal, there is no other source to get money to pay for school contributions, school fees and sustaining the family for clothing, food and health related costs. An elder had this to say,

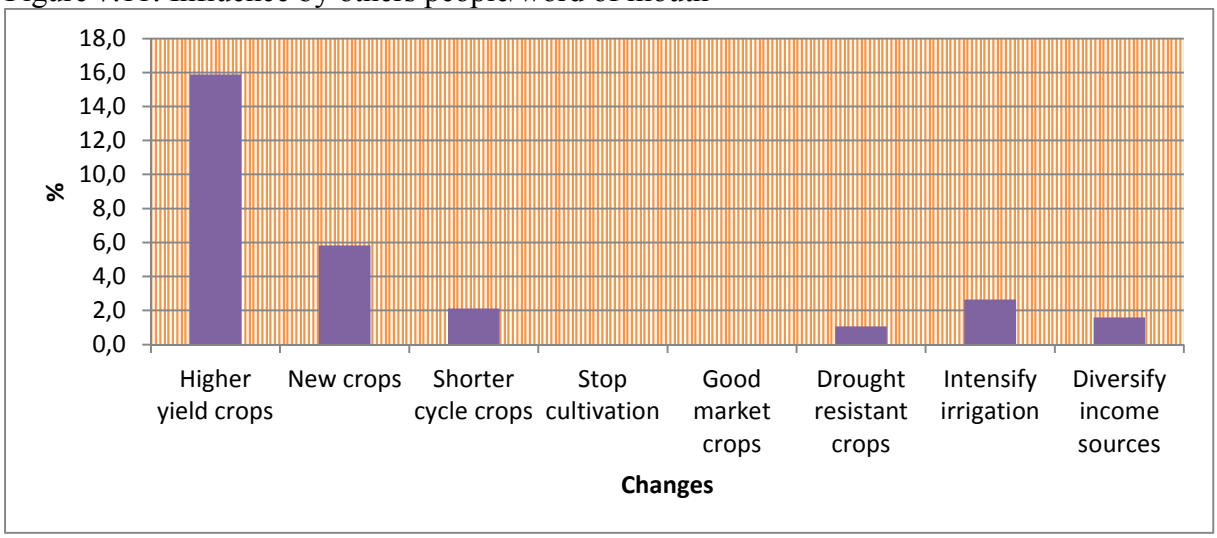
> *"In any case, you find yourself compelled to change because there is no other source one can depend on except cultivation of lablab and making charcoal. These help me to get some money to sustain my family and pay school fees and other contributions. Last year, for example, my daughter spent almost two months at home because I had no money to pay for the school contributions. I had to work hard in the forest to make charcoal and finally, she was back to school."* (Elder2, Mkundi village).

The quote summarizes the role that high living costs and demands for both personal and household needs had influencing changes in the farming practices in the study area.

Influence by other people/word of mouth

Human beings sometimes tend to be influenced by other people (significant others) in their life decisions. This was the reason influence of others, such as neighbors, friends, relatives and the like was considered a potential factor to have motivated changes the farming practices in Mkomazi. In overall terms, its influence was only 3 percent but the details indicate that 15.9 percent of the farmers had shifted to higher yielding crops in response to influence of other people such as neighbors. In addition, 5.8 percent of the farmers reported to have introduced new crops and crop varieties as a result of influence from others. This indicates that much as its overall role was low, these two changes were well motivated by this factor. Details of its influence on other changes are illustrated in Figure 7.11.

Figure 7.11: Influence by others people/word of mouth



The qualitative data also indicated that influence of other people, particularly neighbors and relatives played a role in influencing some of the changes in the farming practices in the area. In addition to good markets and the changing climate that influenced introduction of ginger in Kambeni and lablab in Mkundi as well as Manga Mikocheni villages, influence from neighbors, relatives, new comers and the like was reported to have also contributed in both introduction and spread within Kambeni and other surrounding villages. In Kambeni village, for example, it was reported that an individual farmer from the village visited a relative in parts of East Usambara Mountains in the early 1980s and found they were cultivating ginger. The farmer was interested and took seeds, which he planted in his farm back in the village. That was introduction of the crop in the village and after some years, it started to spread all over in the village and now it is not only cultivated in Kambeni but also neighboring villages. A Ward Councillor had this to say,

> *"There were problems with coffee especially diseases and pests as a result of changes in the local climate. But at the same time, coffee prices were going low. It was during those times one farmer brought ginger from his visit in East Usambara. He started cultivating it at a very small scale mixing it with other crops. After several seasons, he started selling the produce. After two seasons or so, other farmers started to realize that it was a potential cash crop and slowly one by one they started cultivating it."*

The case of Mkundi is similar to this as the following quote justifies:

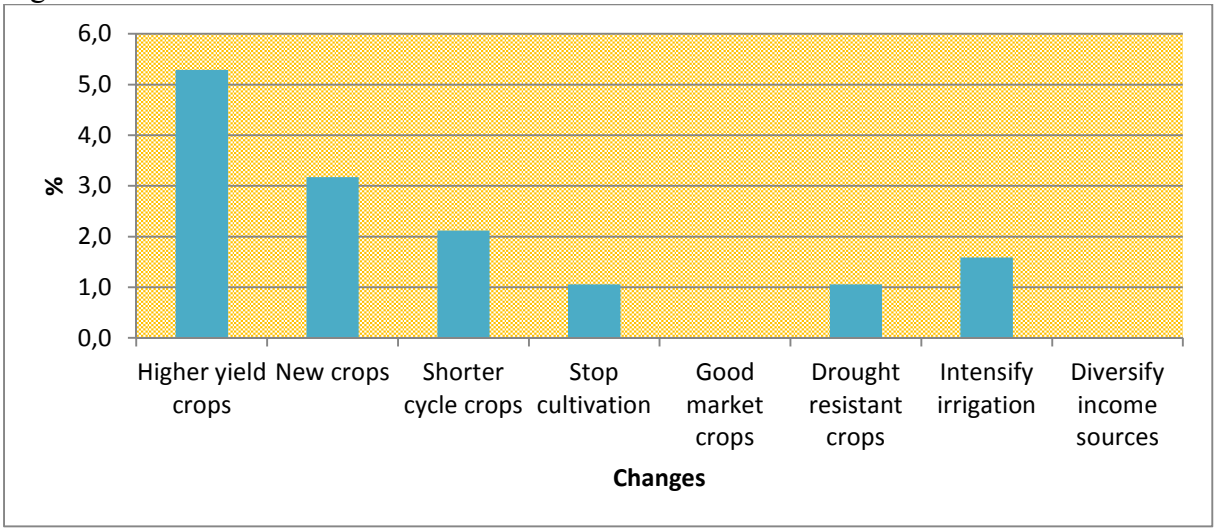
> *"Neighbors also influenced introduction of lablab in this village. Many people from this village were visiting friends, relatives and colleagues in Same. During the visits, they learnt that this crop was doing well in dry conditions in Hedaru, and that it was tolerant to drought. They brought some seeds and planted them as a trial. Farmers started to adopt slowly since then. Now it has become a dominant and helpful crop in this village due to the changes in climate we are experiencing now."* Leader, Mkundi village.

Household Size

Household size had an overall influence by only 1.5 percent in changes in the farming practices by farmers. It was also found to have an influence of 5.3 percent on farmers' shift to higher yielding crops and crop varieties. That was followed by 3.2 percent on introduction of new crops and crop varieties as well as 2.1 percent on the shift of farmers to shorter cycle crops and crop varieties. In addition, intensification of irrigation was reported to have been influenced by

household size by 1.6 percent. Regarding other changes, as illustrated in Figure 7.12, influence of this factor was indeed negligible.

Figure 7.12: Influence of Household size



7.2.4 Discussion

The survey, interview as well as FGD data regarding factors influencing changes in the farming practices by smallholder farmers in the four villages provided the basis for several issues to be discussed. They included dominance of the three main factors that were reported to influence the changes, level of influence of each of the factor at particular changes, multiplicity of roles played by the factors and adaptation information farmers reported to be in need as part of enhancing their adaptive capacity. The discussion is instrumental in expounding these issues so as to draw clear conclusions and concrete recommendations in the final analysis.

Major Factors

Perception is normally a prerequisite for individuals to feel the need for taking action to change the path. In any society, when individuals perceive potential danger, they will normally feel insecure and hence, they will be obliged to take actions to save their interests and livelihoods. As explained before, perception that the local climate is changing played a very significant role in motivating changes in the farming practices by smallholder farmers in all four villages. This is clear from both the quantitative data in all villages because as reported, 62.4 percent of all respondents were in support of this as a major factor that drove them to undertake various changes in their farming practices in the area. In terms of capacity to adapt, this tendency of changing farming practices in response to perceived changes in the climatic condition is positive because it provides a room for the farmers to accommodate themselves to the anticipated or perceived changes before the situation worsens. This is because climate change is real (Adger, *et. al*., 2005) and farmers should not just sit idle waiting for the worst case but, through their knowledge and experience, have to react to the changes they perceive are to come and those they experience (*ibid*.). It is in line with this understanding that Article 3.3 of the UNFCCC requires Parties to take precautionary measures to deal with causes and effects of climate change (UNFCCC, 1992). In this context, farmers at both individual level and community level have the right to make decisions to change farming practices both as a reactive and anticipatory measure to address the impacts of changing climate (Adger, *et. al*., 2005).

In many studies especially in developing countries, changes in climatic variables are documented to have been influenced changes in the farming practices. For example, Mertz and colleagues (2008) conducted a study in Senegal to identify smallholder farmers' perceptions on climate change and their adaptation strategies. They (*ibid.*) found that farmers attributed climatic factors to effects on their livelihoods such as poor crop yields and poor animal health. However, unlike in this study, Mertz and colleagues (2008) found that farmers identified the most destructive climatic variables to be strong winds and occasional excessive rainfall. This is different from the current study in Mkomazi where findings revealed that farmers' perceptions and change in the farming practices are not associated with strong winds but poor rainfall amount, poor distribution of rainfall and recurrent dry spells, just to mention a few. Strong winds were never reported in this study as a climate variable that motivated changes in the farming practices or one perceived to have changed. But findings by Mertz and colleagues (2008) reflect the environmental conditions in which the study was carried out since it is mostly semi-arid environment while Mkomazi sub-catchment (South Pare, West Usambara and Mkomazi valley) contain different environmental conditions, multiple characteristics from humid mountains through extensive wet valleys drained by the Mkomazi river to semi-arid lands in the lower parts of the valley. In spite of the variations, the climatic factor remains to be critical to farmers' perceptions in this regard. Similarly, Acquah and Frempong (2011) identify increase in temperature, decrease in precipitation and increase in wind temperature as climate variables perceived by farmers to have changed in Ketu North district in Ghana. These were reported to be causing several impacts such as increased weed and pests; declining crop quality; declining land, soil and water quality; increased risk of food shortage; poor farm production and the like (*ibid*.).

The recent study by Legesse and co-workers (2013) on assessment of farmers' perceptions and adaptation to climate variability and change in Doba District, West Hararghe, Ethiopia, which also went on investigating what influences adaptation strategies, is another good example of similar findings as far as changes in the farming practices influenced mainly by perceptions on the changes in the local climate. In their (*ibid*.) study, they found that crop diversification, use of soil and water conservation practices, integrated crop and livestock diversification, diversification of income generating sources mainly off-farm activities and rainwater harvesting were the major adaptation strategies (changes) that were being undertaken by the farmers in response to the perception of changes in the local climate. However, the main determining factors found to be influencing adaptation strategies in the area were agro-ecological locations, sex, household size, plot size, off-farm income, livestock holding capacity and frequency of extension contact and training (*ibid*.). While findings in the study by Legesse and others may look similar particularly on what smallholders perceive as far as their local climate is concern, and their responses in changing their farming practices, the combination of the factors influencing the changes found in current study (in the Mkomazi), that is, perceived negative effects of climate change, the role of the markets, high living costs and demand for personal and household needs applying to all four villages show differences because in their study (Legesse et al., 2013), they identified among others, sex and household size, which in the case of Mkomazi, they had no crucial contribution in determining changes made by farmers as far as the data is concerned. Household size, for example, only contributed to the changes by 1.5 percent as per the respondents.

When one looks at specific changes, perceived changes in the local climate were found to have influenced all changes in the farming practices even though at different levels in terms of percentage. However, all the percentages were above 50 percent and the relevant changes to have been influenced by this factor in the order of first rank to the last are as follows: shift to

shorter cycle crops and crop varieties; stop cultivation of some crops and crop varieties; intensify irrigation; shift and concentrate to drought tolerant crops and crop varieties; introduce new crops and crop varieties; concentrate on crops and crop varieties with good markets; and diversify household income sources.

Markets have a very significant role to play in influencing production patterns not only to farmers but also in many other economic fields. In the case of agriculture, influence of markets to farmers' decisions as to what and when to produce is also significant (Bowman and Zilberman, 2013). In this research, the farmers were not isolated from the role of the markets in influencing their decisions on making changes to their farming practices. For many reasons, especially where markets offer opportunity for cash from the farm, farmers would be interested to cultivate and produce crops, which can give them some cash to cater for their personal and family needs. In some cases, however, farmers have tended to produce food crops, which have good markets potentials. It means that farmers can also engage in production of food crops, which can finally be sold for cash. Some literature (e.g. Faschamps, 1986) claim that in the third world context, cash or food crop orientation in terms of production decision depends on the size of land one owns. Large farmers are believed to allocate bigger size of their land to cash crops production than smallholder farmers do (*Ibid.*). However, this argument does not seem to consider the context in which food crops can be produced and sold for cash. It implies that with a potential good market, a smallholder farmer may also allocate almost the whole of the land owned to a type of food crop and after sell, the farmer can then buy the type of food he/she so chooses. This is a clear case for Mtae village where many of the smallholder farmers reported to be engaging themselves heavily in the small-scale production of Irish potatoes not entirely for their own consumption but for cash because there is very good market for this type of produce. The Money obtained from selling of irish potatoes is used to buy maize, rice and other preferred food produce for family consumption. In addition, many farmers in Kambeni village devote most of their time and land for cultivation of ginger, which in this case is a cash crop, because there is good market for the produce, and money they get is used to, among others, purchase of food for the family.

Availability of good markets for lablab, which has been adopted and is cultivated in Mkundi offers another example of influence of the market on decisions by farmers to change their farming practices. In reality, at first farmers in Mkundi adopted the cultivation of lablab due to perception that their local climate has changed and they no longer enjoy good and enough rains. So it is difficult to cultivate and produce their traditional crops like maize, beans, potatoes, bananas and the like. Lablab was introduced by a few individual farmers because they had an idea that the crop is drought tolerant. The crop is common in dry areas of Western part of South Pare Mountains such as Hedaru. Characteristically, it can withstand dry conditions. Therefore, farmers knew it would help them to counteract what they perceived as changes in their local climatic conditions leading to continued and recurrent poor rains. However, as time went on, they realized that the crop not only was drought tolerant but also was marketable. Such realization led to the spread of the crop to almost all farmers and now it is the main crop mostly cultivated in the village. The role of markets was much influential in five changes listed in the order of high to low percentage of influence: shift and concentration of farmers on crops and crop varieties with good markets; shift to higher yield crops and crop varieties; introduce new crops and crop varieties; intensify irrigation; and shift to shorter cycle crops and crop varieties.

Increase in living costs and demands for both personal and family needs may also dictate the household to make some changes in the farming practices and probably adopt some practices that have potential to increase household income. Many farmers reported that they experience

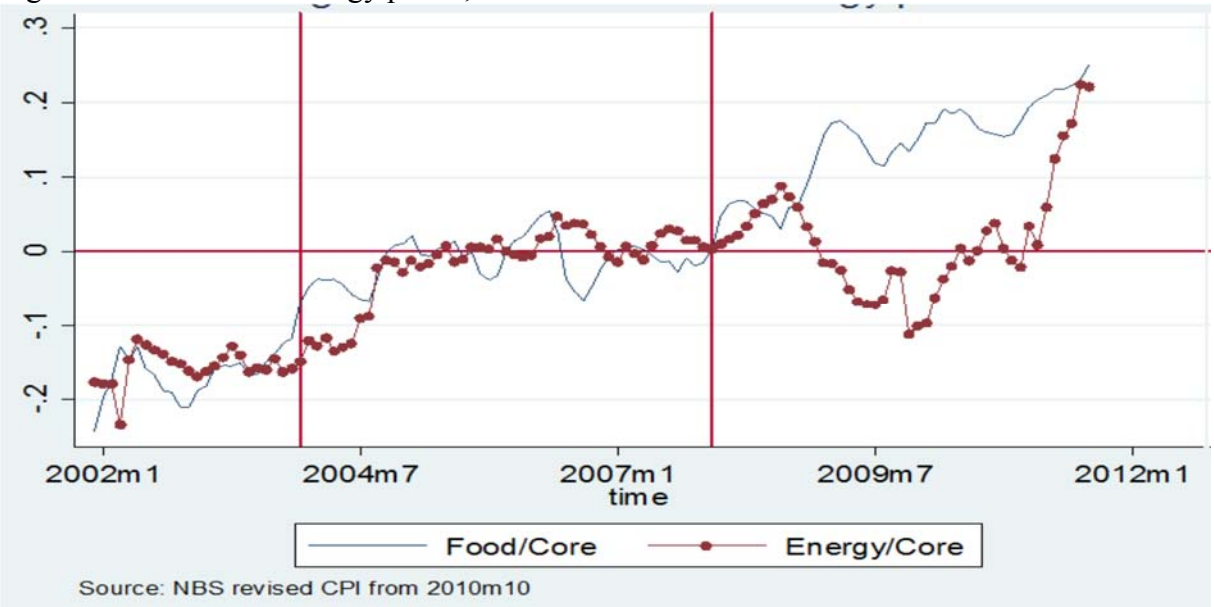
and feel the increased living costs and demands for both personal and family needs. Examples of the costs are health services, food for family consumption and education needs for the children in terms of school fees, uniforms, school contributions and so forth. In addition, health services cost-sharing were reported to compel farmers to adopt some farming practices, such as various crops and crop varieties for the intention of getting money to meet individual and family health costs. Likewise, there are other personal and family needs like clothing, good meals and improved settlements, all of which were reported by the farmers to have contributed in motivating them to adopt some farming practices in the area. The influence of high living costs and demands for personal and family needs was much instrumental in the following changes in the farming practices, in the order of high to low percentage: shift of the farmer to higher yield crops and crop varieties; introduction of new crops and crop varieties; intensify irrigation; diversify household income sources; shift to shorter cycle crops and crop varieties; and shift to crops and crop varieties with good markets.

It is also important to note that, for the past ten years, Tanzania has experienced high inflation rate (Figure 7.13). For example, URT, (2013e) asserts that for the past five years, the country has experienced varying patterns of Annual Average Inflations Rates for Headline, Food and Non-Food items. It (*ibid*.) emphasizes that in 2010 and 2013, the country's economy experienced a low pace of speed increase for prices of commodities where the Annual Average Headline Inflation Rates were 5.5 percent and 7.9 percent, respectively. The country recorded the highest price increase for goods and services in 2012, the Annual Average Inflation Rates recorded was 16.0 percent and the lowest, Annual Average Inflation rate of 5.5 percent was recorded 2010 (URT, 2013e).

Figure 7.13: Tanzania Inflation Rate for 2000-2012

As a result, the country is experiencing higher prices for most of the basic commodities such as foodstuffs, fuel and other consumables (Figure 7.14). Hence, there are higher costs of living as well as life difficulties especially for the smallholder farmers and their families because they have no regular and enough income to cater for their needs. Due to this situation, smallholder farmers, in particular, reported to have been compelled to make some changes in their farming practices and adjust themselves so that they can at least provide for their families. This was also reported by the farmers as one of the motivations, which triggered some changes in the farming practices. The combination of all these contributed to changes farmers made in their farming practices in the area.

Figure 7.14: Food and energy prices, 2002-2012



Other Factors

From the data, it can be seen that in many circumstances, changes in farming practices were not influenced by a single but by multiple factors. There were multiple factors that influenced each of the changes and in each of the village but the key factors were three: perception of negative impacts of climate change; availability of good and reliable markets; and high living costs including demands for personal and family needs. In addition, there were other factors, whose influence was found to be minimal but present. They include influence of other people, mostly neighbors; financial capital; income needs; and household size, which together constitute 7.3 percent of all the responses. While their influence is very minimal as presented before, they played some role in changes in the farming practices in these villages. Their influence and motivation can be appreciated clearly when one looks at specific changes in the farming practices (Figures 7.7-7.8 and 7.11-7.12) and at the village level (Figures 7.2-7.5). Influence of neighbors, for instance, was found to have been contributed to the introduction of new crops and crop varieties especially in Mkundi. At Mkundi, introduction of Lablab was reported to have been a result of some individuals who visited semi-arid places and became interested with this crop in the way it was tolerant to dry conditions and saw the need to introduce it in their village. The neighbors slowly started to adopt its cultivation and until today it is a common crop in the village. In addition, the same factor also had an influence in the introduction of ginger in Kambeni village. Apart from introduction of new crops and crop varieties, this factor also contributed to farmers' decisions to shift to higher yielding crops and varieties because it accounted for 15.9 percent of the respondents who identified it as a factor in that regard.

Financial capital was mentioned by about 7.9 percent of the respondents as a factor to have influenced them to stop cultivation of some crops and crop varieties. A good example was given in Kambeni village where farmers clearly agreed that they had to decide to stop coffee cultivation due to a series of factors. First of all, there was increasing rainfall unreliability coupled with increase in pests and diseases for the crop. All gave rise to two key requirements. One, to have a better source of water and the second is increased use of pesticides. However, the prices for pesticides were also reported to have been increasing thereby demanding more money to service the coffee farms. In addition, coffee markets and prices were fluctuating.

Thus, farmers had no assurance of whether or not investing in coffee would pay off. While coffee production costs were increasing due to those factors and hence, demanding more money to invest, coffee prices were decreasing. The combination of all those factors, i.e. climatic change and variability, high coffee production costs, poor and unreliable markets as well as poor capital compelled farmers to decide to start slowly changing from coffee to ginger cultivation. This made coffee production more costly, requiring good financial capital. Figures 7.7, 7.8, 7.11 and 7.12 illustrate the influence of the four insignificantly contributing factors to the changes in the farming practices in all four villages.

This justifies further that, changes in the farming practices were a result of multiple factors much as the level of contribution varies for each of the changes. Thus, for policy context, detailed analysis of the contribution of each of the factors for each of the change in the farming practice, and at each and every village may be necessary. Furthermore, the situation where one crop can be suitable as an adaptation option, support livelihoods as a source of plant protein and at the same time open a good market for farmers to get income, offers a very good combination and complementarity. All need to be supported and promoted to enhance the farmers' ability to adapt to the changes in the farming practices in the area. Lablab (*Nkwasha*), for example, has shown that it is not only a drought resistant crop but also has a good market. Hence, it has the potential to serve more than one purpose in the village economic process. It holds potential to support the Tanzanian government efforts to reduce poverty amidst perceptions and reports that local climate in the research area is changing.

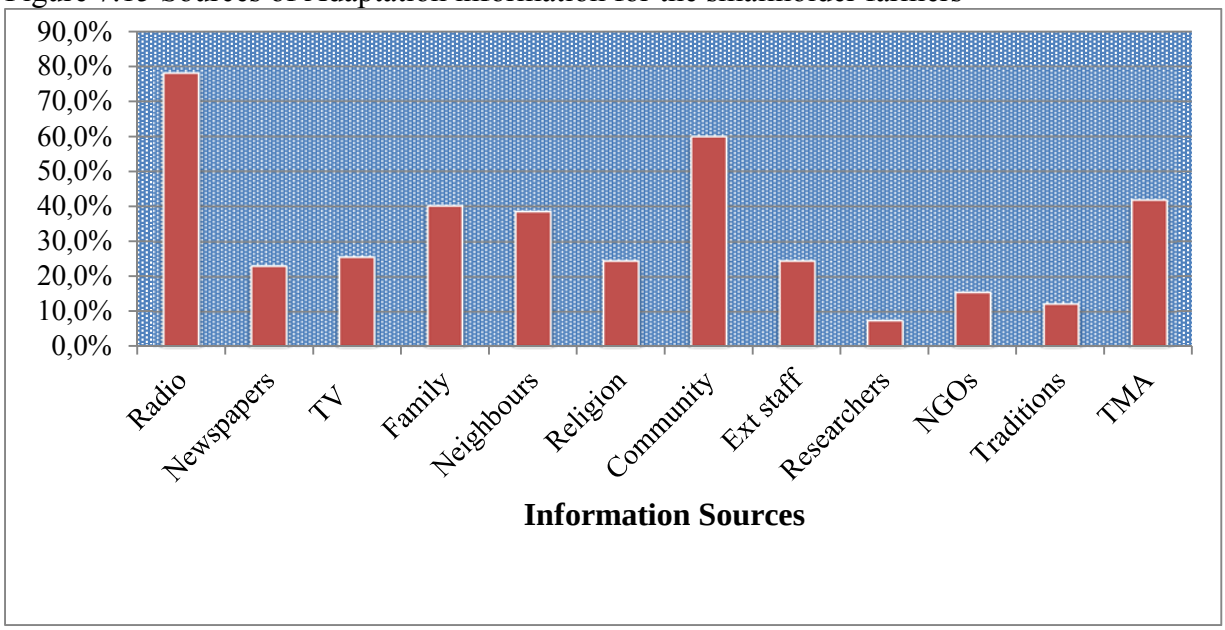
7.3 Data Presentation: Sources and needs of Adaptation related Information

7.3.1 Information sources

Access to climate and adaptation related information is one of the important aspects that may serve to explain adaptive capacity of an individual, a community and so forth (Phillips, 2003). It is due to this fact that the researcher had to seek information from farmers, which could indicate their best means and ways to access adaptation related information. There was also a need to get the type of information they would wish to be informed in order to enhance their adaptive capacity in the future. In other words, the idea behind was to know the media through which smallholder farmers in this area depend on more for accessing climate and adaptation related information and their information preference, depending on their context so as to facilitate their response to the perceived climate change related impacts.

From the analysis, it is clear that most farmers depend on radio as their means for accessing information on climate and adaptation. In addition, community meetings, NGOs, family members and Tanzania Meteorological Agency were also found to be important sources of information to farmers, especially climate change and adaptation related information. Figure 7.15 provides a graphical summary of the responses of the farmers on their sources of adaptation related information to illustrate the findings.

Figure 7.15 Sources of Adaptation information for the smallholder farmers



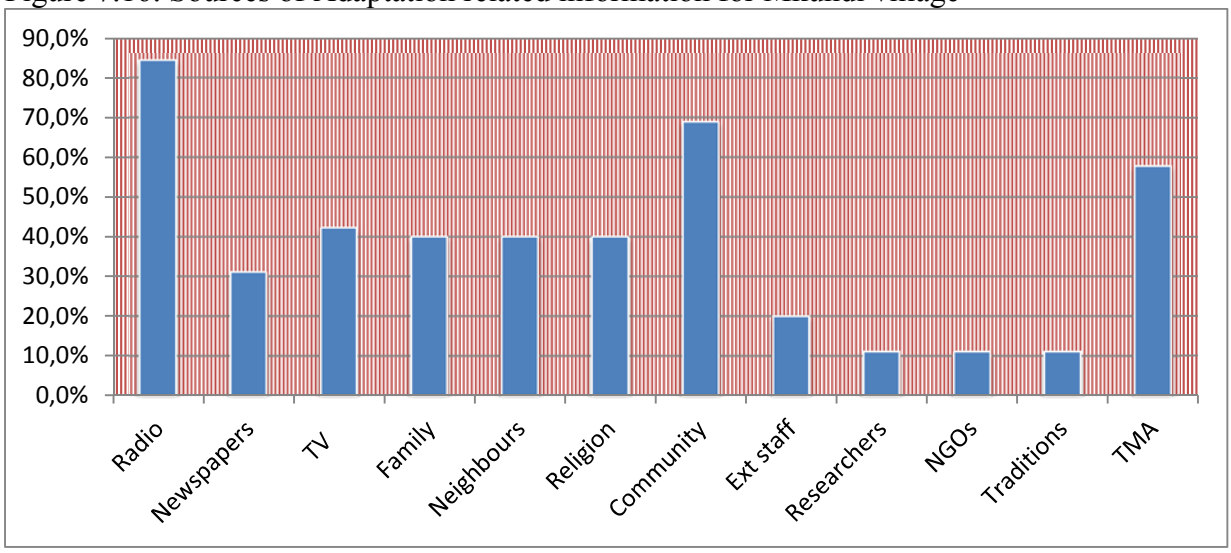
In terms of overall summary, the data revealed that radio is the most dependable source of information by 78.1 percent while community meetings rank the second in terms of importance in this case with 59.9 percent. Tanzania Meteorological Agency (TMA) was also found to be an important source of information for farmers with 41.7 percent. In addition, the use of family members and neighbors seemed to play a great role in facilitation information access to farmers as the former scored 40.1 percent while the latter with 38.5 percent.

At village level, data do not deviate so much from what was illustrated in the overall summary. However, much as the radio remains important almost in all villages, some slight deviations are observed in terms of those to be first in preference for each of the four villages. The following paragraphs explain the pattern with support of graphical illustrations.

Mkundi village

The radio was revealed to be a good and dependable source of information in this village such that 84.4 percent identified it as their major source of information they depend on. In addition to radio, community meetings (with 68.9%) and Tanzania Meteorological Agency (57.8%) were also found to be good sources of information in the village. To indicate influence of development in terms of media in Tanzania, farmers in this village also identified television (TV) as their source of information by 42.2% regardless of the fact that the village even has no electricity. Other sources of information identified by the farmers in Mkundi are family members (40%); neighbors; (40%); religious institutions (40%); newspapers (31.1%); extension workers (20%); and researchers, NGOs and traditional sources each one with a score of 11.1 percent. These details are illustrated in Figure 7.16.

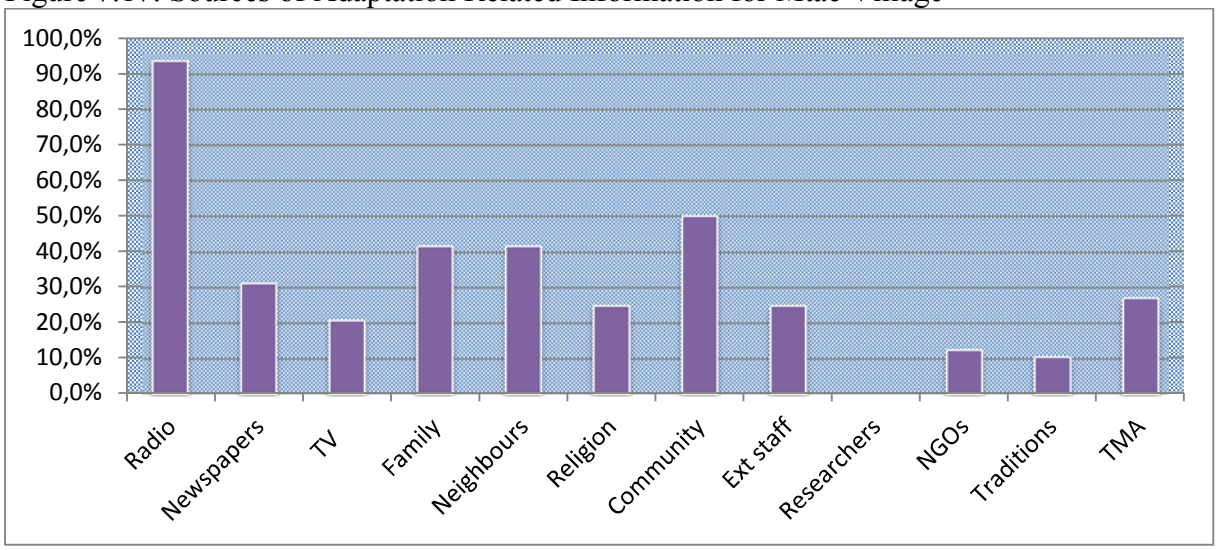
Figure 7.16: Sources of Adaptation related information for Mkundi village



Mtae village

Similar to Mkundi village, radio ranked the first source of information in Mtae village, but was ranked higher (93.8%) than at Mkundi village. While community meetings were also identified to be the second most dependable source of information to radio and scored at 50 percent, the role of TMA in this village (with 27.1%) was not as high as in Mtae village. The farmers in the village showed that family members and neighbors played a good role as sources of information more than community meetings, each one accounted for 41.7 percent of respondents. Figure 7.17 illustrates the details of all other sources of information for Mtae village.

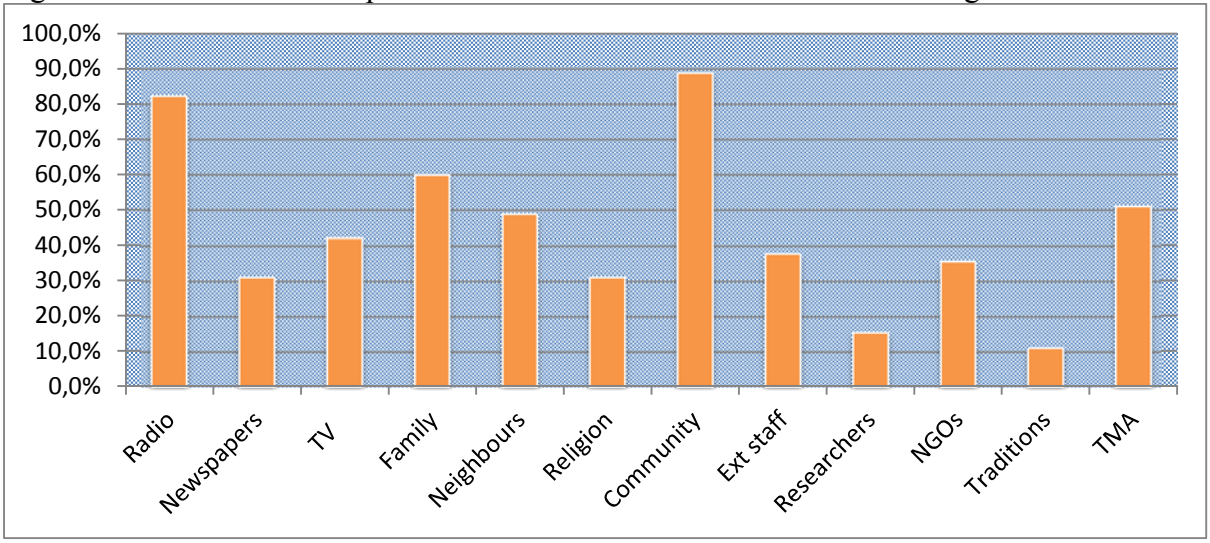
Figure 7.17: Sources of Adaptation Related Information for Mtae Village



Kambeni village

In Kambeni village, data indicated that community meetings, with score of 88.9 percent, were the most dependable of all sources of information followed by radio (82.2%), family members (60%) and TMA with 51.1 percent. This is different from the overall summary in which radio was found to be the most dependable source. All sources of information in this village are illustrated in Figure 7.18.

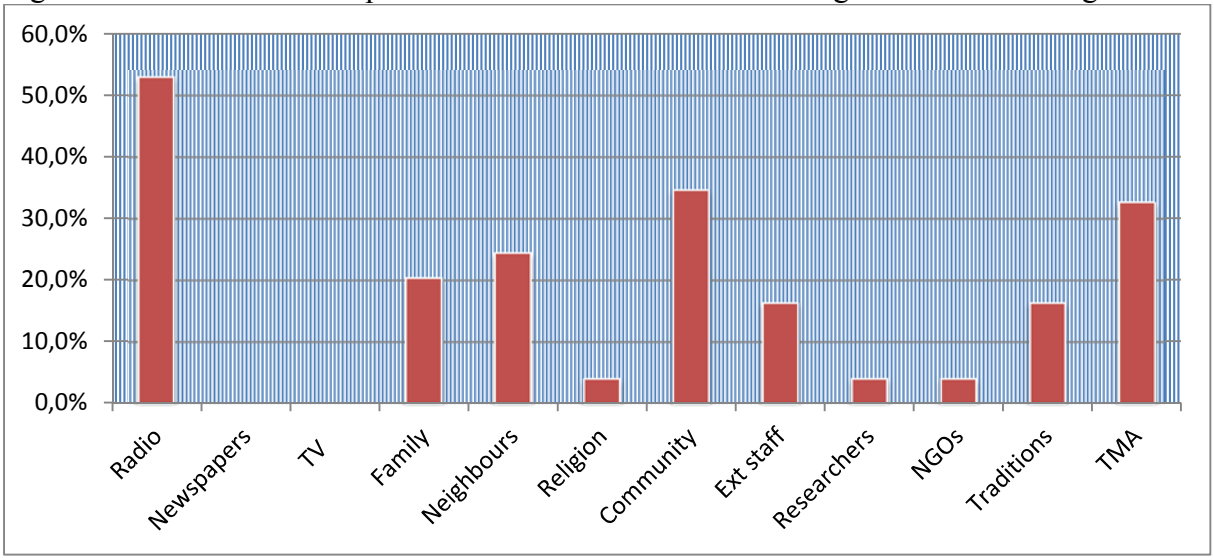
Figure 7.18: Sources of Adaptation Related Information for Kambeni Village



Manga Mikocheni village

Results for Manga Mikocheni village showed a similar picture to the one seen in the overall summary of results on sources of information for farmers as well as those from other villages. Radio, community meetings, TMA and neighbors as well as family members were found to be important sources of information in this village although at different preference levels in terms of percentage. Radio, with 53.1 percent score, was the first followed by community meetings (34.7%) and TMA was the third with 32.7 percent. However, the main difference was percentage level at Manga Mikocheni village seemed to be lower than for all three other villages. In addition, some of the sources of information identified in other villages, even though with a few respondents, for TV and newspapers, were totally rejected in this village. The details are illustrated on Figure 7.19.

Figure 7.19: Sources of Adaptation Related Information for Manga Mikocheni Village



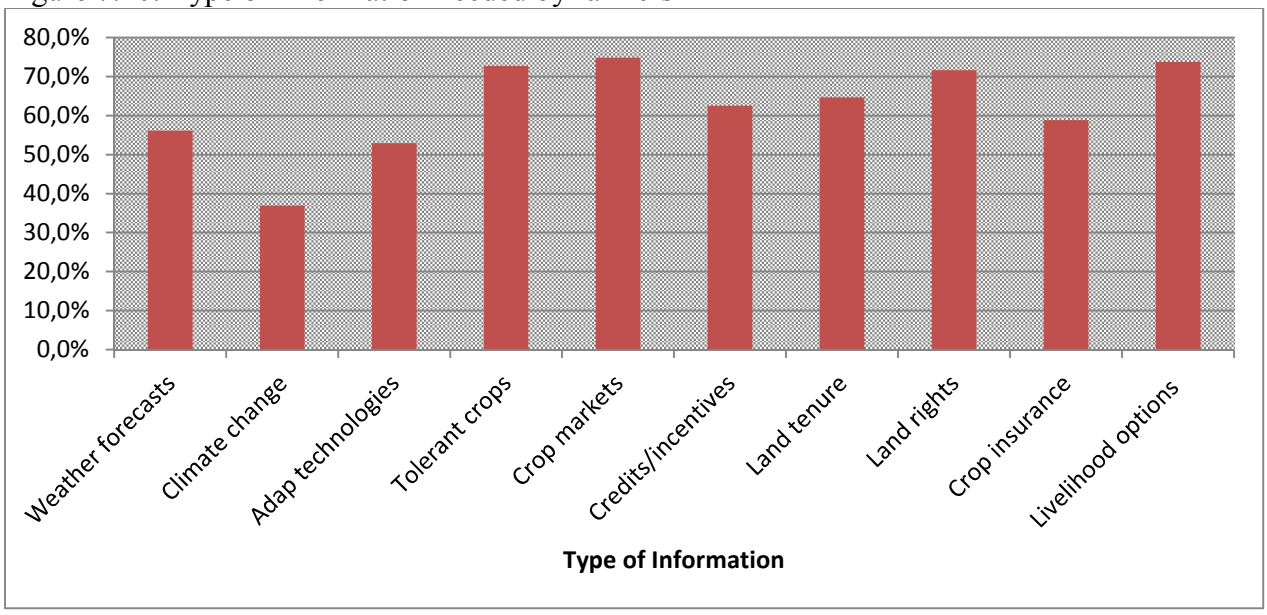
7.3.2 Type of information needed by farmers

To support farmers in enhancing their adaptive capacity and ensure that they are resilient in future, it was important to know the type of information that they needed so that when interventions have to be made, information preferred most by farmers can be made accessible

to them by using the appropriate sources of information they use most. It is under this justification that it was necessary to ask farmers to indicate what type of adaptation related information they mostly need to help them adapt to the changes in the local climate and at the same time support their livelihoods. Using a list of various types of information identified from literature and the pretest, farmers were asked to identify types of information they needed depending on their level of knowledge and experience.

From the questionnaire data, analysis showed that most of the farmers sought pieces of information on the following aspects: different crops and crop varieties with good markets (74.9%); alternative livelihood options to reduce severity of climate change impacts (73.8%); types of crops and crop varieties tolerant to poor conditions such as continued droughts (72.7%); and issues of land rights (71.7%). However, farmers also expressed interest in other types of information on the following themes: land tenure issues with a score of 64.7 percent; availability and accessibility of credits and incentives (62.6%); crop insurance system (58.8%); weather forecasts, predictions, and timely disseminated information to farmers (56.1%); and information about adaptation knowledge and technologies (52.9%). One type of information never received enough attention: on general issues about climate change, its challenges and opportunities, which had a score of only 36.9 percent. Figure 7.20 summarizes results on the type of information needed by smallholder farmers.

Figure 7.20: Type of information needed by farmers



7.3.3 Discussion

Adaptation Related Information Sources

For the past 20 years, Tanzania has been taking good steps towards increasing the number of media to allow easy access to information for many (MCT, 2013). This is because there has been a tremendous increase in number of media from 1992 to date. For example, in 1993, the country had only one radio station, which was a government property called Radio Tanzania (now named Tanzania Broadcasting Corporation) (MCT, 2013). However, by the end of 2012, the country was reported to have had 86 radio stations. Out of these, 5 were operating nationally, 20 were regional operators; 50 operated at district level; and 3 were community based (MCT, 2013). As for the TV stations, by December 2012, there were 26 stations out of which 5 operated national wide; 1 being regional; and 20 district-level TV stations (MCT,

2013). The country also has over 50 newspapers operating at various levels with different themes from politics to technical specific thematic areas (MCT, 2013).

Much as there has been an improvement in the media as primary sources of information, (in this context, adaptation related information for the smallholder farmers); from observation and various scholarly works, there are various obstacles that hinder full access to information by smallholder farmers in rural areas. They include lack of electricity and poor infrastructures (Mafu, 2004); poor or lack of road networks; and lack of internet services (Mafu, 2004). According to Kamba, (2009), the main obstacles to information delivery and access in most developing countries include inadequate basic infrastructure (particularly electricity, telecommunication, roads and transportation), low literacy levels, lack of suitable information services and lack of technical competencies. These render distribution of print and electronic media such as newspapers to rural areas difficult if not impossible, access to TV and internet services very poor and impossible in some areas and to many. It is from this viewpoint that it was expected radio to be the main source of adaptation related information in this research. Adaptation related information in this context is mostly generated and provided by both governmental and Non-Governmental actors. They include ministries, agencies, training and research institutions, religious entities and the media operating in areas like climate change and the environment, small-scale agriculture, forestry, water resource management and so forth. While in urban areas access to electricity is yet to be guaranteed due to frequent power cuts, the situation in rural areas is even worse because many villages have no access to electricity at all. Therefore, access to TV services is difficult such that radio is the mostly dependable source for farmers to access not only adaptation related information but also the entire spectrum of information they mostly receive.

Much as TMA was identified to be another good source of adaptation related information for smallholder farmers, detailed analysis revealed that radio remains the most dependable source of information even within neighbors and relatives as well as family members. This is because when asked about neighbors, family members and relatives' access of information to relay to others (their fellow family members and neighbors), they responded to be the radio. Therefore, it is like information is accessed through the radio and relayed to those who may probably have no or may have never had access to that information even if they possessed the radio receiver. In addition, Tanzania Meteorological Agency informs the public on daily weather forecasts through the media. But since farmers have little access to TV and newspapers, again, the most dependable source remains the radio. It is through this source that farmers also get access to weather forecast information from the TMA but when identifying the sources they identified TMA as another credible source of such information. Thus, radio remains the most important source of information for farmers.

Results from this study are similar from some other studies (for example, Mwalukasa, 2013; Churi, *et. al.*, 2012; Daudu, *et. al*., 2009). In his study on agricultural information sources used for climate change adaptation conducted in Dodoma, Tanzania, Mwalukasa (2013) found that major sources of adaptation information for farmers were predominantly local neighbors and friends plus public extension services. In addition to those, he (*ibid*.) also found use of radio and cellphones were important for farmers to access adaptation information. The study also found that use of advanced technologies such as internet as well as printed materials not so useful to farmers (*ibid*.) similar to the Mkomazi study. While many of his findings are in agreement with findings from this research, it is important to argue here that in this study in the Mkomazi, the role of extension workers as a source of agricultural and adaptation related information to farmers was not much appreciated by the smallholder farmers themselves. This

is unlike the study by Mtambanengwe and colleagues (2012) conducted in Makoni and Wedza Districts in Eastern Zimbabwe to, among others, identify sources of agro-meteorological information who found extension services to be the leading source of such information for farmers. There are several examples of problems that were found and cited by the farmers themselves in relation to effectiveness of the extension workers in this context. As alluded earlier, currently in Tanzania, extension workers are mostly based at the ward level with more than one village to serve. This means that some of them provide service to more than four or five villages. With that in mind, it is also true that not all wards have extension workers. Thus, in some of the wards, such workers are unavailable.

For example, in the study villages, only two of the four villages had extension workers at ward level, namely, Kambeni village (Mamba Myamba ward) and Manga Mikocheni (Mkomazi Ward) during the research period. The other two had none for various reasons including transfers. However, of the two, only one was available (Mamba Myamba ward). In addition, in all three villages (Mtae, Mkundi and Manga Mikocheni), farmers complained that even when the extension worker was available, farmers got many difficulties to access his/her service. Another complaint was that extension workers normally operate for both crop production and animal husbandry. According to the farmers, these workers tend to provide more service to pastoralists than to farmers because pastoralists can pay them some money for every service they provided. This is unlike farmers who seem unable to do that. Examples are in the quote indicating farmers' complaints on this issue:

> *"We have an extension officer at the ward level but he is normally unavailable. He is normally busy with his personal activities. I never get in touch with him. I have complained for several times to his bosses at the district but there has never been a solution to this problem. So we have to get another extension officer covering agriculture only and not covering agriculture and livestock."* (Leader, Manga Mikocheni Village).

Complaints by Manga Mikocheni village chairman mean that farmers hardly get technical services related to their activities from the extension worker. In due regard, they have to work on their own and probably collaborate themselves to address technical challenges, which otherwise would have been helped by the extension worker.

The district authorities in Lushoto also agreed that there are no enough extension workers because not each of the wards has one (at least in the current arrangement). But even where they are available, a lot of complaints are forwarded to the district level from the farmers on the conduct and performance of extension workers. It was argued that,

> *"We need to deploy extension officers at each village because currently, we have some at ward level but the measure does not seem to be effective. It is important also to closely supervise them so as to ensure their effectiveness."* (Official, Lushoto District Council).

Findings by Mwalukasa (2013) mostly are in line with findings from this research due to the fact that farmers in this research indicated also that they accessed information from the radio, community meetings, family members, neighbors and cultural specific knowledge. Also they benefitted from newspapers (23%); TV (25.7%); religious institutions (24.6%); and extension workers (24.6%). However, use of mobile phones seemed to be higher and was one other very essential source of information in this regard. In their study on understanding farmers' information communication strategies for managing climate risks in rural semi-arid areas in Tanzania, Churi and co-workers (2012) found that smallholder farmers need climate, market

and agricultural inputs information for making adaptation related decisions. In terms of sources of information, radio was found to be an important communication channel (*ibid.*). Apart from the radio, extension officers and fellow farmers were also found to be important for farmers in accessing different information (*ibid.*). Also such findings are similar from those revealed from this research in Mkomazi.

It is important to note that much as the radio was identified to be a general source of adaptation information by many smallholder farmers, it never seemed to be used by all farmers in the four sampled villages at the same level. There were deviations in terms of preference at village level. In Mtae village, around 93.8 percent identified radio as their source of adaptation information compared to 84.4 percent in Mkundi, 82.2 percent in Kambeni and only 53.1 percent in Manga Mikocheni village. The data indicate clearly that Manga Mikocheni village lags behind in terms of information access because a very common source of information was used by only 53.1 percent respondents to access information. In addition to this dilemma, the data also indicated that sources such as newspapers, TV, religious institutions, NGOs and cultural specific knowledge were either nonapplicable or negligible. The other sources, which showed village variations, encompassed community meetings because they were very crucial sources of information in Kambeni and Mkundi villages. Kambeni village has access to electricity such that they use TVs for those able to own receivers. It is important to note that the village depends mostly on cultivation of ginger as their cash crop. It is from sales of ginger that they reported to generate money to buy TV receivers and connect to decoders.

Mtae village is not connected to national electricity grid thus lacks access to electricity and this might be the reason the level of TV use is minimum and only accounted for 20.8 percent. Small petrol generators and solar panels (at a limited scale) are used as sources of energy. In the same token, it is interesting to note that Mkundi village has no access to electricity through the National Grid System but reported to have 42.2 percent of farmers having access to adaptation related information through TV. The best explanation is use of a small centre for TV viewing of which the researcher was able to use as well. They operate those using generators and are normally open from 7 p.m. up to midnight. The farmers have access to some important programs like news bulletin, special documentaries and so forth. For most of the time, they are used for show movies such that mainly youths attend and pay TZS 300 (about 15 cents Euro) for each movie they wish to watch (the cost during the time when the researcher conducted this study in the village).

From the presented data, it can be noted also that the role of researchers in supporting farmers for adaptation related information was minimal. Many farmers in all the villages complained that they were visited by several researchers in many fields every year but they did not get any feedback from research works conducted there. Therefore, they did not see the importance of further research being conducted so long as results from researches had no direct impact on their livelihoods. It is from this view point that research seemed to contribute only 7.5 percent of their access to information. Figures 7.15-7.19 illustrate all about information access at village level.

Adaptation related information need for farmers

Influence of markets to farmers' decisions was evident on selection of adaptation related information preference as well. Figure 7.18 summarizes results which clearly showed that they mostly need information about crop markets ranked. Such interest on information about crop markets clearly reflects the data collected especially in Mkundi and Kambeni villages. In Kambeni village, farmers complained about recent fluctuations in ginger prices, which seriously affected their incomes since they mainly depend on this crop after abandoning coffee cultivation. While in the past ten years they enjoyed very good market prices, the fall of prices in recent years stroke a blow to their incomes. In due regard, they present a dilemma on what they should do to compensate loss of their incomes amidst rising living costs and demands. It is this dilemma that led the Ward Councilor for Kambeni made this statement:

> *"We experience serious food shortage here especially when ginger price falls. For instance, last season there was a serious shortage of rain and many farmers did not get good harvests for the food crops. Ginger prices have also fallen this season. For instance, 1 kilogramme of ginger was sold at Tshs. 4000.00 in the last season (about 1.82 Euros) but now it is Tshs. 200.00 (about 10 cents of the euro). As a result, people are unable to buy food as long as ginger prices are very poor."* (Ward Councillor, Kambeni).

In Mkundi village, the main crop, which supports farmers in their livelihoods, is lablab. This is because, from the collected data, it is clear that the conditions hardly favour cultivation of other crops (those known to them). Therefore, consistent cultivation of lablab and availability of good market prices are the main hope for their survival because they enable them to get little money and food to feed. This is what is reflected in Figure 7.21 where 82.2 percent of farmers in Kambeni and all (100%) of those in Mkundi identified information about good markets as their preference from the list of ten types of adaptation related information.

The need for alternative livelihood options amidst concerns that perceived changes in the local climate compromise agricultural production leading to various implications in terms of household incomes and food availability was raised as another type of information farmers needed most to support their adaptation efforts. The overall of 73.8 percent from all villages is a clear reflection of the need for farmers on such kind of information. This is also portrayed at the village level particularly in Mkundi (95.6%), Mtae (66.7%) and Kambeni (86.7%) where farmers expressed their need for this type of information to support their adaptation endeavors (Figure 7.21 illustrates). In addition, it is interesting also to note that information about crops tolerant to poor climatic conditions was found to be importantly needed by the smallholder farmers at an overall of 72.7 percent score but with also 91.1 percent, 72.9 percent and 80 percent for Mkundi, Mtae and Kambeni villages, respectively. The results clearly reflect farmers' concerns, especially on perception of changes in the local climate.

Farmers also indicated that they need information about land rights and land tenure issues as well as credits and incentives together with their availability and access to enable them increase production amidst the perceived increasing changes in the local climate. Such types of information are important because for several reasons. On land rights and land tenure issues, it is clear that in rural Tanzania, many farmers have no formalized form of land ownership. Most of what they own is customarily recognized but there has been increasing land conflicts in many parts of the country, including in the research area where land is scarce due to mountainous nature and population increase. In addition, it should be reiterated that there is high land fragmentation indicating that the increase in population is increasing land shortage

in the area. Thus, it leads to worries about continued possession of land and assurance on farmers' livelihoods. These concerns were also echoed by the district authorities in Lushoto District during the interviews as presented in the following quote:

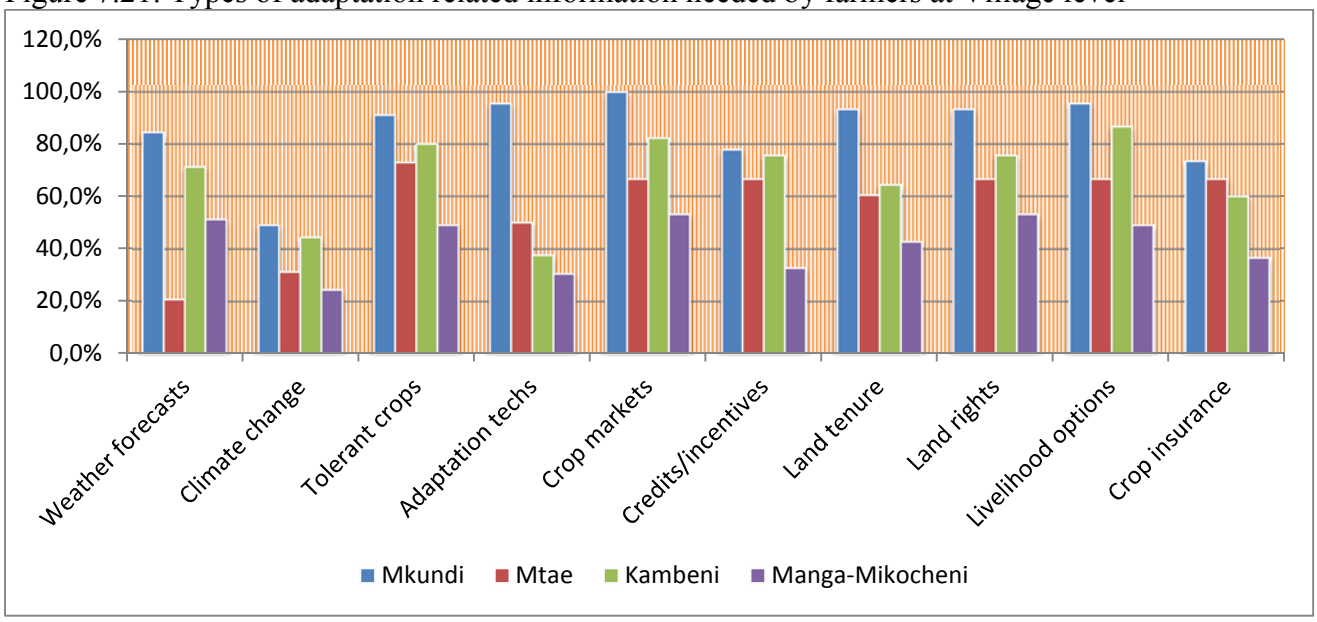
> *"There is a need to prepare land-use plans for the villages so as to avoid conflicts between various land and resource uses. We also have to limit livestock to carrying capacity levels through education to pastoralists and introduce better livestock keeping technologies."* (Official, Lushoto District Council).

Information about availability and access to credits as well as incentives is also needed by farmers. Smallholder farmers wish to obtain such incentives to support them for not only adapting to changes in the climate as they perceive but also for increasing production to ensure food security for their families as well as tangible, enough incomes. Support in terms of inputs, markets, transport and irrigation infrastructures, communication is needed by farmers. Therefore, information about availability and access to incentives and credits, both as individuals or collectively is what they need. However, farmers expressed concerns about better management of the already provided incentives especially in inorganic fertilizers, which they claimed did not reach them and when it did, normally it was insufficient and difficult to access. One village leader had this to say,

> *"The government has to make sure that we get agricultural inputs and accrue them at affordable prices. The farmers' incentives provided by the government such as fertilizers have to be managed well so that they do not fall into bad hands. We need tractors here for us to be able to cultivate paddy using tractors."* (Leader, Manga Mikocheni).

The details on type of information needed by farmers are graphically illustrated in Figure 7.21.

Figure 7.21: Types of adaptation related information needed by farmers at Village level



7.4 Summary

This Chapter presents data and discussion on factors motivating changes in the farming practices in Mkomazi sub-catchment as well as adaptation related information needs for the smallholder farmers in the same area. The data presented vividly indicate the role each factor

in reagrd to changes in the farming practices across villages and in each individual village involved in the study. Much as each of the factors was found to have some contribution, the following four factors were identified by the respondents to play in motivating changes in the farming practices in the area: adverse effects of climate change and variability; influence of markets; high demands for personal and household needs; and influence of other people including neighbors and relatives. This was reflected both in overall summary and even results for each village. It is necessary to note that across all changes and villages, the role of adverse effects of climate change and variability in influencing changes in the farming practices was the highest of all the factors. However, this does not mean that the changes in the farming practices have only been a result of only one factor. It should be noted that much as the effects of climate change and variability were found to be higher in all than other factors, the role played by other factors, such as markets, high living costs and demands for personal including family needs as well as influence of other people such as neighbors, leaders and the family cannot be overemphasized.

This fact implies that while the negative effects of climate change and variability, mostly on rainfall, had key influence behind the changes, some changes were contributed by other factors. For example, introduction of lablab was contributed by poor climatic conditions in Mkundi but acceptance and spread in the village was facilitated by good markets and its other characteristics such as being a shorter cycle, higher yielding as well as drought tolerant crop. Introduction of ginger in place of coffee in Kambeni was a result of changing climatic conditions for coffee cultivation and poor coffee markets but the spread of ginger was facilitated by mainly good markets. This underscores the role of multiple factors having influenced changes in farming practices in the area while strongly stressing the significant role played by changes in the local climate on the same.

The contribution of markets in influencing changes in the farming practices was strong in the concentration on higher yielding crops and crop varieties as well as introduction of new crops and crop varieties. In addition, high living costs and demands for personal as well as family needs influenced intensification of irrigation, concentration on higher yielding crops and crop varieties, new crops and crop varieties, diversification of household income sources and concentration on shorter cycle crops and crop varieties. It is worth noting here that the role of other factors in influencing individual changes was existent but very minimal.

It is important to inculcate farmers' need for information access to support them so as to make some critical decisions related to production in the farm. Radio was found to be an important source of adaptation related information to the farmers. In addition, community meetings, family members and neighbors were found to be key sources of adaptation related information. Furthermore, the role of Tanzania Meteorological Agency was noted to be one of the important sources of adaptation related information, particularly weather forecast information. Furthermore, it was revealed that it was important to learn about farmers' need for information on crop markets, opportunities for different livelihood options, different crops and crop varieties tolerant to dry conditions and other stresses, land rights, crop insurance, opportunities for credits and other incentives such as on inputs and different available adaptation technologies to support farmers.

Socio-economic implications of the changes in the local climate, which subsequently influenced changes in the farming practices are presented and discussed in the next chapter.

CHAPTER EIGHT: SOCIO-ECONOMIC IMPLICATIONS OF CHANGES IN THE LOCAL CLIMATE

8.1 Introduction

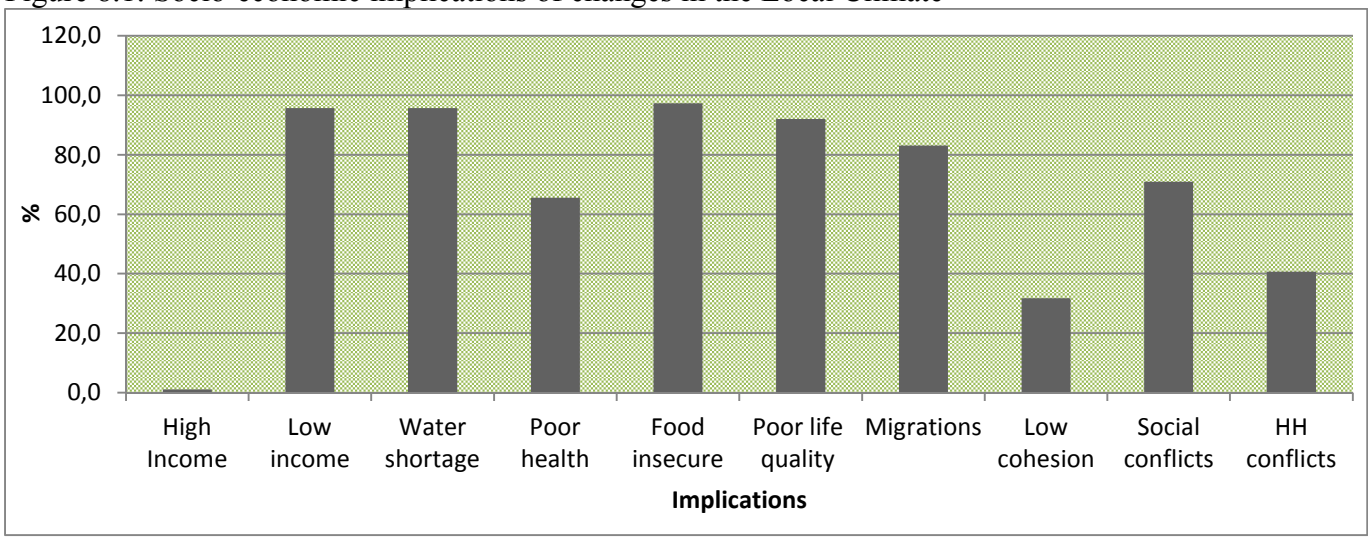
This chapter presents the identified socio-economic implications of perceived changes in the local climate changes, which influenced some changes in the farming practices by the smallholder farmers. The quantitative and qualitative data are presented reflecting what and how exactly farmers saw to be the effects of the perceived changes. The implications are for both household as well as community level.

8.2 The Implications

Results from analysis of questionnaire data showed that farmers have been experiencing negative consequences, in both social and economic aspects, as a result of the perceived changes in the local climate. Some changes motivated other subsequent changes in the farming practices by farmers. Such consequences were mostly reported to have been experienced at both household and community levels. The general portrayal of respondents' views seemed to be spread in almost all the implications. They are depicted in Figure 8.1.

From what is illustrated in Figure 8.1, household and community incomes, water availability, human health, food security, quality of life and social as well as family cohesion were all reported to have been negatively affected by the changes in local climate and subsequent changes in the farming practices in the area. However, in some of the implications, the level of effect differs across implications as well as at both village levels. The analysis informed that 95.8 percent of all the respondents viewed that such changes reduced incomes for both household and the communities. Likewise, 95.8 percent reported that the changes reduced water availability for both domestic and other uses in the area thereby affecting both households as well as the entire communities. Additionally, food security was also reported by 97.4 percent of the respondents to have been threatened as a result of the changes; quality of life to have been deteriorated (92.1%) but awareness on climate change and variability to have increased among smallholder farmers (78.3%). However, there was the report that social conflicts over diminishing resources such as water increased. This was reported by 70.9 percent of the respondents. In addition, it was noticeable even during interviews and the FGD. Other implications were increased rural-urban migrations especially among the youths, leaving behind the elders particularly during bad years, reported by 83.1 percent of the respondents. One can note that the increase in income as a result of the changes was supported by only 1.1 percent, indicating that it was insignificant and hence, it was dropped. Figure 8.1 is a summary of all results.

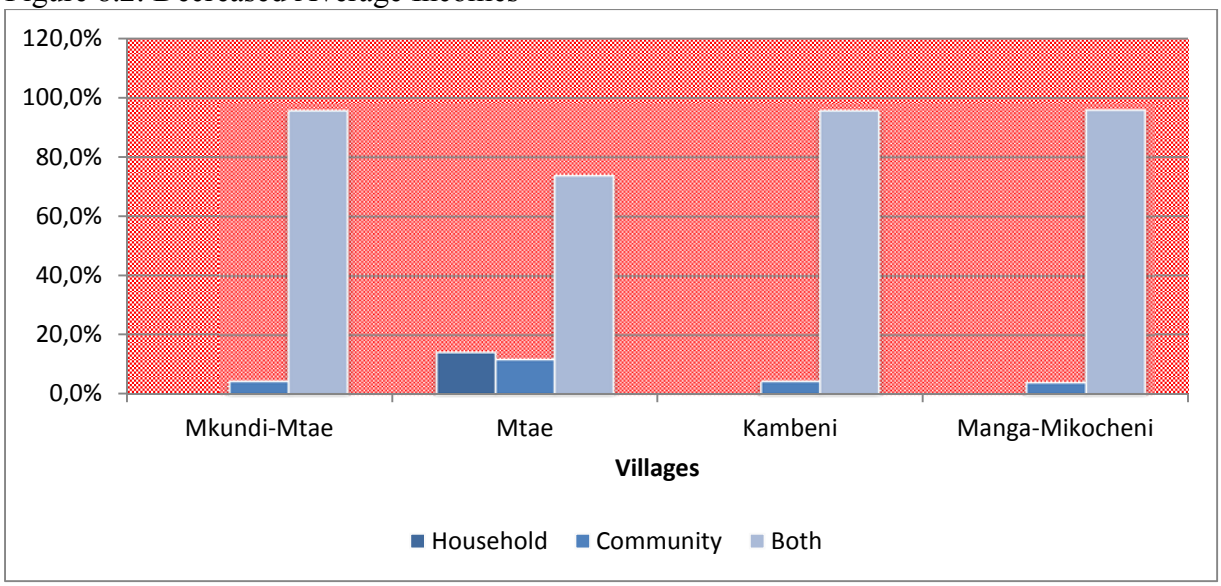
Figure 8.1: Socio-economic implications of changes in the Local Climate



Average annual income decreased/

On average annual income, 95.8 percent of the respondents agreed that one of the serious outcomes of the perceived changes in the local climate and subsequent changes in the farming practices was decrease in the average annual income. Likewise, 95.6 percent of the respondents from Mkundi, the same for Kambeni, 95.9 percent from Manga Mikocheni and 73.8 percent from Mtae were of the view that the implications on incomes were not only at household level but were felt at both the household and the community levels (Figure 8.2).

Figure 8.2: Decreased Average Incomes



It should be noted that despite taking part or engaging in other income generating activities, the main source of incomes for the smallholder farmers is crop production. Therefore, any shortcoming that negatively affects production levels in the farm in a particular season seriously and negatively affects farmers' incomes. If this happens to a village or community, it is translated to affect not only the household but also the community at large even though the intensity of effects may differ from one farmer to the other, depending on various other factors such as timing of planting, location of the farm, type and varieties of cultivated crops cultivated and the like. Some accounts from interviews and FGD were given to indicate that not only

quantitative but also qualitative data justify the effect of poor farm production on the household and community incomes. The accounts given by many interviewees, both villagers and experts illustrate how perceived changes in local climate and subsequent changes in farming practices affected incomes of the households and the community at large. The account by the Ward Councillor in Mtae village expounds what the farmers and villages experience:

> *"In the past, we had no problems with rainfall because it was enough and predictable. But starting from early 1990s to-date, we have been experiencing changes slowly. To-date, we do not receive predictable and enough rainfall in most seasons. This has affected not only farmers' incomes and food availability in their households but also the village government because we normally depend on contributions from villagers to accomplish various village projects. Farmers' incomes are going down. Imagine some of the farmers cannot even meet their household food requirements. Thus, it is very difficult for them to contribute to village development projects and as a leader you cannot even dare to ask for contributions in such a situation."* (Ward Councillor, Mtae).

In this quote, the Councillor expressed farmers' concerned by also insisting that the decrease in farmers' incomes has had broader effects to the village development. The effect is also felt by farmers who sometimes cannot access some important services like school for their children because they are unable to pay for school fees and school contributions. From the FDGs in Mkundi village, one farmer had this remark in responding to the questions about socio-economic implications resulting from the changes:

> *"Incomes are seriously affected also. We do not have enough money to take our children to school. For example, my two children have not been attending school because I failed to pay for school fees and school contributions. I have no money so I have nothing to do. Charcoal is supporting me just for food for my family."* (RM6, Mkundi, FGD).

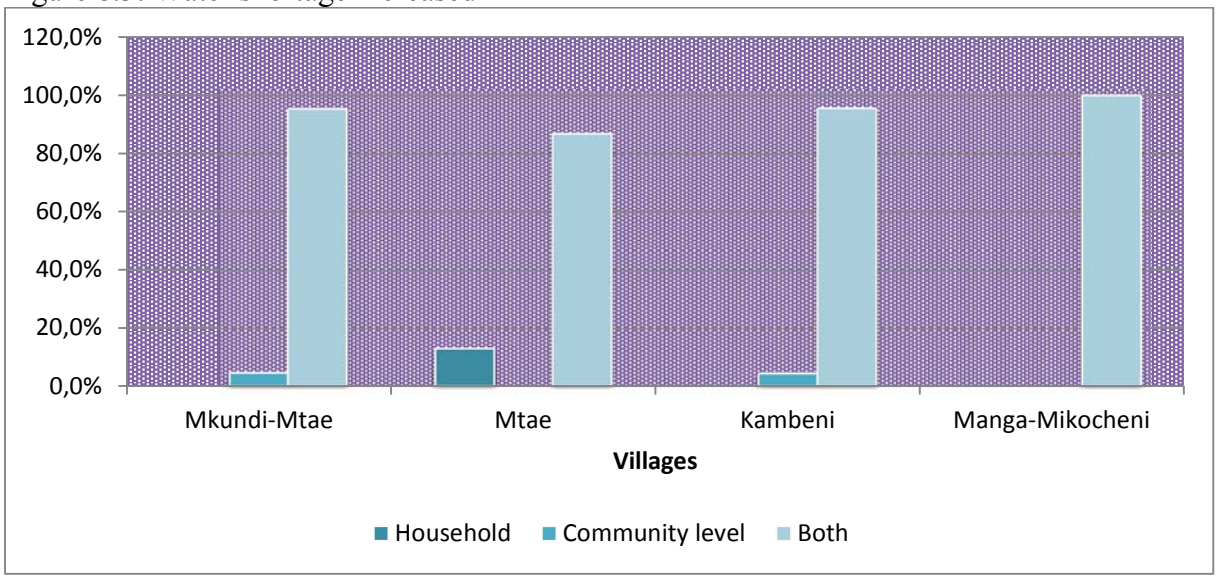
As part of the Secondary Education Development Program (SEDP), in the past few years, villages in Tanzania have embarked on construction of secondary schools through community contributions with the aim of expanding transition from primary education level to secondary education level. The programme has led to registration of many public secondary schools famously known as Ward Secondary schools (*Shule za Kata* in Kiswahili*)* in support of the government policy to make sure that all children eligible for secondary education can have access to such education. The government provided little funding but individual villagers and the community at large had to contribute. It implies that the better the incomes of the farmers, the faster accomplishment of village development projects because villagers had to contribute individually to the projects, and as community through mass work sessions such as in brick making and so forth. In addition to secondary schools, other contributions were also mentioned including school desks, and construction of toilets, dispensaries and the like. But the Ward Councillor's concern was that it is difficult for villagers who cannot feed themselves and their families to be able to contribute money for village development projects.

Increased Water Shortage

Water is an important resource for life. For Mkomazi valley, water availability is a critical issue because it determines not only the ability to fulfil domestic needs but also agricultural activities depend mostly on water availability for irrigation. Thus, it was important to know if there was any implication posed by the changes in the local climate as well as subsequent changes in the farming practices on availability of this important resource.

The analysis revealed concerns by many farmers that water availability was compromised so much by changes and variability in the local climate particularly increased recurrent dry spells. The farmers, leaders, experts and elders had serious concerns that the changes have had effects on rainfall thereby reducing even flow of rivers and streams some of which currently cannot flow annually. Such changes compelled many farmers to entirely depend on streams and thus, leading to increased demand for water abstraction, which, in turn, affects stream flows. This not only threatens to affect further farming activities but also natural flow and ecological functioning of the environment within Mkomazi sub-catchment and Pangani Water Basin. The reflection from these views are illustrated in Figure 8.3 indicating that 95.3 percent of respondents from Mkundi, 87.0 percent from Mtae, 95.6 percent from Kambeni and all (100.0%) from Manga Mikocheni shared a similar concern on this issue.

Figure 8.3: Water shortage increased



Accounts from both interviews and focus group discussions disclosed that for the past 30 years, farmers have increasingly been experiencing water shortage and the situation continues to worsen year after year. From the interviews and FGD, selected quotes illustrate this case. From the researcher's observation and findings from interviews as well as FGDs, it was apparent that Mkundi village is the mostly affected of all villages by water shortage for both domestic and other uses. The village leader had this to say,

> *"Generally speaking, water shortage is a serious problem here. There are occasions, particularly during serious droughts; people go without water for some days. We depend on water that flows from mountain slopes but during dry conditions, it does not flow on a regular basis. It becomes very scarce."* (Leader, Mkundi village).

One farmer had this to complement what the Leader said:

> *"Dry conditions accelerate water shortage. It is difficult to get water here especially during such months of the year. Women spend a day waiting in queues to get at least one bucket of water."* (RM9, Mkundi)

In Kambeni village, farmers also complained to have been experiencing water shortage as a result of the perceived changes in the local climate as it were accounted in the FGDs as follows:

> *"The serious problem here now is water shortage. Water is so scarce that sometimes people fight. Sometimes even those who supervise irrigation activities fail to manage the*

pressure. Therefore, water for irrigation is the most pressing challenge that will probably lead to conflict in the near future. As time goes on, rainfall becomes scarcer and so does water availability." (RK2, Kambeni).

The two accounts from focus group discussions stress the seriousness of water shortage and the implications on both household and community at large. It must be noted that much as water shortage might have affected all villages, Kambeni village remains somehow advantaged because the stream flowing down the mountains passes through this village. In due regard, famers are able to utilize water for irrigation. However, they complained that the flow has been decreasing year after year.

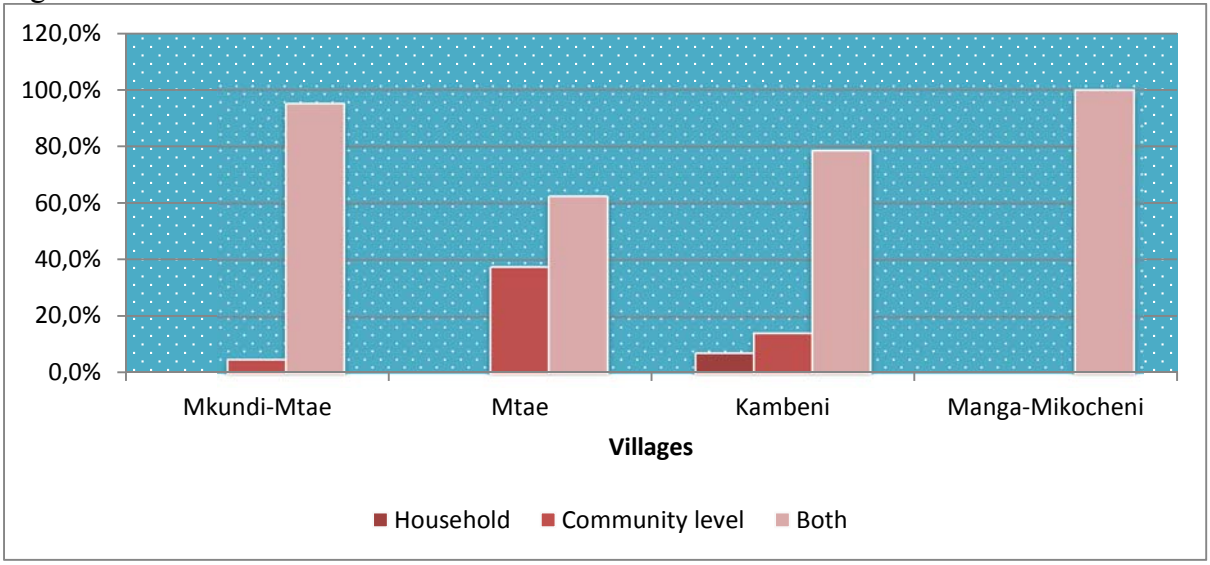
The perceived changes and variability in the local climate coupled with change from coffee to ginger cultivation were cited by some experts as contributing to the problem of water shortage in Kambeni and down the sub-catchment. This implies that much as there might be changes and variability in the local climate, some farming practices are also contributing to water shortage. Unsustainable irrigation of ginger upstream is one of the farming practices cited to be consuming a lot of water thereby affecting flow of water for downstream users as well as for ecological functions in the valley. For example, the representative of the Pangani Basin Water Officer insisted that ginger cultivation is unsustainably undertaken such that it contributes to severity of water shortage in the village as well as within the entire sub-catchment Mkomazi valley. The official had this to say,

"Ginger cultivation is also a challenge. It is a great challenge because a lot of water is used for irrigating even when it is ready for harvesting. Farmers continue to irrigate it while waiting for markets believing that with a lot of water it becomes heavy and therefore, one will fetch many kilogrammes during selling. Water flow is affected so much because of poor rainfall but the little available is unsustainably used for ginger cultivation."

Increased health threats

Health related consequences were also taken into account in this research. As part of the questionnaire, it was important for respondents to indicate whether or not the changes had health related implications. The results showed that farmers associated some changes in the local climate with an increase in some health threats. The health related indications identified by farmers were increased prevalence of malaria infection especially for Mtae and Kambeni villages located in the highlands. Farmers from these villages claimed that within the past 30 years, there has been an increase in malaria incidences than before. Other identified health problems were malnutrition and water borne diseases as a result of poor access to clean and safe water. In some villages, community members have poor access to clean and safe water thereby threatening spread of water borne diseases. In addition, poor production of food crops as a result of recurrent dry conditions is a serious challenge on availability of food in some households in these villages. Thus, such pattern threatened to intensify health problems, especially for women and children. Figure 8.4 illustrates.

Figure 8.4: Increased Health Threats



From the qualitative data, the threat to human health was one other negative implication of the perceived changes in the climate in all four sampled villages. As indicated before, most of what was cited in both interviews and the FGD was related to malaria infection. In addition, poor nutrition and water shortage were also identified as part of the problem, leading to health related consequences. Some selected quotes make a case in point.

> *"Malaria is another problem here. Long ago we never had malaria but now there are many cases in the dispensary and the government distributed mosquito nets recently. So this is another problem that we are facing."* (Leader, Mtae village).

Mtae village is located at 1550 masl in West Usambara (Notter, 2010). Elders claimed that the area used to be very cool (comparing to many other places in Tanzania) and there were no malaria cases in the village but the situation has now changed. This is claimed to be one of the negative implications of the changes in the local climate. Thus, spread of malaria in the highlands was the main health threat mostly noted by many of those who were interviewed and in the focus group discussions. However, as stated before, it is important to also take note of the water shortage and food insecurity as they have potential of causing many health problems as well.

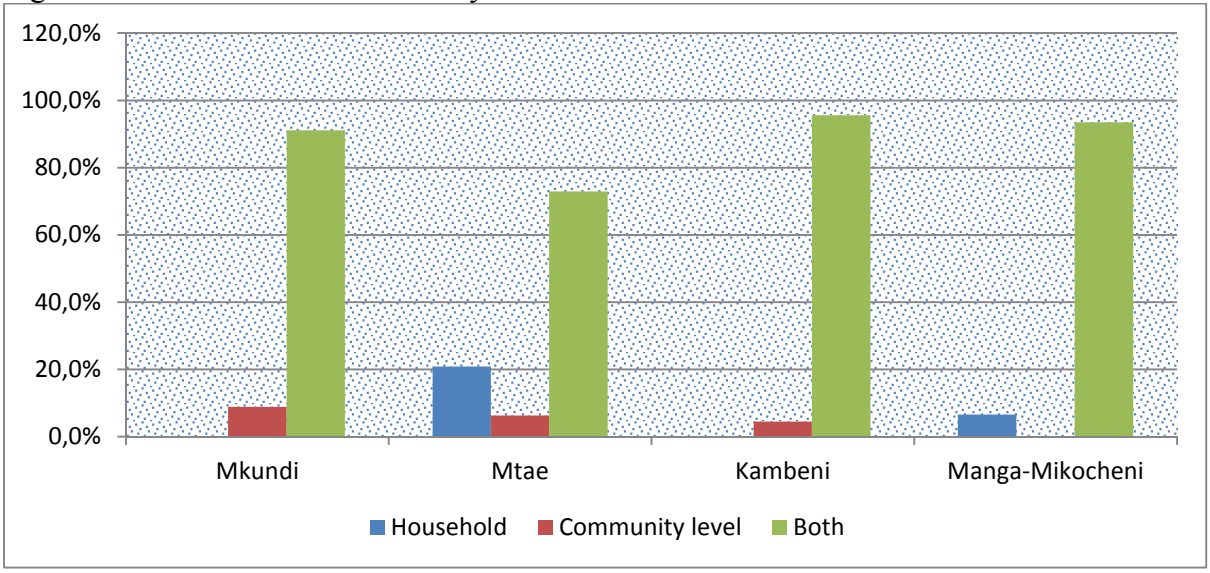
Food insecurity

Food security is critical for most smallholder rural communities in the developing world. It is because these communities do not have good means to produce enough food, which can support them the whole year around, and with excess. They are short of technologies inputs, services and skills (Fairtrade, 2013). Their production level is at small-scale and therefore, they have to struggle to produce every year and with crude farm technologies. Climate change and variability pose serious threats to food security in Africa specifically, to most smallholder farmers and poor rural communities (Fairtrade, 2013). In this study, farmers were also asked to indicate whether or not changes they perceived and experienced have threatened food security in their areas including food insecurity level.

The data indicated that farmers believed food insecurity has been increasing and the threats are further on the increase as well. As it is presented in the qualitative data through the questionnaire, farmers themselves raised their voices that they are now more threatened by

food insecurity than the past 30 years. Examples given by farmers involve frequent food aid provided by the government in two of the four villages as a result of crop failure. In due regard, it is an indicator that they experience food insecurity. Figure 8.5 illustrates that 91.1 percent of the respondents from Mkundi, 72.9 percent from Mtae, 95.6 percent from Kambeni and 93.5 percent from Manga Mikocheni were sure that unlike in the past, now they experience more food insecurity.

Figure 8.5: Increased Food Insecurity Threats



The problem of food insecurity for the four villages was also strongly accounted by farmers and leaders who took part in the interviews and FGDs. They disclosed that it was a serious issue especially for the two villages located in the lowlands, Mkundi and Manga Mikocheni. Some quotes are taken to make the case in point. The village leaders, district authorities as well as farmers clearly accounted that Mkundi and Manga villages have frequently been receiving food aid from the government as a result of crop failures in recent years. Below is an example,

> *"My son, you can see the situation for yourself. Household incomes have been seriously affected by the changes in climate because we cannot produce enough to satisfy our needs. Food insecurity is obvious because for the past 4 or five years, we have been receiving food aid from the Government. Such food aid is normally and always not enough. In most cases, it does not sustain our families. Besides, we feel humiliated as well for our families to depend on food aid while we can work and feed ourselves if there is available water for us to irrigate like our colleagues in Ndungu."* (Elder1, Mkundi village).

The seriousness of the problem is illustrated by the need for the government to support some of these villages, particularly Mkundi and Manga Mikocheni for food aid in some of the years for the past five years. This claim was justified by the village chairpersons of the two villages and the District Agricultural and Livestock Development Officer for Lushoto District as presented in the following two quotes.

> *"There is serious food shortage here as I have just told you. What we get from our small farms is normally insufficient for these years. It is for that reason this village has been receiving food aid from the government almost every year. We work in the farms but we do not get something enough for the families. Crop failure is common and for the past 5*

or six years, this village has been receiving food aid from the government due to prolonged drought." (Leader, Mkundi village).

The Lushoto district authorities confirmed that the problem of food shortage as a result of continued poor harvest exists not only in Mkundi village but also it exists in other parts of the district due to poor rainfall as the following quote illustrates:

> *"The other change that we experience in the district is on duration of the rains. Nowadays, they are normally very short. The result of all these is continued poor harvests in many parts of the district and in some of the villages like Mkundi, which you talked about. We have been giving them food aid almost every year, at least for the past five year. So this is the situation in a nutshell."* (Official, Lushoto District Council).

Much as Manga Mikocheni is downstream, the unreliability of rainfall puts the farmers in suspense because they have to either wait for the rainfall or for the Kalimawe Dam in Ndungu to be opened so that they can irrigate. In either case, rainfall is the determining factor because if there is no rain up in the highlands, the water in the Kalimawe dam becomes scarce and is used by the farmers in Ndungu and Kihurio to irrigate their rice farms, thus limiting access to it from the farmers down the valley in Manga Mikocheni. It is from this experience that they have now changed the type of maize and rice to cultivate from the longer cycle to shorter cycle and tolerant varieties to make sure that even with less water they can be able to get some harvest amidst this situation.

While changes in the local climate are the major concern by both the farmers, experts and authorities, the problem of land fragmentation alongside low productivity surfaces as one of the challenges contributing to food shortage because farmers have small pieces of land such that they cannot satisfy the family needs. Lushoto district is the one that is said to be highly affected by this problem The case the District Agricultural and Livestock Development Officer is making implies that much as the local climate is changing, availability of land for cultivation also poses a big challenge for the continued wellbeing of the farmers particularly in the villages located in the highlands like Mtae.

> *"…….. But these areas also have a number of other challenges one of which is population pressure leading to high land fragmentation."* Official, Lushoto District Council.

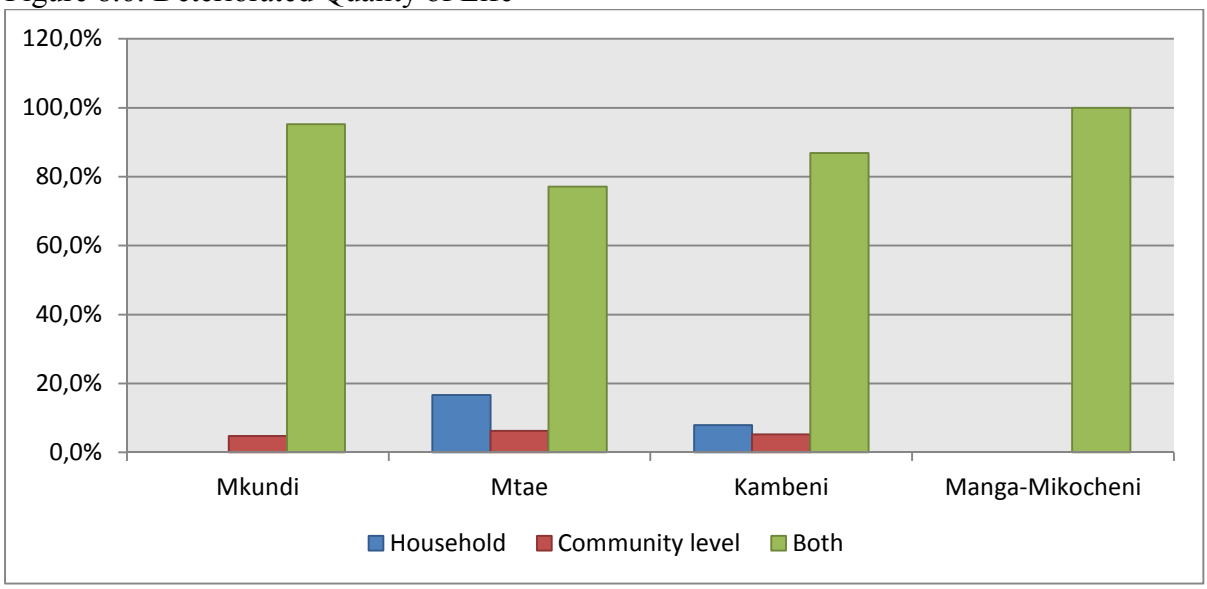
Deteriorating quality of life

Changes and variability of the local climate and subsequent changes in the farming practices may have positive or negative implication on the quality of life of the local communities which experience them. In this study, one other important aspect was to obtain data on whether the changes have had any impact on the quality of life of households and the community at large. Through the questionnaire, smallholder farmers were asked to judge if there has been any implication on their quality of life as a result of the changes they have undertaken in the farming practices and those changes they experience in the local climate.

The data indicated that 92% of the respondents believe their quality of life has deteriorated as a result of the changes. In addition, 82.5% had the view that the deterioration of the quality of life is for both the households as well as the community at large. The details at village level showed that 95.2% of the respondents in Mkundi, 77.1% of them in Mtae, 86.8% in Kambeni and 100.0% of those in Manga Mikocheni believed the changes have contributed to

deterioration in quality of life at both household and community levels as illustrated in Figure 8.6.

Figure 8.6: Deteriorated Quality of Life

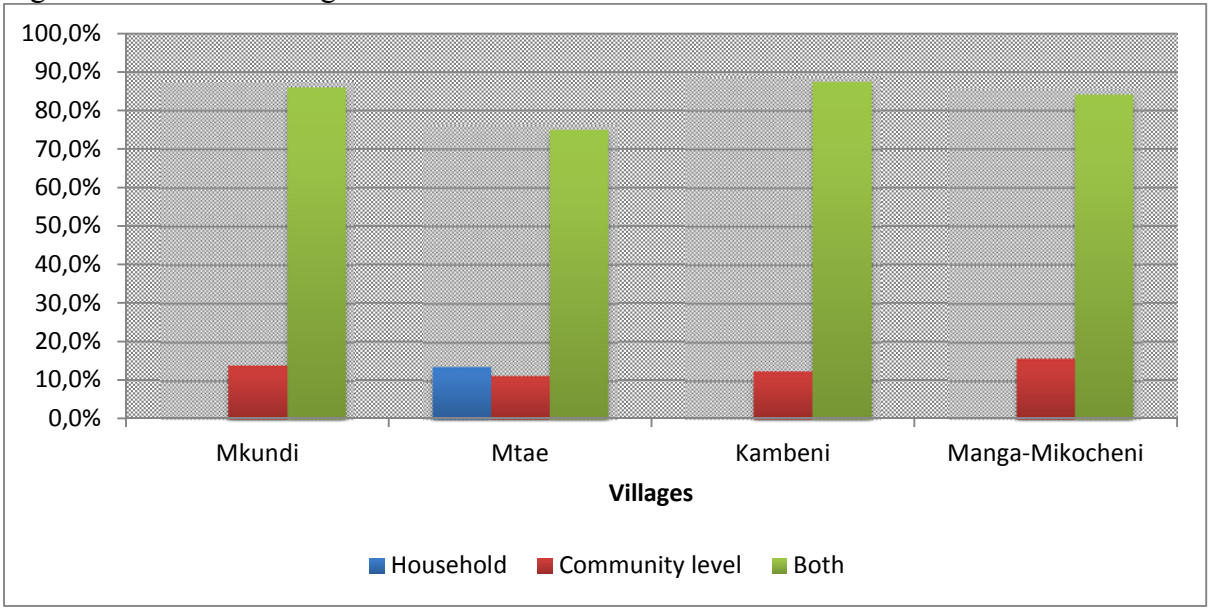


Increasing Rural urban migrations

Rural urban migrations in developing countries especially for youths are somewhat a common phenomenon. However, when life opportunities increasingly dwindle, it more creates motivation for high rate of exodus leaving behind the elderly, women and children. This has to some extent; some benefits particularly when those who move to urban centres get some jobs and can send some money back home (remittance). But it is not always the case especially when availability of jobs in the urban centres becomes a serious challenge for immigrants. In rural areas, the elderly and women are compelled to shoulder the roles of taking care of the family without their youths for that matter. This was the reason why it was necessary to ask the heads of households if the changes in the local climate and the farming practices have had implications on the rate of rural urban migrations.

Smallholder farmers agreed that there has been an increasing trend in the rural-urban migrations among the youths especially when there are frequent dry conditions because it normally leads to crop failure and the boys and girls find it hard to survive in the village and decide to go to towns. This too is an effect at both the household and community level. Some accounts are given in the interview results. However, few parents agree also that their children in the urban areas have at some points been so helpful in supporting them for food, clothing and other family needs. The role of remittance as an alternative income source was highlighted in the previous chapter especially for Kambeni, Manga and Mtae villages. But there are some parents who just complained that their children are not helpful at all and whenever the parents ask for money, they are told that their children have no money because they have no permanent jobs in towns and so life is hard even for them. Figure 8.7 illustrates farmers' views regarding this implication.

Figure 8.7: Increased Migrations

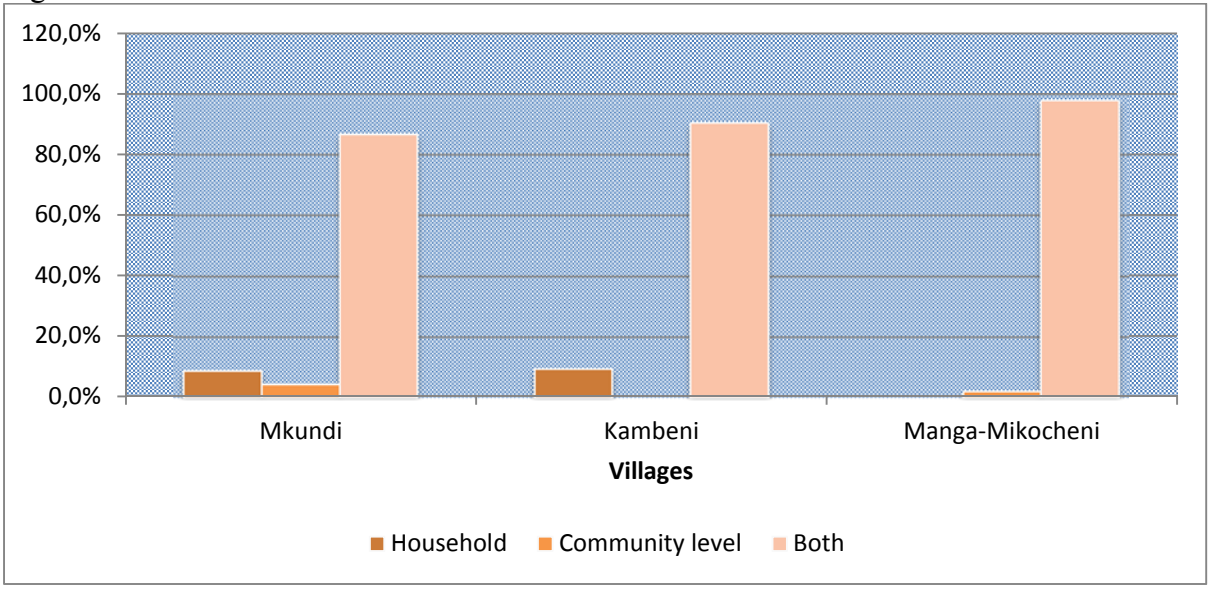


Social conflicts over diminishing resources

Diminishing resources normally fuels conflicts for the little available. In the context of the study area, the most critical resource for all is water and pasture because the communities have both smallholder farmers and pastoralists. Therefore, for them, availability of water and availability of pasture are two key elements that support life. It was thus of interest to identify if the changes in the local climate and the subsequent changes in the farming practices had an implication as a source of conflict in the society.

Both qualitative and quantitative data revealed some level of increase in social conflicts over diminishing resources. As illustrated in Figure 8.8, out of all four villages, one village (Mtae) did not report increase of social conflicts as an implication of the changes but the rest three reported this implication. For Mkundi, 87 of the farmers had the feeling that conflict increased at both household and community level, while in Kambeni the score was 90 percent and Manga Mikocheni village it was 98 percent. Figure 8.8 illustrates the details.

Figure 8.8: Increased Social Conflicts



During interviews and FGD, social conflicts featured as one other negative implication that came out strongly especially at Mkundi and Manga Mikocheni villages. While some conflicts over water for irrigation among farmers were reported in Kambeni, the village government informed the researcher that it formed a committee that manages irrigation activities to make sure that each of the farmers has access to water for irrigation. Smallholder farmers are allocated time to irrigate their farms so as to avoid conflicts. Therefore, much as some conflicts remain, at least the relevant authority took some steps to address them. Luckily, there are no pastoralists in these highlands. Animal keeping is at small scale and not a free grazing like in the lowlands. At Mkundi and Manga Mikocheni, the conflicts are more complex because they involve smallholder farmers and pastoralists. Some quotes can help to illustrate this fact. Mkundi is on the upper part of the valley just down the slopes of West Usambara, while Manga Mikocheni is on the lower part in the Southern part of the valley. The two villages have smallholder farmers and Maasai pastoralists. Conflicts that emerge in the areas are of two types: between farmers and pastoralists; and among farmers themselves. Serious social conflicts reported during interviews and FGDs were between farmers and pastoralists over water and land for grazing (on part of pastoralists) and cultivation (for farmers).

Detailed report of conflicts at Mkundi showed that two young men were killed by pastoralist Maasai. From the focus group discussion, the following quote puts it clear on severity of the conflicts in Mkundi.

> *"Two people have already died from these conflicts between Maasai and Sambaa in this village. Just ask the village leaders, they will tell you about this. So it is a serious conflict here."* (RM2, Mkundi, FGD).

The farmers justified in their accounts below:

> *"Conflicts between Maasai and Sambaa are very common here. Some people have even died. I recall two Sambaa young men were killed in the conflict between pastoralist Maasai and Sambaa farmers. The conflict is over water and pasture."* (Elder1, Mkundi village).

The village chairman in Mkundi clarified on existence of the conflicts by saying that:

> *"In many cases, we experience conflicts between farmers and the pastoralist Maasai who sometimes graze in the farms due to lack of pasture as a result of prolonged dry conditions."* (Leader, Mkundi village).

In Manga Mikocheni village, similar concern was also raised:

> *"Now we have many Maasai with their cattle here. So there are frequent conflicts between farmers and these pastoralists. During these times, they sometimes graze in our farms. There are also conflicts among farmers over water for irrigating the farms. This is because water is insufficient and so conflicts arise for many times."* (Elder, Manga Mikocheni village).

Village leaders in Mkundi confirmed the two deaths in their village. The conflicts were reported to be intensified by lack of serious policy, administrative and legal measures to address them. Farmers, for example, in Mkundi, complained that the village leadership has not done enough to address the conflicts but the village leaders also complained that the district authorities have not been doing enough to intervene. As a result, tensions are suppressed but the root causes of the problem are not addressed such that the possibility of the conflicts to continue is high.

As stated before, in Kambeni village, there were conflicts reported in the questionnaire. In the same token, interviewees and participants in FGDs reported that there were some conflicts among farmers over water for irrigation. But the village government had for the past few years, been instituting appropriate arrangements for farmers to share equitably the little water that

became available in order to reduce the possibility of conflicts to erupt. This was also justified by the Same district authorities by indicating that there were minor conflicts over water among farmers but the scale was very small and conflicts were dealt with by the village government.

> *"Also there are water conflicts among farmers in villages like Kambeni. But they are not very serious so to say. All these are due to water shortage as a result of continued poor rains."* (Official, Same District Council).

Deforestation and forest degradation

Changes in the local climate perceived by farmers were reported to be accelerating deforestation and forest degradation because available forests are used by farmers to support them for their subsistence and cash. That is particularly done during seasons when they experience poor harvests as a result of poor rainfall. Mkomazi Sub-catchment, as it is in other parts of country, experiences deforestation and forest degradation, particularly in Chome Forest Reserve (which is the source of most of the water flowing down South Pare Mountains). This form of harvesting forest resources is mostly a result of quest for economic gains through timber business. However, both deforestation and forest degradation are destructive to not only the environment but also to agricultural activities. The forest degradation by smallholder farmers was found to be mainly for subsistence through selling of charcoal and firewood. Apart from contributing to the changes in the local climate (on a long-term), this can lead to increased soil erosion which, coupled with changes and variability in the climate, may complicate the problem to an extent that farmers will face even a greater challenge. On the other hand, deforestation will continue to contribute to changes in the local climate and degrade water catchments, leading to poor water flow which will affect all forms of economic activities such as farming, pastoralism as well as the ecosystem functioning at large. All these accounts are exemplified in the following quotes.

> *"Deforestation in the Chome Forest reserve has a lot of consequences to the farmers and the environment as well."* (Official, PBWB).

On forest degradation, the chairman of Mkundi village had this to say:

> *"Forest degradation due to charcoal making as a result of prolonged drought is common in this village. Many people here have made charcoal their daily and dependable economic activity. They depend on charcoal making and selling labour in neighboring villages for income so as to buy food for their families."* (Leader, Mkundi village).

8.3 Discussions

Poor people and communities, worldwide, have always been closely dependent on the natural environment, mostly climate and the natural resources such as fertile land, water, forests and fisheries. While wealthy communities have capacity not to depend entirely on the natural environment for their daily livelihoods, the poor cannot and thus, are affected by such aspects like drought, floods, high temperatures and so forth (Wlokas, 2008). As described by Cornish (1998 cited in Morton, 2007), smallholder agriculture denotes a form of agriculture mostly found in developing countries, mainly dependent on family members as a source of labour, the farm as a main source of household income and conducted with little or no modern agricultural inputs. The immediate aim for this type of agriculture is household consumption although in some cases, little surplus might be available for the market. This form of agriculture is mostly dependent on nature, for example, favorable climatic conditions especially rainfall and fertile soils. For the smallholder farmers, climate is the main determinant of their fate because their farming activities are entirely dependent on what the climate offers to them. Smallholder

farmers have little to invest in modern agriculture with advanced technologies in the production process. For example, irrigation technologies would probably ensure continued production regardless of climatic changes. It is from this viewpoint that discussion is on socio-economic implications of the changes in the local climate farmers perceive, and the subsequent changes farmers have been making in their farming practices.

While this form of agriculture is the main source of income (Morton, 2007) and livelihoods for the rural households and communities in Mkomazi and elsewhere in Africa, it is very much vulnerable to climate change and variability. Changes in the climate, particularly rainfall is a blow for smallholder farmers who are yet to be fully supported by their governments to change from total reliance and dependence on rain-fed agriculture to somewhere in transition towards modern agriculture despite availability of many water sources both ground and surface water. Findings from this research regarding implications of the changes as identified by the farmers depict a clear situation of what is and will continue to happen as long as farmers experience more and more changes in the climate. Farmers already perceive changes in the local climate and the existing danger and danger will continue to create in their livelihoods in future. But it is probably still not so intense and that is the reason they still have options to change farming practices and engage in other income generating activities off the farm.

Decrease in income, increase in food insecurity, social conflicts as well as human health threats as reported in the study are just a few of the impacts of perceived changes in the climate. However, they may have far reaching implications beyond what farmers comprehend because as argued in preceding chapters, the same communities are experiencing poverty, malnutrition and diseases, which, integrated with climate change impacts on agriculture and food production, the result might be intensification of the existing stress (Morton, 2007). During interviews and FGD, farmers and other stakeholders argued that changes in the local climate have been affecting crop production and pose threats to livelihoods in many ways including health, food security, water availability, household incomes and the like. This might be correct given the situation portrayed by results. It should be also noted that other studies across the continent have been able to link climate change and variability with economic effects on agriculture (for example, Hassan and Nhemachena, 2008; Deressa, 2006; Molua, *et. al*., 2006; Mano and Nhemachena, 2006).

In this study, farmers reported that their incomes have been decreasing for the past thirty years because production in the farms has been decreasing as a result of frequent dry conditions affecting production in the farms. Decrease in rainfall was also blamed to be causing water shortage. Availability of water could have helped farmers irrigate as a counter measure to poor rainfall. Therefore, the changes in the local climate are believed by farmers to have been a reason for decrease in their average annual household incomes thereby affecting their livelihoods. This is similar to Teka and colleagues (2012) who in their study on the Impact of Climate Change on Smallholder Farming conducted in Eastern Tigray, Northern Ethiopia, found that there was a general perception among rural households that crop and livestock production as well as land productivity declined in the last 20 years. In addition, they (*ibid*.) reported that reduction was related to changes in rainfall. In the same study, it was found that rainfall was extremely unpredictable and erratic (*ibid*.). In other two studies in Ethiopia, NMSA (1996) and Tilahun (1999 cited in Teka, *et. al*., 2012); and Bewket and Conway (2007) it was found that there was a high percentage loss of yields particularly food crops. In some areas, loss was found to be as high as 50 percent due to perceived changes in the climate. Such situations are dangerous and threaten not only survival of many smallholder rural communities

but also constrain social and economic development while undermining efforts to reduce poverty.

Using a survey data of 700 smallholder farming households collected through interviews across Zimbabwe, Mano and Nhemachena (2006) employed a Ricardian approach to examine the economic impact of climate change on agriculture in Zimbabwe. The authors (*ibid*.) regressed net farm revenue against different climate, soil, hydrological and socio-economic variables to determine factors that influence variability in net farm revenues. They (*ibid*.) found that temperature and precipitation had significant effects on net farm revenues in Zimbabwe. Net farm revenues were found to be negatively affected by increases in temperature and were positively affected by increases in precipitation (*ibid*.). The results further indicated that agricultural production in Zimbabwe's smallholder farming system was significantly constrained by climatic factors, particularly high temperature and low rainfall *(ibid*.). These results provide evidence that even in the Mkomazi, increasing temperature and decreasing rainfall trends provide a signal on their economic effects to famers, particularly farm production. Much as the current study did not employ any econometric approach to statistically analyze the impacts of change and variability of the climate, the fact that long-term climate data show a decreasing trend for rainfall and an increasing trend for temperature provide evidence that the situation is not normal and some interventions are required before the situation gets worse.

Decrease in incomes for both households and community was reported in all villages but most strongly in Manga Mikocheni and Mkundi villages such that they threaten to retard village development efforts and even increase household poverty as well. This is because some farmers, particularly in Mkundi village, failed to pay for school fees and school contribution and hence, their children failed to attend school. That being the case, the benefits of education as a catalyst for socio-economic development may not be realized. Poverty and reduced incomes in households and community at large make some children not to attend school, rendering their families to continue living in poverty.

Apart from decrease in income for both households and communities, threats to food insecurity were also found to be an implication worrying smallholder farmers. Decrease in food crop yield as reported in the study by NMSA (1996) and Tilahun (1999 cited in Teka, *et. al.*, 2012); and Bewket and Conway (2007) and subsequent decrease in income both combine to increase threats on food availability and ability to access what is available. Similar findings were reported in a study by Acquah and Frempong (2011) conducted in Ghana on Farmers Perception of Impact of Climate Change on Food Crop Production in the Volta Region in which it was found that there was decrease in quality of crop yield, decline in crop yield and production as well as increased risk of food shortage among others. In addition, the study also found that 98 percent of the farmers perceived increase of weed and pest challenges. These findings are similar to results from the current study particularly on declining crop production and increased risk of food shortage. However, the decline in quality of crop, changes in land, soil and water quality, drying of seedling after germination and increase in weed and pest challenges were not part of the findings in the current study in the Mkomazi. But highlight severity of impacts of any changes in the climate to the smallholder farmers as they could be closely linked with the decrease in production, increased food insecurity, low incomes, increased in malnutrition and in the end, intensifying poverty.

Climate change is reported to affect social and environmental determinants of health, namely, clean air, safe drinking water, and sufficient food and secure shelter (Dekker, 2014). Thus, it

has a wide range of actual and potential impacts on health (Conway, 2009). Diseases such as diarrhoea, malnutrition, malaria and dengue are highly climate-sensitive (Dekker, 2014). Amidst health related stresses such as malaria, HIV/AIDS and malnutrition, smallholder farmers in Mkomazi believed that changes and variability in the local climate are accelerating health related threats. Climate change and variability were reported to have increased threats to human health for the past thirty years. This is through poor nutrition particularly for children and food shortage as a result of continued poor harvests. In due regard, smallholder farmers particularly in Mkundi and Manga villages get food aid from the government. Also there is inability to access good health services due to decrease in incomes as described by farmers and in some cases, water shortage for both domestic and other uses particularly for Mkundi village together with increase in highland malaria incidences for Kambeni and Mtae villages are all experienced problems by villagers. Such situation not only threatens to intensify poverty but also the existing health related stresses, which smallholder farmers are already struggling to address.

In their study, which aimed at quantifying the impact of variations in precipitation and temperature on regional prevalence of diarrhea in children under the age of three in Sub-Saharan Africa, Bandyopadhyay and colleagues (2012) collected demographic and Health Survey data for the regions of 14 Sub-Saharan African countries. They were matched at fine resolution with climate data from the Africa Rainfall and Temperature Evaluation System for the period between 1992 and 2001 (*ibid*.). They (*ibid.*) found that shortage of rainfall in the dry season increased prevalence of diarrhea across Sub-Saharan Africa. In addition, they (*ibid*.) found that an increase in monthly average maximum temperature raised the prevalence of diarrhea, while an increase in monthly minimum temperature reduced diarrheal illness. While the mentioned study concentrated on diarrhea, the increasing trends of temperature for both long- and short- rainfall seasons and decreasing trend of rainfall in all three stations, which were part of the current study in Mkomazi might be highlighting the possibility of some other health related implications on top of what farmers reported. The other study with similar findings on the possibility of increased incidences of highland malaria is that by Siraj and co-workers (2014) who used spatiotemporal data in highlands of Colombia and Ethiopia to examine how the spatial distribution of the disease changes with inter-annual variability of temperature. In the study, they (*ibid*.) found that there was evidence for an increase in distribution of malaria over high altitudes in warmer years. While the current study in Mkomazi did not base on the impacts of climate change on health, and neither did it go into details to include other necessary variables such as humidity, land use pattern and land cover as in Chen, *et. al*., (2006) into the analysis, these results have to be an alarm on possible consequences of increased malaria incidences in the highlands of East Africa including those of South Pare and West Usambara in Tanzania.

Smallholder farmers attributed the existing conflicts between farmers and pastoralists as well as among farmers to shortage of water and pasture. Water shortage, on the other hand, was attributed to changes in the local climate observed by farmers have within the past 30 years. While such conflicts were reported in Mkundi, Manga Mikocheni and Kambeni villages, serious cases were found in Mkundi village where Maasai pastoralists and Sambaa farmers are in conflict over water grazing areas. The main source of conflict in the village between the two groups was reported to be tendency for Maasai pastoralists to leave their cattle grazing in lablab farms due to lack of pasture as a result of poor rainfall. Lablab can tolerate harsh climatic conditions, stays green even during very dry conditions and is believed to form a very good source of fodder (Murphy and Colucci, 1999).

> *"Lablab is tolerant to drought conditions. It needs rainfall or irrigation (minimum of 10 to 20 mm) during germination and early establishment, although once established, it is extremely resistant to drought. It often stays green during the dry season."* (Murphy and Colucci, 1999).

In a report on prevalent conflicts between farmers and pastoralists in Kilosa, Tanzania for example, a team of experts had this to say about causes of frequent clashes between farmers and pastoralists in the district:

> *"Tensions between pastoralists and peasants are high during the dry season as both groups depend on one source for both pastures and water and for the peasants the valleys are suitable for irrigation and dry season farming. This is one of the major factors for the clashes in many areas in the district. Pastoralists from various parts move in Morogoro region and its districts which are endowed with rivers that flow throughout the season. As competition between them intensifies clashes over resource use are inevitable."* (Baha, *et. al*., 2008).

Apart from pasture and water, it is also necessary to note that in the villages, farmers and pastoralists share the same land with very clearly demarcated boundaries because there are no village land use plans indicating all land uses including farming and grazing. This is a common case in almost all villages in Tanzania because almost all villages lack land use plans. According to various reports, this situation is not only found in Mkomazi but also in other areas such as Kilombero valley, Kilosa in Morogoro region and Rufiji river valley in Coast region in Tanzania (e.g. Makoye; Semberya, 2014). The report by Baha and colleagues (2008) informed also that lack of land plans was one among factors that led to escalation of conflicts between farmers and pastoralists in Kilosa. Thus, in addition to perceived changes in the climate, poor land use planning is also another factor, which should be taken into account in this case.

From the district authorities' point of view, apart from being climate change motivated, the conflicts are also due to lack of land use plans and low carrying capacity of livestock. As explained in the previous paragraphs, the district authorities reported that there are no village landuse plans, which demarcate land according to different land use patterns. This causes farmers and pastoralists at some point, to share the same land with each group claiming ownership. This at the end leads to conflicts between the two groups and during bad years, pastures and water are scarce and dry seasons, pastoralists graze in farms owned by farmers thereby escalating the conflicts. On the second one, it is clear that pastoralists own bigger herds of cattle beyond the normal carrying capacity in the area (Lushoto District Council Personal communication, 2012). While the national population density is 51persons per kilometer square (persons//km^2) and the regional is 77persons/km.^{2,} Usambara Mountains were reported to be among the densely populated areas with a population density of 312.6/km^2 (URT, 2013a). According to the district authorities (Personal communication), this has led to high rate of land fragmentation and it is even more difficult to accommodate bigger herds of cattle within the lowlands amidst such situation. Thus, such pattern fuels endless conflicts between pastoralists and farmers particularly in areas, which have potential for pasture and water. The situation is further compounded by the decreasing rainfall thereby increasing water scarcity and lack of pasture.

While climate change and variability are intensifying the impacts on agriculture and rural livelihoods in Africa, their effects are part and parcel of other existing non-climate stressors (Morton, 2007). Prevalence of diseases such as HIV and Malaria together with malnutrition;

environmental degradation; increasing population; and continued dependence on traditional farming systems are just a few challenges stressing farmers in rural areas like in the Mkomazi. Thus, Climate change and variability integrate into such complexity of stressors to intensify hardships compelling smallholder farmers to endure. Much as the farmers possess experiences and knowledge to adapt, climate change and variability impacts to smallholder agriculture will probably intensify to such an extent that they can slowly reduce the capacity of farmers to withstand.

Poor production from the farm as a result of perceived changes in the climate diminishes incomes for households thereby opening up other livelihood options some of which are from the environment such as forests, wildlife and so forth. Excessive dependence and use of forests seems to accelerate environmental degradation thereby threatening sustainability and potentially intensifying poverty in the area. Continued dependence on charcoal and firewood for farmers particularly in Mkundi and Manga Mikocheni villages during prolonged dry conditions accelerates forest degradation in the area, rendering soils bare and thus, leads to soil erosion. Illegal harvesting of forests and forest products in Chome Forest Research, a major source of rivers contributing water to the Mkomazi River, were reported to contribute to environmental degradation. While perceived changes in the local climate contribute to degradation of forests, poor coordination and weak enforcement of environmental as well as water resources management laws are other aspects that need to be taken into consideration in explaining the real cause for accelerated environmental degradation in the area. Coordination between and among stakeholders together with institutions mandated to manage the environment, forestry, water resources, land and fisheries is also another issue to take into account. It can be a clear bottleneck towards sustainable management and utilization of these resources and hence, contribute significantly to degradation of the environment and conflicts over diminishing resources.

From the findings, several issues emerge regarding the socio-economic implications of the changes that were identified by the farmers. First of all, villages located in the highlands have not suffered much from the perceived changes in the local climate as compared to those in the lowlands. Secondly, decrease in incomes for both households and community is affecting development pace and probably threatening to retard poverty reduction efforts in these villages; third, social conflicts between farmers and pastoralists are much more pronounced and evident in the lowlands where pastoralist Maasai are based and depend on grazing; and lastly, much as the two villages in the lowlands share similar concerns on water stress, Mkundi village is more affected and vulnerable than Manga Mikocheni.

The findings on socio-economic implications on changes in the local climate revealed that all four villages have been affected but the level of effects is not similar. This is because the location of the village within the valley was found to be a determining factor for access to water for irrigation, which is dependable by the farmers within the valley for their livelihoods. The two villages in the highlands (Kambeni in South Pare Mountains and Mtae in West Usambara Mountains) have access to some water, which helps them to undertake small-scale irrigation even during bad years/seasons (even though they also become constrained in such situations). Kambeni depends mostly on flow of streams while the case of Mtae is different because many farmers who undertake small scale irrigation use tap water. It means that much as the village undertakes small scale irrigation, not all farmers have access to tap water for irrigation. Manga Mikocheni village also has an opportunity to undertake irrigation but mostly depending on whether or not water is abundant in the Kalimawe dam. If in any case the dam does not contain enough water, farmers in Manga Mikocheni will have no access to water for irrigation. Of all

the four villages, Mkundi is the only one totally disadvantaged because it has no any source of water for undertaking irrigation. It is clear from the data and observation that the village is the most stressed in terms of water access. This village not only suffers from lack of water for irrigation but also for domestic use. The villagers reported to suffer most especially during bad years. It is from such reasons that the village now depends mostly on lablab cultivation (amidst Maasai cattle grazing in their farms) and food aid from the government.

8.4 Summary

In this chapter, there are presentations and discussion on socio-economic implications of the changes in the local climate and consequent changes in the farming practices in the research area. From the data, it is clear from both qualitative and quantitative data that the changes have had more negative implications than positive ones. Poor harvests have negative effects on food availability and malaria infection was reported to have increased especially in the highlands. In addition, malnutrition and water borne diseases were also highlighted as implications resulting from food insecurity and poor water availability, respectively. In some villages, conflicts between different resource user groups were reported to have claimed some lives of people, which are a bad signs for future if these changes continue and there is lack of support for the resource users to adapt. The implications have not only been felt at the household level but also community level. The negative implications on incomes, health, food security, water availability and access and social conflicts have in totality affected life quality of not only the households and the community in general.

It is necessary to say that in Kambeni village, the change from coffee to ginger cultivation and access to water for irrigation has had positive implications to many particularly on incomes thereby improving people's livelihoods even though ginger markets in some of the seasons fluctuate. Continued use of charcoal as an alternative income generating activity by farmers as a result of frequent poor harvests in Mkundi puts more pressure on forests. It is likely that in the near future, farmers will suffer further as a result of consequences of continued deforestation and forest degradation.

The next Chapter presents analyses and discussion the strategic and policy interventions to support smallholder farmers so as to enhance their adaptive capacity and long-term resilience to changes in the climate.

CHAPTER NINE: POLICY AND STRATEGIC INTERVENTIONS TO ENHANCE ADAPTIVE CAPACITY AND LONG TERM RESILIENCE

9.1 Introduction

This chapter presents both near future coping up strategies and adaptation options as well as potential long-term policy and strategic actions, which, according to smallholder farmers' knowledge and experiences, if implemented, will support them to enhance their adaptive capacity and long-term resilience to adverse impacts of global climate change and variability. There is differentiation of coping from adaptation. In the context of climate variability and change, coping refers to use of accessible skills, resources and opportunities to address, manage, and overcome adverse conditions so as to achieve short-term and medium-term necessities (IPCC, 2012b). Adaptation is more focused on adjustment to actual or potential climate and its impacts so as to reduce harm or exploit possible opportunities arising from the changes (*ibid*.). From the two definitions, coping is seen to mainly be short-term and medium-term endeavor while adaptation focuses on long-term results. Dazé and colleagues (2009: 7) provide a list of characteristics compiled from brainstorming sessions by groups of development practitioners in different countries. While some items might be debated, they at least provide an opportunity to try to comprehend how these terms differ in practical terms.

In the current study, near future coping and adaptation options are defined as interventions undertaken by smallholder farmers, may be with little or no support from governmental and non-governmental actors without necessarily requiring policy changes. But long-term strategic and policy interventions are much broader adaptation strategies and policies, which might require some policy decisions and investment. Whereas for near future adaptation options the data are only quantitative, on the potential long-term strategic and policy interventions they are both quantitative and qualitative.

9.2 Near Future Coping/Adaptation Options

The analysis of quantitative data identified four main options each of which had a score of well over 50 Percent as follows: continue changing agricultural practices in line with the changes in the local climate (67.7%); ask for food aid (82.6%); ask for government support such as ensuring access to water for irrigation (72.9%); and seek to obtain more information, knowledge and education on adaptation to climate change (59.4%). The remaining four had an overall score below 50 percent each (Figure 9.1 depicts the results in detail).

Figure 9.1: Coping/Adaptation Strategies if changes continue

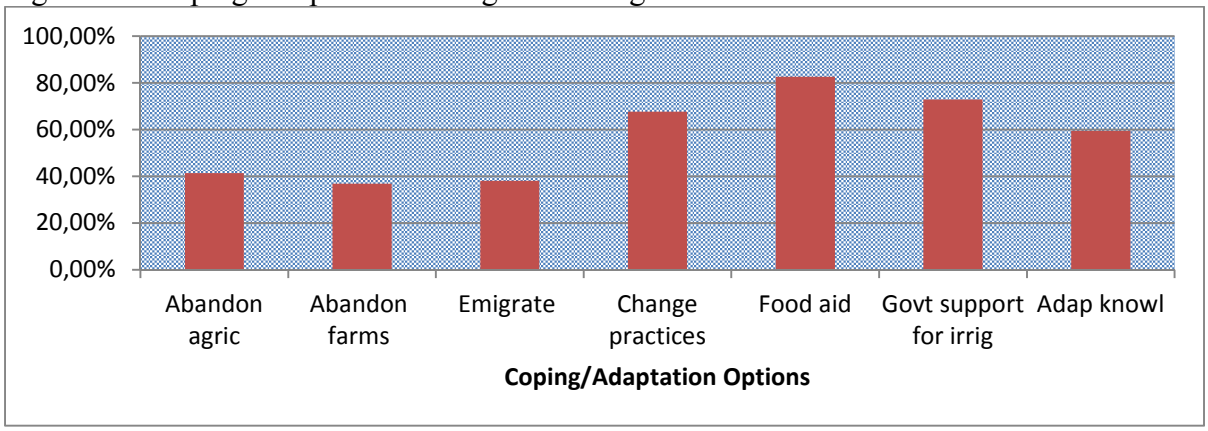
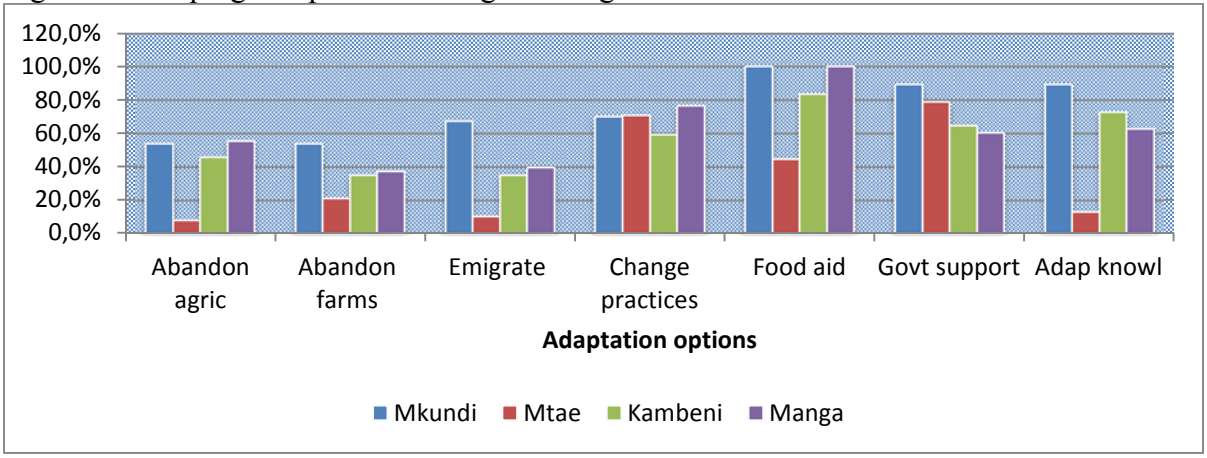


Figure 9.2: Coping/Adaptation Strategies-village level



For comparing results, the three high ranking options for each of the four villages are selected and graphically illustrated. The illustration shows that much as slight variations exist, there is a reflection of similarity in terms of choices of possible options among villages (Figure 9.3). Whereas in Kambeni village the best three options were to ask for food aid, seek to obtain more knowledge, education and information on adaptation and ask for more government support on adaptation; in Mtae village, farmers felt that they had to the following: to ask for more government support for enhanced adaptation through such measures so as to ensure access of water for irrigation, continue changing farming practices further in line with changes in the local climate and ask for food aid. In Manga Mikocheni village, their best three options are: ask for food aid, continue changing farming practices in line with the changes in the local climate and seek for more information, knowledge and education regarding how to adapt. In Mkundi village, their three best options were the following: ask for food aid, ask for more government support for example in looking for alternatives to use ground water for irrigation, seek for more information, knowledge and education regarding how to adapt and look for alternatives to use ground water for irrigation. So looking at the four villages, asking for food aid, and more government support are the cross-cutting and most preferred two best options. Continue changing farming practices in line with changes in the local climate looks to be a more preferred option for Mtae and Kambeni villages while seeking for more information, knowledge and education on adaptation options is a preference for Manga Mikocheni village. In addition, the possibility for use of ground water for irrigation is more an option for Mkundi village only. Figures 9.3a-d summarizes the views on options for each of the four villages.

Figure 9.3: Three High Ranking near future coping/adaptation options for each village

Figure 9.3a: Coping/adaptation options-Mkundi

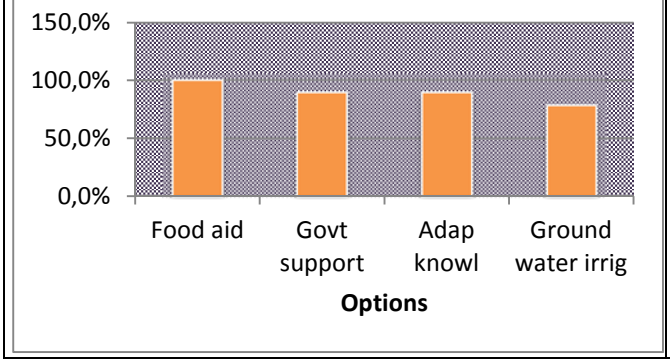


Figure 9.3b: Coping/adaptation options-Mtae

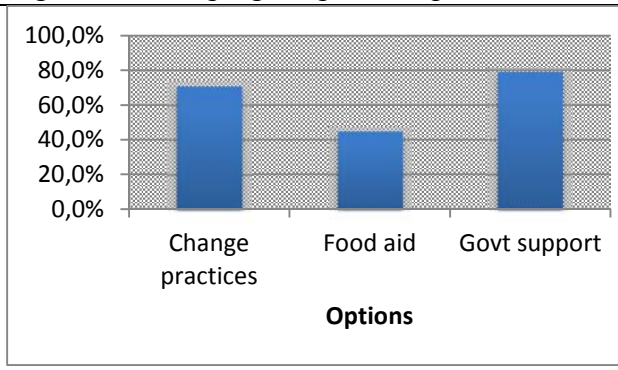


Figure 9.3c: Coping/adaptation options-Kambeni

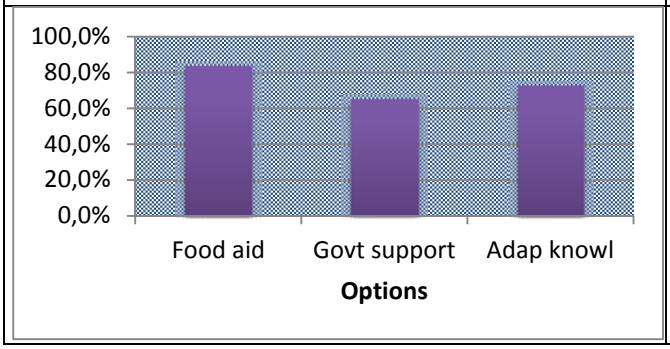
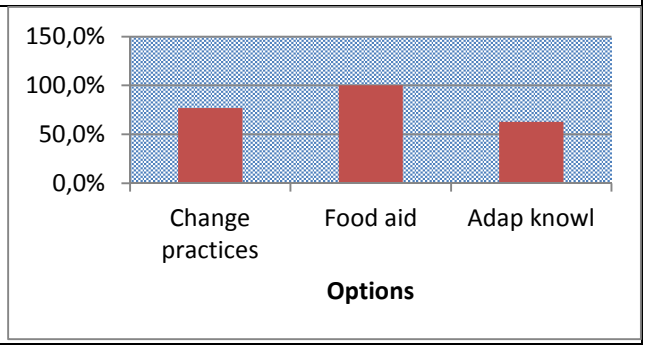


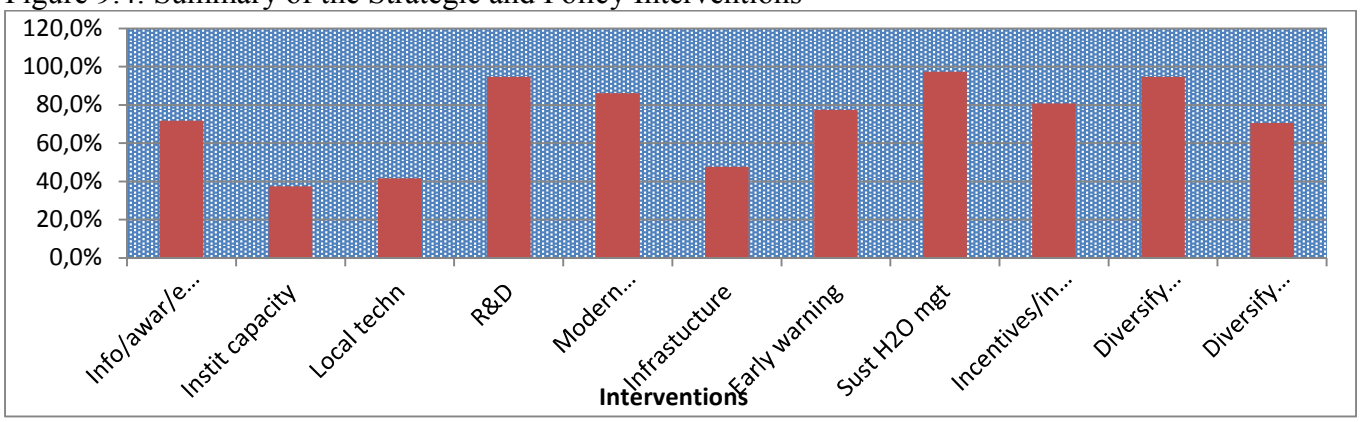
Figure 9.3d: Coping/adaptation options-Manga



9.3 Potential long-term policy and Strategic Interventions

From the questionnaire, results indicated that out of all eleven potential interventions in the list, eight were agreed by the respondents by more than 70 percent for each one as appropriate policy and strategic interventions while the remaining three had a score below 50 percent each. It means that smallholder farmers believed those eight to be appropriate interventions to not only support to enhance their adaptive capacity but also building their long term resilience to adverse impacts of climate change in the future. Figure 9.4 presents summary of results indicating percentage score for each of the interventions, those with the least score as well as those with the most score.

Figure 9.4: Summary of the Strategic and Policy Interventions



The analysis further showed that 97.3 percent respondents identified developing and strengthening water management innovations to address the risk of moisture deficiencies and increasing drought as an appropriate policy and strategic intervention in the area. The intervention was mostly selected one by farmers indicating the role of availability of water for livelihoods support in Mkomazi sub-catchment. The next, according to farmers' preference included research, develop and introduce new crop varieties to increase tolerance of crops to changes in rainfall and temperature regimes with score of 94.7 percent. At the same level of percentage, farmers identified support for diversification of crop production as another important policy and strategic intervention. In addition, the need for support to farmers in terms of modern irrigation and appropriate adaptation technologies clearly raised as stated by 86.1 percent of all farmers who identified it as another appropriate intervention for their struggle to cope with changing climatic conditions. The other interventions with 70 percent and above (their respective percentages in brackets) included the following: introduce and/or improve access to subsidies, incentives and crop insurance provisions to support farmers to adapt

(80.7%); develop and/or strengthen early warning systems for timely weather predictions, forecasts and their dissemination (77.5%); enhance adaptive capacity through information, awareness and education (71.7%); and diversification of animal husbandry (70.6%). Figure 9.4 illustrates all results from the questionnaire including the remaining three interventions with below 50 percent score. Table 9.1 provides details on results at village level.

Table 9.1: Summary of results depicting score of each intervention at each village

Interventions	**Villages (%)**			
	Mkundi	Mtae	Kambeni	Manga
Enhance adaptive capacity through information, awareness and education	68.9	87.5	71.4	59.2
Improve institutional capacity, effectiveness and efficiency	68.9	4.2	40.0	38.8
Use and disseminate appropriate local adaptation experiences and knowledge	68.9	45.8	24.4	28.6
Research, develop and introduce new crop varieties to increase the tolerance to changes in rainfall and temperature regimes	100	100.0	84.4	93.9
Provide support for modern irrigation and adaptation related technologies	95.6	66.7	91.1	91.8
Improve infrastructures, post-harvest support and support for agro industries	55.6	58.3	35.6	40.8
Develop and/or strengthen early warning systems for timely weather predictions, forecasts and their dissemination	95.6	41.7	80.0	93.9
Develop and strengthen sustainable water management innovations to address the risk of moisture deficiencies and increasing frequency of droughts	100	93.8	100.0	95.9
Introduce and/or improve access to subsidies, incentives and crop insurance provisions to support farmers to adapt	93.3	56.3	93.3	81.6
Support diversification of crop production	100	95.8	97.8	85.7
Support diversification of animal husbandry	75.6	62.5	68.9	75.5

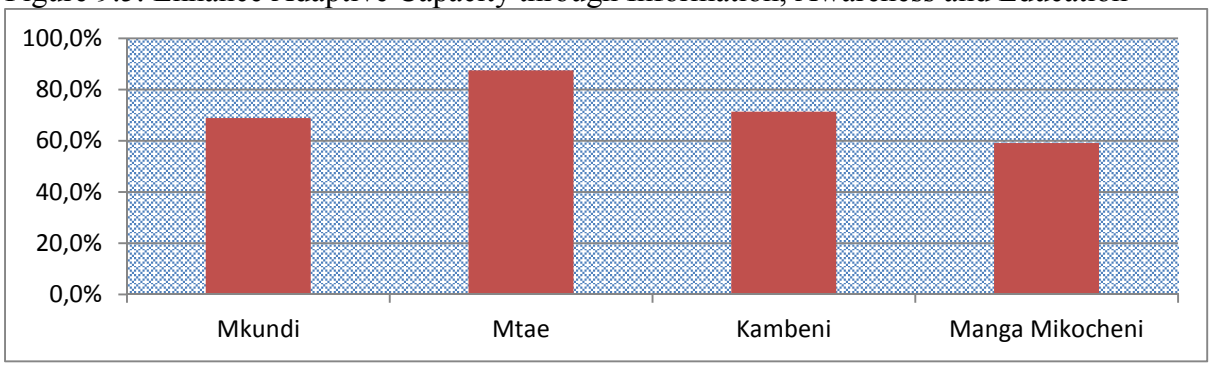
Enhancing Adaptive capacity through Information, Awareness and Education

Adaptive capacity is one of the essential components and prerequisite for effective adaptation actions including resilience of a community to climate change impacts. One of the potential means to improve adaptive capacity is enhancing knowledge through education, training and information access (Smit and Wandel, 2006), which helps to raise awareness (Hinkel, 2011). High level of awareness on climate change and its impacts can make it possible for individuals and communities to take actions towards adaptation. This is possible if there is information sharing and high level of access to important information on climate change, impacts, adaptation potentials and options as well as what is appropriate for their context.

It is interesting to find that 71.7 percent of the respondents identified information access, awareness and education as important aspects that can support them to enhance their adaptive capacity and long-term resilience to adverse impacts of climate change. At village level, slightly similar results were found as follows: 68.9 percent of farmers in Mkundi, 87.5 percent in Mtae, 71.4 percent in Kambeni and 59.2 percent in Manga Mikocheni villages. They supported that information access; awareness creation and education are necessary in enhancing their adaptive capacity and should be considered as appropriate intervention in that regard. This finding is similar to Hassan and Nhemachena (2008) who in their study on

determinants of African farmers' strategies for adapting to climate change concluded that for enhancing adaptation among farmers in Africa, particularly those experiencing drought, government policies and strategies must support them in among others, education, markets, credit and information. Figure 9.5 illustrates these results graphically.

Figure 9.5: Enhance Adaptive Capacity through Information, Awareness and Education

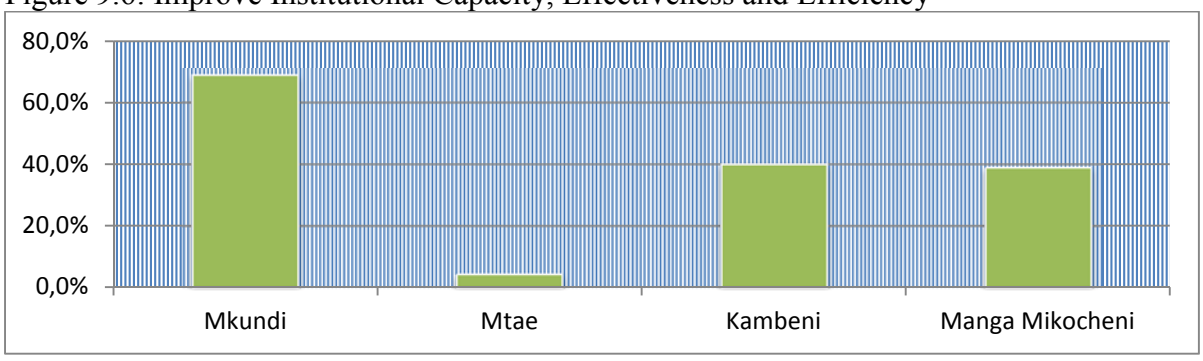


Improve Institutional Capacity, Effectiveness and Efficiency

Availability of resources for adaptation is an element essential but institutional and individual capacities to manage and execute adaptation interventions are very necessary to ensure there is success in the adaptation process. Institutional capacity, however, is much more important in not only managing the resources and making sure that they are accessible to those in need but also in planning, assessing the magnitude, severity of impacts, supervising the process and evaluating the implementation. In the context of this research, capacity of both government and non-governmental actors and institutions in supporting smallholder farmers to adapt to adverse impacts of climate change in Mkomazi sub-catchment was of paramount importance.

The data, however, indicated diversity in terms of priority by farmers as far as this variable is concerned. The overall percentage of those respondents who agreed that this is an important policy and strategic intervention stands at only 37.4 percent and 62.6 percent rejecting it. This might mean that farmers were unable to associate institutional capacity with their adaptive capacity. However, at village level, 69 percent of all the respondents in Mkundi village agreed that this is an appropriate intervention and can enhance their adaptive capacity, while only 4.2 percent of all the respondents in Mtae village shared this view. Kambeni and Manga Mikocheni villages held a similar view with 40 percent of respondents in Kambeni and 38.8 percent in Manga Mikocheni agreed that it is an appropriate potential policy and strategic adaptation intervention. The results are illustrated in Figure 9.6.

Figure 9.6: Improve Institutional Capacity, Effectiveness and Efficiency



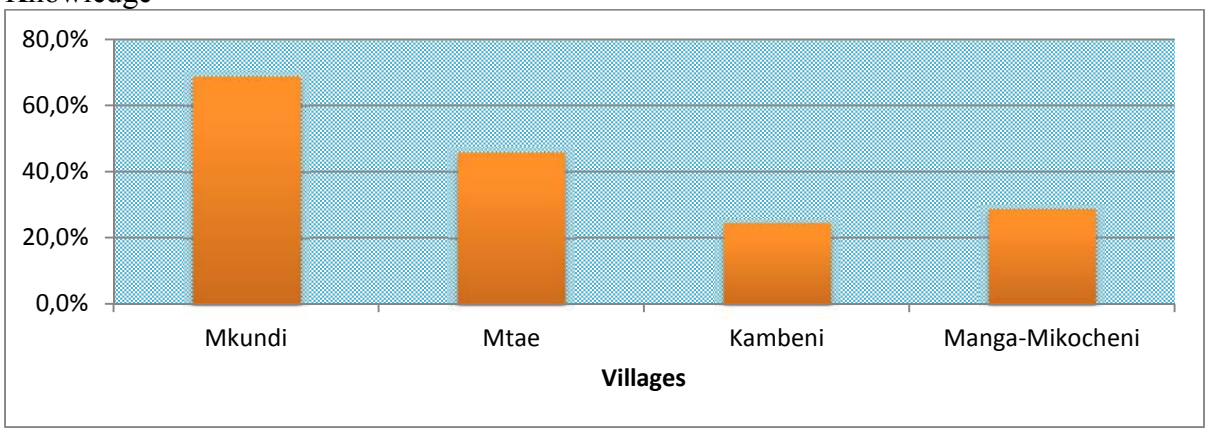
In Figure 9.6, it can be noted that in Mtae village, farmers did not take institutional capacity as a priority intervention, which can help them enhance their adaptive capacity. One explanation of the situation might be that for many years smallholder farmers have been so independent. They had had little support from the government such that their level of production has mainly been dependent on their own ingenuity. Hence, they may not realize the real role of capable institutions in helping them to enhance their adaptive capacity. For over 50 years, little has been done to support them transform technologically so as to increase their production and change their lives. In most cases, smallholder farmers have received little attention much as their contribution to food security and national economy is cited. For example, in Manga Mikocheni, Mtae and Mkundi villages, the researcher was unable to interview extension staff because they were not there. In Tanzania at the moment of undertaking this study, the extension experts were based at ward level. This means that one expert is allocated several villages to provide service too. Apart from that, the expert was supposed to provide service to both animal keepers and crop producers in all the villages he/she is allocated to work. However, during the time this research was conducted, Mtae ward (where Mtae village belongs), Mkomazi ward (in which Manga Mikocheni village is part of) and Mnazi ward (where Mkundi village belongs) had no extension staff. Smallholder farmers also complained that even when the experts are in there, they normally tend to be closer to pastoralists than farmers because they can get some payments from the services they provide unlike to the farmers. Hence, smallholder farmers might not see how exactly institutional capacity can help them.

Use of Appropriate Local Adaptation Knowledge and Experiences

Adaptation is not new in human history. For centuries, individuals and communities have adapted to variability in weather and climate variables to ensure survival (Adger, *et. al*., 2003; Panda, *et. al*., 2013; Below, *et. al*., 2010). In the developed world, technologies are currently proving useful in supporting local populations to cope with the impacts and extremes of changes in the climate. In the developing world, however, there is low level of technological advances and therefore, local communities have accumulated experiences, knowledge and practices that support them to adapt to the changes. The role of traditional knowledge and experiences in supporting smallholder farmers to adapt to climate change impacts especially in the developing world is well elaborated in a number of literature (for example, Ozor, *et. al.*, 2012; Mtambanengwe, *et. al*., 2012; Nyong, *et. al*., 2007; Chinkhuntha, 2004; Goldsmith, 2003; Critchley and Mutunga, 2002; Reij and Waters-Bayer, 2001; O'Neil, 1995).

Taking that into context, it was necessary, during this research, to query smallholder farmers if they believe that the local/traditional adaptation knowledge, experiences and technologies they possess should remain respected and can be disseminated to others as an intervention to support adaptation and enhance long-term resilience. The results showed that only 41.7 percent of the respondents agreed on this proposed intervention while 58.3 percent rejected it. At village level, however, Mkundi came out with 69 percent in accepting as an appropriate intervention but the level of rejection in the other three villages was higher like in Mtae only 45.8 percent accepted it. In Kambeni, acceptance level was as low as 24.4 percent and Manga Mikocheni village scored 28.6 percent. Figure 9.7 summarizes the results.

Figure 9.7: Promote Use and Dissemination of Appropriate Local Adaptation Experiences and Knowledge



The role of traditional knowledge, technologies and experiences in dealing with weather and climate related changes and variability is key to many smallholder farmer communities especially in Africa (e.g. Reij and Waters-Bayer 2001; Critchley and Mutunga, 2002; Chinkhuntha, 2004). However, during the FGDs and interview, many elders complained bitterly that the leaders these years do not respect traditional knowledge arguing that it is outdated and has no room to help farmers during this era of globalization. Nevertheless, they stressed that much as modern technologies are necessary to use, the role of traditional knowledge cannot be ignored completely. It is from this viewpoint that one of the elders had this to say:

> *"The government also has to respect traditional knowledge and the role of elders. Nowadays, even leaders keep saying that elders should rest and stop intervening, but we have knowledge, which can help the society."* (RK11).

Another elder from Mkundi village added that:

> *"The youths should respect our traditional and local knowledge so that we can get good harvests. Because nowadays everything traditional is being abandoned, even the elders are told to rest and wait to die. All rituals have been abandoned but some of them were helpful in former days."* (Elder1, Mkundi).

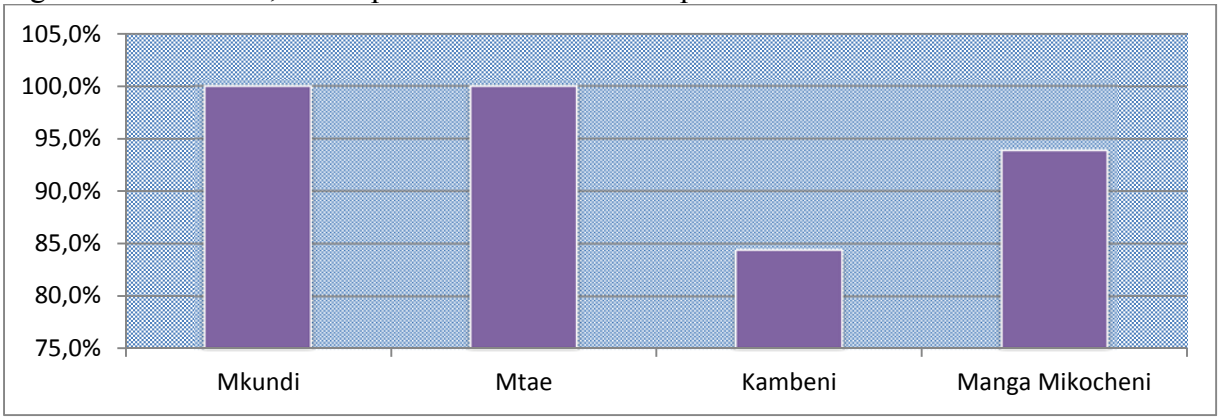
Research, develop and introduce new crop varieties

The importance and role of research in supporting adaptation is well recognized. Smallholder farmers need support from researchers and scientists in many terms such as appropriate water harvesting and storage technologies, different crops and crop varieties tolerant to changing moisture and temperature regimes and soil fertility and management technologies, just to mention a few. However, doing research alone is not enough. Farmers need to get feedback from researchers and the scientific messages should be communicated appropriately with the appropriate language to draw farmers' interest in motivating them to make necessary and required changes to support their adaptation. Introduction of new crops and crop varieties as an adaptation intervention is feasible and has been done by many communities in different agro-ecological systems. It is important in counteracting changes and variability in the climate but also it is helpful in addressing plant pests and diseases.

Through questionnaire, 94.7 percent of the respondents expressed their views in agreement of this as an appropriate long-term policy and strategic intervention to help them adapt as well as

enhance their resilience to impacts of the changing climate. It is also important to note that even at village level, on this variable, almost all the respondents were in support of this item as an important intervention. The percentages were 100 percent for each of the Mkundi and Mtae villages; 84.4 percent for Kambeni village; and 93.9 percent for Manga Mikocheni village. It implies a very high level of understanding by the farmers on the importance of new crops and crops varieties suitable for the changing conditions in the local climate. The details are graphically illustrated in Figure 9.8. Use of new crop varieties as tolerant to changes in the climate was also found to be a necessary intervention in the study by Below and colleagues (2010). In their review of literature to identify micro-level practices to adapt to climate change for African small-scale farmers, the authors (*ibid*.) concluded that at policy level, the government should help farmers through development of new drought-resistant varieties so as to counter the impacts of changes on climate particularly recurrent droughts.

Figure 9.8: Research, develop and introduce new crop varieties



Smallholder farmers and other stakeholders who took part in the interviews and FGD also underscored the importance of research in agriculture and putting research results into practice to help farmers so as to address climate change impacts as important in improving agricultural activities and production. Farmers stressed the need to be supported by researchers in terms of type of crops that are tolerant to dry conditions, shorter cycle, marketable, higher yield as well as resistant to diseases. Farmers strongly argued that this can be done by researchers. However, their complaints were that many researchers conduct research in the areas but afterwards, there were no feedbacks to inform them about the findings, recommendations and aspects to enhance their adaptive capacity.

> *"For a long time now, we have been receiving many researchers in various themes in agriculture but we rarely get feedback from the research projects they conduct within the district. It is important that we must get feedback from researchers so that the district authorities should implement relevant recommendations as appropriate."* (Official, Lushoto District Council).

In the same token, the need for more alternative crops and crop varieties such as drought resistant and shorter cycle also was brought up by many of the interviewees as well as during the focus group discussion. Many were of the view that the changes they are witnessing in the climate seemed to be irreversible and therefore, in the long-term, the need for more crops and crop varieties, which can tolerate the dry conditions in the area is paramount.

> *"I think we need more drought tolerant and shorter cycle crops, and varieties of cassava, maize, bananas and so forth. We have not reached a very critical stage like Mkundi but*

I do not see any better future in terms of the climatic conditions. So we need to be proactive as the climate continues to change." (Leader, Mtae village).

The Leader of Mkundi village had this to say on the same:

"The government should help farmers to obtain seeds for drought tolerant crop varieties over and above the Lablab, which I agree that it is very helpful indeed." (Leader, Mkundi village).

This was stressed also by the Leader of Manga Mikocheni village by saying that:

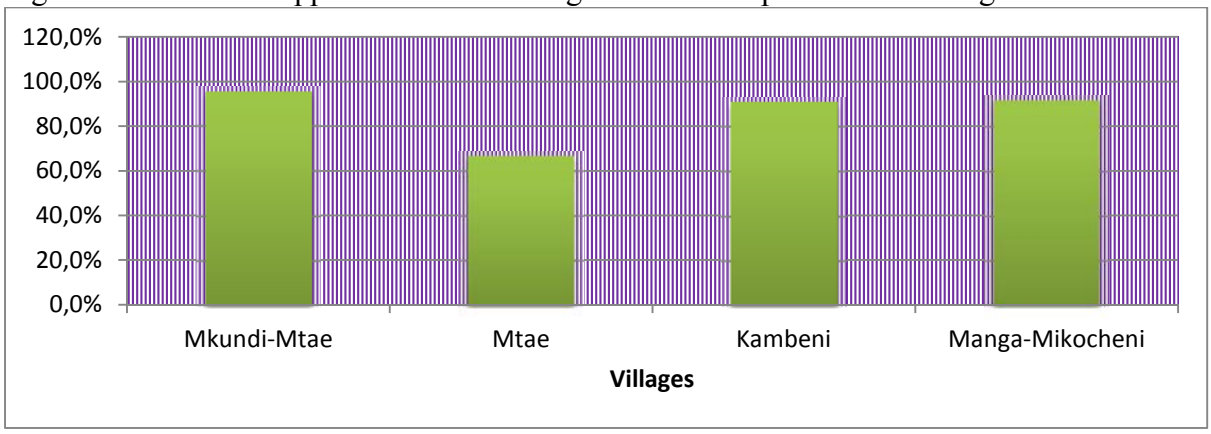
"We need more crop varieties, which are short cycle, higher yielding and drought tolerant. This will be very helpful since we do not expect to go back to those good days we enjoyed long time ago." (Leader, Manga Mikocheni).

Modern irrigation and adaptation Technologies

One other important intervention that was of interest to enquire was on the role of modernizing irrigation and supporting adaptation through appropriate irrigation and adaptation technologies such as those utilizing less water or those promoting water harvesting to counter impacts of climate change while ensuring more production from farms. These are well articulated in a number of literature including Boko and colleagues (2007). They have a potential to support smallholder farmers in producing in the farm with or without total dependence on rainfall taking into account the increasing water scarcity amidst climate change impacts.

From the results, 86.1 percent of the respondents proposed this as one of the potential appropriate policy and strategic intervention, which can support them to adapt and enhance their resilience to climate change impacts. It is similar to Hassan and Nhemachena (2008) who found that technological and institutional methods, particularly for poor farmers in the dry areas, are important in supporting farmers to adapt and enhance their resilience. Within the villages, the results were: 95.6 percent (Mkundi); 66.7 percent (Mtae); 91.1 percent (Kambeni); and 91.8 percent (Manga Mikocheni village) for those who were in support of this potential intervention (Figure 9.9).

Figure 9.9: Provide Support for Modern Irrigation and Adaptation Technologies



Developing of modern and sustainable irrigation systems through construction of irrigation infrastructures emerged in the qualitative data as well. Almost all those who were interviewed proposed promotion of modern and sustainable irrigation systems with the view to support farmers in their endeavor of adapting to changes taking place slowly in the local climate but as part of efforts of being proactive (anticipatory adaptation). The main argument by all was that the region is now entirely dependent on small-scale irrigation but the natural flow of water in the river is dwindling and there is a possibility that in the near future there will be no prospects

for natural water flow due to the fact that the demands are increasing fast while rains are perceived to be decreasing and becoming more unpredictable. Therefore, it is important for the government to construct new and sustainable infrastructures so as to enable farmers to harvest water but use it sustainably through modern canals avoiding wastage. The quotes below make the case in point:

> *"One of the most crucial interventions should be construction of irrigation and water harvesting infrastructures, for example, micro- and macro- dams. These will help farmers as well as pastoralists have easy access to water for irrigation in the farms increasing assurance for food production and pastoralists for their cattle."* (Official, Same District Council).

Farmers' outcry in need for support in terms of irrigation infrastructures was very clear in Mkundi village:
"The government should help us to get access to water for our domestic use, irrigation as well as for the pastoralists. It is important to get a dam and a charco dam for such purposes. In addition, support for irrigation infrastructures will be very helpful because we have no hope here." (Elder1 Mkundi).

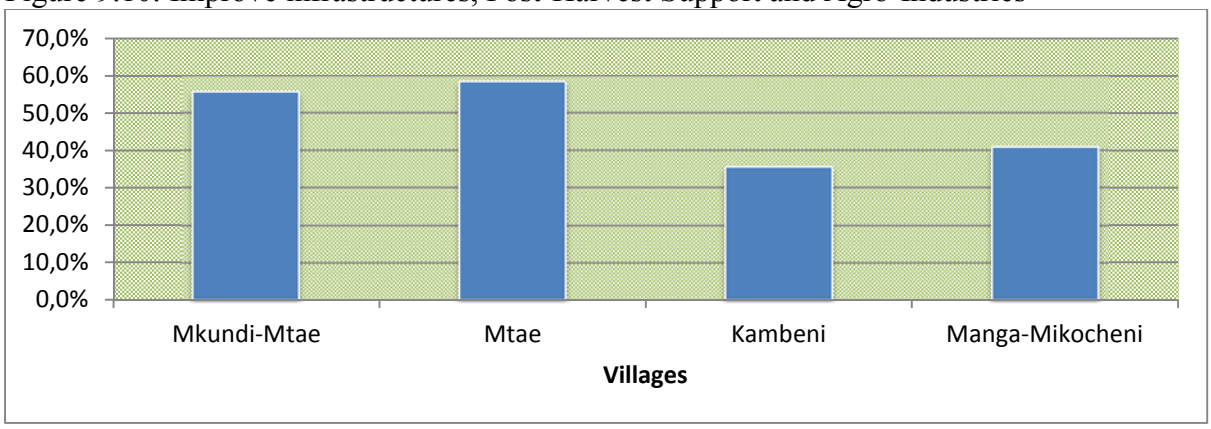
FGD in Kambeni revealed that they also need an improved irrigation system as one farmer said:

> "*I propose that the government should support modern irrigation scheme here especially through water harvesting so that the little water available can continue to support agricultural activities. Some of the small rivers flowing downstream pass here in Kambeni. Thus, it is possible to build modern irrigation infrastructures to support farmers for sustainable irrigation."* (RK10, Kambeni).

Improve infrastructures, post-harvest support and support for agro industries

Rural infrastructures and agro-industries are very significant in supporting smallholder farmers' adaptation efforts. They not only provide quick and easy access to markets for the perishable farm produce but also add value to such produce. In addition, infrastructures such as those for transport and communication can support farmers during disasters and enhance socio-economic development in general. Results from the study revealed by farmers on this aspect revealed that only 47.6 percent accepted it. At village level, the results showed that in Mkundi 55.6 percent accepted this intervention while in Mtae it was 58.3 percent, Kambeni was as low as 35.6 percent and Manga Mikocheni was 40.8 percent. Figure 9.10 illustrates.

Figure 9.10: Improve infrastructures, Post-Harvest Support and Agro-Industries



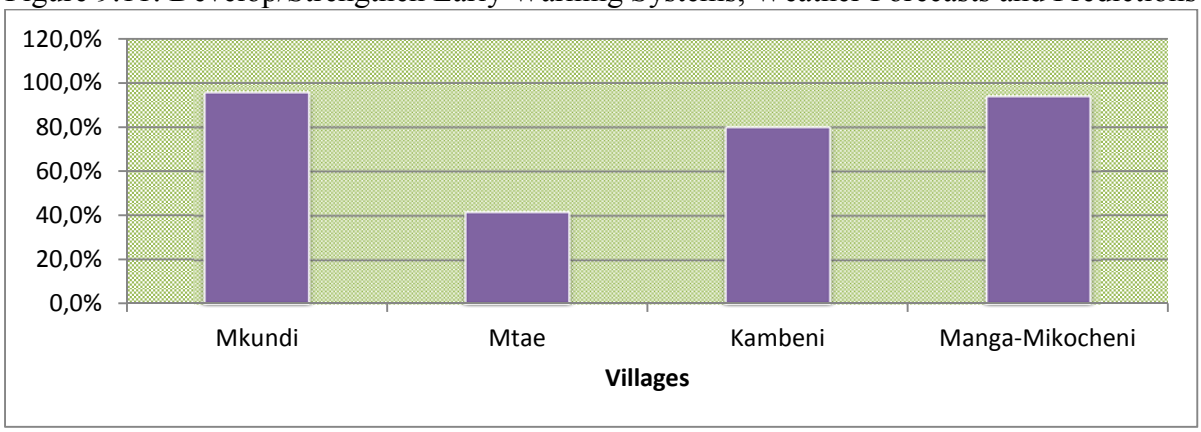
In addition, during the Stakeholders' Validation Workshop, stakeholders, researchers and supervisors were also informed that Same District Council plans to implement a programme that will support farmers to increase their production of ginger in Kambeni and surrounding villages in South Pare Mountains. The programme will involve strengthening infrastructures, getting the ginger processing factory in Kambeni in operation, enhancing capacity of Mamba Myamba Ginger Co-operative Society through micro-financing and training as well as supporting farmers to have access to better markets for ginger and so forth. This in the end will help to strengthen ginger production chain in the area to support livelihood improvement for the farmers.

Develop and/or strengthen early warning systems, weather forecasts and prediction

The Use of early warning systems to strengthen adaptive capacity for farmers is also one among the most important interventions especially for smallholder farmers, whose agriculture is rain-fed or mostly depend on small-scale irrigation using poor technology, like in Mkomazi sub-catchment. Meteorological information is very important to smallholder farmers who depend entirely on rain-fed agriculture for their livelihood. Information about timing of rainfall, how long will the season be, if there are dry conditions or excessive rains expected and many other kinds of weather information patterns that can help farmers plan for what to do during the season are all very necessary. In Tanzania, however, such kinds of services are not strong enough to support the farmers. Timely dissemination of the available information is also very weak due to a number of reasons such as poor communication networks particularly in rural areas. Taking into account its role in supporting farmers to enhance their adaptive capacity, strengthening and timely dissemination of weather forecasting information to farmers as well as putting in place and enhancing early warning systems were included in the questionnaire. Thus, this research had to query if farmers agree that it is an important intervention that need to be taken into account at policy and strategic level to help farmers enhance their adaptive capacity and their long-term resilience to climate change impacts.

In response, 77.7 percent of all farmers responded yes, signifying their agreement on the need to implement this intervention to support their adaptation and enhancing their resilience to impacts of the changing climate. However, contrary to the other three villages, Mtae village respondents had a different view because 58.3 percent of them responded No while only 41.1 percent agreed that it is an appropriate intervention in that regard (Figure 9.11).

Figure 9.11: Develop/Strengthen Early Warning Systems, Weather Forecasts and Predictions



From the qualitative data, timely dissemination of appropriate weather information was identified to be one other necessary technical intervention that is important in enhancing

farmers' adaptive capacity and resilience. Farmers complained that they had little access to weather information and when the information is accessed, it is normally not timely. Thus, it does not really help them to plan for any disaster or crop failure as early as possible. Therefore, they argued that it is necessary for relevant institutions to make sure that the weather forecasting services are enhanced and information is regularly as well as timely delivered to farmers on time. To put this point in concrete terms, Ward Councillor for Kambeni had this to say:

> *"The government should improve weather forecasting services and timely provision of weather information to farmers."* (Ward Councillor, Kambeni).

Water Management Innovations to address moisture deficiencies and increasing frequency of droughts

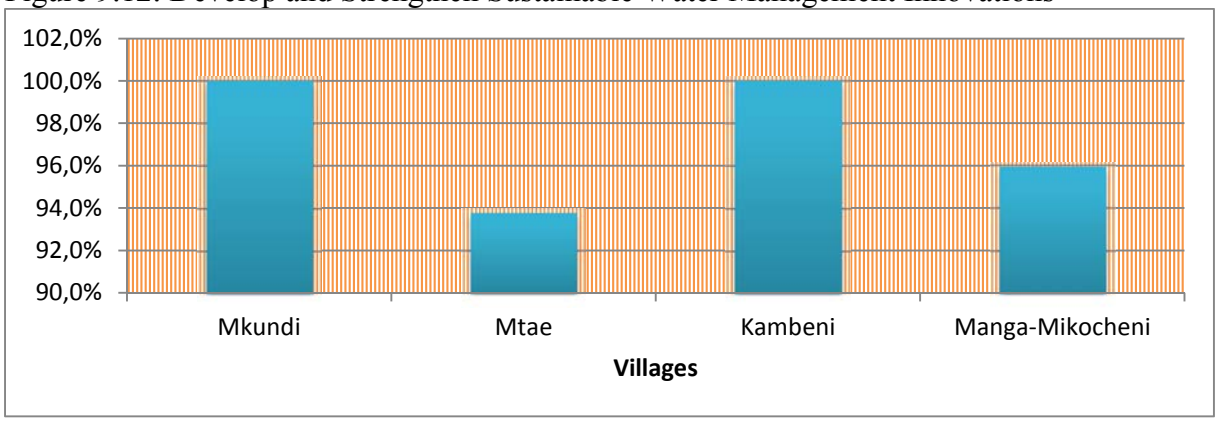
It can be recalled that water availability for Mkomazi sub-catchment is the paramount important variable and the determinant of what farmers do and how they survive. This is because their main economic activity is smallholder farming and those who do not take part in crop production engage themselves in pastoralism, which also requires availability of water and pasture. Water scarcity has also been a source of conflict among farmers and between farmers and pastoralists as the data indicate in chapter seven. However, during the interview, the Pangani Basin Water Board complained that there is poor management of water among users in different locations. For example, those who reside in the highlands felt like they have the right to utilize the water regardless of whether or not it is going to affect flow of rivers downstream. Hence, not only affecting water use downstream but also threatening the ecological system in general. The quote from one of the experts in Pangani Water Basin Office justifies this point.

> *"Water users do not know how better to use water resources. Upstream people feel that they have right to use water and they do not consider other people downstream and the ecosystems all along. Politicians and people upstream feel that water can be managed through administrative boundaries but it's not the case."* (Official, PBWB).

Therefore, strengthening water management and innovations especially in water harvesting and sustainable utilization of water through modern irrigation is necessary in supporting farmers to adapt to the impacts of climate change and enhance their resilience.

As to whether or not farmers agree that developing and strengthening water management innovation should be one of the policy and strategic intervention to support their adaptation as well as enhance their resilience demonstrate the importance farmers attached to water availability as 97.3 percent of all the respondents responded yes. While this is the general view, the details on the responses at the village level provide the same picture as 100 percent of all respondents from each of the two villages, Mkundi and Kambeni responded Yes while for Mtae and Manga Mikocheni villages was 93.8 percent and 95.9 percent, respectively. This is well illustrated in Figure 9.12.

Figure 9.12: Develop and Strengthen Sustainable Water Management Innovations

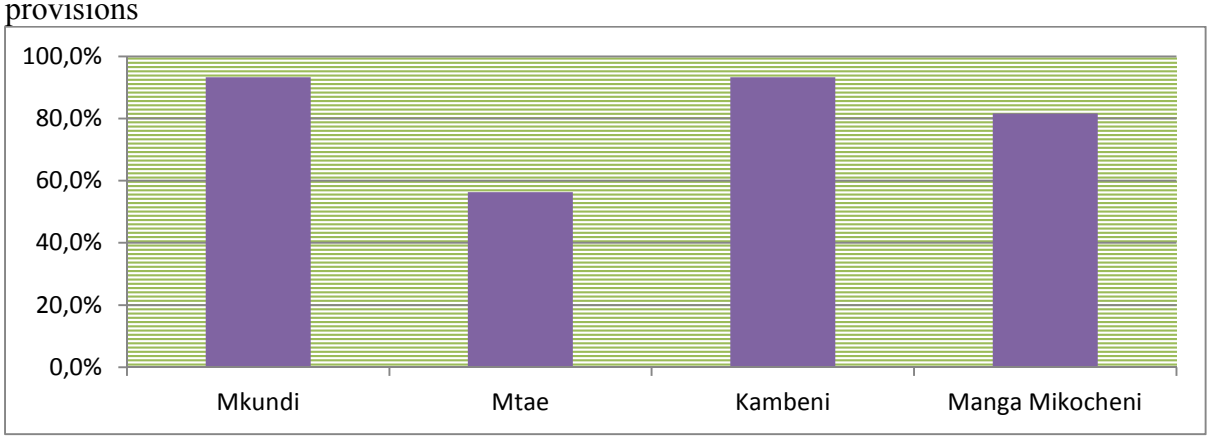


Subsidies, incentives and crop insurance provisions to support adaptation

Incentives such as subsidies, tax refund, credits and crop insurances are identified as possible policy and strategic interventions to support enhancing adaptive capacity and resilience of the farmers to the adverse impacts of climate change (IPCC, 2007d). In the face of efforts to enhance adaptive capacity of many farmer communities vulnerable to the impacts of the changing climate, the importance of crop insurance cannot be overemphasized (Boko, *et. al*., 2007). From observations, many adaptation discussions within the UNFCCC context, for example, emphasize on the need to consider crop insurance as an option to support smallholder farmers in the developing world, especially in Africa, to enhance their adaptive capacity. Panda and colleagues (2013), for example, attempted to define adaptive capacity in agricultural as the tendency towards adopting farming practices intended to maintain higher yields amidst climate change. In that context, the authors (*ibid*.) identified crop insurance as a stronger variable characterizing high adaptive capacity against low adaptive capacity because with crop insurance. Farmers can take risk of planting higher yielding crop varieties and in the end, they can be able to harvest unlike those with no access to crop insurance. It is this necessity and need for such incentives that led to inclusion of these issues in the list of possible intervention for enhancing adaptive capacity and long-term resilience to farmers.

Figure 9.13 provides detailed illustrations reflecting the responses of the farmers on this very important variable. In general, it was well accepted by 80.7 percent of all respondents as an appropriate policy and strategic intervention to support farmers' adaptation and enhance long-term resilience to climate change. Mtae village, however, showed discontent that this can have an important role in supporting adaptation and enhancing resilience of the farmers because only 56.3 percent of the respondents from this village agreed on this. For the other three villages, the results showed a slight margin of difference as Mkundi and Kambeni villages supported it by 93.3 percent for each of the village while Manga Mikocheni village with 81.6 percent supported.

Figure 9.13: Introduce and/or improve access to subsidies, incentives and crop insurance provisions



The qualitative data also stressed on incentives as an important intervention to support farmers in enhancing their adaptive capacity and long term resilience. Financial and other forms of incentives such as subsidies to farmers are proposed as appropriate interventions, which can enhance farmers' adaptive capacity especially in the developing world where the smallholder farming system mostly depends on rainfall and less sophisticated farming technologies. The incentives have potential to both increase production through intensification and enhance sustainable utilization of little available resources such as water for irrigation. These forms of incentives have been a subject for discussion even within the UNFCCC negotiation process. They are appropriate potential policy and strategic interventions for long-term resilience to farmers (IPCC, 2007d).

It is from this viewpoint that many farmers and experts as well as leaders who participated in interviews as well as FGDs had strong arguments that the government has to support farmers to access soft loans, inputs, machineries and improved drought resistant, higher yields and other crop taking into account the state of the changing climate. Many farmers complain that poor access to inputs is exacerbating effects of the perceived changes in the local climate hence poor harvests. While the government provides little inputs to farmers, they are not enough, its management is very poor, leading to corrupt practices. These will improve their farming activities in a sustainable way and increase production. The following quotes justify their arguments:

> *"We need more incentives and better management of those currently provided. The government has to make sure that we get agricultural inputs at affordable prices. We need tractors here for us to be able to cultivate paddy using tractors. The farmers' incentives provided by the government such as fertilizers have to be managed well so that they do not fall into bad hands."* (Leader, Manga Mikocheni village).

Enhancing provision of technical support services for farmers such as extension services, land use planning and so on is one other intervention proposed to be part of the efforts to enhance adaptive capacity and resilience. This has potential to address crop failure, sustainable use of land and other natural resources as well as social conflicts over diminishing resources. Some quotes justify the ideas of the interviewees.

> *"The district council has to ensure that we have the required manpower such as agricultural extension officer and many others in all sectors."* (Leader, Mkundi village).

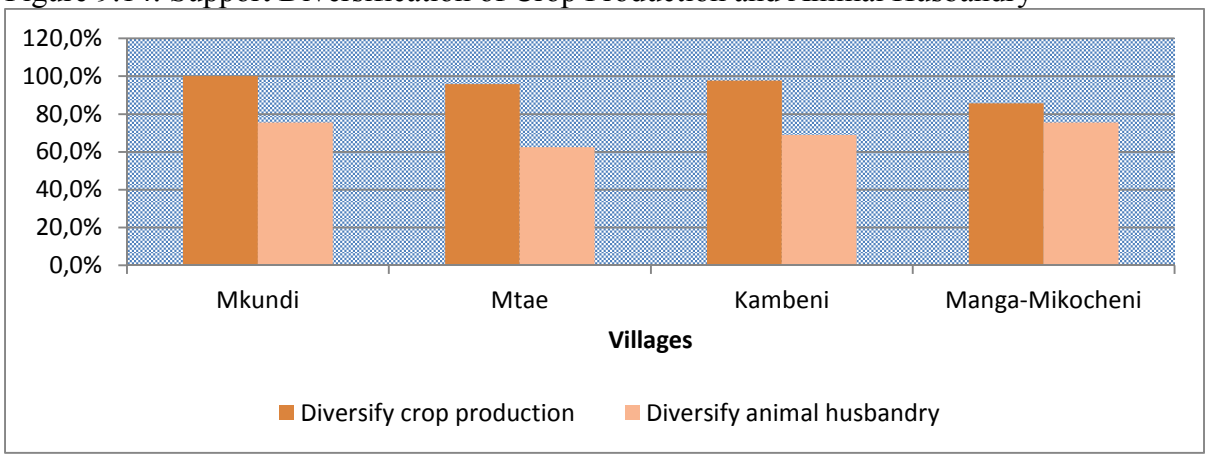
In addition, much as the farmers insisted on the need for more extension workers to help them technically, there were also complaints that some of those who were available, were not performing to the expectations of the farmers. For example, one interviewee had this to say:

> *"We have an extension officer at the ward level but he is not available. He is normally busy with his personal activities I never get in touch with him. I have complained for several times to the District Agricultural Officer but there has never been a solution to this problem. So we need another extension officer covering agriculture only and not covering agriculture and livestock. Let the government make sure that we have several visits of experts, researchers and many others who can scrutinize situations of the changing climate and advise accordingly."* (Leader, Manga Mikocheni village).

Diversification of crop production

While smallholder farming has and continues to be a major economic mainstay for many in Tanzania, diversification of both crop production and animal husbandry is much necessary in addressing climate change impacts and enhancing their resilience amidst climate change impacts. From this research, the data indicated that diversification of agriculture actually received high support from the smallholder farmers with 94.7 percent support while the diversification of livestock keeping being supported by the farmers at 70.6 percent. Details of the results at the villages level is illustrated in Figure 9.14.

Figure 9.14: Support Diversification of Crop Production and Animal Husbandry



Environmental conservation

Conservation of the environment to enhance provision and access to ecosystem goods and services, especially sustaining water flow, is one other interventions farmers, experts and local leaders raised as part of the policy and strategic interventions appropriate to support farmers to adapt and enhance resilience to changes in the local climate in the future. This is because there were some of those who believed and argued that the perceived changes in the local climate are partly a result of environmental degradation through deforestation and forest degradation particularly in the Chome Forest Reserve. Therefore, one of the interventions they thought important is to enhance conservation and sustainable use of natural resources particularly Chome Forest Reserve and its surrounding environment.

One of those who had this idea is the official from the District Council who insisted that much as water harvesting and sustainable use through modern irrigation scheme is necessary, the

need to enhance efforts to sustainably use and manage the environment cannot be overemphasized.

> *"It is necessary to also enhance sustainable use and management of the environment in the district particularly forestry and water resources."* (Official, Same District Council).

This idea was echoed by the official from the PBWB who not only insisted on sustainable management of the environment but also stressed the need to educate people across the entire basin on proper utilization of the available water resources and avoiding conflicting interests because they further widen the divide and at the end of the day, it is mostly the poor farmers and the ecosystem, which will be on the losing side.

> *"Educating people and politicians on how best to use and manage the environment, especially water resources, is key. People should know that climate has and will continue changing; we should not expect good conditions anymore in my view. Establishing water user associations so as to regulate water uses and minimize water conflicts among users is not an option. For that to happen, we should ask the government to establish modern irrigation scheme and technologies in the area. In addition, I insist on integrated water resource management because Tanzania still has a lot of water. If we manage and use it in a proper manner, it cannot only support adaptation but will serve for other purposes including maintaining ecological functions. I must also tell you that we should make sure that all the government machinery within the government work together with a similar goal. Right now we have conflicting interests among ourselves."* (Official, PBWB).

The last sentence in the quote makes reference to the fact that management of the resources within the basin involves a number of government ministries and departments (both central and local governments). The central government, for example, manages forests reserves such as Chome Forest Reserve under the Ministry of natural Resources and Tourism. In addition, water resources are managed by the Ministry of Water through Pangani Basin Water Board based in Moshi town. This Office regulates use of water among different users within the Basin. Some other forests are managed by local governments (district council and village governments).

Within Mkomazi sub-catchment, there are various resource users such as smallholder farmers, pastoralists, small scale fishers, small-scale miners, hunters, and loggers, wood fuel harvesters (charcoal and firewood) and so on. Each of these users has interests in the basin and clear coordination and regulation is important. While laws and by-laws as well as policies might be in place, their implementation and enforcement are critical. Any conflicting interests among the government departments contradicts the management process of the available resources within the basin and as the Basin Officer said, in the end, it is the poor smallholder farmers, resource users and the environment, which become losers. One of the examples he gave in clarifying his point is that from the water sector point of view, they would advise the government to introduce another cash crop in the South Pare Mountain area instead of ginger because it seems to consume much water amidst challenges of dwindling water resources, decreasing flow in rivers and streams as well and increasing demands from multiple users.

> *"For example, we in the water sector wish to advise the government to discourage ginger cultivation and introduce as well as motivate farmers to go for an alternative crop because it consumes too much water. But the politicians do not understand and they keep motivating farmers in the highlands to use much water as they can by ignoring interests of other users downstream. We have conflicting interests. We are for sustainability while others are for political power."* (Official, PBWB).

Not only experts but also even farmers themselves stressed on the need to conserve and sustainably manage the environment so as to allow it to provide as much ecosystem goods and services as it can. For example, one elder from Mtae village had this to say:

> *"Environmental conservation should be enhanced. Provision of education to farmers on better use of agricultural inputs and sustainable farming is very useful. Enhancing sustainable irrigation through proper irrigation infrastructures is necessary. Respecting local knowledge and technologies can also advance the adaptive capacity of the community while sustainably utilizing the available resources."* (Elder1, Mtae).

Village Land use Plans

Lack of village land use plans is not only a problem only in the four villages but also in almost all villages in Tanzania. In the research area, lack of land use plans was identified to be one of the sources of social conflicts. Examples were given in the preceding Chapter as to how the conflicts between farmers and pastoralists in Mkundi and Manga Mikocheni villages are partly contributed by lack of land use plans. Regarding the need for land use planning, the official for Lushoto District Council had this to say:

> *"One of the factors that contribute to conflicts between farmers and pastoralists is lack of village land use plans. Therefore, on a long-term, we have to make sure that we prepare land-use plans for the villages to avoid conflicts between various land and resource users. In addition, we have to deploy more extension workers at each village. Then we have to ensure law enforcement and compliance by the villagers on management of natural resources."* (Official, Lushoto District Council).

In addition, one elder from Mkundi had a similar view regarding addressing the conflicts between pastoralists and farmers:

> *"The conflict between Sambaa and Maasai should be addressed by demarcating the land for pasture and water for their cattle so that they do not come to interfere our agricultural activities otherwise we are going to witness war in future."* (Elder1, Mkundi).

9.4 Discussion

Identification of socio-economic implications of changes in the local climate as well as subsequent changes in the farming practices is inadequate unless it is accompanied by adaptation options and appropriate interventions. This Chapter proposes measures which can be implemented to help smallholder farmers in Mkomazi sub-catchment and other areas with similar characteristics and challenges to enhance their adaptive capacity and long term resilience to impacts of climate change and variability while improving livelihoods and reducing poverty. As presented, four key coping/adaptation options were identified, namely, ask for food aid; request for adaptation related technological and technical support; making more changes in farming practices as deemed necessary; and seek for more adaptation related information, knowledge and education. In terms of long-term strategic and policy interventions, a wide range of interventions were identified from both quantitative and qualitative sources. They highlight the need for incentives, subsidies and crop insurance for farmers; modern adaptation techniques and technologies on several thematic areas such as irrigation, new and/or improved crops and crop varieties; technical and technological support to farmers; sustainable use of the available resources; early warning systems and timely dissemination of weather forecast information; enhancing integrated water resource

management; land use planning; and diversification of agriculture as examples of the necessary policy and strategic interventions for enhancing adaptive capacity and long term resilience of the farmers to climate change impacts.

The data on near future coping/adaptation options informed that much as the farmers were pessimistic about the stability of the state of the climate, they were optimistic to continue changing their farming practices as the situation continues to worsen. The data also displayed a clear pattern of preference of options in all four villages with a few variations from one village to another. Food aid; promotion of irrigation; more access to adaptation information, knowledge and education; government support such as in introduction of effective adaptation options as well as continue changing farming practices were identified by many of the respondents from all villages (at least each one was among the first ranking three options for each of the villages).

Food aid was one of the high ranking coping strategies options identified in all four villages. From the data presented and as highlighted in the previous paragraphs, it can be noted that in Mkundi, Manga Mikocheni and Kambeni villages, food aid was ranked number one option in the near future. In Mkundi and Manga Mikocheni, this option was identified by all (100%) of the respondents. But it should be recalled that the two villages were reported to have been receiving food aid in the past few years. Therefore, all (100%) of respondents from each village identified this coping strategy as an appropriate option in the near future might have some relationship with their past experience. This might mean that continued food aid for the past few years in these two villages has made them feel they can possibly depend on government support in terms of food aid. This in a way is not a good sign in the context of adaptation because it is important that farmers and communities can produce and feed themselves. However, it is important that they are supported and enabled through infrastructure, education, technological and technical support etc. food aid should probably be a short term coping strategy during disasters to support farmers and enable them to recover but it cannot be a dependable option by the farmers. This option is not sustainable and does not promote independence and human dignity but humiliation and dependence culture. However, there were good signs among farmers because during interview in Mkundi village, some of the farmers were categorical that they are compelled to accept food aid because they find themselves with no alternative. But they feel humiliated for not being able to feed themselves all the time. Thus, they would wish to be supported so that they can produce enough to feed themselves instead of continued food aid from the government. In addition, both in Manga Mikocheni and Mkundi villages, farmers complained that they received food aid but what was provided was very little and did not satisfy their household needs. Hence, appropriate support to enable them to produce enough to feed their households amidst changing climatic conditions is what is necessary. This will restore their pride and ensure that they have food sovereignty.

Respondents in all four villages selected with high percentage the option: ask for support such as ensuring access to water for irrigation as second best option after food aid. This might reflect the level of need for support not only from the governmental but also non-governmental actors so as their adaptive capacity is enhanced amidst changing climate and variability situations. At village levels during the interviews and FGD a number of concerns related to this were raised. For example, in Manga Mikocheni village, farmers argued that Kalimawe dam is full of mud hence it cannot retain enough water which could help them to irrigate in cases when they experience rainfall shortage. In addition, they noted that their irrigation system is very unsustainable as it has traditional canals which do not use water sustainably thus they need support in terms of a new system with appropriate canals. This means a lot during the times

when rainfall is diminishing and so the need to use the available water sustainably is paramount. Likewise, in Mkundi village, their outcry was availability of water for irrigation. This could be done through construction of a dam and a system of canals to serve not only Mkundi but also other surrounding villages. While some of these might be considered in the long term, others can be implemented in the short term as well to help enhance these farmers adaptive capacity and as part of poverty reduction efforts. The farmers' commitment to continue changing farming practices in line with changes and variability of the climate signified that in some of these villages there is still a room for accommodating the impacts of climate change and variability. Hence, farmers remaining optimistic that much as the conditions are not the same as they used to be in the past, they can still make some changes and continue to survive. With this commitment by the farmers, such kind of support will be important to make sure that on a short-term, they are assured of their survival while long-term plans take shape.

Of much interest was the farmers seeking to obtain more information, knowledge and education on adaptation to the impacts of climate change and variability as a near future adaptation option. This is because the role of information access, knowledge and education in enhancing adaptive capacity of households and communities has been stressed in a number of literature (for example, Smit and Wandel, 2006; Brooks, *et. al*., 2005; Yohe and Tol, 2002; Yohe, 2001). Identification of this option out of the list might also be a good indicator that farmers have a quest to not only be supported but also learning more so that they can be able to support themselves in the adaptation process.

In a general sense, results at village level showed a pattern in which Mkundi village looks to be emerging selecting many of the options while Mtae village rejects many of these options. For example, in Mtae village, smallholder farmers based their choices mainly on three options which are government support; continue changing farming practices and food aid. This was contrary to Mkundi village where in many of the changes the village ranked high in terms of percentage of selection. Mkundi village was the highest in selecting the following options: abandon farms, emigrate, food aid, government support, adaptation knowledge and ground water irrigation. This may mean that the level of suffering in Mkundi makes them feel that they are ready for any change and support provided that it can help them to be able to adapt while in Mtae, farmers still have some advantage especially because they can irrigate using tap water and be able to produce shorter cycle crops.

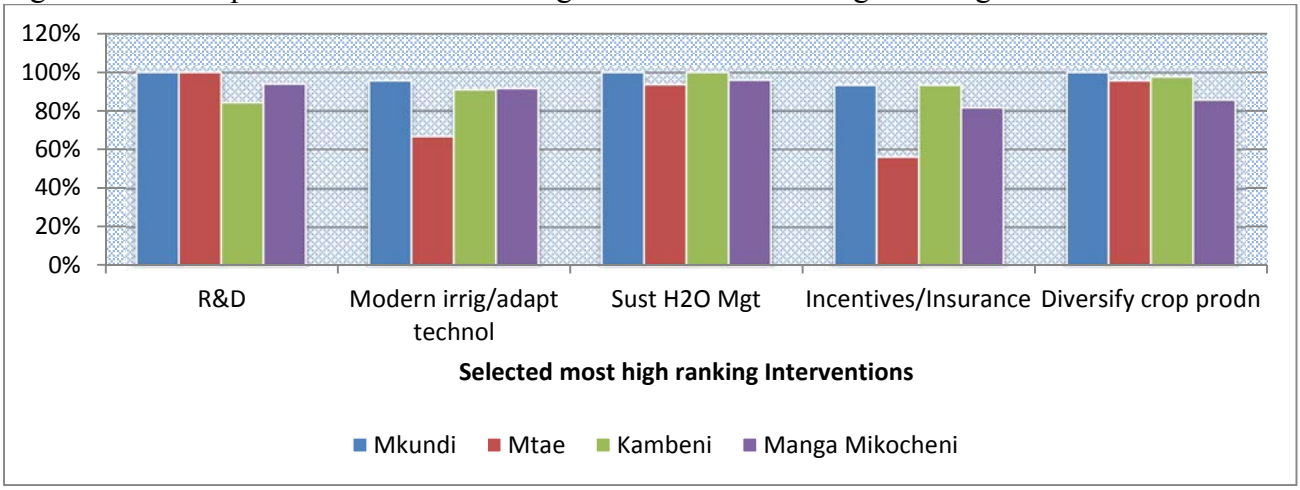
On the long-term policy and strategic interventions, the data presented indicate some similarities in farmers' choices. For example, if we compare the overall five high ranking interventions out of the entire list (from the first to the fifth) which are: develop and strengthen water management innovations to address the risk of moisture deficiencies and increasing frequency of droughts; research, develop and introduce new crop varieties to increase the tolerance to changes in rainfall and temperature regimes; diversify crop production; provide support for modern irrigation and adaptation related technologies; and introduce and/or improve access to subsidies, incentives and crop insurance provisions to support farmers to adapt. If one looks closely at Figure 9.12, it is clear that almost all the villages had similar views on each of these five interventions hence indicating that farmers share almost similar challenges and they have similar needs. In addition, a similar pattern is also clear when you select the high ranking five interventions for each village (see Table 9.2 for the details).

As illustrated in Table 9.2, over 80 percent of the respondents for each of the four villages identified: research, develop and introduce new crop varieties to increase the tolerance to changes in rainfall and temperature regimes; develop and strengthen water management

innovations to address the risk of moisture deficiencies and increasing frequency of droughts; and diversify crop production as important interventions while provision of support for modern irrigation and adaptation technologies was identified by over 80 percent in each of three villages namely Mkundi, Kambeni and Manga Mikocheni.

Minor differences can also be observed however in each of the overall five interventions in terms village views. For example in Figure 9.15, on introducing and/or improving access to subsidies, incentives and crop insurance provisions, the views from Mtae village were somehow different from the other three villages as just 56.3 percent of the farmers in this village accepted this intervention. One possible explanation of these results is the bad experience farmers have on incentives and subsidies in many parts of the country. Many of the farmers during the study complained that the subsidized inputs have always been mismanaged and the appropriate farmers do not benefit so much but such inputs end up being sold for high prices to businessmen who also sell them to farmers. Therefore, in some of the villages it is possible to have different results on the same because farmers may not see the need and meaning of having in place subsidies and incentives while at the end it benefits few. Likewise in Table 9.2, Mtae village differed with the rest by identifying enhancing adaptive capacity through information, awareness and education within the high ranking five interventions.

Figure 9.15: Comparative view across villages on selected most high ranking Interventions



It is also interesting to note that there is perfect similarity between Mkundi and Manga Mikocheni villages in terms of their selection of the appropriate policy and strategic interventions when one considers the five high ranking interventions from each village. If one picks the high ranking five selections from each of the two villages, a clear pattern of similarity between these two villages can be observed (see Table 9.2). This is possibly due to the fact that the two villages share somehow similar characteristics including being on the lowlands and having no direct access to water for irrigation unlike their counterparts in the highlands. They are the villages which have both adopted cultivation of lablab although it is more so in Mkundi village. In addition, as presented in Chapter Five, the rainfall data indicate a clear decreasing trend of rainfall for the villages in the lowland showing that their perceptions that rainfall is decreasing and is unpredictable is justifiable.

Table 9.2: Top Five Interventions for Each Village

Policy and Strategic Interventions	Villages			
	Mkundi	Manga Mikocheni	Mtae	Kambeni
Research, develop and introduce new crop varieties to increase the tolerance to changes in rainfall and temperature regimes	100.0%	93.9%	100.0%	84.4%
Develop and strengthen water management innovations to address the risk of moisture deficiencies and increasing frequency of droughts	100.0%	95.9%	93.8%	100.0%
Diversify crop production	100.0%	85.7%	95.8%	97.8%
Provide support for modern irrigation and adaptation related technologies	95.6%	91.8%	66.7%	91.1%
Introduce and/or improve access to subsidies, incentives and crop insurance provisions to support farmers to adapt	93.3%	81.6%		93.3%
Develop and/or strengthen early warning systems for timely weather predictions, forecasts and their dissemination	95.6%	93.9%		
Enhance adaptive capacity through information, awareness and education			87.5%	

These results seem to share similar line of argument with Mano and Nhemachena (2007), who in their study on Assessment of the Economic Impacts of Climate Change on Agriculture in Zimbabwe, recommended that in order to support farmers in terms of adaptation, it is important for the government and other stakeholders to provide adequate extension information services to farmers. That was important so as to empower them to make informed decisions such as on what to plant and at what time to plant depending on the seasonal climatic variations they experience (*ibid.*). This recommendation demonstrated the role of information, education and awareness of the farmers in the whole spectrum of adaptive capacity and adaptation. Apart from that, they also recommended policy interventions related to supporting farmers to improve their farm performances through training, access to subsidies as well as incentives e.g. fertilizers and crop seeds. On the other hand, Lema and Majule, (2009) emphasized on water harvesting to ensure water storage for crops and livestock while Hassan, (2010) recommended an emphasis be made on farmers' education; provision of improved climate information as well as crop insurance to farmers.

From the qualitative data, a range of interventions were highlighted. Modern irrigation infrastructures are essential in supporting farmers to adapt in the area as stressed by both the farmers and experts. The Pangani Water Basin Office argued clearly that the area is already water stressed due to high level of abstraction coupled with low rainfall within the valley hence affecting water flow. The forms of irrigation, especially in the highland areas were reported to be consuming much water unsustainably thereby denying farmers in the lowlands access to water while also threatening to affect the ecological functioning of the rivers. Therefore, supporting farmers to modernize their small-scale irrigation will help them to utilize the little and dwindling water sustainably while sharing the same with the ecosystem.
Using Multinomial model, Hassan and Nhemachena (2008) analysed determinants of farm-level climate adaptation measures in Africa. They (*ibid*.) found that more farming experience being an important attribute in promoting adaptation hence suggesting the role of education to farmers as a necessary policy measure in order to enhance adaptive capacity of farmers particularly at farm level. In addition, they (*ibid.*) also found that improved access to climate

and adaptation related information as well as information on credit; access to electricity and capital; technology and technical support; and markets for both agricultural produce as well as inputs were necessary in enhancing farmers' adaptive capacity. Thus, their study findings share some similarities with those from the current study because most of what they found was identified by smallholder farmers themselves as necessary interventions which can support enhancing their adaptive capacity and long-term resilience. However, the current study did not capture information regarding farming experience and no model was used as part of analysis. The current study was mostly based on multiple sources of data as a way of ensuring that each and every response is cross-checked to establish validity and reliability of results, which can support conclusions in the end.

Addressing the conflicts between farmers and pastoralists as well as potential conflicts among farmers is also critical. This brings the need for village land use plans, deployment of extension workers and educating and technically supporting pastoralists to not only limit their livestock to appropriate carrying capacity according to land but also improving their quality. In Mkundi and Manga villages, for example, the district authorities indicated that pastoralists owned bigger herds of cattle in areas where human population has been increasing, leading to high levels of land fragmentation. This, in turn, fuels conflicts. Thus, village land use plans demarcating areas for grazing, farming and other land uses within each village will help address this problem while implementing other interventions to support adaptation efforts amidst changing climatic conditions.

Since the area is already perceived to experience changes in the climate, farmers have highest priority to new crops and crop varieties which can help them improve production amidst such changes. Higher yield and shorter cycle as well as drought tolerant crops will be very helpful to farmers. From the data, they are already using similar varieties but they need more of such crops and varieties which can also have good markets so that they both address food shortage while ensuring income for their livelihoods. In addition, availability and access to inputs such as fertilizers and pesticides, access to credits and incentives will help farmers to enhance their adaptive capacity.

9.5 Summary

Several adaptation strategies can conclusively be highlighted as appropriate in supporting smallholder farmers in Mkomazi sub-catchment to help them to address the challenges they are currently facing in terms of changes and variability of the local climate and those ones to be expected in the future within same context of changing climate. Support to ensure access of water for irrigation and adaptation related technologies is one of the appropriate interventions farmers feel will help them address dependency on rain-fed farming because rainfall is decreasing and is also unreliable in terms of amount, onset and distribution. Enhancing agricultural research, development and introducing new crop varieties appropriate in increasing tolerance to changes in rainfall and temperature regimes will help farmers more than traditional crops which seem to be failing leading to poor harvest and food shortage especially for Mkundi and Manga villages.

To ensure that what is produced is not wasted and value is added, there is need to improve infrastructures, post-harvest support and support for agro industries. The construction of ginger processing factory in Kambeni is a very good start and a best example of what farmers need because much as it will provide employment in the rural setting, it is also going to increase value of what farmers produce before getting to markets. This will further empower

smallholder farmers to address their adaptation needs. However, some efforts are required to find alternative less water consuming ginger varieties so as to address water shortage problems. This will also ensure continued and increased ginger production to feed the factory and the market. Otherwise, sustainability of ginger production and the operation of the factory is questionable.

Developing and strengthening water management innovations with the aim of addressing risks of moisture deficiencies and increasing frequency of droughts is necessary so as to ensure farmers have access to water and they use it sustainably for irrigation and increase farm production. The current water use practices especially in Kambeni are unsustainable because a lot of water is used even though it does not increase production of ginger. A much better way of sustainably using water to address issues related to moisture deficiencies is what farmers need.

To improve production amidst changing climate and need for adaptation, introduction and/or improving access to subsidies and incentives cannot to be overemphasized. In addition, introduction of crop insurance provisions to support farmers adapting to the changing climate and address issues of loss and damage is critical. It is from this understanding that farmers need to be supported in accessing such services. Provision of education, improving access to appropriate adaptation related information and awareness to farmers will enhance their adaptive capacity. Finally, supporting diversification of crop production and animal husbandry is of paramount importance in order to limit the impacts of changing climate and enhance adaptive capacity of the smallholder farmers. The final chapter makes a general summary, draws general conclusions and advances recommendations from this research.

CHAPTER TEN: CONCLUSIONS AND RECOMMENDATIONS

10.1 Introduction

This chapter presents conclusions and advances recommendations out of the study. Climate change has currently been recognized across disciplines and groups of people as a serious challenge facing societies today. This study was motivated by the fact that agriculture is a key economic sector in the world feeding all people, providing employment to billions world-wide while supporting economic growth. Smallholder farming as part of the broader agricultural sector world-wide has immense contribution to food security, economic growth and employment provision particularly in the developing world. This economic activity however is very vulnerable to impacts of the changing climate due to among others, high dependence on rainfall; lowly developed irrigation potential; and limited access to improved agricultural technologies, inputs and finance. It is in this context that the researcher developed quest to contribute to addressing challenges facing smallholder farmers in the developing world in terms of informing policy and strategic actions to support these farmers in their course of adapting to the impacts of climate variability and change for their survival and contribution to socio-economic growth.

This research sought to explore, analyze and explain the factors that motivated smallholder farmers in the developing countries to change from one farming practice to another at different times. It further aimed to analyze the socio-economic implications of the perceived changes in the local climate and recommend appropriate policy and strategic actions to support smallholder farmers in their quest to adapt and enhance their long term resilience.

10.2 Main findings

Results from the study indicated that the state of climate of the area has been changing when a comparison is made with over 30 years based on smallholder farmers', local elders', local leaders' and experts' perceptions; and over 30 years rainfall (Same Meteorological Station and Buiko Hydromet Station: 1962-2012; and Suji Mission Station: 1977-2012) and temperature data (Same Meteorological Station: 1970-2013). Smallholder farmers and other stakeholders' perceptions on the state of climate being changing are confirmed by the long term temperature as well as long-term rainfall trends. Average seasonal temperature for Same Meteorological Station shows an increasing trend, while annual rainfall for all three stations show decreasing trend for those years (51 year for Same and Buiko Hydromet, and 36 year for Suji Mission station). While rainfall indicates a decreasing trend, the average number of rain days shows a mixed picture. For Same Meteorological Station, the average number of rain days indicates a significant decreasing trend while for Buiko and Suji Mission stations; it indicates an insignificant or else slight increasing trend, which means that it is somehow stable. This shows that there might be mismatch between the meaning of the number of rain days between meteorological experts and smallholder farmers.

All five sources of data collection used, namely, questionnaire, interview, FGD, rainfall and temperature records as well as the stakeholders' validation workshop strongly supported the conclusion that in line with the changes in the climate globally, the state of the climate in Mkomazi sub-catchment has been changing. Therefore, the local climate in Mkomazi is slowly changing and will possibly continue to do so and hence, affecting smallholder farmers and their

livelihoods. However, the changes are not uniform because some areas still have good conditions and the changes do not seem severe. The impacts of the changes in the local climate are significantly felt in the lowland areas compared to highlands because of poor access to water for irrigation and due to the fact that some areas in the highlands still receive adequate rainfall in some of the seasons, much as it might be below the amount they had been receiving in the past. While the impact of the changes in the local climate on livelihoods may not seem to be so serious now, it is necessary that some measures at both technical and policy level are devised because such changes in future may have serious consequences to smallholder farmers, other resource users and the ecosystem at large.

Smallholder farmers in the Mkomazi sub-catchment are already using various strategies to both cope and adapt to the changes and variability of the local climate. They have been compelled to make decisions to change their farming practices by adopting shorter cycle crops and crop varieties to maximize possibility of harvesting amidst decreasing rainfall conditions. They have also introduced drought tolerant crops and crop varieties while abandoning cultivation of some other crops and varieties. The changes made in the farming practices are not uniform across all villages. Some variations are observed from one village to the other. These variations reflect a number of issues such as water access for irrigation, location within the valley and so forth. These changes also serve more than one purpose in the villages.

The data obtained support the conclusion that changes in the farming practices, which smallholder farmers have been making, are motivated by multiple factors such as negative effects of climate change and variability, the role of markets and high living cost and demands for personal and family needs. Much as each of the three factors contributes in motivating farmers to change their farming practices, changes and variability in the local climate has very significant influence than all the rest of the factors. This is evident across all changes and in all villages. Influence of the impacts of climate change and variability was between 55 percent (the lowest) and 95 percent (the highest). This means that for all changes in the farming practices, the influence of change and variability of the climate was over 50 percent.

The changes and variability in the local climate, which consequently motivated many of the changes in the farming practices had many socio-economic implications at both household and community levels. The implications were on decrease in incomes, threats to human health, food insecurity, increased water shortage, increased social conflicts over scarce resources as well as increased deforestation and forest degradation due to forest serving as an alternative household income source amidst changing and variability of the climate.

The findings support a conclusion that much as there are signs of negative implications in all villages, such changes have affected quality of life and increase vulnerability of the farmers more in Mkundi and Manga villages than in Kambeni and Mtae villages. This is a result of decrease in incomes; increased poor access to water for both domestic use and irrigation; increasing food insecurity leading to frequent food aid; increased health threats; and accelerating social conflicts and hence, affecting stability, peace and security. It is also true that amidst lack of proper alternative income from crop production, the changes have and are accelerating environmental degradation through deforestation and forest degradation in Mkundi village which may jeopardize sustainable development in the Mkomazi sub-catchment and within the Pangani Basin.
Combining data from all sources, the findings support a conclusion that smallholder farmers' ability to cope has sometimes been pushed to the limit thereby seeking for food aid being

identified as an immediate and short-term coping strategy. In the short-term, it is important for the government and other stakeholders to establish a favorable environment to enable smallholder farmers to be food secure and sovereign especially amidst climate change and variability concerns. In the long-term, findings support a general conclusion that five interventions at policy and strategic level will be necessary to enhance smallholder farmers' adaptive capacity and long-term resilience to climate change and variability. They include:

- More research and development on to enhance resilience to changes in rainfall and temperature regimes;
- Enhance and strengthen sustainable and Integrated Water Resources Management (IWRM) to address the risk of moisture deficiencies and increasing frequency of dry conditions and unpredictability of rainfall;
- Support diversification of household incomes by designing, introducing and promoting alternative income generating activities which are less climate sensitive such as tourism in non-climate dependent attractions; and
- Enhance access to incentives, subsidies and introduce crop insurance to farmers
- Enhance capacity of the farmers to adapt through provision of technological and technical support in adaptation technologies in agriculture, early warning systems, climate predictions, education and training.

Availability and access to water in the Mkomazi Sub-catchment are vital in supporting people's livelihoods through small scale irrigation. However, findings revealed that water availability is decreasing hence threatening survival of the people and threatening ecological functioning. Therefore, enhancing IWRM efforts and innovations will be necessary in addressing increasing risks of moisture deficiency and the ever increasing frequency of dry conditions so as to promote sustainable development. A possibility of combining insurance and incentives to come up with a special scheme for supporting smallholder farmers as part of enhancing adaptation and at the same time improving sustainability, will be a necessary intervention. For example, farmers in Mkundi and even other villages in the country (compare Paavola, 2008 study in Morogoro) have been unsustainably using available resources such as forests as an alternative due to impacts of change and variability in the climate. However, such resources are depleted and the rate of replacement is smaller than that of exploitation. These kinds of schemes will help to abate the unsustainable use of such resources while enhancing adaptive capacity of the smallholder farmers and other resource users to change and variability in the climate.

Providing technological and technical support services such as provision of inputs and extension services to farmers, timely provision of more accurate weather forecasting information, early warnings as well as developing a system which can help farmers beyond normal adaptation particularly addressing issues of loss and damage are all necessary. They would include but not limited to crop insurance for the farmers. Improving and/or provision of modern and sustainable irrigation infrastructure, system as well as water harvesting technologies will be critical. Improving provision of subsidies amidst changing climate will also support farmers in terms of enhancing their adaptive capacity. Similarly, better management of and ensuring equitable access to subsidies and different kinds of support to farmers is of paramount importance. The role of appropriate adaptation related information access, education and training to farmers in enhancing smallholder farmers adaptive capacity should also be recognized.

It is equally necessary to sustainably manage and use the available resources amidst changing and increased variability of the climate to not only enhance adaptive capacity but also ensure that the ecosystem continues to provide goods and services to the farmers for their survival. A good example is the need for conserving water sources like Chome Forest Reserve, which is the main source of most of the stream forming Mkomazi River. Deforestation and forest degradation in this and other forests within the sub-catchment area can affect the farmers more because water flow may continue to decrease and in the future, most of the stream may even dry-up. Apart from decrease in water flow, soil erosion may also increase, rendering soils poor and unproductive. Such a pattern will not only affect farmers but also the ecosystem at large.

Finally, the importance of village land use plans in addressing social conflicts over resources use should be recognized. Continued poor rainfall affects availability of pasture for cattle and water for both animals and human beings. Conflicts between farmers and pastoralist communities in Mkundi and Manga Mikocheni villages exemplify the growing demand for the district authorities to make sure that they prepare village land use plans, which will clearly draw lines to separate farmers and pastoralists. Thus, they should show where farms and settlements should be, where water for both animals, domestic use are obtained as well as grazing land for the pastoralists. This will be successful if implemented alongside other measures to ensure permanent availability of water for the farmers and the pastoralists.

10.3 Implications and Recommendations

10.3.1 Contribution of the Research to Understanding Smallholder Farmers' Decisions

Understanding smallholder farmers decision making on farm production through combining agro-ecological, socio-economic and meteorological data

This research contributes to knowledge of smallholder farmers' decision-making through combining agro-ecological, social and meteorological data to bring up: the multiple considerations taken into account by smallholder farmers to make farm production decisions; and heterogeneity of crops and crop varieties for the four villages within similar agro-ecological characteristics. Chapter six presented various changes, which smallholder farmers had been making in their farming practices in Mkomazi sub-catchment. It was articulated, in chapters six and seven that smallholder farmers took into account many aspects in arriving at decisions of changing their farming practices from time to time. It was further noted that much as the villages were about 25km apart, and shared almost similar agro-ecological conditions, smallholder farmers from each of the four villages had different considerations, which guided them to decide to change their farming practices leading to different crops and crop varieties as well as alternative household income sources. The farmers integrate climatic conditions; market conditions of the produce; characteristics of the crop and crop varieties to be cultivated; the need for fulfilling personal and household needs; and what fellow farmers, neighbors and relatives have managed to test and find successful and the like. As a result, some crops and crop varieties were found to be fulfilling many considerations. The best examples are lablab and the improved paddy varieties, which were shorter cycle, higher yielding, of good market, tolerant to dry conditions and disease resistant. This means that interventions to support smallholder farmers' adaptation through changes in the farming practices must be identified, recognized and consider the varying attributes, which will maximize chances for helping farmers to adapt, improve their livelihood conditions and contribute to sustainable development. Such efforts also should realize the fact that each local community might be

sharing similar agro-ecological characteristics but do not share similar farm production considerations

The role played by climate change and variability in influencing changes in the farming practices was found to be critical due to the fact that in the area, agriculture is mainly rain-fed. Thus, increasing scarcity of rainfall influenced adoption of lablab in Mkundi village as other crops crop varieties cannot do well. In Mtae village, some of the farmers are able to produce vegetables and potatoes in their gardens through irrigation using tap water, while many depend entirely on rainfall. The case of Manga Mikocheni is more or less similar to Mtae because farmers have no direct access to water for irrigation but depend on water released from Kalimawe dam but this is only possible if the amount of water is good enough to satisfy villages in the mountains. If it is scarce, farmers in Manga Mikocheni have poor chance of getting water in their rice fields. The adoption of tolerant paddy and maize varieties was motivated by this situation. Farmers in Kambeni village have direct access to water for irrigation but they have to always hope that rainfall is good enough to ensure continued water flow so that irrigation is possible. This entirely means that almost all villages depend on rainfall for their survival because much as some of the villages like Kambeni have access to water for irrigation, without enough rainfall to feed the flowing streams, such irrigation cannot be sustained. It is from this knowledge that farmers take into account the state of the climate, how it changes and what they expect it to be in future as one of the aspects to lead them to decisions on what they should produce.

Markets of what farmers should produce was also found to be one of the aspects farmers take into account in their decision making process. While they acknowledge that the climate has been a key factor in driving changes in the farming practices, respondent farmers in all villages underscore the role of markets in those decisions to change their farming practices. Farmers stressed the fact that what they produce must be one that is acceptable in the current state of the climate but must also have some markets so that when produced, can be sold if need be. It is for this reason that in each of the village, the changes undertaken reflect the role of the two factors. In Kambeni village, availability of good market for ginger has all along been the factor that helped the crop to be accepted and spread from one farmer and one village to another. A similar case is for Mkundi because availability of market for lablab was a supporting factor as to why it spread and became a common crop in the village side dry conditions. Good markets for potatoes and vegetables, land fragmentation and poor and unpredictable rainfall were key factors for farmers to decide to concentrate more on shorter cycle crops and crop varieties but with good markets. Manga Mikocheni village adopted improved rice and maize varieties taking into account availability of markets alongside poor rainfall as well.

Characteristics of crops and crop varieties, their ability to withstand certain conditions, their level of production (higher yielding) and their cycle are also key aspects that were found to be important in farmers' decision making. Crops with shorter cycle were found to be more preferred than those with longer cycles. Higher yielding crops and crop varieties were highly preferred as well. Crops and crop varieties, which are more tolerant to poor climatic conditions, were more preferred than weaker crops. It is from this fact that changes have been made on the type of rice, maize, beans, cassava etc., which are cultivated in these villages today.

Hence, the combination of three categories of data from five sources enabled not only to successfully identify multiple factors motivating changes in the farming practices but also results of the varying considerations from village to village within a similar agro-ecological

zone in the small research area. In summary, this research documents enough empirical findings with valuable details and case study experiences in the study area and the region, bringing together a significant number of data sources and methods, all of which helped to validate the data and the findings. In addition, the connection of the findings to broader ongoing debates in the literature have a significant contribution to a better understanding of the problems and response options in the field of adaptation to climate change, particularly in smallholder farming rural Africa.

10.3.2 Contribution of research findings to policy

The key contribution of this research to policy is the need for integrating and linking climate change, natural resources management policies and strategies with efforts to increasing farm production; access to good markets; provision of technological, technical, support services to smallholder farmers in enhancing their adaptive capacity and long-term resilience to adverse impacts of climate change and variability. From the findings, it is evident that there is less intervention by the government to support farmers in Mkomazi sub-catchment in their efforts to adapt to changes and variability of the climate. This is a similar case to many other parts of Tanzania. The government is constrained in terms of funding and the international adaptation framework is yet to bear tangible fruits to support smallholder farmers in most of the developing countries, particularly LDCs. Therefore, what farmers are doing to ensure their survival amidst changing and variability of climatic conditions is purely their own efforts with little support from the very few extension staff as well as non-governmental actors where possible. This study outlines several policy and strategic interventions to be implemented to support farmers' efforts to adapt and achieve long term resilience.

While efforts to help farmers to enhance their adaptive capacity might be put in place in the future, it is not only important but also necessary to integrate or else link these adaptation strategies and policies to the ongoing and planned interventions to help smallholder farmers to increase farm production. In addition, linking such efforts with current policy and strategic debates on climate change and natural resources management will be necessary in order to create synergies and establish complementarity on adaptation support to farmers. This will also contribute in supporting poverty reduction efforts while achieving sustainability objectives. These efforts include emission reduction, sustainable natural resources management and increased farm production.

Sustainable use and management of the available resources such as water and forestry amidst changing climate is a key challenge. In the study, it was found that in many cases the resources are not sustainably utilized hence threatening sustainability. The example of unsustainable irrigation in Kambeni where too much water is utilized for irrigating ginger while denying other users downstream such as those in Manga Mikocheni village, and use of forests for charcoal making and selling are a case in point. At policy level, there are various options, which could be employed to both provide opportunity for the resource users to manage and use such resources in a sustainable manner. The use of compensation schemes such as REDD+ and PES is one among such policy options.

According to UNFCCC (2010), REDD+ is a climate change mitigation policy intervention aimed at providing economic incentives, through market and non-market mechanisms, upon verification of the reported emission reduction using forestry sector. It has five key elements, which are of potential for reducing emissions that inculcate the following: reducing emissions

from deforestation; reducing emissions from degradation; conservation of forest carbon stocks; sustainable management of forests; and enhancement of carbon stocks. While REDD+ is designed to help reduce GHG emissions, and PES designed to support ecosystem conservation, the two compensation schemes have good potentials to enhance adaptation efforts and long term resilience of the smallholder farmers in the developing countries particularly in Africa.

REDD+ has potentials to support various adaptation endeavors in the developing world. Seppälä and colleagues (2009) document that REDD+ have potential to contribute to both forest and human adaptation. Within the UNFCCC negotiations, arguments advocating for ensuring REDD+ non-carbon benefits are given weight have been increasing because many believe that these will not only enhance its acceptability at national and subnational levels but also can benefit adaptation (Elias, *et. al.*, 2014; Smith and Mbow, 2014). It is argued that for REDD+ to register success, it has to also incentivize other key outcomes such as land tenure and governance reforms, sustainable livelihoods and enhancement of ecosystem services and biodiversity (REDD+ Safeguards Working Group, 2013). In so doing, countries will be able to address underlying drivers of deforestation and forest degradation while supporting communities to adapt. Pressure and strength of these arguments led to the COP 18 to request the Subsidiary Body for Scientific and Technological Advice (SBSTA) to initiate work on methodological issues related to non-carbon benefits (UNFCCC, 2013). As an opportunity emerging from international efforts to address climate change through mitigation, REDD+ is a possible policy option to address issues of deforestation and forest degradation such as those in the Mkomazi and beyond.

Payment for Ecosystem Services (PES) is a policy instrument designed to influence behavior of natural resource users towards sustainability by incentivizing (Kaczan, *et. al*., 2013). It has potential to support both sustainable utilization and management of natural resources while contributing to poverty reduction (van de Sand et al., 2012) but since it involves willing participation, the program has to be designed in such a way that it takes into account resource users' interests, needs and priorities to maximize success in the end (Kaczan et al., 2013). Effective implementation of PES has potential to support adaptation in a number of ways most of which are a result of enhanced availability of ecosystem goods and services, financial benefits as well as behavior change. Amidst enhancing adaptive capacity of smallholder farmers, PES can support adaptation by minimizing the possibilities of unsustainable use of natural resources (Van de Sand, *et. al*., 2012) for short-term coping strategies such as deforestation and forest degradation, enhancing adaptive capacity by providing finances as well as increasing production in the farm as a result of improved soil quality (*ibid*) and water availability among others.

The two mechanisms present an opportunity to help adaptation in the Mkomazi and beyond. If used properly, they will be able to reenergize conservation efforts of forests and other natural resources. They can reduce pressure on forests, which will in turn not only promote conservation of biodiversity but also improve and sustain availability of ecosystem goods and services. The availability of such ecosystem goods and services like water, are necessary in supporting smallholder farmers to adapt and for their survival. Access to ecosystem goods and services like water for irrigation, domestic and energy production as well as livestock use will be a great contribution of REDD+ and PES to adaptation. In addition, REDD+ and PES can also contribute to providing alternative income generation opportunities such as ecotourism. This can reduce dependency on smallholder farming hence concentration to less vulnerable and most sustainable economic activities. Apart from those, REDD+ and PES are a good source

of adaptation funding since the funds obtained through REDD+ and PES can support implementation of adaptation projects at local level. Ingram and colleagues (2014) provide examples of four initiatives in Guatemala, Cambodia, and Tanzania that were designed to support conservation of biodiversity through use of community-based PES. Much as variations in terms culture, economic activities, attitudes, willingness and even the type of biodiversity exists from one area to the other, similar policy related interventions can be implemented in Mkomazi and other areas to support management of the ecosystem. In doing so, they will enhance smallholder farmers adaptive capacity through increased availability of ecosystem goods and services, foster alternative incomes and adaptation financing; reducing conflicts between and among resource users; supporting poverty reduction efforts; and contributing to sustainable development (Smith and Mbow, 2014).

However, there will be some challenges to be experienced in the process. In the study to understand how local priorities and needs could be met in REDD+ implementation and how these expectations match with global mitigation benefits, Mustalahti and colleagues (2012) found that local community in one village were excited by REDD+ thereby generating a lot of expectations while in the other village, farmers identified water scarcity, rural development needs, and food security as their priority needs. This means that for REDD+ to be successful in different communities, it has to take into account local needs and priorities and reconcile them with national as well as global needs and priorities. In addition, some areas and resources have other non-monetary values attached to it by the local communities which may not be possible to assign monetary values and attach them some monetary benefits. Such values might be cultural, spiritual, inspirational or aesthetic (MA, 2005). Different societies in the developing world for example value various resources such as forests, valleys, mountains, rivers, land, cattle differently. Thus, introduction and success of REDD+, PES or any similar mechanism to incentivize communities towards sustainable utilization of natural resources must also consider awareness, sensitization as well as specific approaches including assessments to clearly understand the local context and the possible socio-cultural impacts of implementing such interventions in such areas (Luck, ***et. al***., 2012).

Much as so many challenges exist at both international level (for example, adaptation funding and various procedural as well as policy matters) and at national and sub-national level (such as policy and strategic arrangements as well as local needs assessments, awareness creation and mobilization), several opportunities also are available. At international level, for example, the existence of various climate change funds such as the Adaptation Fund provide an opportunity for Tanzania and other developing countries to support smallholder farmers adaptation, poverty reduction and contribute to efforts to achieve sustainable developments amidst climate change challenges. It is also worth noting that the plan to implement Nationally Appropriate Mitigation Actions (NAMAs) for developing countries which aims to enhance sustainable development through technology, financing and capacity-building support presents a policy option to enhance adaptation of the smallholder farmers. While at the international level some issues remain under discussion, as a step forward, a fully functional and publicly available version of the UNFCCC NAMA Registry was released on 16 October 2013 (Agarwal, ***et. al.***, 2013). In addition, a fund special for NAMA implementation was also launched in 2013 (Ibid.). The African Climate Change Fund, which is a thematic, bilateral trust fund with an initial contribution of 4.725 million Euros from Germany, aims to support African countries in their transition to a more climate-resilient and low-carbon mode of development (AfDB, 2014). It is hosted and managed by the African Development Bank's environment and climate change division (*ibid*.). This fund is another area offering opportunities to support adaptation of the

smallholder farmers in various themes like technologies, overall capacity building at institutional, policy and technical levels, research and development as well as concrete adaptation projects on the ground.

The role of Public Private Partnership (PPP) in supporting adaptation of smallholder farmers is also an issue for policy consideration. Tanzania adopted a PPP policy in 2009 for promote private sector participation in the provision of resources for PPPs in terms of investment capital, managerial skills and technology. This policy is envisaged to bring participation of the Private sector in national development to new highs. In addition, the government in collaboration with the Tanzania Business Council prepared the *Kilimo Kwanza* (Agriculture first) resolution which aims to transform agriculture in the country towards a green revolution. This is an area with a lot of potentials to support agricultural development for both smallholder and large scale perspectives and enhancing adaptation for the smallholder farmers in the Mkomazi and beyond. It has the potential to finance and ensure availability of appropriate farm and adaptation technologies, inputs, rural produce processing industries and value addition to rural produce, and stimulating various services to rural farmers and linking rural markets to the broader economic opportunities etc. Hence, its role in both success of the revolution, poverty reduction and adaptation cannot be overemphasized. It is from this understanding that the Prime Minister made the following remarks in the foreword of the Policy document on PPP.

> *"Public-Private Partnerships (PPPs) have been identified as viable means to effectively address constraints of financing, management and maintenance of public goods and services. Additionally, PPPs can enable the Government to fulfil its responsibilities in efficient delivery of socio-economic goods and services by ensuring efficiency, effectiveness, accountability, quality and outreach of services."* URT, (2009c).
> *"To achieve the goal of poverty reduction by 2025, Tanzania has chosen to initiate and implement measures for the realization of green revolution by adopting KILIMO KWANZA resolution……. In this regard, the government recognizes that, greater private sector participation through PPPs in providing efficient, reliable and affordable socio-economic services is fundamental for green revolution and broad based growth and sustainable poverty reduction. "* (*Ibid.*).

To maximize contribution of the private sector in supporting adaptation and poverty reduction efforts, it will be necessary to take extra care of the challenges that may arise. For example, smallholder farmers' interests and rights such as on land ownership and use should not be compromised.

Exploring better options for the introduction of crop insurance to support farmers in overcoming risks associated with climate change impacts through a loss and damage mechanism should also be an area of policy interest and relevance. While at the UNFCCC, negotiations on this item have not yielded concrete progress, the establishment of the Warsaw International Mechanism for Loss and Damage, under the Cancun Adaptation Framework (UNFCCC, 2014) is a promising step. At the national level, some assessments can be made to determine appropriate approaches to put this into practice so as to support farmers amidst chancing climate while integrating poverty reduction objectives and sustainable development variables. The need for reviewing the experiences on provision of subsidies, including both success and failures will be necessary in order to provide a starting point on how future crop insurance arrangements can be successful.

The need for more research and development so as to support smallholder farmers in the region in terms of crops and crop varieties, which are highly tolerant, and less water consuming, shorter cycle, higher yield and with good markets is important in addressing increasing dry conditions and land fragmentation particularly in the mountains. The role of crops and crop varieties which are tolerant to dry conditions and pest and diseases in enhancing adaptive capacity of smallholder farmers in a changing climate context is recognized in the National Climate Change Strategy of 2012 (URT, 2012b) and other adaptation studies (for example, Nnadi, *et. al*., 2013). To address challenges of the changing climate, it will be necessary to broaden the scope of such crops and crop varieties through research and development in order to support more farmers in different agro-ecological conditions in Tanzania and even beyond. Introduction of Lablab by farmers in Mkundi village for example, is a case in point. It is possible for such kind of crops to be promoted and used elsewhere depending on the agro-ecological characteristics. While uptake and acceptability of such crops and crop varieties in different areas and cultures might be a matter of discussion, their significance amidst changing climatic conditions and the need to enhance adaptive capacity and long term resilience is not a matter of debate. Development and dissemination of less water consuming common crops and crop varieties in some areas will also be necessary. Ginger cultivation in Kambeni, South Pare Mountains was cited as one of the key challenges water managers are experiencing because it consumes much water and denies other water users downstream to access such a vital resource amidst changing climate, hence exacerbating vulnerability. In addition, it threatens to affect normal ecological functioning in the basin. Amidst changing climate and dwindling water availability, the introduction and dissemination of less water consuming ginger varieties in the area while upscaling the idea of creating awareness of farmers in other areas to concentrate on crops and crop varieties with less water consumption characteristics is vital and an issue of policy relevance. Continued dependency on ginger may also be catastrophic as it is not certain that markets will continue to be favorable. This brings the need to link and integrate ginger production plans with diversification of crop production and animal husbandry so as to increase adaptive capacity of the farmers.

Information access, education and training to smallholder farmers is documented and emphasized as an important and necessary element to not only enhance adaptive capacity but also increase production in the farm amidst changing climatic conditions (Hassan, 2010). As a policy issue to support adaptation, the need for the government to enhance collaboration with a spectrum of stakeholders such as civil society and the private sector in ensuring that smallholder farmers have access to appropriate information, education and training on both farm production and climate change adaptation is necessary. In doing so, linking traditional and formal knowledge systems will be crucial because such linkage is highly advocated in order to realize conservation and sustainable use of ecosystems (MA, 2005). This kind of a policy approach will support farmers through putting in place and/or strengthening early warning systems for timely weather predictions, forecasts and dissemination of the information; enhancing adaptation related information access, awareness and education; providing advisory services to farmers on markets and production strategies within the context of a changing climate but taking into consideration broader market needs etc. All these have a critical role to play in increasing farmers' production, enhancing adaptive capacity and reducing poverty.

Likewise, supporting smallholder farmers in the market chains is necessary to be linked with adaptation strategies and policies. Based on the findings, an argument is advanced that efforts to support adaptation through strategies and policies must also take into account markets

considerations. From the validation workshop, it was revealed by the Same District Council official that the district has good plans to strengthen ginger production and market chain in Kambeni village and much more areas in the South Pare Mountains to ensure that ginger production increases to benefit the farmers. The plans include supporting farmers in terms of sustainable water use for irrigation through modern irrigation canals, water harvesting and storage; provision of subsidized inputs; revitalizing the process to launch the operation of the ginger processing factory; construction and improvement of infrastructures in the area to ensure smooth transportation of people, inputs and agricultural produce; and supporting the Mamba Myamba Ginger Co-operative Society to strengthen its work for the farmers including micro financing; and networking farmers to ginger markets. This is a good example and highly promising on what it should be done to improve further production and enhance adaptive capacity as well promote resilience of the smallholder farmers to changing and variability of climatic conditions in the Mkomazi and probably other places with similar characteristics to Mkomazi. It is important to state that the plans by Same District Council are very commendable efforts to support smallholder farmers in improving their production and alleviating poverty. However, these plans to some extent exclude some very important adaptation strategies and policy interventions. The questions of ensuring sustainable water flow; addressing, on a long term basis, the effects of changes in rainfall and temperature regimes; too much emphasis on a single crop alongside market uncertainties; issues of weather forecasting and prediction as well as early warnings to farmers; and conservation of the environment to sustain access to ecosystem good and services just to mention a few, ought to be taken into consideration in such plans and policies. It will be necessary to integrate and link such plans with adaptation strategies and policy interventions which can address the issues raised.

10.3.3 Contribution to further research

While this study contributes to both knowledge and policy, it was limited in terms of climate variables covered, i.e. only temperature and rainfall. This study also did not model climate variables against crop production to clearly identify the extent to which changes in the local climate economically affect smallholder farmers' production and incomes. The study also did not economically identify the contribution of each of the several economic activities and income sources farmers depend on, i.e. crop production, remittance, charcoal making, animal keeping, small-scale fishing, small business, tourism, selling labour etc. It is from this line of arguments that there are research gaps to fill.

The need to broaden and deepen the study to include other elements of climate (such as wind, humidity etc.) and non-climate variables (such as markets, geographical locations, infrastructure etc.), in modelling long term climate change impacts on crop production and other economic activities will help to broaden understanding on how smallholder agriculture is and will further be affected by changes in the climate in the future in concrete terms. This will also help policy making and strategic investment in supporting smallholder farmers to adapt. The study must disaggregate areas according to location within the valley (those which are located in the highlands where rainfall is high and ones located in the lowlands where vulnerability is already high) and access to water for irrigation. It can also take into account access to sustainable alternative household and community income sources such as tourism activities in Mtae village. Such study will have to identify the magnitude of change in the local climate by looking at all key elements of climate, as suggested by stakeholders in the validation workshop who underscored the fact that the current study did not cover other elements of climate, e.g. the state of wind. They expressed concerns that according to their experience,

wind direction patterns and speed have also been changing in the past 30 years. The study will also gauge the extent to which such magnitude of change has been and will continue to affect smallholder agricultural activities, production as well as increasing pressure on other natural resources within the area.

Another important gap is an economic study to identify the contribution made by crop production against other alternative income generating activities and sources at both household and community levels. The current study identified various alternative income generating activities which farmers engage in alongside crop production. However, little is known on the contribution of each economic activity as well as source and how sustainable each one is. This is an important research gap to be filled. Such research will also provide a detailed assessment of which alternative income generating activities are sustainable and have high potentials to help farmers to obtain income while undertaking changes in the farming practices to adapt and reducing pressure on the available natural resources. At policy and strategic levels, the study will identify which economic activities can be promoted in the region to support farmers to adapt while enhancing sustainable development objectives.

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APPENDICES

Research Instrument 1: Questionnaire

Questionnaire No:	Date: / / Day/month/year

Demographic and Socio-economic Characteristics of Respondents:

General Information

Village/ District:	Ward:
Region:	Name (optional)

Personal Information

1.1 What is your gender? (Tick the appropriate answer)

A. Male [ ] B. Female [ ]

1.2 Which age group do you belong to? (Tick the appropriate answer)

A. 18 – 25 years [ ]

B. 26 – 35 years [ ]

C. 36 – 45 years [ ]

D. 46 – 55 years [ ]

E. 56 – 65 years [ ]

F. Over 66 years [ ]

1.3 How do you group your household size?(Tick the appropriate answer)

A. 1-3 [ ]
B. 4-6 [ ]
C. 7-9 [ ]
D. 10 or more [ ]

1.4 What is your highest educational or professional qualification? (Tick the appropriate answer)

A. No Education [ ]
B. Primary School [ ]
C. Middle School [ ]
D. Secondary School [ ]
E. High school [ ]
F. Vocational [ ]
G. College [ ]
H. University [ ]
I. Informal or other (Please specify)……

1.5 What is your average annual household income in Tsh? (Tick the appropriate answer)

A. Less than 500,000 [ ]
B. Between 500,000 and 1,000,000 [ ]
C. Between 1,000,000 and 3,000,000 [ ]
D. Between 3,000,000 and 5,000,000
E. Between 5,000,000 and 7,000,000 [ ]
F. More than 7,000,000 [ ]

1.6 Do you own the following? (Tick the appropriate answer)

House(s)

A. Yes
B. No

Land

A. Yes
B. No

2. **Respondent's agricultural activities details**

2.1 Land holding details (Please fill in the boxes indicating the amount of land in acres)

Land area owned	Cultivated area in past 20 years	Grazing land	Cultivated Land this year	Land under irrigation	Cultivated leased land

2.2 Land use intensity details (please fill in the boxes the amount of land in acres)

Area Cropped once in a Year	Area Cropped twice in a Year	Area Cropped three times in a Year

2.3 Crops intensity details (Please list the types of crops in the boxes)

Crops cultivated once in a Year	Crops cultivated twice in a Year	Crops cultivated three times in a Year

2.4 Can you please categorise the amount of production of your farm per acre per year per crop for the good and bad years?

Crop	Amount of land cultivated	Production per year (Bugs)	
		Good year	Bad year

2.5 Do you mainly produce for cash or subsistence?
A. Subsistence [ ] B. Cash [ ]

2.6 If you produce various crops for both cash and for food, please list down the crops you produce for cash and those ones you produce for food

Crop name	**Subsistence or Food (tick)**	**Cash**

3. **Perception of changes in the climate variables**

3.1 How do you perceive climate change and variability through? (Tick as appropriate)

Code	**Perceptions**	**Tick**
A.	Change in amount of rainfall during main rain season	
B.	Increasing rainfall in amount during main rain season	
C.	Decreasing rainfall in amount during main rain seasons	
D.	Shift in the timing of the onset of rain in the main season	
E.	Rain starting later than normal	
F.	Rain starting earlier than normal	
G.	Short rains than normal	
H.	Long rains than normal	
I.	Planting date change applying to most crops	
J.	Temperature of the area decreasing	
K.	Temperature of the area increasing	
L.	Rainfall increasing	
M.	Rainfall decreasing	
N.	Rainfall fluctuating	
O.	Increase in recurrences of floods	
P.	Decrease in recurrence of floods	
Q.	Increase in intensity of floods	

R.	Increase in recurrence of droughts	
S.	Increase in intensity of droughts	

4. What has been the trend of rainfall for the past 20 years to date according to your memory? (Please tick as appropriate)
   A. Increasing [ ]
   B. Decreasing [ ]
   C. Fluctuating [ ]
   D. Constant [ ]
   E. unpredictable [ ]
   F. Don't know [ ]

5. What has been the trend of temperature for the past 20 years to date according to your memory? (Please tick the appropriate answer)
   A. Increasing [ ]
   B. Decreasing [ ]
   C. Fluctuating [ ]
   D. Constant [ ]
   E. Don't know [ ]

6. **Information on existing adaptation strategies and motivating factors**

6.1 Please tick in the appropriate box matching the factors that motivated you to change farming practices (listed in the first row) against the changes that you have made in response to changing climate (listed in the first column).

Adaptation Strategies	**Possible Factors**						
	Negative CC effects	Financial capital	Income	Good markets	High living costs	Others Influence	Household size
Shift to higher yielding crop varieties							
Introduce new crop varieties							
Shift to shorter cycle crop varieties							
Stop cultivating some crop varieties							
Shift to crops that command good market prices							

Shift to drought resistant crop varieties							
Intensify irrigation							
Diversify household income sources							

6.2 In the third column, please provide more details including examples regarding the adaptation strategies you have been using

Code	**Adaptation Strategy**	**Details on the responses (e.g. the new crop varieties, other economic activities opted for etc)**
A.	Shift to higher yielding crop varieties	
B.	Introduce new crop varieties	
C.	Shift to shorter cycle crop varieties	
D.	Stop cultivating some crop varieties	
E.	Shift to crops that command good market prices	
F.	Shift to drought resistant crop varieties	
G.	Intensify irrigation	
H.	Diversify household income sources	

7. **Socio-economic implications of the impacts of the changes farmers have made in their farming practices as adaptation options**

7.1 What are the socio-economic implications of the changes you have made (as your adaptation to the changes in the local climate that you have been experiencing) at your household as well as at the community level? (Please fill in the two blank columns as appropriate,)

Code	Implications	Details on the implications	Level (H=Household or C=Community)
A.	Average annual income has increased		
B.	Average annual income has decreased		
C.	Awareness on climate change has risen		
D.	Water shortage for domestic and other uses		
E.	Human health threats have increased		
F.	Food insecurity threats have increased		
G.	Quality of life deteriorated		
H.	Migrations increased		
I.	Social cohesion threatened		
J.	Social conflicts over diminishing resources increased		
K.	Family conflicts increased		

8. **Knowledge on the appropriate adaptation options**

8.1 How do you get to know that the options you select and adopt (as listed in the table in question 6.2) are good to support you to adapt with the changes? (Please tick as appropriate)

A. The radio ☐

B. Newspapers ☐

C. TV ☐

D. Family Members ☐

E. Neighbours ☐

F. Religious institution ☐

G. Community Meetings ☐

H. Agriculture Extension Officers ☐

I. Researchers ☐

J. NGOs: Specify ☐

K. Traditional and cultural knowledge including forecasting ☐

L. Just intuition ☐

M. Cultural specific knowledge ☐

N. Tanzania Meteorological Agency forecast information ☐

O. Others sources of knowledge (Specify)

8.2 What type of information do you think you need most to increase your ability to adapt to climate change impacts? (Please tick as appropriate)

S.No.	Type of information	Tick
1.	**Scientific Information about**	
1.1	The causes of climate change	
1.2	Weather and meteorological information (e.g. early warnings)	
1.3	Knowledge about soils and how to improve its fertility	
1.4	Predictions in relation to climate change	
2.	**Agricultural Practices, Knowledge and information**	
2.1	Better management of agricultural land for sustainable production	
2.2	Proper use of agricultural inputs	
2.3	Climate change and sustainable farming systems	
2.4	Crop varieties tolerant to harsh climatic conditions	
2.5	Intensification of agriculture	
2.6	Adaptation knowledge and technologies for farmers	
3.	**Economic/Commercial Information about**	
3.1	Crops commanding good prices in the market	
3.2	Financial opportunities arising from climate change	
3.3	Credits availability and access	
3.4	Incentives availability and access, e.g. inputs	
4.	**Social Information about**	
5.1	Local and traditional adaptation knowledge and technologies	
4.2	Culture and sustainable adaptation	
4.3	Blending scientific and local knowledge to support adaptation	
5.	**Legal Information about**	

5.1	Land tenure issues	
5.2	Land rights	
5.3	Contracts issues	
6.	**Strategic and Policy information about**	
6.1	Government efforts to address the challenges of climate change and variability	
6.2	Alternative livelihoods options to reduce severity of climate change impacts	
6.3	Crop insurance	
6.4	Sustainable climate change adaptation policies and strategies	

9. **Future adaptation options**

9.1 Generally, do you think these changes in the local climate will continue in the future

Yes	No

9.2 What do you think you can do in the future to be able to adapt to the changes if they persist?

Code	Future adaptation options	Tick
A.	Abandon agriculture at the expense of other economic activities	
B.	Abandon the current farms and move to wetter areas like river banks	
C.	Emigrate from your village to other areas with better conditions	
D.	Continue changing agricultural practices in line with the changes in the local climate	
E.	Ask for food aid	
F.	Ask for government support like introduction of new and modern adaptation options	
G.	Seek to obtain more information, knowledge and education on adaptation to climate change	
H.	Promote irrigation using underground water	
I.	Promote conservation practices further	

10. **Policy and Strategic Interventions for long term resilience:**

10.1 What do you propose to be done by policy makers and other relevant stakeholders to help you to adapt to the changes in the long term? (Please tick as appropriate)

Code	Intervention	Yes
A.	Enhance your capacity through education and training	
B.	Improve institutional capacity and efficiency	
C.	Improve access to credits	
D.	Enhance awareness and information provision	
E.	More research and dissemination of research results to farmers	
F.	Respect and disseminate local experience and knowledge	
G.	Develop and introduce new crop varieties to increase the tolerance and suitability of plants to temperature, moisture and other relevant climatic conditions	
H.	Introduce crop insurance	
I.	Support to adopt improved crop varieties, modern irrigation and agricultural related better technologies	
J.	Provide the needed infrastructure in the rural areas, post-harvest support and support for agro industries	
K.	Develop and/or strengthen early warning systems that provide daily weather predictions and seasonal forecasts	
L.	Strengthen timely dissemination of weather forecasting information to farmers	
M.	Encourage participation of private sector in agriculture investment;	
N.	Undertake research to quantify the magnitude of climate change for each agro-ecological zone and advise accordingly	
O.	Develop and strengthen water management innovations to address the risk of moisture deficiencies and increasing frequency of droughts	
P.	Introduce and/or improve subsidy and incentives provisions to support farmers to adapt	
Q.	Develop and implement policies and programs to influence farm-level land and water resource use and management practices	
R.	Support diversification of agriculture as an economic activity	

Research Instrument 2: Interview Guide

University of Oldenburg			
Ph.D Project=Climate Change Adaptation in Smallholder Farmers Rural Communities: The Case of the Mkomazi sub-catchment, Tanzania			
Interview Questions			
Information Required	**General Question**	**Possible Guiding Questions**	**Interviewees**
The long term trend of changes in the key elements of climate (rainfall and temperature) at the local level with a minimum of the past 20 years	Are there any past, present and future changes in the local climate and how are they perceived and explained by the local communities?	Are there any changes in the state of the climate e.g. rainfall, temperature for the past 20-30 years?	PBWB, DALDOs-WAEO, VCPs, Ward Councillors and Village Elders
		Why do you perceive the changes?	PBWB, DALDOs-WAEO, VCPs, Ward Councillors and Village Elders
		What are the reasons for the changes?	PBWB, DALDOs-WAEO, VCPs, Ward Councillors and Village Elders
Changes in the farming practices as a result of climate change and variability and sustainability of such changes	Are there any changes in farming practices that have been or are being made in the area within past 20-30 years ago? Are these changes sustainable?	Have there been changes in the farming practices as an adaptation response to climate change and variability?	PBWB, DALDOs, WAEO, VCPs, Councillors, Village Elders
Motivating factors for decision to change farming practices	What are the motivating factors for the local communities to make decisions in certain times to change from one farming/land use practice to another?	Does availability of good market price particular crops and crop varieties play a role in the changes?	PBWB, WAEO, DALDOs, VCPs, Councillors, Village Elders
		How does the available infrastructures and communication system motivate changes farming?	PBWB, WAEO, DALDOs, VCPs, Councillors, Village Elders
		Did perceived changes in the local climate motivate changes in the farming practices?	PBWB, WAEO, DALDOs, VCPs, Councillors, Village Elders

		Does the availability of extension and other services motivate changes in the farming practices in the area?	WAEO, VCPs, Councillors, Village Elders
		Could the availability and access to agricultural and weather information services have played a role in the changes in the farming practices?	WAEO, VCPs, Councillors, Village Elders
		Any other possible factors which motivated changes in the farming practices in the area?	WAEO, VCPs, Councillors, Village Elders
The socio economic implications of the changes to the household and community	What are the socio-economic implications of the changes at community level in the study area?	What socio-economic changes do you experience at the household as well as community level as a result of changes in the local climate?	PBWB, DACO, WAEO, VCPs, Councillors, Village Elders
Policy and strategic interventions appropriate to support smallholder farmers in the area to adapt and enhance resilience to climate change	What are the appropriate policy and strategic interventions that can support smallholder farmers to adapt to the changes they perceive and why?	What can you propose as appropriate interventions to help you to adapt sustainably and enhance your resilience to climate change and variability?	PBWB, DALDOs, WAEO, VCPs, Councillors, Village Elders

Note:

Interviewees Groups: (Pangani Water Basin Officer; Same District Agricultural Officer; Lushoto District Agricultural Officer; Ward Agricultural Extension Officer; Village Chairpersons; Ward Councillors; selected elders from each village)

Meaning of Abbreviations

PBWB-Pangani Basin Water Board

DALDO-District Agricultural and Livestock Officer

WAEO-Ward Agricultural Extension Officer

VCPs-Village Chairpersons

Research Instrument 3: FGD Broad Guiding Topics

Research Instrument 3

1) **State of the local climate:**
   a) The state of the local climate in the past 30 years to-date
   b) Any changes so far (good/bad ones)
   c) Why those changes (if any)?
   d) The state of the climate to change further in the future? Good or bad?

2) **Key changes in the farming practices and their sustainability.**
   a) What are these changes (specifically) e.g. type and characteristics of crops, soil management techniques, water harvesting and storage etc.
   b) Timing of the changes
   c) Alternative income sources and whether they are sustainable

3) **Motivating factors for changes in the farming practices and adoption of alternative income sources**
   a) Climatic conditions
   b) Economic factors
   c) Policy changes
   d) Any other

4) **Socio-economic implications of the changes in the local climate.**
   Identification of the effects of the changes, e.g.

   - Incomes
   - Water availability
   - Food production and security
   - Social conflicts
   - Health status
   - Household conflicts etc.

5) **Policy and strategic interventions for enhanced adaptive capacity and long term resilience.**